PAEE ALE 2016

8TH INTERNATIONAL SYMPOSIUM ON PROJECT APPROACHES IN ENGINEERING EDUCATION

14TH ACTIVE LEARNING IN ENGINEERING EDUCATION WORKSHOP

GUIMARÃES - PORTUGAL
CENTRO CULTURAL VILA FLOR

SUSTAINABILITY IN ENGINEERING EDUCATION

06-08 JULY 2016

PROJECT
APPROACHES
IN ENGINEERING
EDUCATION

TITLE

International Symposium on Project Approaches in Engineering Education
Volume 6 (2016) ISSN 2183-1378

Proceedings of the PAEE/ALE'2016, 8th International Symposium on Project Approaches in Engineering Education (PAEE) and 14th Active Learning in Engineering Education Workshop (ALE)

Guimarães, Portugal – 06-08 July 2016

EDITORS

Rui M. Lima, Erik de Graaff, Anabela Alves, Andromeda Menezes, Diana Mesquita, José Dinis-Carvalho, Lamjed Bettaieb, Natascha van Hattum-Janssen, Nelson Costa, Rui M. Sousa, Sandra Fernandes, Valquíria Villas-Boas

PUBLISHER

Department of Production and Systems – PAEE association

School of Engineering of University of Minho, Campus de Azurém, 4800-058 Guimarães, Portugal

GRAPHIC DESIGN

Gen – Comunicação Visual

ISBN

978-989-20-6829-9

ISSN

2183-1378

PAEE/ALE'2016, 8th International Symposium on Project Approaches in Engineering Education (PAEE) and 14th Active Learning in Engineering Education Workshop (ALE) was organized by PAEE – Project Approaches in Engineering Education Association, in collaboration with Active Learning in Engineering Education Network (ALE).

PROJECT APPROACHES IN ENGINEERING EDUCATION

http://paee.dps.uminho.pt/ http://www.ale-net.org/

This is a digital edition.

WELCOME TO PAEE/ALE'2016

Dear Participants,

Welcome to PAEE/ALE'2016, the 8th International Symposium on Project Approaches in Engineering Education (PAEE) and 14th Active Learning in Engineering Education Workshop (ALE). Educating engineers that will shape our future is an important task. But to be frank, in many places engineering education has a bad reputation: it is boring. The study to become an engineer is difficult and requires a lot of hard work. Engineering education is no fun. But it does not have to be that way. Engineering education can be stimulating and motivating, challenging students to solve problems from engineering practice like real professionals.

The past years PAEE and ALE have been organized in different parts of the world, aiming to enhance Active Learning, Problem and Project-Based Learning in Engineering Education through active involvement of participants in a variety of sessions, hands-on, workshops, debate sessions, industry panel, interactive poster session, paper sessions, keynote sessions and student project awards. This year is a special edition of the symposium as we continue to join forces with Project Approaches in Engineering Education (PAEE) and ALE (Active Learning in Engineering Education Network) to create opportunities for learning and networking of Engineering Education professionals who are dedicated to active learning.

The PAEE symposium is organised by the PAEE association (http://paee.dps.uminho.pt/) and the Department of Production and Systems of the University of Minho, Portugal, since 2009, and aims to join teachers, researchers and professionals concerned with Engineering Education. ALE (http://www.ale-net.org/) is an international network of engineering educators, initiated in 2000, dedicated to improving engineering education through active learning.

The theme of this year's conference - Sustainability in Engineering Education - is aligned with the location of the hosting event. The city of Guimarães is candidate for the 2020 European Green Capital Award, an excellent opportunity to discuss research and current practice under this challenging theme.

We would like to express our sincere gratitude to the participants that makes this event possible and for all the support that we had during this last year from different persons and organizations.

We hope you will enjoy the conference, the social program and your stay in Guimarães,

Rui M. Lima

Erik de Graaff

(Chairs of the PAEE/ALE'2016)

PAEE/ALE'2016 Organization

PAEE/ALE'2016 Chairs

Rui M. Lima - Department of Production and Systems - Engineering School, University of Minho

Erik de Graaff - Department of Development and Planning - Aalborg University, Denmark

PAEE/ALE'2016 Organising Committee

Rui M. Lima - Department of Production and Systems - Engineering School, University of Minho, Guimarães, Portugal

Erik de Graaff - Department of Development and Planning - Aalborg University, Denmark

Anabela Alves - Department of Production and Systems - Engineering School, University of Minho, Guimarães, Portugal

Andromeda Menezes - Department of Production and Systems - Engineering School, University of Minho, Guimarães, Portugal

Diana Mesquita - Institute of Education / Dep. Production Systems - University of Minho, Braga, Portugal

Dinis Carvalho - Department of Production and Systems - Engineering School, University of Minho, Guimarães, Portugal

Lamjed Bettaieb - Directeur ESPIRIT Ingénieur, Tunisia

Natascha van Hattum-Janssen - School of Creative Technology - Saxion University of Applied Sciences, Enschede, the Netherlands

Nélson Costa - Department of Production and Systems - Engineering School, University of Minho, Guimarães, Portugal

Rui M. Sousa - Department of Production and Systems - Engineering School, University of Minho, Guimarães, Portugal

Sandra Fernandes - Department of Psychology and Education, Portucalense University, Porto, Portugal

Valquíria Villas Boas - Centro de Ciências Exatas e Tecnologia - Universidade de Caxias do Sul, Brasil

PAEE/ALE'2016 SCIENTIFIC COMMITTEE

Scientific Committee	Affiliation
Adriana Fischer	Post-graduate Programme in Languages, Universidade Regional de Blumenau (FURB), Brazil
Aida Guerra	UNESCO Chair in PBL in Engineering Education, Department of Development & Planning, Aalborg University, Aalborg, Denmark
Ana Lúcia Manrique	Faculty of Science and Technology, PUC São Paulo, Brazil
Ana Margarida Veiga Simão	Faculty of Educational Science, University of Lisbon, Portugal
Anabela Alves	Department of Production and Systems, Engineering School, University of Minho, Guimarães, Portugal
André Fernando Uébe Mansur	Instituto Federal Fluminense e Universidade Federal Fluminense
André Luiz Aquere	Department of Civil and Environmental Engineering, Faculty of Technology, University of Brasília, Brazil
Andromeda Menezes	Department of Production and Systems, Engineering School, University of Minho, Guimarães, Portugal
Bernd M. Zunk	Institute of Business Economics and Industrial Sociology, Graz University of Technology, Austria
Bill Williams	Escola Superior de Tecnologia do Barreiro, Instituto Politécnico de Setúbal, Portugal
Celina Leão	Department of Production and Systems, Engineering School, University of Minho, Guimarães, Portugal
Ciliana Regina Colombo	Departamento de Engenharia de Produção, Centro de Tecnologia, Universidade Federal do Rio Grande do Norte, Natal, Brasil
Claisy Marinho-Araújo	Institute of Psychology, University of Brasília (UnB), Brasília, Brazil
Diana Mesquita	Institute of Education / Dep. Production Systems, University of Minho, Braga, Portugal
Diana Pereira	Institute of Education, University of Minho, Braga, Portugal
Dianne M. Viana	Department of Mechanical Engineering, Faculty of Technology, University of Brasília, Brazil
Donald D. Carpenter	Great Lakes Stormwater Management Institute, Department of Civil Engineering, Lawrence Technological University, USA
Elisabeth Saalman	Engineering Education Research, Chalmers University of Technology, Sweden
Ely A. T. Dirani	Faculty of Science and Technology, PUC São Paulo, Brazil
Erik de Graaff	Department of Development and Planning, Aalborg University, Denmark
Filomena Soares	Department of Industrial Electronics, Engineering School, University of Minho, Guimarães, Portugal
Francisco Gomes	Department of Electrical Engineering, Faculty of Technology, University of Juiz de Fora, Brazil
Francisco Moreira	Department of Production and Systems, Engineering School, University of Minho, Guimarães, Portugal
Guilherme Pereira	Department of Production and Systems, Engineering School of the University of Minho
Isabel Loureiro	Department of Production and Systems, Engineering School, University of Minho, Guimarães, Portugal
Jaime Salazar	Executive Secretary of ASIBEI, Departamento de Ingeniería Civil y Agrícola, Universidad Nacional de Colombia, Colombia
João Mello da Silva	Production Engineering, Faculty of Technology, University of Brasília, Brazil
José Carlos Reston	Academic Director, IDAAM Higher Education Institution, Manaus, Brazil
José Couto Marques	Department of Civil Engineering, Faculty og Engineering, University of Porto, Portugal
José de Souza Rodrigues	Faculdade de Engenharia de Bauru, Universidade Estadual de São Paulo (UNESP)
José Dinis-Carvalho	Department of Production and Systems, Engineering School, University of Minho, Guimarães, Portugal
José Manuel Oliveira	Higher Education Polytechnic School of Águeda, University of Aveiro, Portugal
Lamjed Bettaieb	Directeur ESPIRIT Ingénieur, Tunisia
Leidy Johanna Rendón Castrillón	Centro de Estudios y de Investigación en Biotecnología (CIBIOT), Universidad Pontificia Bolivariana
Luiz Carlos de Campos	Faculty of Science and Technology, PUC São Paulo, Brazil
Marco Antonio Pereira	Escola de Engenharia de Lorena (EEL) , Universidade de São Paulo (USP)
Margarita Enid Ramírez Carmona	Facultad de Ingeniería Química, Escuela de Ingeniería, Universidad Pontificia Bolivariana, Medellín, Colombia
Maria Assunção Flores	Institute of Education, University of Minho, Braga, Portugal
Mauricio Duque	Departamento de Ingeniería Eléctrica, Universidad de los Andes, Colombia
Michael Christie	School of Science, Education & Engineering, University of the Sunshine Coast, Australia
Miren Zubizarreta	Engineering School, Mondragon University
Mladen Radisic	Industrial Engineering and Management Department, Faculty of Technical Sciences, University of Novi Sad, Serbia
Montse Farreras	Departament d'Arquitectura de Computadors, Universitat Politècnica de Catalunya/Barcelona Tech, SPAIN
Natascha van Hattum-Janssen	School of Creative Technology, Saxion University of Applied Sciences, Enschede, the Netherlands
Nelson Costa	Department of Production and Systems, Engineering School, University of Minho, Guimarães, Portugal
Nestor Arana	Engineering School, Mondragon University, San Sebastian, Spain
Nival Nunes de Almeida	Chair of ABENGE - Associação Brasileira de Educação em Engenharia, Brazil
Octavio Mattasoglio Neto	Instituto Mauá de Tecnologia, Escola de Engenharia Mauá - São Caetano do Sul - SP - Brazil
Otilia L. Heinig	Universidade Regional de Blumenau (FURB), Blumenau, Brazil
Patricio Poblete	Escuela de Ingeniería y Ciencias, Universidad de Chile, Chile
Rui M. Lima	Department of Production and Systems, Engineering School, University of Minho, Guimarães, Portugal
Rui M. Sousa	Department of Production and Systems, Engineering School, University of Minho, Guimarães, Portugal
Sandra Fernandes	Department of Psychology and Education, Portucalense University, Porto, Portugal
Simone Borges Simão Monteiro	Department of Production Engineering, Faculty of Technology, University of Brasilia (UnB), Brasília, Brazil
Sonia Gomez Puente	Technical University of Eindhoven, The Netherlands
Stevan Stankovski	Industrial Engineering and Management Department, Faculty of Technical Sciences, University of Novi Sad, Serbia
Teresa Restivo	LAETA-INEGI, Faculty of Engineering, University of Porto, Portugal
Valquiria Villas-Boas	Centro de Ciências Exatas e Tecnologia, Universidade de Caxias do Sul, Brazil
Yesid Vélez Salazar	Facultad de Ingeniería Química, Escuela de Ingeniería, Universidad Pontificia Bolivariana, Medellín, Colombia

PAEE/ALE'2016 Invited Speakers

PAEE/ALE'2016 attracted renowned keynote speakers, who are experts at Engineering Education in general and Project Approaches in particular. We are honoured to have the following inspiring keynote speakers:

- Anette Kolmos - Director for the Aalborg (UNESCO) Centre for Problem-Based Learning in Engineering Science and Sustainability, Denmark.
- Valquíria Vilas-Boas - Full professor at Centro de Ciências Exatas e da Tecnologia of the Universidade de Caxias do Sul (UCS) in Brasil.
- Donald D. Carpenter - Professor of Civil Engineering at Lawrence Technological University in Southfield Michigan, USA

ANETTE KOLMOS

Theme: Global Sustainability Goals and PBL in Engineering

Short bio

Professor Anette Kolmos is the Director for the Aalborg Centre for Problem-Based Learning in Engineering Science and Sustainability. Her other portfolios include Guest Professor at KTH Royal Institute of Technology, Guest Professor at UTM University Technology Malaysia, Associate Editor for the European Journal of Engineering Education and was Associated Editor for Journal of Engineering Education (ASEE) and President of the European Society for Engineering Education. She was awarded the IFEES Global Award for Excellence in Engineering Education in 2013. Over the last 20 years, Professor Kolmos has researched on development and evaluation of project based and problem based curriculum, change from traditional to project organized and problem based curriculum, development of transferable skills in PBL and project work, and methods for staff development. She has supervised 13 PhD projects and published over 200 articles.

VALQUÍRIA VILLAS-BOAS

Theme: The importance of Team Work in Engineering Education: from High School to University

Short bio

Valquíria Villas-Boas is a full professor at Centro de Ciências Exatas e da Tecnologia of the Universidade de Caxias do Sul (UCS) in Brazil. She has a B.S., M.S. and PhD in physics from the Universidade de São Paulo. Her M.S. and PhD theses treated magnetic and structural properties of hard magnetic materials. Before working at UCS, she was an assistant professor at Universidade de São Paulo, University of San Diego and Evergreen Valley College. She is also part of the faculty of the Master's Program in Science and Mathematics Teaching at UCS. She teaches basic physics for the engineering and physics students. She has been teaching engineering students for the last 20 years. She is the coordinator of the Engineer of the Future project at UCS. She is a member of the Steering Committee of the Active Learning in Engineering Education (ALE) of which she was chairperson from January 2011 to January 2014. She is also a member of the Consultative Committee for the Aalborg Centre for PBL in Engineering Science and Sustainability.

DONALD CARPENTER

Theme: Engaging and Motivating Students (and Faculty) Through an Active Exercise

Short bio

Donald D. Carpenter, PhD, PE, LEED AP is Professor of Civil Engineering at Lawrence Technological University in Southfield Michigan USA. He is an accredited green design professional (LEED AP) and practicing professional engineer (PE) whose expertise and research interests include engineering ethics, entrepreneurial engineering, green infrastructure, innovative stormwater best management practices (BMPs), hydraulic and hydrologic modeling. As a researcher, he has been an author on nearly 100 peer reviewed manuscripts, an investigator on over $5M USD in external funding, and a presented his research and development projects on five continents. His University appointments include serving as University Director of Assessment from 2009 to 2012 after serving as founding Director of the Center for Teaching and Learning from 2006 to 2009. He has co-developed a series of faculty development workshops to bring innovative team based problem solving into the engineering curriculum to promote the entrepreneurial mindset. Over 800 of faculty from around the world have participated in versions of this workshop and activities were featured in the past two Active Learning in Engineering Conference in Brazil and Spain. In 2014, the Kern Family Foundation named him their national Most Outstanding Faculty member for these efforts. Finally, he is a member of the Steering Committee of the Active Learning in Engineering Education network.

MICHAEL CHRISTIE

Theme: Using Flanagan's Critical Incident Technique to Improve Active Teaching and Learning in Engineering Education

Short bio

From 1999 to 2012 Michael Christie worked in Sweden, first at Chalmers University of Technology in Gothenburg, where he was in charge of a teaching and learning centre, and then from 2010 at Stockholm University, where he was Sweden's first Professor of Higher Education. During that time he has been an active member of ALE and served on the advisory committee. Michael's research is concerned with fundamental epistemological questions such as how knowledge is built and the best ways of promoting learning in engineering and higher education. He is also interested in the most pedagogical ways of using digital tools in teaching and learning. Having run courses for PhD supervisors as well as supervising and marking PhD theses, he is currently researching the most efficacious way of supporting the PhD process. His own PhD was a contact history between Aborigines and Colonists in early Victoria, 1836-1886, and he has maintained an interest in cross-cultural research. In Sweden he received substantial funding for research and development projects aimed at improving learning and teaching in Higher Education. He took up his current post at the University of the Sunshine Coast in February 2013. He is also interested in the most pedagogical ways of using digital tools in teaching and learning – see Michael's response to the question 'Does ICT affect higher education?' at: http://www.youtube.com/watch?v=mWDOER_mPXo

PAEE/ALE'2016 Industry Panel: Sustainability in Engineering Education for Sustainable Engineering Practice

Engineers must be able to develop their professional activities to deal with a large variety of different problems, using different competences. They should be able to mobilize adequate knowledge, methods and abilities, both in industrial and service business contexts. Furthermore, future engineers must be able to address real problems in practice and come up with solutions that integrate simultaneously economic, environmental and social needs. Developing competences during the initial training phase requires that the curriculum and learning methodologies are adapted to that purpose. Moreover, it is not enough to develop learning processes centred in knowledge transfer, but it is necessary to go one step further and apply active learning methodologies, like peer instruction and problem and project-based learning.

The members of this panel and the audience will discuss the fundamental professional competences required for future engineers, and the best approaches for developing those competences in interaction with industry partners.

- Marta Catarino - TecMinho and ASTP-PROTON pan-European association - **moderator**.
- Augusto Gomes - IKEA Industry Portugal, Lda.
- Clementina Freitas - Latino Group
- Estevão Silva - Bosch Car Multimedia Portugal, S.A
- Jorge Rodrigues - Nanium S.A.
- Nuno Barros - Leica Portugal

MARTA CATARINO

Short bio

Marta Catarino is the Director of the Technology Transfer Office of University of Minho - TecMinho, where she manages a team of 12 professionals in 3 business units: Industrial Property Management, Technology Commercialization and Entrepreneurship. With an academic background in Engineering and post-grad studies in Industrial Property, Marketing and Strategic Management, Marta has managed more than 20 European projects and overseen exploitation of more than 100 research results, through licensing, venturing and collaborative research. Marta has delivered seminars, workshops and training in more than 25 countries, and is regularly invited as an expert by the World Intellectual Property Organization and as an evaluator of proof-of-concept projects for the European Research Council, the Ministry of Education of the Czech Republic, the Finnish Academy of Science and the Generalitat de Catalunya. Since 2016, Marta is President of ASTP-Proton, the European Knowledge Transfer Association, that represents knowledge transfer professionals and offices in Public Research Organizations throughout Europe.

PAEE/ALE'2016 Hands-on sessions

An important feature of the ALE workshop is the hands-on programme. Active learning approaches are usually aimed at the increase of student involvement in learning, therefore, a hands-on session on active learning count on active involvement of its participants. Three different hands-on are scheduled, meant to enable the enhancement of active learning practice.

HANDS-ON 1 - WHAT IS THE ROLE OF GROWTH WHEN TALKING ABOUT TECHNOLOGY AND SUSTAINABILITY?

Miguel Romá and Tomás Martínez - Signals, Systems and Telecommunications group (SST), University of Alicante, Spain

In the context of engineering education, it is compulsory to make the students think about the impact that technology has in many aspects of life. We, as engineers, and our students as future engineers, must be aware of both kind and awkward effects of technology from the widest possible range of points of view. Issues like how to manage technological waste (related to programmed obsolescence), the risk of the generation of unemployment caused by the use of technology (automation and robotics), the relevance of having a strong technological industry to support our working environment, the relationship between sustainability and renewable resources…, are clear examples of aspects suitable to generate interesting debates. However, there is a key element that is commonly left apart as it derives to uncomfortable conclusions. Can we talk about sustainability avoiding thinking about the effects of economic growth? In this hands-on we will present an activity used to promote critical thinking in students about the relationship between economic growth and sustainability. We will try to present the most common thoughts when technology, energy, sustainability and growth are placed in the same bowl. If we conclude that economic growth and sustainability are not odd with each other, a pleasant landscape will be shown in front of our eyes. Notwithstanding, if we conclude that sustainability is not achievable in a growth environment, the panorama will possibly be comfortless.

HANDS-ON 2 - SUSTAINABILITY IN ENGINEERING EDUCATION

Pau Bofill, Montse Farreras - Department of Computer Architecture, UPC Barcelona Tech, Barcelona, Catalonia

This document presents a Hands-On session on Sustainability in Engineering Education. Sustainability is defined as the use of resources in such a way as to allow them to regenerate in time. Sustainability should be considered in connection with equity, so that the resource is equally available to everyone. Then several categories for analysis are defined, such as GDP growth, progress, environment or holistic so as to guide the discussion. The hands-on takes place in small groups, that are asked to write a short poster on how they would introduce the subject of sustainability in a project with their students. The learning goal is that sustainability is a holistic quality, that has to do with many dimensions at the same time.

HANDS-ON 3 - INTEGRATION OF THE MODEL BASED DESIGN – INDUSTRIAL APPROACH - FOR TEACHING ENGINEERING SCIENCE

Ascension Vizinho-Coutry - The Mathworks, Inc.

Model-Based Design (MBD) has been adopted in the past two decades by engineers and researchers. By adopting MBD the development process is centered on the system model, from requirements capture, design to implementation and test throughout the process. Using Modeling, Simulation, Automatic Code generation and Test capabilities, MBD can be applied to any project ranging from small device implementation to enterprise applications and vehicles. The French Ministry of Education is revamping the science and technology flow, starting from High-School to University levels with the integration of "Engineering" into schools. This is being done for two reasons: 1- to attract students to become engineers and 2- to reduce the gap between Educational schools and Industry by developing appropriate skills for the next generation of engineers. Engineering Sciences topics are attracting more attention and weight during evaluations and exams. French teachers are increasingly adopting MBD workflows within their courses. This workshop will present the association of the Model Based Design (MBD) and the recent French teaching Gap Analysis approach. This combination enables students not only to learn the Engineering workflow (or V-cycle) but also learn the disciplines relevant to the selected course. The main topics are: (i) Model-Based Design principles; (ii) Gap Analysis approach for teaching Sciences and Engineering; (iii) Teaching concepts through a simple problem: the design of logic of the angular position controller of a DC motor; (iv)Focus on different domains: mathematical equations describing the systems behavior and concepts relevant to engineering.

PAEE/ALE'2016 Workshops

An important feature of the PAEE Symposium is the workshop programme. Projects approaches to learning are usually aimed at the increase of student involvement in learning, therefore, a symposium on project approaches like PAEE/ALE'2016 count on active involvement of its participants. Two different workshops are scheduled, meant to enable the enhancement of project practice and the reflection on practice.

Workshop 1 - RoboSlam: Robot-Building Workshops for Engineering Educators

Shannon Chance, Damon Berry, Ted Burke and Frank Duignan - College of Engineering and the Built Environment, Dublin Institute of Technology, Ireland

A volunteer team of engineering and robotics teachers from Dublin Institute of Technology (DIT) will offer a two-hour hands-on *RoboSlam: Robot Building Workshop* for educators who attend the PAEE and ALE conferences. Participants in this workshop will each construct a working robot and will also learn about our train-the-trainer program. No prior robotics experience is necessary!

Our team has used this Problem Based Learning format to teach hundreds of students and teachers in Ireland how to build and program robots. To date, RoboSlam has been delivered 38 times, to more than 677 participants and to an additional 100 students at our sister Institute of Technology in Blanchardstown (ITB), Ireland. We have trained many people to facilitate these workshops successfully, including third-level students studying electrical and electronics engineering and also tutors running a professional practice module at ITB.

Workshop 2 - Active Learning Exercise: Viewing Other Students' Projects through Green Lenses

Jacqueline Asscher - Quality and Reliability Engineering, Kinneret College on the Sea of Galilee, Israel

The activity as run with 3rd year undergraduate students. This 2.5-hour activity has several learning objectives: get to know a number of good projects carried out by students from previous classes; learn about writing an abstract and writing and editing a project by experiencing reading 10 abstracts and one project; practice viewing projects from a sustainability point of view ("green lenses"); practice summarizing and presenting. The lecturer selected ten projects based on criteria of relevance to sustainability, good quality and variety of topics. Step 1: Working in pairs, students read all ten abstracts and selected and ranked five. This was done in advance by email. Step 2: Students worked in class in pairs, reading the project they were allocated and preparing a five minute presentation that answered two questions: What was the content of the project? How was sustainability considered, and how could it have been considered further? For example, in one project the reliability of a system was evaluated, but the cost of over-design (using materials and processes that are more expensive than required) was not considered. Step 3: Students gave presentations, each student answering one of the two questions. Step 4: Each student wrote a reflection exercise consisting of writing five points on "how to write a good abstract" and five points on "how to write and edit a good project". The students found the activity very useful as they will soon start their own final projects. They had ideas about how sustainability could have been incorporated in the projects that they reviewed. For the conference. Participants will enjoy seeing projects from other programs ("benchmarking") and experiencing one way that they can be used as a teaching resource. Also, this is an opportunity to look at a range of engineering projects from a sustainability point of view.

PAEE/ALE'2016 Programme

06 July		
8h30	**Registration desk open**	**Foyer**
9h00	**Opening Ceremony**	**Auditorium**
9h30	**Valquíria Villas-Boas**	**Auditorium**
	The importance of Team Work in Engineering Education: from High School to University	
	University of Caxias do Sul (Br)	
11h00	**Coffee break**	**Foyer**
11h30	**Donald Carpenter**	**Auditorium**
	Icebreaker Hands-on session	
12h30	**General Information**	**Auditorium**
13h00	**Lunch**	
14h30	**Hands-on Sessions HO.A**	**Room S4**
	Hands-on Sessions HO.B	**Room S3**
	Hands-on Sessions HO.C	**Room S2**
16h00	**Coffee break**	**Foyer**
16h30	**Michael Christie**	**Auditorium**
	Invited Hands-on Session	
18h00	**Welcome**	

07 July		
8h30	**Registration desk open**	**Foyer**
9h30	**Anette Kolmos**	**Auditorium**
	Global Sustainability Goals and PBL in Engineering	
	Aalborg University (Denmark)	
11h00	**Coffee break**	**Foyer**
11h30	**Students Sessions ST.A**	**Auditorium**
	Students Sessions ST.B	**Room S4**
	Students Sessions ST.C	**Room S3**
	Paper Sessions PS1.D	**Room S2**
13h00	**Lunch**	
14h30	**Debate Session DB.A**	**Auditorium**
	Debate Session DB.B	**Room S4**
	Debate Session DB.C	**Room S3**
	Debate Session DB.D	**Room S2**
16h00	**Coffee break**	**Foyer**
16h30	**Interactive Poster Session**	**Hall**
18h00	**End of Poster Session**	
20h00	**Symposium Dinner**	

08 July		
8h30	**Registration desk open**	**Foyer**
9h30	**Industry panel**	**Auditorium**
	Sustainability in Engineering Education for Sustainable Engineering Practice	
	Industry representatives	
11h00	**Coffee break**	**Foyer**
11h30	**Paper Sessions PS2.A**	**Auditorium**
	Paper Sessions PS2.B	**Room S4**
	Paper Sessions PS2.C	**Room S3**
	Paper Sessions PS2.D	**Room S2**
13h00	**Lunch**	
14h30	**Paper Sessions PS3.A**	**Auditorium**
	Workshops WK.A	**Room S2**
	Workshops WK.B	**Room S1**
16h00	**Coffee break**	**Foyer**
16h30	**Paper Sessions PS4.A**	**Auditorium**
	Paper Sessions PS4.B	**Room S4**
	Paper Sessions PS4.C	**Room S3**
	Paper Sessions PS4.D	**Room S2**
18h00	**Closing Ceremony**	**Auditorium**

PAEE/ALE'2016 Paper Sessions, Debate Sessions, Students Sessions and Interactive Poster Session

This program of sessions can be changed during the event. Please check the web version for updates.

Row Labels	#	presenter	authors
Debate session			
DB.A			
EN			
07/07/2016			
14:30:00			
1	13	Benedita Malheiro	Ádám Jenei, Aleksandra Bazylinska, Joanna Walczak, Sander Küttis, Manuel Silva, Benedita Malheiro, Cristina Ribeiro, Nidia Caetano, Paulo Ferreira and Pedro Guedes
			Learning Sustainability with EPS@ISEP – Development of a Water Disinfection System
2	26	Benedita Malheiro	Anthony Fountain, Bartosz Kuron, Carina Bentin, Eughan Davies, Kristjan Suits, Paloma Fernandéz de Toro Ronda, Abel Duarte, Benedita Malheiro, Cristina Ribeiro, Fernando Ferreira, Luís Lima, Paulo Ferreira and Pedro Guedes
			Learning Sustainability with EPS@ISEP – Development of an Insectarium
3	36	Michael Christie	Michael Christie, Maureen O'Neill, Kerry Rutter, Graham Young and Angeline Medland
			Engendering diversity in Engineering Education and other STEM subjects: a case study in sustainability
4	141	Ricardo Abdoel and Ilona Verwaal	Ricardo Abdoel and Ilona Verwaal
			How to create an ecosystem for engineering education to prepare future professionals to sustain in a fast changing and dynamic environment?
DB.B			
EN			
07/07/2016			
14:30:00			
1	46	João Mello Da Silva, João Carlos Felix Souza	João Mello Da Silva, João Carlos Felix Souza, Marcia Longen Zindel, Simone Borges Simão Monteiro, Andrea Cristina Santos and Carlos Henrique Rocha
			Innovative Experiences and Proposals in Engineering Education for Sustainability: Application to the University of Brasilia Undergraduate Production Engineering Program
2	76	Dan Centea	Dan Centea, Allan MacKenzie and Greg Zilberbrant
			Framework for Implementing a Sustainability Curriculum in an Engineering Technology Program
3	130	Anabela Alves	Ciliana Regina Colombo and Anabela Alves
			Sustainability in Engineering Courses in UMinho
4	146	Maria Olga Bernaldo, Gonzalo Fernandez	Maria Olga Bernaldo, Gonzalo Fernández and Iván Hilliard
			How To Measure The Contribution Of Universities To Sustainable

DB.C			
EN			
07/07/2016			
14:30:00			
1	1	Stuart Palmer	Stuart Palmer and Wayne Hall
			A text analytics evaluation of a first-year engineering project-based unit
2	19	Sivachandran Chandrasekaran	Sivachandran Chandrasekaran, Guy Littlefair, Parminder Singh Badwal and Gokul Thirunavukkarasu
			Collaborative Learning Experience of Students in Distance Education
3	103	Andre Mansur	Andre F Uebe Mansur, Brian Joyce, Maria Cristina V Biazus and Elizabeth L G Siqueira
			Results Analysis from Peer Assessment for Entrepreneurship's PBL class in a Business Management Undergraduation Course
4	108	Marjolijn Burman	Marjolijn Burman, Elsje Londers, Inge Van Hemelrijck and Yolande Berbers
			Developing and assessing the learning pathway 'Problem-Solving and Design'

DB.D			
PT			
07/07/2016			
14:30:00			
1	80	Diana Mesquita	Diana Mesquita, Maria Assunção Flores and Rui M. Lima
			O Contributo da Aprendizagem Baseada em Projetos Interdisciplinares para o desenvolvimento de um Currículo por Competências
2	98	Claisy Marinho-Araújo e Mauro Rabelo	Claisy Marinho-Araujo and Mauro Rabelo
			Matriz de Referência para Avaliação de Perfil e Competências na Educação Superior
3	136	Diana Pereira	Diana Pereira and Maria Assunção Flores
			Perceções de alunos universitários sobre avaliação das aprendizagens: um estudo em cinco universidades públicas portuguesas
4	139	Patrícia Santos	Patrícia Santos, Maria Assunção Flores, Paulo Flores, Rui Pereira and Nuno Dourado
			O contributo da Avaliação para a Aprendizagem no Ensino Superior: um projeto de intervenção em Engenharia

Hands-on			
HO.A			
EN			
06/07/2016			
14:30:00			
1	78	Miguel Romá and Tomás Martínez	Miguel Romá and Tomás Martínez
			What is the role of growth when talking about technology and sustainability?

HO.B			
EN			
06/07/2016			
14:30:00			
1	95	Pau Bofill	Pau Bofill and Montse Farreras
			Sustainability in Engineering Education

HO.C			
EN			
06/07/2016			
14:30:00			
1	999	Ascension Vizinho-Coutry	The Mathworks, Inc.
			Integration of the Model Based Design – Industrial Approach - for Teaching Engineering Science

Paper session			
PS1.D			
EN			
07/07/2016			
11:30:00			
1	14	Stuart Palmer	Stuart Palmer and Malcolm Campbell
			Characterising the Australian engineering workforce and engineering graduate occupational outcomes using national census data
2	2	Stuart Palmer	Stuart Palmer
			The representation of engineering education as a social media topic on Twitter
3	22	Rosalie van Baest	Rosalie van Baest
			SCS (Social and Communication Skills)
4	89	Natascha Van Hattum-Janssen	Natascha Van Hattum-Janssen and Sacha Tournier-Pelle
			The design of a master programme in Innovative Textile Development: designing relevant projects
5	66	Cleginaldo Carvalho	Marco Pereira and Maria Barreto
			PBL in School of Engineering of Lorena at the University São Paulo: Lessons learned and challenges.

PS2.A			
EN			
08/07/2016			
11:30:00			
1	17	Terry Lucke	Terry Lucke and Michael Christie
			Evaluating the Effectiveness of the Flipped Classroom Approach in Engineering Courses
2	37	Michael Christie	Michael Christie and Terry Lucke
			Project management in Engineering Education: key issues in supervising PhD students in project based learning
3	90	William Bergqvist	Lars Uppvall, Pär Blomkvist and William Bergqvist
			Opening the Black Box of Collaborative Writing: Experiences from a Teamwork Based Course in Industrial Management
4	42	Elisabeth Saalman	Elisabeth Saalman
			Active learning with the use of MOOCs at Chalmers University of Technology – experiences, challenges and future
5	110	Jens Myrup Pedersen	Jens Myrup Pedersen, M. Şükrü Kuran, Jan Frick and Lea Mank
			Colibri: An International Blended Learning Experience based on Real-World Problems

PS2.B			
PT			
08/07/2016			
11:30:00			
1	23	Carlos Sacchelli	Carlos Sacchelli, Tatiana Renata Garcia, Susie Cristine Keller and Kelen Silva
			Incentivando as mulheres na Ciência
2	35	Mauro Rabelo	Mauro Rabelo, Celius Magalhaes, Marcelo Furtado and Claisy Marinho-Araújo
			A Matriz De Referência Como Suporte Para Avaliação De Competências Em Cálculo Diferencial E Integral
3	71	Maria Araujo	Maria Araujo, Afranio Araujo and Maria Brito
			Casos para Ensino, Aprendizagem baseada em problemas e Consultoria: percepção de alunos da aplicação de um projeto piloto no curso de administração da UFRN
4	48	João Carlos Felix Souza	João Carlos Felix Souza, João Mello Da Silva, Carlos Henrique Rocha, Simone Borges Simão Monteiro and Andrea C. Santos
			Influence of Problem-Based Learning via Projects in INEP/MEC Student Performance Evaluation: Case of the Production Engineering Undergraduate Program at UnB
5	91	João Mello Silva, João C. F. Souza	Simone Borges Simão Monteiro, João Mello Silva, João Carlos Félix Souza and Ana Carla Bittencourt Reis
			PjBL Evolution in the course of Production Engineering at the University of Brasilia
PS2.C			
EN			
08/07/2016			
11:30:00			
1	97	Octavio Mattasoglio	Octavio Mattasoglio, Rui M. Lima, Diana Mesquita, Geysa Carvalho Losovoi and Mylla Ciciliano
			The perceptions of faculty engaged in a curricular change to Project Based Learning in an Engineering School at Brazil
2	100	Octavio Mattasoglio	Mylla Ciciliano and Octavio Mattasoglio
			Mapping of a mechanical engineering course curriculum focusing on the implementation of learning strategies - Project Based Learning
3	54	Fares Ben Amara	Fares Ben Amara and Walid Ayari
			Team-based serious game and useful mathematics in engineering education
	131	Luiz Carlos de Campos	Alessandro Silva, Eduardo Ianaguivara and Luiz Carlos de Campos
			Serious game for help children with ADHD learning the basics math concepts
4	87	Luiz Carlos de Campos	Samuel Tavares, Lea Paz da Silva and Luiz Carlos de Campos
			The Perceptions of Engineering Teachers on a “Practice What You Preach” PLE Training Program
PS2.D			
PT			
08/07/2016			
11:30:00			
1	73	Diana Mesquita	Waydja C. C. Correia, Marcos G. Ghislandi, Rui M. Lima, Diana Mesquita and Maria Conceição Amorim
			A experiência de aprendizagem baseada em projetos interdisciplinares em um novo campus de engenharia sob a perspectiva dos discentes
2	148	Liane Ludwig Loder	Liane Ludwig Loder
			About engineering undergraduate students: improving the efficiency of ALE strategies in engineering courses
3	156	Valquiria Villas-Boas	Laurete Zanol Sauer and Isolda Gianni de Lima
			Programa Integração Universidade e Escolas de Ensino Médio
4	116	Valquiria Villas-Boas	Valquiria Villas-Boas, Diana Mesquita, Rui M. Lima and Ivete Booth
			Professores de Engenharia Podem Aprender a Tornar a sua Prática Docente Eficaz
5	137	Crediné Menezes	Crediné Menezes and Rosane Aragón
			Aprendizagem Ativa no Desenvolvimento de Sistemas Colaborativos
6	4	Renatos Martins Das Neves	Sidnei Silva e Silva, Elon Lopes da Silva, Vitor William Batista Martins and Renatos Martins das Neves
			Identificação de competências docentes a serem potencializadas para o uso do PBL no ensino de graduação em engenharia de produção

PS3.A			
EN			
08/07/2016			
14:30:00			
1	77	Dan Centea	Dan Centea, Timber Yuen and Moein Mehrtash
			Implementing a Vehicle Dynamics Curriculum with Significant Active Learning Components
2	6	Domingos Sávio Giordani	Domingos Sávio Giordani and Elisângela De Jesus Cândido Moraes
			Simulating a business competitive environment in a discipline of the Chemical Engineering course
3	18	Nele Rumler	Nele Rumler and Susanne Staude
			Applying Problem-Based Learning In Laboratory Education
4	5	Cleginaldo Carvalho	Cleginaldo Pereira de Carvalho
			Project- Based Learning: An Approach to one House Automation Design
5	65	Cleginaldo Carvalho	Marina Pazeti and Marco Pereira
			Entrepreneurship: A Practical Approach With Project-Based Learning

PS4.A			
EN			
08/07/2016			
16:30:00			
1	121	Sandra Fernandes	Dinis Carvalho and Sandra Fernandes
			Student's role in the Implementation of a Lean Teaching and Learning Model
2	122	Luciano Soares	Luciano Soares, Paulina Achurra and Fabio Orfali
			A hands-on approach for an integrated engineering education
3	151	Hideaki Aburatani	Hideaki Aburatani, Shigeyoshi Nakamura, Shinya Maki, Takashi Yamaguchi, Makoto Ichitubo, Misuzu Okada and Kyohei Kuroda
			Use of Large-Sized Handout (LSH): A Template for Group Learning and Active Learning
4	111	Ghazi Abdelkader Khodjet El Khil	Ghazi Abdelkader Khodjet El Khil, Zied Alaya, Meriem Ben Aissa and Kaouther Louati
			The agile games for freshmen students
5	150	Duarte Sousa	Duarte Sousa, Marta Abrantes, Edgar Fernandes, José Falcão de Campos, Jorge Matos and Fátima Montemor
			Managing students with different backgrounds within the same Master program

PS4.B			
PT			
08/07/2016			
16:30:00			
1	32	José Rodrigues, Mariana Marinho	José de Souza Rodrigues, Mariana de Toledo Marinho, Kátia Lívia Zambon, Renato Campos, Jorge Muniz Jr. and Fernando Bernardi Souza
			Modelo de um sistema MTS com ponto de pedido, lote econômico e processamento FIFO de ordens e pedidos
2	149	Milton Francisco de Brito	Milton Francisco de Brito, Robson Santos, Marcos Antonio Maia de Oliveira, Alexandre Formigoni, João Roberto Maiellaro, Caio Flavio Stettiner and Paulo Ramirez
			Learning Technology in Logistics at the Faculty of Technology of Guarulhos - FATEC, São Paulo, Brazil based in one Gamified system
3	28	Midori Pitanga	Joselito Chagas
			Replicação da Disciplina Mecânica dos Fluidos Totalmente em PBL com o Foco na Evolução do Aprendizado e Avaliação Plena do Aluno
4	30	Cleginaldo Carvalho	Lucio Veraldo Jr, Bianca Soares Lucio, Danillo Vicente Silva, Karine Borges Oliveira, Jorge Muniz Jr and Messias Borges Silva
			Projeto Interdisciplinar Aplicado na Engenharia de Produção – Resultado da Proposta de Serviços Copaker
5	15	Fátima Monteiro	Fátima Monteiro, Carlinda Leite and Cristina Rocha
			A Formação Ética e Cívica nos Currículos dos Cursos de Engenharia do Ensino Superior Português

PS4.C			
SP			
08/07/2016			
16:30:00			
1	125	Karen Lemmel Vélez	Karen Lemmel Vélez and Carlos Alberto Valencia Hernandez
			PBL aplicado a proyectos de grado que demandan incorporar nuevos conocimientos académicos.
2	57	Hernán Mora	Hernán Gustavo Cortés Mora, José-Ismael Peña-Reyes and Alfonso Herrera Jimenez
			Implementation of education for sustainable development in engineering education. Adjustments in the curriculum design of a course that has elements of project-based learning
3	51	Miriam Chan Pavón_	Francisco Hernández Vázquez Mellado, Miriam Chan Pavón and Jesús Escalante Euán
			Utilización del Aprendizaje Basado en Proyectos (PBL) aplicando la metodología de las 5'S para el mejoramiento de áreas de trabajo, en escenarios reales, por estudiantes de Ingeniería.
4	93	Jesús Escalante Euán_	Jesús Escalante Euán, Ileana Monsreal Barrera and Francisco Hernández Vázquez Mellado
			Del laboratorio de Ingeniería industrial hacia un escenario real de aprendizaje

PS4.D			
EN			
08/07/2016			
16:30:00			
1	145	Kurt Amann	Kurt Amann
			Implementation of the PBL approach to the “Foundations and Earth Works” Discipline: a Brazilian Experience
2	47	Martín Tarragona	Martín Tarragona, Ignacio Irigaray, Pablo Zinemanas and Jimena Arruti
			The construction of an analog Vocoder as a hands-on introductory course in Electrical Engineering
3	101	Magdalena Bogacka	Krzysztof Pikon and Magdalena Bogacka
			Pedagogical evolution based on implementation of case teaching method in masters engineering courses
4	118	Lucyna Czarnowska	Lucyna Czarnowska and Zbigniew Żmudka
			Targeted post-course survey of project organised course as an example of students' engagement in learning process

Poster session			
PTS.H			
EN			
07/07/2016			
16:30:00			
1	69	Erik Degraaff	Erik Degraaff
			The Global UCPBL network for PBL in Engineering Education: sharing PBL expertise
2	94	Octavio Mattasoglio	Nathally Macedo and Octavio Mattasoglio
			A percepção dos estudantes sobre Projetos e Oficinas com ênfase em Engenharia Civil, oferecidas na série inicial de um curso de Engenharia.
3	102	Józef Pastuszka	Józef Pastuszka, Krzysztof Pikon and Monika Czop
			Air pollutants and adverse health effects as the subject of the seminars using the new pedagogical approach – case teaching implementation example
4	107	Setsuko Isoda	Chihiro Morimoto, Hikari Mitsuta, Sadayuki Shimoda and Setsuko Isoda
			A Study on Characteristics of Architectural Working Space for Group Works
5	117	Jacek Kalina	Jacek Kalina
			Strengthening competences of engineering graduates through supplementary actions - experience gained
6	134	Karol Sztekler, Grzegorz Jodłowski, Marta Wójcik	Karol Sztekler, Marta Wojcik and Grzegorz Jodlowski
			Raising the students skills through teaching by Cease teaching method - AGH experiences
7	153	Klaus Wuersig	Klaus Wuersig
			Toward a more practical Engineering Curriculum (A Sequal)
8	158	Esly Silva	Esly C. M. Silva, Claudia C. Torres and Solange D. S. Alves
			Mechanical Engineering and PBL methodology in the Federal Institute of Bahia - campus Simões Filho
9	115	Midori Pitanga	Gabriella Alves, Dário Silva, Mayara Mantovani, Nicholas Santos, Midori Pitanga and José Lourenço
			Unisal Aerodesing team: Sucessful PBL approach

Students session			
ST.A			
EN			
07/07/2016			
11:30:00			
1	124	Gonçalo Cruz	Gonçalo Cruz and Caroline Dominguez
			How can we prepare future engineers to the labour market? A University-Business Cooperation project using Context and Problem-Based Learning approaches
2	113	Fernando Rodriguez	Fernando Rodriguez and José-Ismael Peña-Reyes
			Teaching Problem-Based Learning to engineering interdisciplinary graduate students
3	55	Daniela Pedrosa	Daniela Pedrosa, José Cravino, Leonel Morgado and Carlos Barreira
			Self-regulated learning in higher education: strategies adopted by computer programming students
4	105	Magdalena Bogacka	Magdalena Bogacka and Krzysztof Pikon
			Learning by doing approach implementation in project management courses
5	56	Hernán Mora	Hernán Gustavo Cortés Mora, Jonatan Hans Tovar Rodriguez, Juan Carlos Espinosa Moreno and José-Ismael Peña-Reyes
			Measuring sustainable lifestyles of engineering students from the Universidad Nacional de Colombia. Construction of the instrument

ST.B			
EN			
07/07/2016			
11:30:00			
1	152	Rita Faria	Andreia Almeida, Mariana Masteling, Mariana Sousa, Marta Cortesão and Rita Faria
			EBEC Bridges University-Business skills
2	140	Rui Baía	Rui Baía, Ana Martins, António Gonçalves, Filipa Barros, Inês Vilas Boas, José Rodrigues, Pedro Araújo, Tiago Pereira, Vasco Areias and Rui M. Lima
			Analysis and Diagnosis of a Hand Tools Production System
3	45	Hector Bosso	Hector Bosso
			Proposal for setup time reduction of a cold chamber die casting machine
4	84	Filipe Santos	Filipe Santos, Simone Borges Simão Monteiro and André Luiz Aquere
			Incorporating Agile Project Management Methodologies To The Production Systems Project 5 Course Within The Production Engineering Undergraduate Program At The University Of Brasilia

ST.C			
EN			
07/07/2016			
11:30:00			
1	144	Mariana Martins, Francisco Ramires, Miguel Cunha	Mariana Martins, Francisco Ramires, Miguel Cunha and Anabela Alves
			Different Structures of Projects in Engineering: Perspective of Freshmen Students
2	50	Mariana Marinho	Mariana Marinho, José Rodrigues and Kátia Zambom
			Distance Learning for training of the Business Game Bom Burguer's tutors
3	143	Francisca Ribeiro, João Nobre, Liliana Silva	Francisca Ribeiro, João Nobre, Liliana Silva and José Dinis-Carvalho
			A student team project in real context: The team view

Workshop			
WK.A			
EN			
08/07/2016			
14:30:00			
1	88	Damon Berry	Shannon Chance, Damon Berry, Ted Burke and Frank Duignan
			RoboSlam: Robot-Building Workshops for Engineering Educators

WK.B			
EN			
08/07/2016			
14:30:00			
1	106	Jacqueline Asscher	Jacqueline Asscher
			Active Learning Exercise: Viewing Other Students' Projects through Green Lenses

List of Authors

Row Labels	Email	Country	Affiliation	#
Abel Duarte	ajd@isep.ipp.pt	Portugal	Instituto Superior de Engenharia do Porto	26
Ádám Jenei	1111815@isep.ipp.pt	Hungary	Instituto Superior de Engenharia do Porto	13
Afranio Araujo	afranioga@gmail.com	Brazil	Universidade Federal do Rio Grande do Norte	71
Aleksandr Chuchalin	chai@tpu.ru	Russian Federation	Tomsk Polytechnic University	59
Aleksandra Bazylinska	1111344@isep.ipp.pt	Poland	Instituto Superior de Engenharia do Porto	13
Alessandro Silva	alessandrops@umc.br	Brazil	Universidade de Mogi das Cruzes	131
Alex Stojcevski	alex.stojcevski@rmit.edu.vn	Viet Nam	RMIT University	135
Alexandre Formigoni	alexandre.formigoni@fatec.sp.gov.br	Brazil	Faculdade de Tecnologia de Guarulhos - Fatec Guarulhos	149
Alfonso Herrera Jimenez	aherreraj@unal.edu.co	Colombia	Universidad Nacional de Colombia	57
Allan MacKenzie	(blank)	Canada	McMaster University	76
Ana Carla Bittencourt Reis	anacarlabr@unb.br	Brazil	University of Brasilia	91
Ana Martins	ana_pmartins@live.com.pt	Portugal	University of Minho	140
Anabela Alves	anabela@dps.uminho.pt	Portugal	University of Minho	130
				144
Andre F Uebe Mansur	andreuebe@gmail.com	Brazil	Instituto Federal Fluminense	103
André Luiz Aquere	andre@unb.br	Brazil	University of Brasilia	84
Andrea C. Santos	andreasantos@unb.br	Brazil	University of Brasilia	48
Andrea Cristina Santos	andreasantos@unb.br	Brazil	University of Brasilia	46
Andréa P. Mendonça	andrea.ifam@gmail.com	Brazil	IFAM	123
Andreia Almeida	andreia.ms.almeida@gmail.com	Portugal	Board of European Students of Technology, Porto	152
Angeline Medland	amedland@usc.edu.au	Australia	University of the Sunshine Coast	36
Anna Lyza Felipe	anna.felipe@rmit.edu.vn	Viet Nam	RMIT University	135
Anthony Fountain	1141647@isep.ipp.pt	Belgium	Instituto Superior de Engenharia do Porto	26
António Gonçalves	antoniocvbg@gmail.com	Portugal	University of Minho	140
Bartosz Kuron	1141605@isep.ipp.pt	Poland	Instituto Superior de Engenharia do Porto	26
Benedita Malheiro	mbm@isep.ipp.pt	Portugal	Instituto Superior de Engenharia do Porto	13
				26
Benedito Almeida	salomaoalmeida@uol.com.br	Brazil	Centro Universitario Salesiano de São Paulo - Unisal	147
Benedito Manoel de Almeida	salomaoalmeida@uol.com.br	Brazil	UNISAL - Centro Universitário Salesiano de São Paulo	33
Bianca Soares Lucio	bianca.soares.lucio@gmail.com	Brazil	UNISAL - Centro Salesiano de São Paulo	30
Brian Joyce	brianjyc@gmail.com	Finland	HAMK University of Applied Science	103
Caio Flavio Stettiner	caio.stettiner@fatec.sp.gov.br	Brazil	Faculdade de Tecnologia de São Paulo - Sebrae	149
Carina Bentin	1141590@isep.ipp.pt	Germany	Instituto Superior de Engenharia do Porto	26
Carlinda Leite	carlinda@fpce.up.pu	Portugal	FPCEUP	15
Carlos Alberto Valencia Hernandez	carlos.valencia@pascualbravo.edu.co	Colombia	Institución Universitaria Pascual Bravo	125
Carlos Barreira	cabarreira@fpce.uc.pt	Portugal	Faculdade de Psicologia e de Ciências da Educação - Universidade de Coimbra	55
Carlos Henrique Rocha	chrocha@unb.br	Brazil	University of Brasilia	46
				48
Carlos Sacchelli	carlos.sacchelli@gmail.com	Brazil	UFSC	23
Caroline Dominguez	carold@utad.pt	Portugal	Universidade de Trás-os-Montes e Alto Douro and CIDTFF	124
Celius Magalhaes	celiusm@gmail.com	Brazil	University of Brasilia	35
Cesar Botura	cabotura@gmail.com	Brazil	Centro Universitario Salesiano de São Paulo - Unisal	147
Chihiro Morimoto	ap5537mori@g.kumamoto-nct.ac.jp	Japan	National Institute of Technology, Kumamoto College	107
Ciliana Regina Colombo	anailicobmoloc@gmail.com	Brazil	Universidade Federal do Rio Grande do Norte	130
Claisy Marinho-Araujo	claisy@unb.br	Brazil	University of Brasilia	98
Claisy Marinho-Araújo	claisy@unb.br	Brazil	University of Brasilia	35
Claudia C. Torres	claudiatorres@ifba.edu.br	Brazil	Instituto Federal da Bahia	158
Cleginaldo Pereira de Carvalho	cleginaldopcarvalho@hotmail.com	Brazil	Centro Universitário Salesiano de São Paulo	5
Crediné Menezes	credine@inf.ufes.br	Brazil	Universidade Federal do Espírito Santo	137
Cristina Ribeiro	mcr@isep.ipp.pt	Portugal	Instituto Superior de Engenharia do Porto	13
				26
Cristina Rocha	crocha@fpce.up.pt	Portugal	FPCEUP	15
Damon Berry	damon.berry@dit.ie	Ireland	Dublin Institute of Technology	88
Dan Centea	centeadn@mcmaster.ca	Canada	McMaster University	76
				77

Row Labels	Email	Country	Affiliation	#
Daniela Pedrosa	dpedrosa@utad.pt	Portugal	Universidade de Trás-os-Montes e Alto Douro / CIDTFF	55
Danillo Vicente Silva	danillovicente@hotmail.com	Brazil	UNISAL - Centro Salesiano de São Paulo	30
Dário Silva	tomaz.dario@yahoo.com	Brazil	UNISAL	115
Diana Mesquita	diana@dps.uminho.pt	Portugal	University of Minho	73
				80
				97
				116
Diana Pereira	dianapereira@ie.uminho.pt	Portugal	University of Minho	136
Dinis Carvalho	dinis@dps.uminho.pt	Portugal	University of Minho	121
Domingos Sávio Giordani	dsgiordani@usp.br	Brazil	University of São Paulo	6
Duarte Sousa	duarte.sousa@ist.utl.pt	Portugal	Instituto Superior Técnico/DEEC/AC Energia	150
Edgar Fernandes	edgar.fernandes@tecnico.ulisboa.pt	Portugal	Instituto Superior Técnico/DEM	150
Edouard Amouroux	edouard.amouroux@rmit.edu.vn	Viet Nam	RMIT University	135
Eduardo Ianaguivara	eduardo_seige@hotmail.com	Brazil	Universidade de Mogi das Cruzes	131
Elisabeth Saalman	saalman@chalmers.se	Sweden	Chalmers University of Technology	42
Elisângela De Jesus Cândido Moraes	elisangela.moraes@usp.br	Brazil	University of São Paulo	6
Elizabeth L G Siqueira	bethlandim99@gmail.com	Brazil	Insitutos Superiores de Ensino do CENSA	103
Elon Lopes Da Silva	elonlopes@hotmail.com	Brazil	UEPA - Universidade do Estado do Pará	4
Elsje Londers	elsje.londers@eng.kuleuven.be	Belgium	Faculty of Engineering Science at KU Leuven	108
Esly C. M. Silva	eslymarinho@ifba.edu.br	Brazil	Instituto Federal da Bahia	158
Eughan Davies	1141649@isep.ipp.pt	United Kingdom	Instituto Superior de Engenharia do Porto	26
Fabio Orfali	fabioo1@insper.edu.br	Brazil	Insper	122
Fares Ben Amara	fares.benamara@esprit.tn	Tunisia	ESPRIT	54
Fátima Monteiro	fatcmont@gmail.com	Portugal	ISEC - IPC	15
Fátima Montemor	mfmontemor@tecnico.ulisboa.pt	Portugal	Instituto Superior Técnico/DEQ	150
Fernando Bernardi Souza	fbernardi@feb.unesp.br	Brazil	UNESP	32
Fernando Ferreira	fjf@isep.ipp.pt	Portugal	Instituto Superior de Engenharia do Porto	26
Fernando Rodriguez	fjrodriguezm@unal.edu.co	Colombia	Universidad Nacional	113
Filipa Barros	marianabarros1994@gmail.com	Portugal	University of Minho	140
Filipe Santos	filipehssantos@gmail.com	Brazil	University of Brasilia	84
Francisca Ribeiro	ple_grupo_3@sapo.pt	Portugal	University of Minho	143
Francisco Hernández Vázquez Mellado	francisco.hernandez@correo.uady.mx	Mexico	Universidad Autónoma de Yucatán	51
				93
Francisco Ramires	fdsramires@gmail.com	Portugal	University of Minho	144
Frank Duignan	frank.duignan@dit.ie	Ireland	Dublin Institute of Technology	88
Gabriella Alves	gabriella.marialves@hotmail.com	Brazil	UNISAL	115
Geysa Carvalho Losovoi	geysalosovoi@yahoo.com.br	Brazil	Instituto Mauá de Tecnologia	97
Ghazi Abdelkader Khodjet El Khil	ghazi.khodjetelkhil@esprit.tn	Tunisia	ESPRIT	111
Gokul Thirunavukkarasu	gthiruna@deakin.edu.au	Australia	Deakin University	19
Gonçalo Cruz	goncaloc@utad.pt	Portugal	Universidade de Trás-os-Montes e Alto Douro and INESC TEC	124
Gonzalo Fernández	gonzalo.fernandez@universidadeuropea.es	Spain	Universidad Europea de Madrid	146
Graham Young	gyoung1@usc.edu.au	Australia	University of the Sunshine Coast	36
Greg Zilberbrant	(blank)	Canada	McMaster University	76
Grzegorz Jodlowski	jodlowsk@agh.edu.pl	Poland	AGH University of Science and Technology	134
Guy Littlefair	guy.littlefair@deakin.edu.au	Australia	Deakin University	19
Hector Bosso	hbosso@outlook.com	Brazil	Pontifical Catholic University of São Paulo	45
Henrique Sampaio	henrique.sampaio@lo.unisal.br	Brazil	Centro Universitario Salesiano de São Paulo - Unisal	147
Hernán Gustavo Cortés Mora	hgcortesm@unal.edu.co	Colombia	Universidad Nacional de Colombia	56
				57
Hideaki Aburatani	abura@apps.kct.ac.jp	Japan	National Institute of Technology, Kitakyushu College	151
Hikari Mitsuta	ac1593mits@g.kumamoto-nct.ac.jp	Japan	National Institute of Technology, Kumamoto College	107
Ignacio Irigaray	irigaray@fing.edu.uy	Uruguay	Facultad de Ingenieria - Universidad de la Republica	47
Ileana Monsreal Barrera	ileana.monsreal@correo.uady.mx	Mexico	Universidad Autónoma de Yucatán	93
Ilona Verwaal	i.verwaal@fontys.nl	Netherlands	Fontys UAS - Objexlab	141
Inês Vilas Boas	ines.martinezvb@gmail.com	Portugal	University of Minho	140
Inge Van Hemelrijck	inge.vanhemelrijck@eng.kuleuven.be	Belgium	Faculty of Engineering Science at KU Leuven	108
Isolda Gianni de Lima	iglima1@gmail.com	Brazil	Universidade de Caxias do Sul	156
Iván Hilliard	ivanoliver.hilliard@universidadeuropea.es	Spain	Universidad Europea de Madrid	146

Row Labels	Email	Country	Affiliation	#
Ivete Booth	iasbooth@ucs.br	Brazil	UCS	116
Jacek Kalina	jacek.kalina@polsl.pl	Poland	Silesian University of Technology	117
Jacqueline Asscher	jasscher@inter.net.il	Israel	Kinneret College	106
Jan Frick	janfrick@me.com	Norway	University of Stavanger	110
Jens Myrup Pedersen	jens@es.aau.dk	Denmark	Aalborg University, Dept. of Electronic Systems	110
Jesús Escalante Euán	jesus.escalante@correo.uady.mx	Mexico	Universidad Autónoma de Yucatán	51
				93
Jimena Arruti	jarruti@fing.edu.uy	Uruguay	Facultad de Ingeniería - Universidad de la República - Uruguay	47
Joanna Walczak	1111818@isep.ipp.pt	Poland	Instituto Superior de Engenharia do Porto	13
João Carlos Félix Souza	jocafs@unb.br	Brazil	University of Brasilia	46
				48
				91
João Mello da Silva	joaomello@unb.br	Brazil	University of Brasilia	46
				48
				91
João Nobre	joaoandrenobre@gmail.com	Portugal	University of Minho	143
João Roberto Maiellaro	joaomaiellaro@yahoo.com.br	Brazil	Faculdade de Tecnologia de Guarulhos - Fatec Guarulhos	149
Jonatan Hans Tovar Rodriguez	jhtovarr@unal.edu.co	Colombia	Universidad Nacional de Colombia	56
Jorge Matos	jorge.matos@tecnico.ulisboa.pt	Portugal	Instituto Superior Técnico/DECivil	150
Jorge Muniz Junior	jorge86056@gmail.com	Brazil	FEG/UNESP	32
	jorgemuniz@feg.unesp.br	Brazil	UNESP - Universidade Estadual Paulista	30
				33
José Cravino	jcravino@utad.pt	Portugal	Universidade de Trás-os-Montes e Alto Douro / CIDTFF	55
José de Souza Rodrigues	jsrod@feb.unesp.br	Brazil	FEB/UNESP	32
				50
José Dinis-Carvalho	dinis@dps.uminho.pt	Portugal	University of Minho	143
José Falcão de Campos	falcao.campos@tecnico.ulisboa.pt	Portugal	Instituto Superior Técnico/DEM	150
José Lourenço	lourencojr.jose@gmail.com	Brazil	UNISAL	115
Jose Lourenço Junior	lourencojr.jose@gmail.com	Brazil	Centro Universitario Salesiano de São Paulo - Unisal	147
José Rodrigues	ze_braga_pedro@hotmail.com	Portugal	University of Minho	140
José-Ismael Peña-Reyes	jipenar@unal.edu.co	Colombia	Universidad Nacional de Colombia	56
				57
				113
Joselito Chagas	joselito.moreira.chagas@gmail.com	Brazil	UNISAL - Lorena	28
Józef Pastuszka	jozef.pastuszka@polsl.pl	Poland	Silesian University of Technology	102
Juan Carlos Espinosa Moreno	jucespinosamo@unal.edu.co	Colombia	Universidad Nacional de Colombia	56
Kaouther Louati	kaouther.louati@esprit.tn	Tunisia	ESPRIT	111
Karen Lemmel Vélez	karen.lemmel@pascualbravo.edu.co	Colombia	Institución Universitaria Pascual Bravo	125
Karine Borges Oliveira	karineborges.eng@gmail.com	Brazil	UNISAL - Centro Salesiano de São Paulo	30
Karol Sztekler	sztekler@agh.edu.pl	Poland	AGH University of Science and Technology	134
Kátia Lívia Zambon	katia@feb.unesp.br	Brazil	CTI/FEB/UNESP	32
Kátia Zambom	katia@feb.unesp.br	Brazil	CTI/FEB/UNESP	50
Kelen Silva	lkelen.silva@hotmail.com	Brazil	UFSC	23
Kerry Rutter	KRutter@usc.edu.au	Andorra	University of the Sunshine Coast	36
Klaus Wuersig	wuersig@pitt.edu	United States	University of Pittsburgh at Bradford	153
Kristjan Suits	1141655@isep.ipp.pt	Estonia	Instituto Superior de Engenharia do Porto	26
Krzysztof Pikon	krzysztof.pikon@polsl.pl	Poland	Silesian University of Technology	101
				102
				105
Kurt Amann	kpereira@fei.edu.br	Brazil	Centro Universitário da FEI	145
Kyohei Kuroda	kkuroda@kct.ac.jp	Japan	National Institute of Technology, Kitakyushu College	151
Lars Uppvall	lars.uppvall@indek.kth.se	Sweden	KTH	90
Laurete Zanol Sauer	lzsauer@ucs.br	Brazil	Universidade de Caxias do Sul	156
Lea Mank	l.mank@atenekom.eu	Germany	Atene KOM	110
Lea Paz Da Silva	leapazsilva@gmail.com	Brazil	UNINOVE - Universidade Nove de Julho	87
Leonel Morgado	leonel.morgado@gmail.com	Portugal	INESC TEC / Universidade Aberta	55
Liane Ludwig Loder	lianeludwig@gmail.com	Brazil	Federal University of Rio Grande do Sul	148
Liliana Silva	liliana.ds.silva@gmail.com	Portugal	University of Minho	143
Luciano Soares	lpsoares@gmail.com	Brazil	Insper	122
Lucio Veraldo Jr	lucioveraldo@gmail.com	Brazil	UNISAL - Centro Salesiano de São Paulo	30
Lucio Veraldo Junior	lucioveraldo@gmail.com	Brazil	UNISAL - Centro Universitário Salesiano de São Paulo	33
Lucyna Czarnowska	lczarnowska@polsl.pl	Poland	Silesian University of Technology	118

Row Labels	Email	Country	Affiliation	#
Luís Lima	lul@isep.ipp.pt	Portugal	Instituto Superior de Engenharia do Porto	26
Luiz Carlos de Campos	lccampos@pucsp.br	Brazil	Pontificia Universidade Católica de São Paulo	131
			PUC-SP - Pontifícia Universidade Católica de São Paulo	87
M. Şükrü Kuran	sukru.kuran@agu.edu.tr	Turkey	Abdullah Gul University	110
Magdalena Bogacka	magdalena.bogacka@polsl.pl	Poland	Silesian University of Technology	101
				105
Makoto Ichitubo	ichitubo@vos.nagaokaut.ac.jp	Japan	Nagaoka University of Technology	151
Malcolm Campbell	malcolm.campbell@deakin.edu.au	Australia	Deakin University	14
Manuel Silva	mss@isep.ipp.pt	Portugal	Instituto Superior de Engenharia do Porto-IPP and INESC TEC ROBIS	13
Marcelo Furtado	mfurtado@unb.br	Brazil	University of Brasilia	35
Marcia Longen Zindel	marcialz@unb.br	Brazil	University of Brasilia	46
Marco Pereira	marcopereira@usp.br	Brazil	USP	65
				66
Marcos Antonio Maia de Oliveira	marcos.maia@fatec.sp.gov.br	Brazil	Faculdade de Tecnologia de Guarulhos - Fatec Guarulhos	149
Marcos G. Ghislandi	ghislandi@gmail.com	Brazil	Universidade Federal Rural de Pernambuco (UFRPE)	73
Margarita Gomez	mgomez@pequenoscientificos.org	Colombia	Universidad de Los Andes	155
Maria Araujo	valeriaaraujoufrn@gmail.com	Brazil	Universidade Federal do Rio Grande do Norte	71
Maria Assunção Flores	aflores@ie.uminho.pt	Portugal	University of Minho	80
				136
			Instituto de Educação, University of Minho	139
Maria Barreto	maribarreto@usp.br	Brazil	Universidade de São Paulo	66
Maria Brito	belmedeiros@gmail.com	Brazil	Universidade Federal do Rio Grande do Norte	71
Maria Conceição Amorim	ceca1977@gmail.com	Brazil	UFPE	73
Maria Cristina V Biazus	mcbiazus@gmail.com	Brazil	Universidade Federal do Rio Grande do Sul	103
Maria Olga Bernaldo	olgabernaldo@hotmail.com	Spain	Universidad Europea de Madrid	146
Mariana De Toledo Marinho	mariana.tmarinho@gmail.com	Brazil	FC/UNESP	32
Mariana Marinho	mariana.tmarinho@gmail.com	Brazil	FC/UNESP	50
Mariana Martins	msocm97@gmail.com	Portugal	University of Minho	144
Mariana Masteling	mariana.masteling@bestporto.org	Portugal	Board of European Students of Technology, Porto	152
Mariana Sousa	mariana.sousa@bestporto.org	Portugal	Board of European Students of Technology, Porto	152
Marina Pazeti	marina.p@alunos.eel.usp.br	Brazil	USP	65
Marjolijn Burman	marjolijn.burman@eng.kuleuven.be	Belgium	Faculty of Engineering Science at KU Leuven	108
Marta Abrantes	marta.abrantes@tecnico.ulisboa.pt	Portugal	Instituto Superior Técnico	150
Marta Cortesão	marta.cortesao@bestporto.org	Portugal	Board of European Students of Technology, Porto	152
Marta Wojcik	mwojcik@agh.edu.pl	Poland	AGH University of Science and Technology	134
Martín Tarragona	tarragona@fing.edu.uy	Uruguay	Universidad de la República	47
Maureen O'Neill	moneill@usc.edu.au	Australia	University of the Sunshine Coast	36
Mauricio Duque	ismaduque@mac.com	Colombia	Universidad de Los Andes	155
Mauro Rabelo	tunoluiz@gmail.com	Brazil	University of Brasilia	35
				98
Mayara Mantovani	mayaramantovani@yahoo.com.br	Brazil	UNISAL	115
Meriem Ben Aissa	meriem.benaissa@esprit.tn	Tunisia	ESPRIT	111
Messias Borges Silva	messias@dequi.eel.usp.br	Brazil	USP - Universidade de São Paulo	30
				33
Michaël Canu	m.canu134@uniandes.edu.co	Colombia	Universidad de Los Andes	155
Michael Christie	michael.christie@usc.edu.au	Australia	University of the Sunshine Coast	17
	michael@cwrite.net	Australia	University of the Sunshine Coast	36
				37
Midori Pitanga	midori.pitanga@lo.unisal.br	Brazil	UNISAL	115
Miguel Cunha	mnbcunha@gmail.com	Portugal	University of Porto	144
Miguel Romá	miguel.roma@ua.es	Spain	University of Alicante	78
Milton Francisco de Brito	britomf@uol.com.br	Brazil	Faculdade de Tecnologia de Guarulhos - Fatec Guarulhos	149
Miriam Chan Pavón	cpavon@correo.uady.mx	Mexico	Universidad Autónoma de Yucatán	51
Misuzu Okada	okada@kct.ac.jp	Japan	National Institute of Technology, Kitakyushu College	151
Moein Mehrtash	mehrtam@mcmaster.ca	Canada	McMaster University	77
Monika Czop	monika.czop@polsl.pl	Poland	Silesian University of Technology	102
Monique G. Bastos	monique.bastos@gmail.com	Brazil	IFAM	123
Montse Farreras	mfarrera@ac.upc.edu	Spain	UPC Barcelona	95

Row Labels	Email	Country	Affiliation	#
Mylla Ciciliano	myllamc@hotmail.com	Brazil	Instituto Mauá de Tecnologia	97
				100
Natalia Daneikina	mischenko@tpu.ru	Russian Federation	Tomsk Polytechnic University	59
Natascha Van Hattum-Janssen	n.vanhattum@saxion.nl	Netherlands	Saxion University of Applied Sciences	89
Nathally Macedo	Nathallyd3@gmail.com	Brazil	Instituto Mauá de Tecnologia	94
Nele Rumler	nele.rumler@hs-ruhrwest.de	Germany	University of Applied Sciences Ruhr West	18
Nicholas Santos	nicholas.delf@gmail.com	Brazil	UNISAL	115
Nidia Caetano	nsc@isep.ipp.pt	Portugal	Instituto Superior de Engenharia do Porto	13
Nuno Dourado	nunodourado@dem.uminho.pt	Portugal	Escola de Engenharia, University of Minho	139
Octavio Mattasoglio	omattasoglio@uol.com.br	Brazil	CEUN IMT - Escola de Engenharia Mauá	97
			Instituto Mauá de Tecnologia	94
				100
Pablo Zinemanas	zinehh@gmail.com	Uruguay	Facultad de Ingeniería - Udelar	47
Paloma Fernandéz de Toro Ronda	1141657@isep.ipp.pt	Spain	Instituto Superior de Engenharia do Porto	26
Pär Blomkvist	par.blomkvist@indek.kth.se	Sweden	KTH	90
Parminder Singh Badwal	pbadwal@deakin.edu.au	Australia	Deakin University	19
Patrícia Santos	patricia.santos@ie.uminho.pt	Portugal	Instituto de Educação, University of Minho	139
Pau Bofill	pau@ac.upc.edu	Spain	UPC	95
Paulina Achurra	paulina.achurra@insper.edu.br	Brazil	Insper	122
Paulo Ferreira	paf@keeh.net	Portugal	Instituto Superior de Engenharia do Porto	13
				26
Paulo Flores	pflores@dem.uminho.pt	Portugal	Escola de Engenharia, University of Minho	139
Paulo Ramirez	pramirez@uol.com.br	Brazil	Instituto Federal de São Paulo	149
Pedro Araújo	pedroaraujo_94@hotmail.com	Portugal	University of Minho	140
Pedro Guedes	pbg@isep.ipp.pt	Portugal	Instituto Superior de Engenharia do Porto	13
				26
Renata Chagas	renataperrenoud@hotmail.com	Brazil	Centro Universitário Salesiano - Campus Lorena	27
Renato Campos	rcampos@feb.unesp.br	Brazil	FEB/UNESP	32
Renatos Martins Das Neves	neves@ufpa.br	Brazil	UFPA - Universidade Federal do Pará	4
Ricardo Abdoel	r.abdoel@fontys.nl	Netherlands	Fontys UAS - Objexlab	141
Rita Faria	rita.faria@bestporto.org	Portugal	Board of European Students of Technology, Porto	152
Robson Santos	robson@fatec.sp.gov.br	Brazil	Faculdade de Tecnologia de Guarulhos - Fatec Guarulhos	149
Rosalie van Baest	r.vanbaest@fontys.nl	Netherlands	Fontys Hogescholen Eindhoven	22
Rosane Aragón	rosane.aragon@gmail.com	Brazil	Universidade Federal do Rio Grande do Sul	137
Rui Baía	rui.baia94@gmail.com	Portugal	University of Minho	140
Rui M. Lima	rml@dps.uminho.pt	Portugal	University of Minho	73
				80
				97
				116
				140
Rui Pereira	rmp@math.uminho.pt	Portugal	Escola de Ciências, University of Minho	139
Sacha Tournier-Pelle	s.n.tournier@saxion.nl	Netherlands	Saxion University of Applied Sciences	89
Sadayuki Shimoda	shimo@kumamoto-nct.ac.jp	Japan	National Institute of Technology, Kumamoto College	107
Samuel Tavares	samueltavares@yahoo.com	Brazil	UNINOVE - Universidade Nove de Julho	87
Sander Küttis	1111823@isep.ipp.pt	Estonia	Instituto Superior de Engenharia do Porto	13
Sandra Fernandes	sandraf@upt.pt	Portugal	Portucalense University	121
Setsuko Isoda	isodas@kumamoto-nct.ac.jp	Japan	National Institute of Technology, Kumamoto College	107
Shannon Chance	shannonchance7@gmail.com	Ireland	Dublin Institute of Technology	88
Shigeyoshi Nakamura	snakamura@kct.ac.jp	Japan	National Institute of Technology, Kitakyushu College	151
Shinya Maki	maki@vos.nagaokaut.ac.jp	Japan	Nagaoka University of Technology	151
Sidnei Silva E Silva	sidnei-abu@hotmail.com	Brazil	UEPA - Universidade do Estado do Pará	4
Simone Borges Simão Monteiro	simoneborges@unb.br	Brazil	University of Brasilia	46
				48
				84
				91
Sivachandran Chandrasekaran	siva.chandrasekaran@deakin.edu.au	Australia	Deakin University	19
Solange D. S. Alves	sdalves@ifba.edu.br	Brazil	Instituto Federal da Bahia	158
Stuart Palmer	spalm@deakin.edu.au	Australia	Deakin University	1
				2
				14
Susanne Staude	susanne.staude@hs-ruhrwest.de	Germany	University of Applied Sciences Ruhr West	18
Susie Cristine Keller	susie.keller@ufsc.br	Brazil	UFSC	23
Takashi Yamaguchi	ecoya@vos.nagaokaut.ac.jp	Japan	Nagaoka University of Technology	151
Tatiana Renata Garcia	tatiana.rgarcia@gmail.com	Brazil	UFSC	23

Row Labels	Email	Country	Affiliation	#
Ted Burke	ted.burke@dit.ie	Ireland	Dublin Institute of Technology	88
Terry Lucke	tlucke@usc.edu.au	Australia	University of the Sunshine Coast	17
				37
Thanh Chi Pham	thanh.pham@rmit.edu.vn	Viet Nam	RMIT University	135
Tiago Pereira	tmiguelpereira@hotmail.com	Portugal	University of Minho	140
Timber Yuen	timber@mcmaster.ca	Canada	McMaster University	77
Tomás Martínez	tomas@dfists.ua.es	Spain	Univerity of Alicante	78
Valquiria Villas-Boas	vvillasboas@yahoo.com	Brazil	University of Caxias do Sul	116
Vasco Areias	vascoareias9@gmail.com	Portugal	University of Minho	140
Vitor William Batista Martins	vitor_engenharia@hotmail.com	Brazil	UEPA - Universidade do Estado do Pará	4
Walid Ayari	walid.ayari@esprit.tn	Tunisia	ESPRIT	54
Waydja C. C. Correia	waydja.correia@yahoo.com.br	Brazil	Universidade Federal Rural de Pernambuco (UFRPE)	73
Wayne Hall	w.hall@griffith.edu.au	Australia	Griffith University	1
William Bergqvist	wber@kth.se	Sweden	KTH	90
Yolande Berbers	yolande.berbers@eng.kuleuven.be	Belgium	Faculty of Engineering Science at KU Leuven	108
Yury Daneykin	daneykin@tpu.ru	Russian Federation	Tomsk Polytechnic University	59
Zbigniew Żmudka	zbigniew.zmudka@polsl.pl	Poland	Silesian University of Technology	118
Zied Alaya	zied.alaya@esprit.tn	Tunisia	ESPRIT	111
Erik De Graaff	degraaff@plan.aau.dk	Denmark	Aalborg University	69

PAEE/ALE'2016 Submissions

The Seventh International Symposium on Project Approaches in Engineering Education (PAEE'2015), integrated in the International Joint Conference on the Learner in Engineering Education (IJCLEE'2015) has three type of submissions in up to three languages (English, Portuguese and Spanish):

- **Workshop submissions**, aiming to encourage discussion of current practice and research on project approaches.
- **Full Papers** for paper sessions, including standard research submissions, papers of PBL experiences describing implementation issues. Any of these papers can be selected and presented in a Debate Session, in which a set of papers' authors will be invited to discuss a common theme.
- **Poster submissions**, including submissions adequate for a poster presentation in an interactive model.

All full paper submissions were double reviewed by the PAEE 2015 scientific committee, and in same cases add a third review. After notification of acceptance authors were invited to submit a final paper of 6 to 8 pages long in Microsoft Word format, using the available PAEE template. Accepted contributions were invited to make a presentation at the symposium.

The proceedings are published under the Guidelines on Open Access to Scientific Publications and Research Data in Horizon 2020 (http://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/hi/oa_pilot/h2020-hi-oa-pilot-guide_en.pdf): "Open access to scientific publications refers to free of charge online access for any user." The authors retain the copyright of their work.

Publication Ethics and Malpractice Statement

The International Symposium on Project Approaches in Engineering Education – PAEE, is being organized by the Department of Production and Systems Engineering, University of Minho, since 2009, aiming to join teachers, researchers on Engineering Education, deans of Engineering Schools and professionals concerned with Engineering Education, to enhance Project Approaches in Engineering Education through workshops and discussion of current practice and research.

The PAEE editorial board is committed to preventing publication malpractice, does not accept any kind of unethical behaviour, and does not tolerate any kind of plagiarism. Authors, editors, and reviewers of PAEE are to be committed with good practice of publications and accept to fulfil the duties and responsibilities as set by the COPE Code of Conduct (http://publicationethics.org/resources/code-conduct). Based on these, PAEE expects authors, editors and reviewers to be committed to the following general guidelines:

- Editors take decisions on the acceptance of papers, and compose and evaluate the proceedings quality.
- Ensure that all published papers have been fairly reviewed by suitably qualified reviewers.
- Expect original submissions from the authors, and discourage misconduct.
- Expect that authors are responsible for language quality.
- Expect that the authors adequately reference the sources of their work.
- Ensure confidentiality of submissions and reviews.
- Reviewers do a fair and detailed review of paper(s) assigned to them.

PAEE/ALE'2016 LIST OF SUBMISSIONS

PAEE/ALE'2016 HANDS-ON SUBMISSIONS

Submissions accepted for the PAEE/ALE'2016 hands-on sessions.

What is the role of growth when talking about technology and sustainability?

Miguel Romá[1], Tomás Martínez[1]

[1] Signals, Systems and Telecommunications group (SST), University of Alicante, Spain

Email: miguel.roma@ua.es, tomas@dfists.ua.es

Abstract

In the context of engineering education, it is compulsory to make the students think about the impact that technology has in many aspects of life. We, as engineers, and our students as future engineers, must be aware of both kind and awkward effects of technology from the widest possible range of points of view. Issues like how to manage technological waste (related to programmed obsolescence), the risk of the generation of unemployment caused by the use of technology (automation and robotics), the relevance of having a strong technological industry to support our working environment, the relationship between sustainability and renewable resources..., are clear examples of aspects suitable to generate interesting debates. However, there is a key element that is commonly left apart as it derives to uncomfortable conclusions. Can we talk about sustainability avoiding thinking about the effects of economic growth?
In this hands-on we will present an activity used to promote critical thinking in students about the relationship between economic growth and sustainability. We will try to present the most common thoughts when technology, energy, sustainability and growth are placed in the same bowl. If we conclude that economic growth and sustainability are not odd with each other, a pleasant landscape will be shown in front of our eyes. Notwithstanding, if we conclude that sustainability is not achievable in a growth environment, the panorama will possibly be comfortless.

Keywords: Education for Sustainability, Sustainability and Economic Growth, Engineering and Technology.

1 Introduction

We, as educators, expect engineering students to be aware of the future as a global issue. In fact, students explicitly want to discuss about ethic and sustainable development in engineering and engineering education, as conclude in the Board of European Students of Technology Symposium hold in Madrid in 2006 (BEST, 2006). Anyway, we can introduce elements closely related with the engineering framework in order to generate the appropriate working environment to think actively and critically about the future. The relationships of technology and sustainability, renewable energies and life-style, economic growth and ecologic waste management and, in general, the role of Engineers and Engineering in the consecution of a 'friendly' future are topics relevant enough to be taken into account in the engineering education process.

As a sample of different ways to tackle these kind of debates with engineering students, we introduce a first relationship of engineering and economy with first year students using the same state-space formulation used for electrical circuit analysis to study the behaviour of economic problems. In this course, the students learn to represent any electrical network with passive and active components using state-space equations [Martinez-Marin, 2010]. They solve problems both from engineering (the state variables are the voltage on capacitors and/or intensity in inductors) and economy (the state variable is money). For example, a simple RC serial circuit is formulated by the following equation:

$$\frac{dx}{dt} = -\frac{1}{RC}x + \frac{1}{RC}u$$

where x is the state variable and represents the voltage on the capacitor (C), R is the resistor, and u(t) is the input. On the other hand, an economic problem is modelled by the equation:

$$\frac{dx}{dt} = ix + L$$

where x represents the capital, i is the annual interest rate and L is a monthly payment. For instance, this simple state-space model can represent a deposit (L=0), a retirement plan (L>0) or a mortgage (L<0). Very interesting issues arise when the state-space equations are analysed in terms of stability, transient response, overshoot and steady-state (sustainability). A key difference between engineering systems and economic systems is that electrical networks are designed to avoid the exponential growth (of electrical variables) in most applications, whereas economic systems are designed to promote the exponential growth as an desirable and necessary outcome.

With third year students, we use role-play to promote discussion about the gap of ethics in engineering [Romá and Ballester, 2012]. In this case, teams of students are asked to prepare arguments in favour or against some particular cases previously presented in which technology presents a clear ethical issue. In a second stage, teams have to confront their arguments and very interesting debates arise. Question like 'would you develop your work in a weapons factory?' or 'will you agree with locating the manufacturing centre of your enterprise in a developing country to reduce costs and ensure firm availability?' lead to incredibly interesting debates.

In this sense, we try to reach a new level of debate taking into account global variables. The proposed activity presents two different levels. On the content side, we propose to discuss about sustainability, future, economic growth, technology and the role of engineers in this puzzle. The second level of the activity will explore the effects of confronting one's mind scheme against facts that may not fit well in this structure. Usual reactions can be to deny the facts, re-interpret the facts to make them fit with the mind scheme so this scheme will be stronger or to make tremble the mind scheme. At first sight, the discussed questions may seem simple, but the pack formed by economy, environment and society is a very complex dynamic system. The fact that the system is dynamic is one of the key elements justifying the interest of making students think about these concepts. As stated in [Booth-Sweenwy and Sterman, 2000], highly educated subjects with extensive training in maths and science have poor understanding of some of the most basic system dynamics, as a result of some tests with students at the MIT Sloan School of Management.

2 Activities

There are many contributions analysing the factors affecting sustainability. The funny part is that it is possible to find the same factor considered as an element that will and will not ensure sustainability. Ecologists, economists, engineers or scientists show very different points of view polarized by their academic profiles. For instance, while ecologists clearly rely on renewable energies as the key element for sustainability, [Cheng, 2015] clearly states that renewable energy will not be able to replace fossil fuels, and the work by [Adair, 2010] points out that the installation, operation and maintenance of renewable plants needs fossil fuel questioning the sustainability of renewable energies. In this sense, the evolution (and future projection) of energy production is used as a key argument (figure 1). In figure 1 the units used to measure fossil and renewable production have been intentionally selected different. The drawback is that the tendency observed in the figure, even that the evolution is clear, it is not sufficient, as the scales are different measuring fossil and renewable production. Nowadays the energetic efficiency of renewable sources cannot be compared to that provided by fossil fuel.

Even general people without specific knowledge can also defend very different positions depending on their mind model. One of the most found positions is that based on the hope that technological improvements will be able to manage energy-related issues. In this sense, as pointed out in [Tlusty, 2015] influencing people, as the General Electric CEO Jeffrey Immelt claimed that *for achieving sustainability, technology is the only answer*. A curious aspect highlighted in this work is that, in almost all the cases, when technology is apparently used with sustainability goals, the reality is that these technological improvements, under the tag of *restorative technologies*, their real mission is to reduce our impact on the planet caused by older technological developments.

The main goal of the session will be to explore the initial position regarding this topic and confront it with analytical information that can be easily handled from an engineering profile. Some recommended reading available on the Web is provided in the reference section.

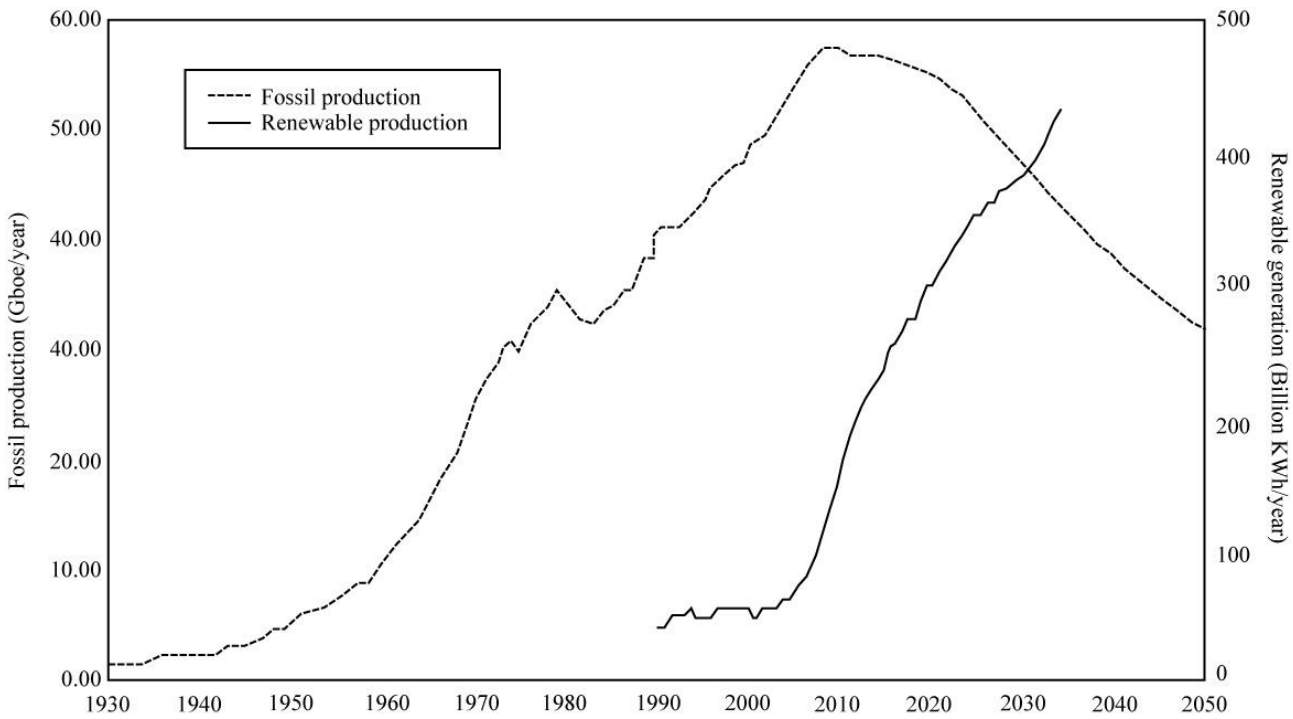


Figure 1. Evolution and future projection of fossil and renewable energy in the United States (source: peakoilbarrel.com / U. S. energy information administration).

In order to avoid the possibility of generating different ideas from those previously owned by the attendants to the proposed session, we will advance just an overview of the kind of activity that will be performed, as it is important to allow each participant to present his or her ideas about the topics presented. Moreover, as there are many possible different ideas, it is impossible to know in advance how the session will evolve. Working groups will be aimed for the first part of the session in order to get a general idea of related topics by answering to a series of questions as:

- What is sustainable development?
- What is green capitalism?
- Is there any potential problem related with the actual economic model?
- Is our actual economic model sustainable?
- Is there any dangerous factor compromising future sustainability?
- Can renewable energies ensure sustainability?
- Which is the role of technology to ensure future sustainability?
- Can we, as engineers, take an active role towards sustainability?
- Is slow economic growth compatible with sustainability?

Some literature will be available for in-situ reading.

The main ideas will be stated in posters.

After a brief presentation of the previous results and a subsequent discussion, teams formed by people showing similar points of view will be organize to prepare arguments to defend a concrete position. During the following discussion, new elements will be introduced and we will explore their effect in the initial points of view.

The final part of the session will be used to conclude the key elements considered to be able to ensure sustainability and how these factors will affect to our future life. We will also analyse how this ideas can be fitted in our mind model. We will finish with the presentation of a three minutes video as a closing conclusion.

3 Expected results

As we are proposing a hands-on activity, its conclusion cannot be presented until the realization of the activity itself, so this section presents just as an outline, the main ideas we expect to debate. The starting point will necessarily be to share a definition of sustainability.

We expect that, after the session, attendees will have a technically sounding vision of sustainability that may provoke some discomfort. We will discuss about the future from an economic point of view and the role of technology and energy to ensure a sustainable future. We will introduce the concept of economic growth in the equation and a discussion about economic growth and sustainability will follow [Higgins, 2013].

Due to the engineering profile of the attendees, the role of technology in the puzzle formed by society, economy and environment.

We will explore if the initial mind model has or not been affected with the inclusion of new data. We will assess the interest of carrying this activity with attendees' students. We will study the possibility of exporting the idea of mind model confrontation to the particular attendees' areas.

4 References

Adair, R. (2010). How sustainable is renewable energy? *Energy Bulletin*.

BEST (2006). Ethics and sustainable development issues in engineering education. *Board of European Students of Technology Symposium on Education*. Madrid.

Booth-Sweeney,L & Sterman, J. D (2000). Bathtub dymanics: initial results of a systems thinking inventory. *Systems dynamics review*, Vol. 16.

Cheng, F. (2015). Renewable energy can't replace fossil fuels entirely. *The Straits Times*, Dec. 17, 2015.

Higgins, K. L. (2013) Economic growth and sustainability - are they mutually exclusive? Available on-line at thttps://www.elsevier.com/connect/economic-growth-and-sustainability-are-they-mutually-exclusive (last seen on may 2015).

Martínez-Marín, T. (2010). State-Space formulation for circuit analysis. *IEEE transactions on education*, Vol. 53, No. 3.

Romá, M & Ballester, J. D. (2012). Using role-play to think about ethical issues in engineering education. *11th active learning in engineering workshop*. Copenhagen, Denmark.

Tlusty, M. (2015) Why sustainability reuqires more than technological advances. *Triple Pundit*, May 21, 2015.

5 Internet resources

http://www.oeaw.ac.at/ita/en/topics/technology-and-sustainability/

http://greenfleet.dodlive.mil/energy/shore/renewable/

http://www.theresourcebasedeconomy.com/

http://www.oeaw.ac.at/ita/en/topics/technology-and-sustainability/

http://www.triplepundit.com/2015/05/sustainability-requires-technological-advances/

http://www.theguardian.com/sustainable-business/technological-innovation-sustainability-energy-green-investment

https://www.uow.edu.au/~sharonb/RoleTech.html

https://www.elsevier.com/connect/economic-growth-and-sustainability-are-they-mutually-exclusive

http://www.un.org/en/sections/priorities/economic-growth-and-sustainable-development/index.html

http://www.humansandnature.org/sustainability-well-being-and-economic-growth

http://www.globalurban.org/sustainable_econ.htm

Risks of active learning approach: Missing the learning goals

Michaël Canu[1], Mauricio Duque[1], Margarita Gómez[1]

[1] Department of Electrical Engineering, Faculty of Engineering, University of Los Andes, Bogotá, Colombia

Email: m.canu134@uniandes.edu.co, maduque@uniandes.edu.co, mgomez@uniandes.edu.co

Abstract

Properly designed active learning instruction using "Hands-on" activities could result in higher student motivation and also higher teacher involvement, particularly when it implies a change from less active learning strategies (lectures, presentations) that are more commonly found in the daily life of students and teachers. Often, the expected learning improvement after these changes in instructional strategies, are assessed by standardized tests that usually assess only the declarative knowledge of the students. Occasionally, the impact of these proposals is measured by means of perception of the students. These ways of assessing fail to address the question of what really students learn in Hands-on sessions and if they really learn "better" or "more" using this kind of approach. Actually, recent research suggest that not every active learning session could promote improvements in learning, particularly in terms of conceptual knowledge and deep understanding. This workshop aims to explore an active learning approach for equilibrium and stability concepts. The activities proposed will show different ways in which these topics can be addressed in an active way with potentially very different learning results. After analysing this experience, participants will be asked to design another learning activity using approaches that effectively promote the expected learning. Designs and their analysis will allow the comprehension of frameworks as Understanding by design or didactic engineering for the development of effective active learning sessions.

Keywords: Active Learning; Engineering Education; Symposium Information; Project Approaches.

1 Introduction

"Hands-on" (Ho) activities are considered to develop a deeper kind of knowledge (conceptual) as well as links between theory and practice. Often, the expected learning improvement after these changes in instructional strategies, is assessed by standardized tests that usually address only students' declarative knowledge. Even if it can be expected an improvement in declarative knowledge due to the higher students motivation using this kind of activities, this is not generally the main objective. Moreover, studies show that standardized tests are not suitable for assessing this knowledge (Shavelson et al., 2005) except in case of Conceptual Inventory tests (Pellegrino et al., 2013). Occasionally, the impact of these proposals is measured by means of perception of the students which can be suitable for assessing students´ motivation or involvement but gives few information about knowledges.

So, common ways of assessing fail to address the question of what really students learn in Hands-on sessions and if they really learn "better" or "more" using this kind of approach. Actually, recent research suggests that not every Ho active learning session could promote improvements in learning, particularly in terms of conceptual knowledge or deep understanding. For example, whether Ho is better than other approximation like virtual laboratories or more classical paper and pencil activity (Schwishow et al., 2016; Triona & Klahr, 2007; Brinson, 2015) has been discussed.

This workshop aims to explore some active learning approaches for equilibrium and stability concepts. The activities proposed will show different ways in which these topics can be addressed in an active way with potentially very different learning results. After analysing this experience, participants will be asked to design another learning activity using approaches that effectively promote the expected learning. Designs and their analysis will allow the comprehension of frameworks as Understanding by Design (UbD; Mac Tighe & Wiggins, 2012) or Didactic Engineering (Artigue, 1988) for the development of effective active learning sessions.

Hands-on activities and active learning

Prince (2004) argues "Active learning is generally defined as any instructional method that engages students in the learning process. In short, active learning requires students to do meaningful learning activities and think

about what they are doing[1]". So, active learning is generally associated to problem-based learning, project-based learning and hands-on session. Some authors like Chi (2009) call this kind of activities "constructive learning" and it is considered that it implies more than simply "doing something" (Hands-on/Mind-off). Moreover, Bonwell & Eison (1991) wrote in their report about what Active Learning is, students "must read, write, discuss, or be engaged in solving problems", namely be *involved,* which not necessarily implies hands-on or group activities. In fact, the effectiveness of hands-on activities is questioned by various authors. On the one hand, the necessity of "doing something with hands" is not very clearly linked to all kinds of learnings except for young students and for some class of knowledges (Zacharia et al., 2012). On the other hand, some authors (like Schwichow et al., 2016) have showed that the cognitive load during hands-on activity could compete with deep learning. Moreover, comparative studies (Triona & Klahr, 2007; Brinson, 2015; Ma & Nickerson, 2006; Wiesner & Lan, 2004; Zacharias & Constantinou, 2008) between real laboratories and virtual or remote ones (i.e. using computer) also showed that manipulating real world is not a necessary condition to reach effective learning (for example conceptual knowledges).

In this workshop, we propose three different activities about the same concept (equilibrium): two of these activities are manipulative ones and the other one is a paper-and-pencil activity. The paper-and-pencil activity was designed using the Didactical Engineering framework we present in the following.

The Didactical Engineering framework

One part of this workshop is based on an engineering students classroom sequence that promotes a *conceptual change* in students' mind in order to bring them to understand all equilibrium situations in a suitable coherent way (Canu et al., 2014). As it is a constructivist point of view, this aim cannot be reached without the use of a student-centered teaching approach, namely an Active Learning approach. The design and the assessment of the activity are in fact embedded in the Didactical Engineering (Artigue, 1994) methodology. As Artigue said, "Didactical engineering is the design and experimentation of teaching sequences, adopting an internal mode of validation based on the comparison between a priori and a posteriori analysis within the framework of the Theory of Didactical Situations (Brousseau, 1997)". It is, with some precautions, at the same time a research methodology and a methodology to develop teaching products.

The foundation of Didactical Engineering is the Brousseau's Theory of Didactical Situations. As Brousseau claimed, "Teaching consists exactly in bringing about expected learnings in students by putting them in appropriate *situations* in which they will respond spontaneously by some *adaptations*" (Brousseau, 1988, p. 324). The (learning) *situations* to which he refers are real *active* learning situations because they cause students *adaptations,* namely *constructions* of knowledge.

The Didactical Engineering includes four steps (that we are not going to detail here):

- A preliminary analysis investigating the epistemological, cognitive and institutional conditions and constraints;
- A design and *a priori* analysis with particular attention paid to the identification and selection of values for the didactic variables and anticipation of their potential effect on the "students-*milieu*[2]" interaction;
- An experimentation;
- And *a posteriori* analysis and validation of the hypotheses underlying the design

Here, participants will experiment only one part of the entire didactical sequence designed for the students as it consists normally in two 1h30 sessions.

Active learning design

During the second step of the workshop, participants will be asked to analyse the activity they experienced. In order to do that, we propose to use a guide based on the Understanding by Design framework (UbD).

---

[1] Bonwell, C.C., and J. A. Eison, "Active Learning: Creating Excitement in the Classroom," ASHEERIC Higher Education Report No.1, George Washington University, Washington, DC , 1991.

[2] For more details about this notion of *milieu*, which is more than a simple *social environment*, read Brousseau (1988) *La théorie des situations didactiques,* La pensée Sauvage, pp. 115–160, Grenoble.

UbD is a curriculum design framework based on an assessment perspective. The knowledges assessment of a learning sequence is included in the firsts steps of the activity design in order to insure an exact match between the activity and the expected knowledges. Effective curriculum is planned backward from long-term, desired results through a three-stage design process: Desired Results, Evidence, and Learning Plan. Even if this framework was developed to curriculum design, it can be used to guide sequence design inside this curriculum. For that, six facets of understanding — the capacity to explain, interpret, apply, shift perspective, empathize, and self-assess — can serve as indicators of understanding. This process helps avoid the common problems of treating the textbook as the curriculum rather than a resource, and activity-oriented teaching in which no clear priorities and purposes are apparent.

The proposed backward design is composed of three stages guides by some key questions (Mac Tighe & Wiggins, 2012, p.2):

First stage: Identify Desired Results

Key Questions: What should students know, understand, and be able to do? What is the ultimate transfer we seek as a result of this unit? What enduring understandings are desired? What essential questions will be explored in-depth and provide focus to all learning?

Stage 2: Determine Assessment Evidence

Key Questions: How will we know if students have achieved the desired results? What will we accept as evidence of student understanding and their ability to use (transfer) their learning in new situations? How will we evaluate student performance in fair and consistent ways?

Stage 3: Plan Learning Experiences and Instruction

Key Questions: How will we support learners as they come to understand important ideas and processes? How will we prepare them to autonomously transfer their learning? What enabling knowledge and skills will students need to perform effectively and achieve desired results? What activities, sequence, and resources are best suited to accomplish our goals?

As said before, UbD is originally shaped for curriculum design but it is possible to use it as an activity or small sequence design. This framework will also be used by participant to analyse the three firsts activities, in the second step, as well as to attempt to improve them, in the third step of the workshop.

2 Activities

The aim of this communication is to show that not all hands-on activities lead to knowledge acquisition, or, in some cases, drive to useless or irrelevant knowledge learnings with respect to the concepts goals. In fact, many active learning sequences or sessions are not design from clear learning objectives. Frequently, the practical or manipulative aspect is the only clear explicit objective while the professor wants to reach many other implicit objectives. The main goal of the workshop is to drive the participant to identify the real – effective - learning objectives in the three activities and to learn some elements that allow a more effective learning activity design. As said before, the participants will be involved in three different activities (Hands-on and Hands-off) around the same concept, each of them driving to different knowledges:

- Pendulum control activity
- Equilibrium cases study (like in Canu et al., 2014, 2015)
- Prototypic arm balance activity

Participants will be shared in small groups in order to probe one of the three activities. Then, a short presentation of each activity will be organised so as to share each activity with the others and to discuss the presumed learning objectives of each one. The second step consists in analysing each activity with the UbD methodology in each group. In the third step, participants will be asked to attempt to improve the design of each activity if it is possible, using the same framework.

2.1 First step: group activities

After a short organisation phase each group receives a document with the description of the proposed activity as well as some material depending on it. In this step, participants will experience the activities as student would do it.

In the pendulum activity, participants should handle a metallic pendulum in order to find some important variables that rule the pendulum equilibrium. They have to design some experiments so as to find these variables as in an inquiry-based activity.

In the arm prototypic balance activity, participants should handle a metallic couple arm/fulcrum and some counterweights in order to find important variables and rules that determine the balance equilibrium. They have to design some experiments so as to find these variables as in an inquiry-based activity.

In the paper-and-pencil activity, participants are asked to define the equilibrium concept analysing some fundamental and well-chosen situations (Canu et. al., 2014).

At the end this step, each group is asked to expose the content of its activity to the other groups. They are invited to answer some questions about the presupposed learning objectives of each activity, and discuss those objectives with the others. The aim of this debate is to test the participant ability to find explicit or implicit learning objectives in the proposed activities. Participants have also to define if each situation is an active one, and why.

2.2 Second step: activity analysis

In fact, few variables are controllable in the two hands-on activities, so only some aspects (and not the most important ones) could be managed. In consequence, only very limited knowledges about the concept could be reached:

In the pendulum situation, only the distance between the rotation axle and the pendulum centre of mass can be changed. As the pendulum possesses only two equilibrium positions independent of the centre of mass position, a very limited knowledge about the equilibrium concept can be acquire.

On the contrary, in the arm balance situation, as the fulcrum can be moved along the arm, it is then possible to design richer experiments in order to investigate the system variables and rules (for example, the Archimedes law of the lever). Nevertheless, only horizontal equilibrium positions can be reached. This implies also a quite limited knowledge of the concept.

In the paper-and pencil situation, participants have to define the concept of equilibrium from the study of three systems: an equal arm balance, a pendulum-on-a-cart system and a book on a table. In this activity, there is a frail hands-on aspect contrary to the others. But, due to the adopted methodology (Didactical Engineering), we can ensure a minimum level of understanding in the students/participants.

In this step, participants are asked to analyse the situation proposed in his/her group using the UbD key questions described above. They are expected to detect the gap that exists in some situations between the learning objectives and the knowledges promoted or induced by the situation. The key concept here is the *didactic variables* (Brousseau, 1997) and their role in the behavior of the participant/student in front of such situations. Here, the nature of the studied system is one of these didactic variables. Didactic variables are fundamentals because they constrain the problems studied by students in an activity and drive their behavior. So, through this behavior, they induce or prevent learnings in an implicit manner (Canu et al., 2014).

Many hands-on activities, like the pendulum situation or the arm balance situation, lean on the use of too specific situations. Many times, the choice of these situations is not the product of the learning situation design but the result of some preceding choices (the existence of some material in the professor laboratory is sometime the cause of such a pre-choice). One of the aims of this step is to question this kind of implicit choice. During the analysis of the three situations the participants are expected to detect this lack of adequate connexion between situations and learning objectives in the first's two situations. The host will give some basic elements of the Didactical Engineering methodology during this step.

2.3 Third step: design activity

With the same tool (the UbD key questions), the participants are invited to find some ways of improvement for the two hands-on situations. They have to study two ways: the first one is to change the situation and the second one is to redefine the learning objectives of the situation, in order to reach a more accurate match between these two elements.

3 Expected results

This workshop should drive the participant to a deeper understanding of the link between learning objectives and activity in the framework of active learning. They are expected to understand the bases of two design methodologies, the Understanding by Design and the Didactical Engineering one. They are expected to understand some of the limits of hands-on activities and to be able to decide what kind of activity could lead to what kind of knowledge.

4 References

Artigue, M., & Perrin-Glorian, J. (1991). Didactic Engineering, Research and Development Tool: Some Theoretical Problems Linked to This Duality. *For the Learning of Mathematics*, *11*(1), 13–18.

Artigue, M. (1994). Didactical engineering as a framework for the conception of teaching products. In R. Biehler, R. W. Scholz, R. Sträßber, & B. Winkelmann (Eds.), Didactics of mathematics as a scientific discipline (Mathematic., Vol. 54, p. 481). Dordrecht: Kluwer Academic Plublishers. doi:10.1007/0-306-47204-X

Artigue, M. (2009). Didactical design in mathematics education. In C. Winslow (Ed.), Nordic research in mathematics education. Proceedings from NORMA08, Copenhagen, 21–25 Apr 2008 (pp. 7–16). London: Sense.

Brinson, J.R. (2015). Learning outcome achievement in non-traditional (virtual and remote) versus traditional (hands-on) laboratories: A review of the empirical research.

Brousseau, G. (1997). *Theory of didactical situation in mathematics*. (N. Balacheff, M. Cooper, R. Sutherland, & V. Warfield, Eds.). Dordrecht, The Netherlands: Kluwer Academic Publishers.

Canu, M. (2015). Apport de l'étude conjointe de systèmes libres et commandés dans la compréhension des concepts d'équilibre et de stabilité. *IREM de Paris. ISBN : 978-2-86612-358-1. https://hal.archives-ouvertes.fr/tel-01108459*

Canu, M., de Hosson, C., & Duque, M. (2014). STUDENTS' UNDERSTANDING OF EQUILIBRIUM AND STABILITY: THE CASE OF DYNAMIC SYSTEMS. *International Journal of Science and Mathematics Education*, (on-line first edition). doi:10.1007/s10763-014-9565-6

Canu, M. & Duque, M. (2014). Didactic engineering for conceptual change in students' equilibrium and stability understanding. Active Learning in Engineering Education – Caxias du Sul, 20-22th of January 2014, 292-299.

Ma, J. & Nickerson, J. V. (2006). Hands-On, Simulated, and Remote Laboratories: A Comparative Literature Review. *CM Computing Surveys*, 38(3), Article 7.

MacTighe, J. & Wiggins, G. (2012). Understanding by Design Framework. www.ascd.org.

Pellegrino, J. W., DiBello, L. V. and Brophy, S. P. (2013). The Science and Design of Assessment in Engineering Education. In Cambridge Handbook of Engineering Education Research. Ch. 29. ISBN 978-1-107-01410-7.

Prince, M. (2004). Does Active Learning Work ? A Review of the Research. Journal of Engineering Education. 93(3), 223–231.

Shavelson, R., Ruiz-Primo, M. A. and Wiley, E. W. (2005). Windows into the mind. *Higher Education*. 49, 413-430.

Schwichow, M., Zimmerman, C. and Croker, S. (2016). What students learn from hands-On activities. *Journal of Research in Science Teaching*, DOI: 10.1002/tea.21320.

Triona, L. M. & Klahr, D. (2007). Hands-On Science: Does it Matter What Students' Hands are on? *The Science Education Review.* (6)4.

Wiesner, T. F. & Lan, W. (2004). Comparison of Student Learning in Physical and Simulated Unit Operations Experiments. *Journal of Engineering Education.* 93(3), 195-204.

Zacharia, C. Z. & Constantinou, C. P. (2012). Comparing the influence of physical and virtual manipulatives in the context of the Physics by Inquiry curriculum: The case of undergraduate students' conceptual understanding of heat and temperature. *American Journal of Physics*. 76(4&5), 425-430.

Sustainability in Engineering Education

Pau Bofill[1], Montse Farreras[1]

[1] Department of Computer Architecture, UPC Barcelona Tech, Barcelona, Catalonia

Email: pau@ac.upc.edu, mfarrera@ac.upc.edu

Abstract

This document presents a Hands-On session on Sustainability in Engineering Education. Sustainability is defined as the use of resources in such a way as to allow them to regenerate in time. Sustainability should be considered in connection with equity, so that the resource is equally available to everyone. Then several categories for analysis are defined, such as GDP growth, progress, environment or holistics so as to guide the discussion. The hands-on takes place in small groups, that are asked to write a short poster on how they would introduce the subject of sustainability in a project with their students. The learning goal is that sustainability is a holistic quality, that has to do with many dimensions at the same time.

Keywords: Active Learning; Engineering Education; Hands on; Sustainability.

1 Introduction

The word *sustainable* is nowadays quite worn-out, and we should better redefine it before addressing the subject of this paper.

A sustainable use of a resource means making use of it in such a way that it can replace itself fast enough, so that it is still available the next time we need it. Using too much of the resource would drain it out, and it would become unavailable. Such resources tend to be of common use, and if one person abuses from them, the whole community runs out of them.

An example of sustainable consumption might be the use of fire-place wood at a pace that the forest has time enough to replace the wood that has been used. A non-sustainable use of the air is pollution with carbon dioxide, faster than the atmosphere has time to reabsorb it, leading to the greenhouse effect and global warming.

Other resources, such as oil, exist in fixed quantities, and can never be replaced. They are not sustainable at all.

Sustainability should always be considered in connection with equity. The use of a resource is sustainable if it is, at the same time, available to all. Selling and buying pollution rights is, from this point of view, not ethical.

From that point of view, money (and wealth) is also a non-sustainable resource. Credit apart, the overall amount of money at a given time is fixed and scarce. Then, if some people or companies get more and more of it, the rest or the world goes gradually into starvation.

Sustainability in Engineering Education should mean weather future engineers are educated in sustainability, and how. The main question to have students reflect on might be: "Do engineering projects have anything to do with sustainability?" The most common answer is "No". Yet, since engineering is intrinsically reductionist, engineering projects tend to take into account just a few physical variables like: "Will the dam resist the weight of the water?", and a few chrematistic ones: "Is the project profitable in the long run?" But nobody cares about the trouts that used to live in the river, or about the aboriginal community that used to live on those trouts.

Sustainability in engineering must be looked for in the collateral effects of engineering projects. And not only on the immediate effects of whatever is being built, but also in indirect relationships with society, the environment and the economy. And, most of all, sustainability must be contrasted with the necessity of making more and more projects at all.

The goal of the workshop is to make participants reflect on the links between engineering and sustainability and how this might be introduced in the engineering curricula.

2 Categories for the analysis

Sustainability can be analysed with respect to the following categories and dichotomies: GDP growth, development, progress, energy consumption, environment (resources and pollution), reductionism of science, technification of society,

patriarchy etc. And some of their counter-parts: happiness index, welfare economies, the commons, care-based societies, the ecology of nature, holistic analysis, bio-feminism, etc.

3 The hands-on session (90')

Participants arrange themselves in groups of 3-5 people:

- (15') Introduction. Sustainability vs Equity. The dimensions of sustainability.
- (25') Group work. Engineering and Sustainability. Select one project that you have sometime made with your students. Analyze it in group, in terms of sustainability. Was the question of sustainability posed or discussed with the students? How? Write a short poster.

  Some guiding questions to enhance group discussion:

  - What is the relationship between engineering and sustainability?

  - What was the impact of the project in the following areas: environment, energy, economy and social and political equity?

  - Was the project designed with sustainability in mind? Does the project have an immediate relationship with sustainability?

  - Was sustainability discussed or taken into account with the students?
- (20') Groups present their results. A list is written on the blackboard with answers to the following questions: What categories have been of interest in the analysis for sustainability? What are the elements of sustainability in a project?
- (30') Full group discussion. Conclusions.

4 Expected outcomes:

Participants are expected to share experiences, ideas and to collectively reflect on why and how we should educate future engineers in sustainability. We expect as an outcome to define some criteria on how to approach the discussion on sustainability in engineering education.

The learning goal is that sustainability is a holistic quality, that has to do with many dimensions at the same time.

PAEE/ALE'2016 WORKSHOP SUBMISSIONS

Submissions accepted for the PAEE/ALE'2016 workshop sessions.

RoboSlam for Engineering Educators: A Workshop for Learning to Facilitate Robot-Building Workshops

Shannon Chance[1], Damon Berry[2], Ted Burke[2], Frank Duignan[2]

[1] CREATE Research Group, College of Engineering and the Built Environment, Dublin Institute of Technology, Ireland
[2] School of Electrical and Electronics Engineering, College of Engineering and the Built Environment, Dublin Institute of Technology, Ireland

Email: shannon.chance@dit.ie, damon.berry@dit.ie, ted.burke@dit.ie, frank.duignan@dit.ie

Abstract

A volunteer team of engineering and robotics teachers from Dublin Institute of Technology (DIT) will offer a two-hour hands-on *RoboSlam: Robot Building Workshop* for educators who attend the PAEE and ALE conferences. Participants in this workshop will each construct a working robot and will also learn about our train-the-trainer program. No prior robotics experience is necessary!

Our team has used this Problem Based Learning format to teach hundreds of students and teachers in Ireland how to build and program robots. To date, RoboSlam has been delivered 38 times, to more than 677 participants and to an additional 100 students at our sister Institute of Technology in Blanchardstown (ITB), Ireland. We have trained many people to facilitate these workshops successfully, including third-level students studying electrical and electronics engineering and also tutors running a professional practice module at ITB.

Keywords: Robotics; Electronic Engineering; Active Learning; Engineering Education

1 Introduction

We have developed a robotics workshop at Dublin Institute of Technology (DIT) that we have been able to deliver to people of all ages around Ireland. Our intention with this workshop, to be held at the 2016 PAEE/ALE conference in Guimarães, Portugal, is to give conference participants the chance to build a robot for themselves and ask them to consider conducting similar outreach programs themselves. Given about 2 hours, each participant can assemble a working robot using an off-the-shelf kit of parts and an Arduino Nano. With an additional 2-3 hours, the participant can learn to code the robot to make decisions and do specific tasks. We offer this workshop to children, teenagers, and adults in workshops ranging from 2-5 hours in length.

2 Activities

We are team of academics from DIT, which is a third-level Higher Education Institute founded under the Dublin Institute of Technology, Act 1992. We conduct RoboSlam robotics and computer programming workshops for children and teens. The mission of RoboSlam is to use fun robotics based programming activities to encourage children to consider careers in engineering, computer science, and other areas of STEM. Our RoboSlam public outreach and STEM engagement activities were founded by a team of four volunteer academic staff in Dublin Institute of Technology (DIT) who specialize in computer engineering, electrical and electronics engineering, and educational research.

To date we have delivered RoboSlam 38 times, to over 677 participants. We have conducted workshops at festivals, Coder Dojo events and science shows across Ireland. We've conducted others in Dublin's Science Gallery, public libraries, and secondary schools. We've delivered workshops on our campus to visiting groups of Transition Year engineering enthusiasts as well as third-level level students, educators, and researchers.

In addition, we have reached a wide audience by hosting Maker faire booths fro the past three years and providing interviews for national television and radio programs.

Our work started in 2012 when the first RoboSlam robot-building workshop for beginners was developed, pilot tested with DIT staff, and then delivered to a group of Transition Year students. There are now 14 staff and 10 student volunteers actively involved. The RoboSlam workshop is delivered to students of all ages in Ireland. The workshop curriculum ideally takes five hours, and was developed from a module provided to third level students as part of the Electrical Engineering course at DIT. That module is named RoboSumo and the robots compete against each other on various challenges culminating in a "Sumo wrestling" competition where each robot locates and attempts to push its opponent out of the Sumo circle.

In the RoboSlam workshop each student is given the components to build and program an autonomous robot that changes its behavior based on various environmental conditions. In all workshops, participants learn to assemble electronic circuitry (first 2-3 hours). Often this is all the hosting organization has time for us to do with the students. In optimal cases, we are able to provide the extended workshop (which takes 5-6 hours), where participants also learn to modify and write code to change behavior and upload it into the robot's memory chip.

In RoboSlam, participants learn together in a stimulating atmosphere, led by third-level educators who are experts in Student-Centered, Problem-Based Learning pedagogies. The RoboSlam program has, to date, had a direct and positive impact on participants. During the workshop participants learn about a core element of programming called program control flow. By mixing digital and analogue techniques, students get an insight into how programming makes "smart" computer-based systems such as robots, aircraft, and the Internet of Things (IoT) interact with the physical world. In addition, participants get to bring home a working robot, a tangible and engaging output for their efforts, which they can further develop.

Recently, we developed a "train the trainer" program and used it to teach others to facilitate RoboSlam workshops. Last autumn (2015), we taught lecturers at Ireland's Institute of Technology in Blanchardstown (ITB), who are not experts in robotics, to facilitate workshops. The lecturers subsequently delivered the project to over a hundred students, under the guidance of one faculty member who had technical expertise in the area. He offered trouble-shooting services to the students, who actually did the project as part of their professional practice class. The project was framed around the topic of collaboration, because this was the most practical way to get teachers at ITB to implement Problem-Based Learning approaches. As a result of this program, ITB engineering students successfully built their first robots and competed in a highly visible competition on their campus. The main challenge was achieving buy-in from ITB lecturers and supporting their work so that their students were able to succeed with minimal stress on the part of facilitators who were new to robotics.

This spring (2016), we delivered our "train the trainer" program to ten third-level engineering students at DIT and they successfully delivered a RoboSlam workshop to 37 second-level students, as depicted in Figure 1.

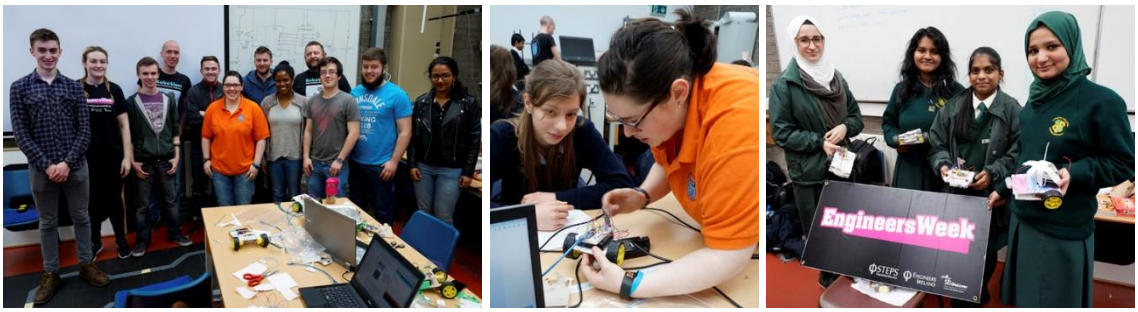


Figure 1. Student facilitators from DIT with their tutors and some of the 37 students they taught during Engineers Week 2016.

We believe that embedding coding in physical objects helps participants better understand the relevance of engineering and computer programming. The activities introduce participants to the Internet of Things, turn abstract concepts into tangible products that they can manipulate, help them achieve a sense of success in their preliminary endeavors, help them visual other applications for technology, and help them see a range of different career paths.

Our workshop program is unique in that the robot we help participants assemble and code is fully transparent. We take care to ensure that the participants learn the role of each component—from the breadboard to the resistors to the memory chip and controller. They get to see the code and learn how small changes in the code affect their robot's behavior. They get to write and modify the code to make their robot achieve various challenges (such as running a figure 8 around cones, or locating and charging an object or competitor). They learn to understand the direct correlation between while loops, binary bit patterns, and robot behaviors.

Many contemporary tech toys and learning products such as remote controlled robots, computer games, and programming apps hide the interesting technical details in an effort to make things more accessible for young customers. RoboSlam is designed to make all technical details—including the code—visible to the participants. Each person who attends a RoboSlam workshop receives a bag simple, off-the-shelf electronic parts. These look like random electronic and mechanical parts, but over the course of two hours, the participant transforms this kit into a working robot. With an additional two hours, the participant learns to modify and upload code in order to refine and control and the robot's behavior. As a result, there is no "hidden magic" in this set of parts. The robot is built from "first principles". Past participants have repeatedly commented about the strong sense of technical achievement they derived from building their own autonomous robot. The final hour typically consists of participants working together to compete and decorate (i.e., design the body style of) their robots. Another unique and key characteristic of RoboSlam is that it allows each participant to take his or her completed (assembled and programmed) robot home in order to keep innovating after the workshop. To keep the costs of the workshop to a minimum, we have put considerable effort in the past into selecting parts for the robot kit that are as inexpensive as possible.

3 Expected results

In this workshop, each participant will assemble a working robot. The participant may take the robot home for a small fee (€15) to cover the purchase price of the robot kit.

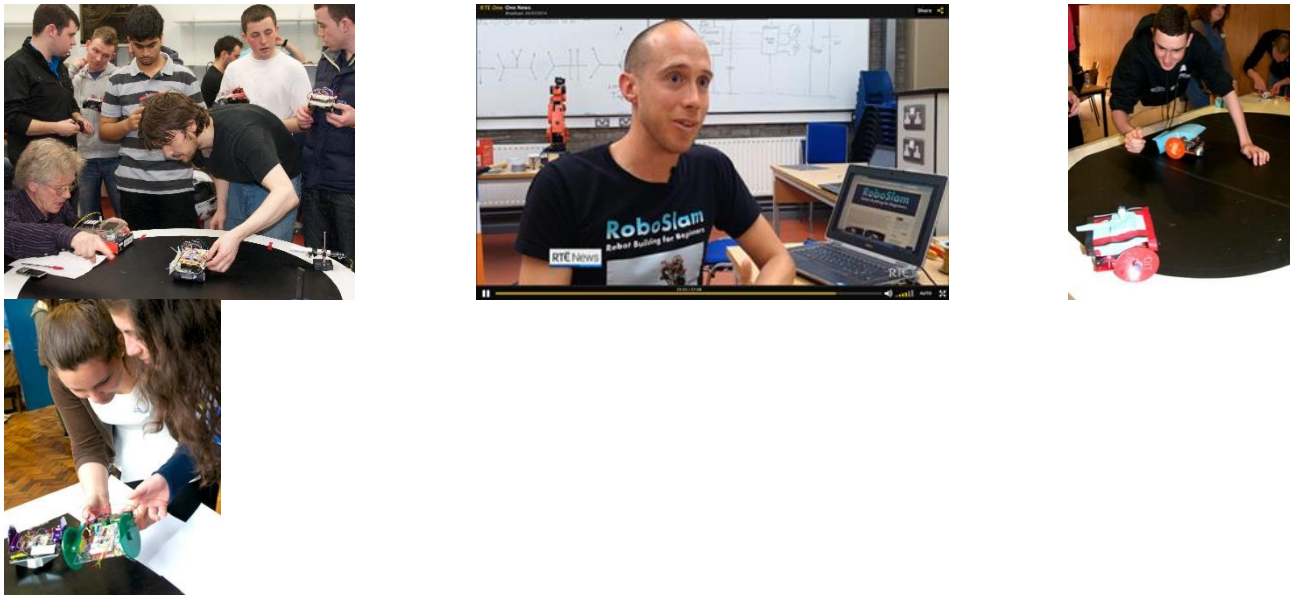


Figure 2. Left to right: DIT RoboSumo event, Ted Burke on national television, and Transition Year students at a 2013 RoboSlam.

Active Learning Exercise: Viewing Other Students' Projects through Green Lenses

Jacqueline Asscher[1]

[1] Quality and Reliability Engineering, Kinneret College on the Sea of Galilee, Israel

Email: jasscher@inter.net.il

Abstract

The activity as run with 3rd year undergraduate students. This 2.5-hour activity has several learning objectives: get to know a number of good projects carried out by students from previous classes; learn about writing an abstract and writing and editing a project by experiencing reading 10 abstracts and one project; practice viewing projects from a sustainability point of view ("green lenses"); practice summarizing and presenting. The lecturer selected ten projects based on criteria of relevance to sustainability, good quality and variety of topics. Step 1: Working in pairs, students read all ten abstracts and selected and ranked five. This was done in advance by email. Step 2: Students worked in class in pairs, reading the project they were allocated and preparing a five minute presentation that answered two questions: What was the content of the project? How was sustainability considered, and how could it have been considered further? For example, in one project the reliability of a system was evaluated, but the cost of over-design (using materials and processes that are more expensive than required) was not considered. Step 3: Students gave presentations, each student answering one of the two questions. Step 4: Each student wrote a reflection exercise consisting of writing five points on "how to write a good abstract" and five points on "how to write and edit a good project". The students found the activity very useful as they will soon start their own final projects. They had ideas about how sustainability could have been incorporated in the projects that they reviewed. For the conference. Participants will enjoy seeing projects from other programs ("benchmarking") and experiencing one way that they can be used as a teaching resource. Also, this is an opportunity to look at a range of engineering projects from a sustainability point of view.

Keywords: Sustainability; Students' Projects; Experiential Activity; Writing

1 Introduction

The conference workshop focuses on how we can use completed students' projects and presentations as a resource, and on how sustainability can be incorporated in projects.

Conference participants will experience one way that the projects and presentations can be used as a resource, and will participate in a discussion about pitfalls and alternative approaches. In addition, we will discuss if and how sustainability is addressed in projects.

2 Activities

The workshop at the conference will be conducted in three stages. First, each pair of participants receives a printed report or a printed version of a presentation of a final project to read. The projects themselves will be from a variety of engineering programs. At the conference, the project reports will be brief and in English, while with students the full length booklets were used. Second, each pair of participants gives a short presentation that answers two questions: What was the content of the project? How was sustainability considered, and how could it have been considered further? Focus is on reporting the content, not on criticism. Finally, a group discussion will be conducted, considering among other topics pitfalls, alternative approaches and suggestions for improvement.

3 Expected results

The expected result is that the discussion will generate new perspectives and ideas, and that participants will form their own opinions on the usefulness of this approach with their own students. For example, while seeing

projects completed by students in the same program is very motivating to students, who are worried about their own impending projects, the projects are problematic as a teaching resource. How do they compare with alternative resources? How does this type of activity compare with a peer review of projects in progress, where feedback can be used for improvement rather than only post mortem?

PAEE/ALE'2016 Full Papers Submissions (English)

Submissions accepted for the PAEE/ALE'2016 papers sessions in English.

A Text Analytics Evaluation of a First-Year Engineering Project-Based Unit

Stuart Palmer[1], Wayne Hall[2]

[1] Faculty of Science, Engineering and Built Environment, Deakin University, Geelong, Australia
[2] Griffith School of Engineering. Griffith University, Southport, Australia

Email: stuart.palmer@deakin.edu.au, w.hall@griffith.edu.au

Abstract

In the undergraduate engineering program at Griffith University in Australia, the unit 1006ENG Design and Professional Skills aims to provide an introduction to engineering design and professional practice through a project-based learning (PBL) approach to problem solving. It provides students with an experience of PBL in the first-year of their programme. The unit comprises an underpinning lecture series, design work including group project activities, an individual computer-aided drawing exercise/s and an oral presentation. Griffith University employs a 'Student Experience of Course' (SEC) online survey as part of its student evaluation of teaching, quality improvement and staff performance management processes. As well as numerical response scale items, it includes the following two questions inviting open-ended text responses from students: i) What did you find particularly good about this course? and ii) How could this course be improved? The collection of textual data in in student surveys is commonplace, due to the rich descriptions of respondent experiences they can provide at relatively low cost. However, historically these data have been underutilised because they are time consuming to analyse manually, and there has been a lack of automated tools to exploit such data efficiently. Text analytics approaches offer analysis methods that result in visual representations of comment data that highlight key individual themes in these data and the relationships between those themes. We present a text analytics-based evaluation of the SEC open-ended comments received in the first two years of offer of the PBL unit 1006ENG. We discuss the results obtained in detail. The method developed and documented here is a practical and useful approach to analysing/visualising open-ended comment data that could be applied by others with similar comment data sets.

Keywords: Engineering Education; Project-Based Learning; First-Year Design; Student Evaluation of Teaching; Text Analytics.

1 Introduction

Design is an essential element of engineering education – the rationale being that 'design' is the essential characteristic of engineering practice (Dym, Agogino, Eris, Frey, & Leifer, 2005; Schubert, Jacobitz, & Kim, 2012). Exposure to aspects of design are typically distributed throughout the undergraduate engineering curriculum (Davis, Gentili, Trevisan, & Calkins, 2002). Student design projects have long been used as a key pedagogical element for the development of engineering student design knowledge and skills. Historically, these have taken two complementary forms:

- First-year design courses – often referred to as 'cornerstone' design courses; and
- Final-year design courses – often referred to as 'capstone' design courses.

Cornerstone design courses arose in response to perceptions that first-year engineering curricula, historically loaded with math, physics and other theoretical foundation studies, often left commencing students wondering what engineers actually do. It is suggested that first-year design courses enhance commencing student motivation and retention, and introduce engineering application content and basic design experience early in the curriculum (Dym et al., 2005). There exists a range of pedagogical models, badged with a range of names, for teaching engineering design. However, generically, one of the most common is project-based learning (PBL) (Agouridas, 2007). A wide variety of practices with varying purposes are subsumed under the banner of PBL (Helle, Tynjälä, & Olkinuora, 2006), however in the literature (Frank, Lavy, & Elata, 2003; Helle et al., 2006; Macías-Guarasa, Montero, San-Segundo, Araujo, & Nieto-Taladriz, 2006; Prince & Felder, 2006) there can be found a general consensus that PBL incorporates the following elements:

- solution of a problem or completion of a task requiring students to complete a number of educational activities that drive learning;
- generally, students work in teams to complete a project;
- the project is non-trivial and often multidisciplinary in nature, requiring work over an extended period of time;
- normally, the project involves the development of a concrete artefact – a design, a model, a thesis, a computer simulation, etc.;
- the culmination of the project is often a written report and/or oral presentation describing the project methods and the final product; and
- teaching staff take an advisory rather than authoritarian role.

The Griffith School of Engineering offers four-year Bachelor of Engineering (BEng) and three-year Bachelor of Engineering Technology (BEngTech) degrees at its Nathan and Gold Coast campuses, in Queensland, Australia. The BEng programs are accredited by Engineers Australia, the Australian engineering professional body. Those programs offered on the Gold Coast campus were restructured to facilitate a common first-year. A new first-year unit '1006ENG Design and Professional Skills' was created in the revised structure. The unit aims to provide an introduction to engineering design and professional practice through a project-based approach to problem solving. PBL is used in a number of units in the program, and 1006ENG provides students with an experience of PBL in their first-year. The unit comprises an underpinning lecture series, design work including group project activities, individual Computer Aided Drawing (CAD) exercises and an oral presentation.

Many PBL case studies are documented in the literature, but these case studies are frequently little more than unit descriptions presenting the implementation details of individual courses. More serious evaluation is harder to find (Helle et al., 2006). Detailed evaluations of the initial and subsequent offerings 1006ENG were undertaken, and the full results have been previously published (Hall, Palmer, & Bennett, 2012; Palmer & Hall, 2011). The evaluation was based on a survey of enrolled students that sought responses from students relating to:

- respondent demographic information;
- prior experience with PBL;
- prior perceptions of key pedagogic elements of 1006ENG;
- perceptions of the experience of aspects of 1006ENG; and
- open-ended comments on the 'best aspects' and 'needs improvement' elements of 1006ENG.

In summary, the findings from the evaluations of both offerings were similar, and included: the respondent samples were representative of the whole unit enrolment; the responses were not significantly different between demographic sub-groups; about half of the respondents had previous experience with PBL; respondents generally enjoyed the unit; and, rating responses to the question "Do you enjoy giving oral presentations?" was significantly lower than other responses. The open-ended comments provided important additional insights into students' perceptions of the unit.

Griffith University employs a 'Student Experience of Course' (SEC) online survey as part of its student evaluation of teaching, quality improvement and staff performance management processes. The SEC survey is opened for students to voluntarily complete towards the end of the teaching period, but prior to the examination period, so SEC data are unlikely to overly influenced by students' perceptions of how they performed on the exam and/or the unit overall. The SEC survey instrument contains six scale items, framed as questions, to which students can indicate their level of agreement with on a five-point response scale. Additionally, the SEC survey contains the following two open-ended response items to which students can provide a free text response:

- SEC7 - What did you find particularly good about this course? and
- SEC8 - How could this course be improved?

The SEC scale items (SEC1 to SEC6) are generic for use in all units of study at Griffith University, so are generally not similar to those used in the separate evaluations of 1006ENG noted above. However, the two open-ended text response SEC items are sufficiently similar to those employed in the previous evaluations of 1006ENG to provide a complementary set of text-based evaluation data.

The collection of textual data in surveys is commonplace, due to the rich descriptions of respondent experiences they can provide at relatively low cost. However, historically these data have been underutilised because they are time consuming to analyse manually, and there has been a lack of automated tools to exploit such data efficiently (Bolden & Moscarola, 2000; Jackson & Trochim, 2002). It is possible to manually tabulate the frequency of common themes observed in text data (Hall et al., 2012; Palmer & Hall, 2011). A simple form of computer-based analysis is visualisation using word clouds - a visual representation of the ranked frequency of occurrence of words in a text source (Hall & Palmer, 2015; Miley & Read, 2012). More sophisticated computer-based analysis and visualisation of textual data goes by various names, including lexical analysis, concept mapping, text mining, and text analytics. We will use the latter term as the general name for describing, "… a set of linguistic, statistical, and machine learning techniques that model and structure the information content of textual sources for business intelligence, exploratory data analysis, research, or investigation." (Hu & Liu, 2012, p. 388). A typical visualisation output from text analytics software is a two-dimensional (2D) chart that identifies key words or themes in the source text, indicates the relative frequency or importance of those words/themes, and represents in 2D some aspect of the relationships between the words/themes. There are many published examples of text analytics applied to open-ended text data, including survey comments, but case studies using student evaluation of teaching data are much less common. This paper presents a text analytics-based evaluation of the SEC open-ended comments received in the first two years of offer of the unit 1006ENG. We address the method developed and the results obtained in detail.

2 Methodology

Approval was sought from the Griffith University Human Research Ethics Committee to use the data presented on the SEC reports from the initial and subsequent offering of the unit 1006ENG, and approval was granted. The text analytics software package KH Coder (Higuchi, 2014; Ishii, Suzuki, Fujii, & Fujiyoshi, 2013; Minami & Ohura, 2013) was used to analyse the text content of the open-ended comments from the SEC surveys. KH Coder was selected as it is free and provides a range of analysis and visualisation options. KH Coder supports the use of a dictionary of 'stop words', that is, words to be ignored in any analysis of the text (Hu & Liu, 2012). Common English words and parts of speech, such as 'I', 'a', 'am', 'be', 'my', 'the', etc., add little to the analysis, and their relatively high frequency often masks the words/terms that are actually of significance (Bolden & Moscarola, 2000). A stop word dictionary was developed based on the example English stop word dictionary supplied with KH Coder, after inspection to remove any words likely to be relevant in the context here, such as 'computer'. A second issue that can mask the significance of words/terms in text analytics is the presence of inflected and/or derived forms of words, for example, a root word such as 'write' may also be present in the source text as 'writing', 'wrote', 'written', etc. KH Coder implements 'stemming' to consolidate inflected and derived words into their root form. Stemming via lemmatisation (Bolden & Moscarola, 2000) based on English parts of speech (nouns, proper nouns, adjectives, verbs, etc.) was used. In text analytics a 'unit of analysis' is required, that is, the smallest elemental grouping of text upon which the analysis will be based. KH Coder supports sentences and paragraphs as units of analysis. In the data, each student comment was represented as a paragraph, so paragraphs were chosen as the unit of analysis. KH Coder supports a range of text data analysis and visualisation methods – the two employed here were the co-occurrence network (CON) (Namey, Guest, Thairu, & Johnson, 2007) and hierarchical cluster analysis (HCA) (Bridges Jr, 1966).

Co-occurrence refers to the presence of two (or more) terms in the same text unit of analysis – here we are interested if the same term groups frequently co-occur in student comments. KH Coder uses the Jaccard distance (Hu & Liu, 2012) as a measure of co-occurrence for term pairs. Based on specifying the minimum frequency of occurrence of a term for inclusion in the CON analysis and visualisation, terms appear as nodes in a network plot based on the Fruchterman and Reingold layout algorithm (Fruchterman & Reingold, 1991). Frequently co-occurring terms in the visualisation are connected by lines/edges. It is possible to configure the plot to indicate the relative frequency of terms by the relative size of their node, and to indicate the relative frequency of co-occurrence of terms by the relative thickness of the edge connecting their nodes. HCA produces a unique set of nested clusters by agglomeration - sequentially pairing terms, and then clusters of terms, using a clustering method applied to a distance measure for those terms. KH Coder supports a number

of distance measures and clustering methods – here we use the Jaccard distance (Hu & Liu, 2012) and the Ward clustering method (Blashfield, 1976). Based on specifying the minimum frequency of occurrence of a term for inclusion in the HCA analysis, and the number of clusters desired, the resultant dendrogram locates closest together those terms within clusters, and then those clusters of terms, that have the lowest distance measure (dissimilarity coefficient). The visualisations resulting from the CON and HCS analyses were examined to find evidence of key themes in the student open-ended comments provided in the SEC evaluation survey.

3 Results

For the initial offering of 1006ENG, the SEC report contained 83 SEC7 'good about this course' comments and 85 SEC8 'course be improved' comments, from a unit enrolment of 237. In the subsequent offering, the SEC report contained 44 SEC7 'good' comments and 40 SEC8 'be improved' comments, from a unit enrolment of 260. Based on the separate formal evaluation of the initial offering of 1006ENG (Palmer & Hall, 2011), some targeted refinements were made to the unit learning design for the subsequent offering (Hall et al., 2012), however these were essentially points of finesse rather than significant structural changes to the content, teaching methods or assessment. Particularly for the subsequent offering of 1006ENG, the number of comments was modest. Pooling of student evaluation data is a suggested approach to create a more significant data set (Aungles & Karmel, 2000). Based on the fact that the unit learning design was largely identical between the two offerings, the comment sets were pooled to obtain 127 'good' comments and 125 'be improved' comments for analysis. Figure 1 presents the CON visualisation for the 'good' comments generated using KH Coder.

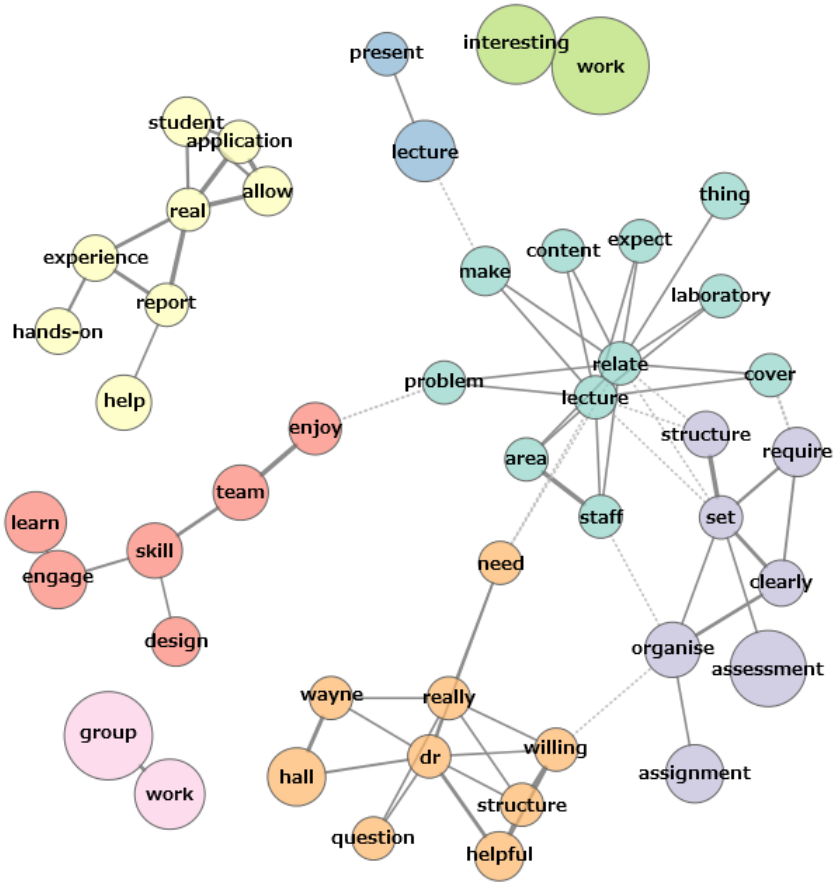


Figure 1. Co-occurrence network for 'What did you find particularly good about this course?' student comments.

Figure 2 presents the CON visualisation for the 'be improved' comments generated using KH Coder.

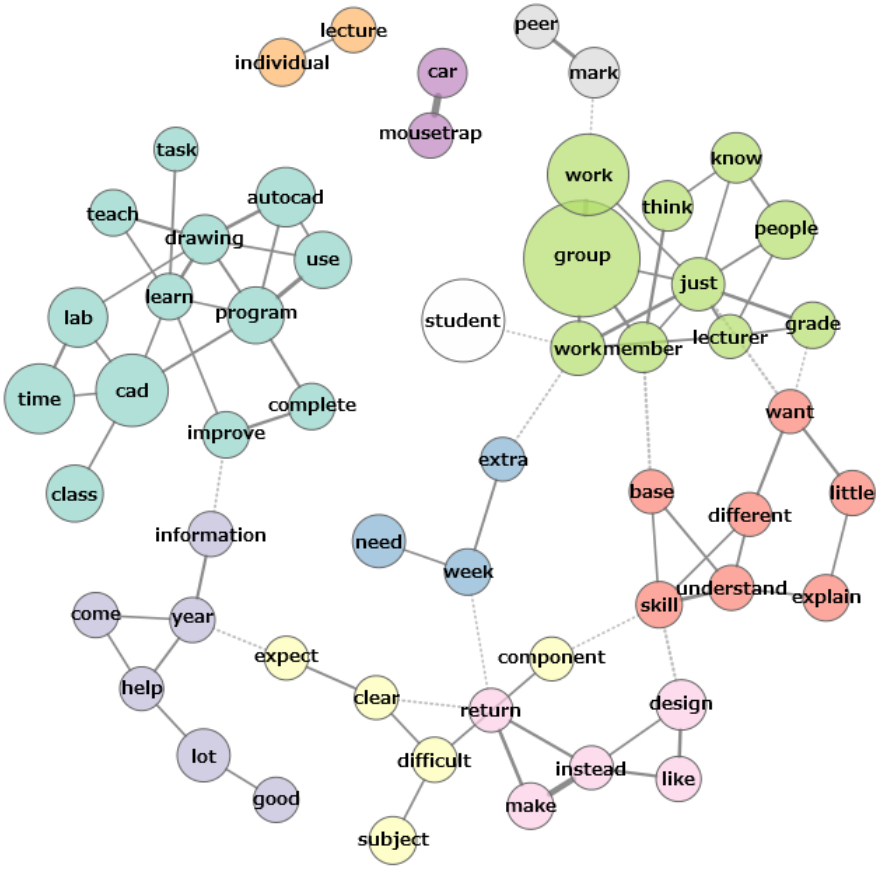


Figure 2. Co-occurrence network for 'How could this course be improved?' student comments.

Figure 3 presents the HCA dendrogram visualisations for the 'good' (left) and 'be improved' (right) comments, based on 7 clusters, with the cluster number indicated. The horizontal bars in Figure 3 are a relative frequency histogram for the terms in the dendrograms. The scales at the bottom of Figure 3 give the values of the dissimilarity coefficient for each clustering pair at that point in the agglomeration process.

4 Discussion

Figure 1 and Figure 3 were examined to identify 'good' themes that were prominent, especially similar themes that were common to both visualisations. Table 1 summarises the findings. Figure 2 and Figure 3 were similarly examined to identify 'be improved' themes, and Table 2 summarises the findings. The visualisations of the 'good' comments revealed themes representing a number of the benefits of PBL claimed in the literature, including experience of group/team work, experience of design processes, and experience of aspects of engineering practice. Additionally, students perceived a number of desirable characteristics of good teaching, including a helpful lecturer and clear assessment requirements. Finally, students reported that the PBL format was interesting and engaging. The CON and HCA visualisations for the 'good' comments showed a high level of consistency in the themes apparent. A key purpose of student evaluation of teaching is to identify areas of the unit learning design and/or delivery that could be revised to improve the students' experience – to this end the 'be improved' visualisations were examined. Figure 2 (CON) showed two large clusters related to group work (including peer marking) and CAD (including learning to use AutoCAD and CAD class time). Additional themes apparent include the mousetrap car project, the time demands of the project work, the need for explanation of design skills, and assessment feedback (an almost universal theme in student evaluation of teaching). Again, the CON and HCA visualisations for the 'be improved' comments showed a high level of consistency in the themes apparent.

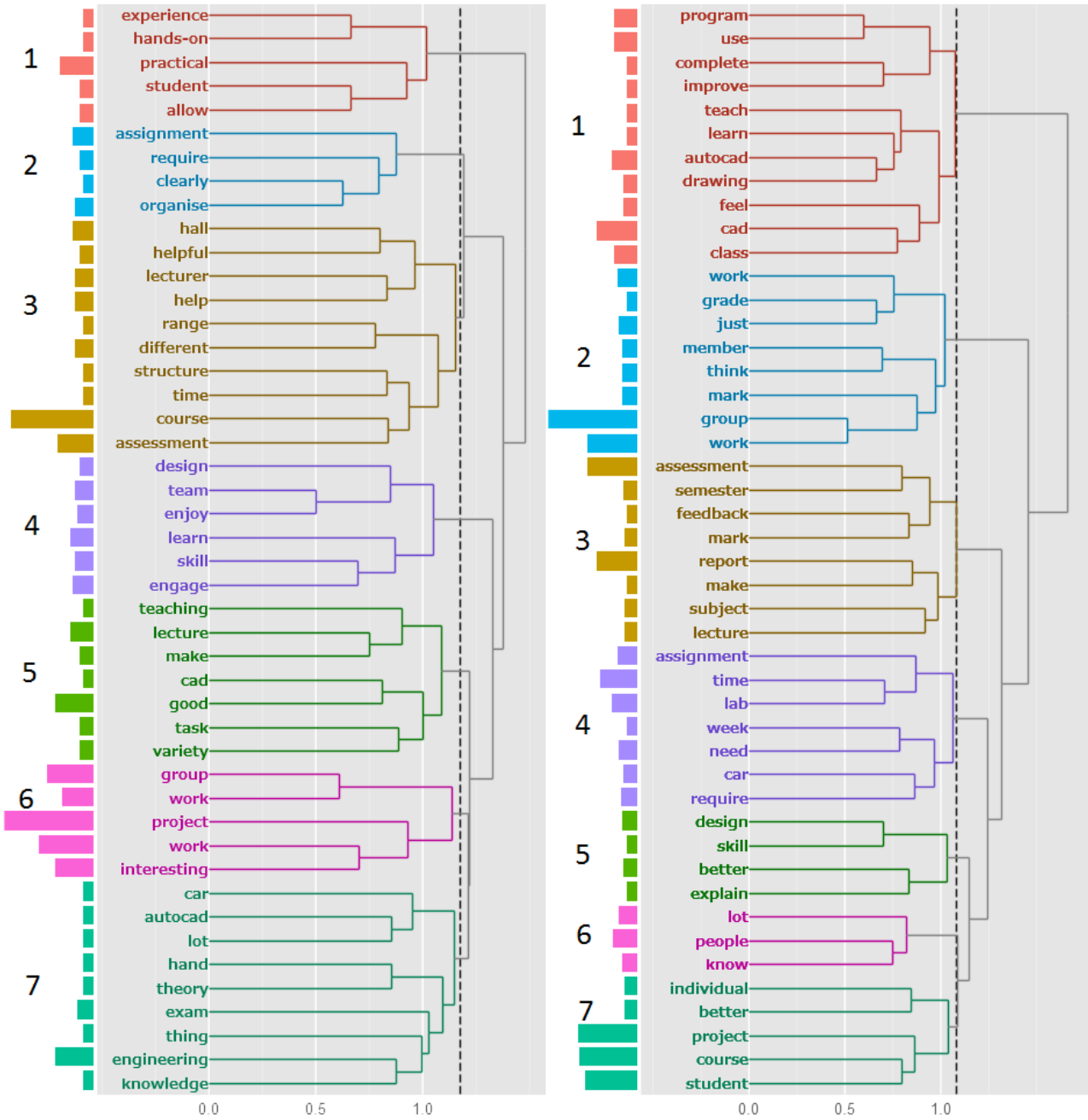


Figure 3. Hierarchical cluster analysis dendrograms for 'What did you find particularly good about this course?' (left) and 'How could this course be improved?' (right) student comments.

KH Coder provides a key-word-in-context (KWIC) concordance feature that can identify the locations in the source comments of phrases that contain one or more specified keywords within a specified distance of each other (Bolden & Moscarola, 2000). Based on identifying pairs/groups of terms appearing in the CON and HCA visualisations that are of interest to investigate further, the KWIC concordance feature allows these term groupings to be located in their original comment context for consideration. The previous evaluation of 1006ENG contained two open-ended text response items asking students about the best aspects of 1006ENG, and those aspects of 1006ENG that most need improvement. While these questions were not identical to the SEC7 and SEC8 items, they were very similar, and provided a point of triangulation for the results obtained here. As previously reported (Hall et al., 2012), based on manual analysis of the student comments from the initial and subsequent offerings of 1006ENG, the principal 'best aspects' identified by students were: group work; the hands-on/practical nature; enjoyable project work; the assessment (specifically that there was no

Table 1. Prominent themes in the SEC7 'What did you find particularly good about this course?' student comments.

Theme	Terms from Figure 1	Terms from Figure 3 (left) [cluster number]
Interesting work	interesting-work	interesting-project-work [6]
Group work	group-work	group-work [6]
Unit assessment	set-assessment-structure	assessment-course-structure [3]
Practical/real experience	student-real-experience-hands-on	student-practical-hands-on-experience [1]
Engaging learning	learn-engage	learn-engage [4]
Helpful lecturer	dr-wayne-hall-helpful	lecturer-hall-helpful [3]
Team design enjoyable	enjoy-team-design-skill	enjoy-team-design [4]
Assignment requirements clear	assignment-requirements-clearly-organised	assignment-requirements-clearly-organised [2]
Exposure to engineering		engineering-knowledge [7]
Variety of tasks		cad-good-task-variety [5]

exam); the CAD component; and the helpful staff. The principal 'needs improvement' suggestions from students were: more instruction on CAD; better explanation of expectations; more even group participation; a better spread in assignment due dates; the heavy workload of the projects; and more feedback on work. The key themes from the open-ended student comments in both evaluations were largely the same, providing a measure of cross-validation between the two sets.

Table 2. Prominent themes in the SEC8 'How could this course be improved?' student comments.

Theme	Terms from Figure 2	Terms from Figure 3 (right) [cluster number]
Group work	group-work group-member-work	group-work [2] know-people [6]
CAD classes	time-cad-lab	cad-class [1]
Use of AutoCAD	use-autocad-program teach-learn-drawing	autocad-drawing [1]
Mousetrap car project	mousetrap-car	need-week-lab-time-car [4]
Peer assessment	peer-mark lecturer-just-grade	group-work-mark [2] better-individual [7]
Time demands	need-extra-week	assignment-time-lab [4]
Explanation of basic design skills	explain-understand-base-skill difficult-subject-clear	better-explain-design-skill [5]
Assessment feedback		semester-assessment-feedback-mark [3]

5 Conclusion

A method for analysing student evaluation of teaching comment data with the free KH Coder text analytics software package to produce relevant and informative visualisations was developed. Co-occurrence network and hierarchical cluster analysis visualisations were found to provide a useful overall representation of the key words/themes in SEC comment data, and they exhibited good consistency between the visualisation forms. Key 'good' themes that students identified about 1006ENG included: group/team work; experience of design; experience of engineering practice; helpful lecturer; clear requirements; and PBL was interesting and engaging. Key 'be improved' themes included: group work (including peer marking); learning to use AutoCAD; CAD class time; the mousetrap car project; the time demands of project work; explanation of design skills; and assessment feedback. These findings were largely in agreement with the outcomes of a separate evaluation of 1006ENG. The text analytics method developed for analysing SEC open-ended comment data using the KH Coder software package produced useful comment text visualisations that, in turn, provided a valuable perspective on these comment data in a straightforward and timely manner. The method developed and documented

here is a practical and useful approach to analysing/visualising open-ended student evaluation comment data that could be applied by others with similar comment data sets.

6 References

Agouridas, V. (2007, 11-14 June). *Towards the systematic Definition of Project-Based Design Modules.* Paper presented at the 3rd International CDIO Conference, MIT, Cambridge, Massachusetts.

Aungles, P., & Karmel, T. (2000, 8-10 November). *Measuring Outcomes in Australia's Higher Education Sector.* Paper presented at the International Conference on Quality Assurance in Higher Education: Standards, Mechanisms and Mutual Recognition, Bangkok.

Blashfield, R. K. (1976). Mixture model tests of cluster analysis: accuracy of four agglomerative hierarchical methods. *Psychological Bulletin, 83*(3), 377-388. doi:10.1037/0033-2909.83.3.377

Bolden, R., & Moscarola, J. (2000). Bridging the Quantitative-Qualitative Divide: The Lexical Approach to Textual Data Analysis. *Social Science Computer Review, 18*(4), 450-460. doi:10.1177/089443930001800408

Bridges Jr, C. C. (1966). Hierarchical cluster analysis. *Psychological reports, 18*(3), 851-854.

Davis, D. C., Gentili, K. L., Trevisan, M. S., & Calkins, D. E. (2002). Engineering Design Assessment Processes and Scoring Scales for Program Improvement and Accountability. *Journal of Engineering Education, 91*(2), 211-221. doi:10.1002/j.2168-9830.2002.tb00694.x

Dym, C. L., Agogino, A. M., Eris, O., Frey, D. D., & Leifer, L. J. (2005). Engineering Design Thinking, Teaching, and Learning. *Journal of Engineering Education, 94*(1), 103-120. doi:10.1002/j.2168-9830.2005.tb00832.x

Frank, M., Lavy, I., & Elata, D. (2003). Implementing the Project-Based Learning Approach in an Academic Engineering Course. *International Journal of Technology and Design Education, 13*(3), 273-288. doi:10.1023/a:1026192113732

Fruchterman, T. M. J., & Reingold, E. M. (1991). Graph drawing by force-directed placement. *Software: Practice and Experience, 21*(11), 1129-1164. doi:10.1002/spe.4380211102

Hall, W., & Palmer, S. (2015). Student Opportunities in Materials Design and Manufacture: Introducing a new Manufacturing with Composites Course. *Journal of Materials Education, 37*(3-4), 155-168.

Hall, W., Palmer, S., & Bennett, M. (2012). A longitudinal evaluation of a project-based learning initiative in an engineering undergraduate program. *European Journal of Engineering Education, 37*(2), 155-165. doi:10.1080/03043797.2011.593095

Helle, L., Tynjälä, P., & Olkinuora, E. (2006). Project-Based Learning in Post-Secondary Education – Theory, Practice and Rubber Sling Shots. *Higher Education, 51*(2), 287-314. doi:10.1007/s10734-004-6386-5

Higuchi, K. (2014). KH Coder (Version 2.00beta.32). Japan: Koichi Higuchi. Retrieved from http://khc.sourceforge.net/en/

Hu, X., & Liu, H. (2012). Text Analytics in Social Media. In C. C. Aggarwal & C. Zhai (Eds.), *Mining Text Data* (pp. 385-414): Springer US.

Ishii, N., Suzuki, Y., Fujii, T., & Fujiyoshi, H. (2013). Development and Evaluation of Question Templates for Text Mining. In F. L. Gaol (Ed.), *Recent Progress in Data Engineering and Internet Technology* (Vol. 156, pp. 469-474): Springer Berlin Heidelberg.

Jackson, K. M., & Trochim, W. M. K. (2002). Concept Mapping as an Alternative Approach for the Analysis of Open-Ended Survey Responses. *Organizational Research Methods, 5*(4), 307-336. doi:10.1177/109442802237114

Macías-Guarasa, J., Montero, J. M., San-Segundo, R., Araujo, A., & Nieto-Taladriz, O. (2006). A project-based learning approach to design electronic systems curricula. *IEEE Transactions on Education, 49*(3), 389-397.

Miley, F., & Read, A. (2012). Using word clouds to develop proactive learners. *Journal of the Scholarship of Teaching and Learning, 11*(2), 91-110.

Minami, T., & Ohura, Y. (2013, 31 August-4 September). *Investigation of Students' Attitudes to Lectures with Text-Analysis of Questionnaires.* Paper presented at the IIAI International Conference on Advanced Applied Informatics, Los Alamitos, CA.

Namey, E., Guest, G., Thairu, L., & Johnson, L. (2007). Data reduction techniques for large qualitative data sets. In G. Guest & K. M. MacQueen (Eds.), *Handbook for team-based qualitative research* (pp. 137-162). Plymouth, UK: Altamira Press.

Palmer, S., & Hall, W. (2011). An evaluation of a project-based learning initiative in engineering education. *European Journal of Engineering Education, 36*(4), 357-365. doi:10.1080/03043797.2011.593095

Prince, M. J., & Felder, R. M. (2006). Inductive Teaching and Learning Methods: Definitions, Comparisons, and Research Bases. *Journal of Engineering Education, 95*(2), 123-138.

Schubert, T., Jr., Jacobitz, F., & Kim, E. (2012). Student perceptions and learning of the engineering design process: an assessment at the freshmen level. *Research in Engineering Design, 23*(3), 177-190. doi:10.1007/s00163-011-0121-x

The Representation of Engineering Education as a Social Media Topic on Twitter

Stuart Palmer[1]

[1]Faculty of Science, Engineering and Built Environment, Deakin University, Geelong, Australia

Email: stuart.palmer@deakin.edu.au

Abstract

Online social media systems have created new ways for individuals to communicate, share information and interact with a wide audience. For organisations, social media provide new avenues for communication and collaboration with their stakeholders. The potential value of social media tools to assist in the successful communication and marketing inside and outside of engineering organisations has been identified. In the context of engineering education, the potential of social media to open new modes of communication, interaction and experimentation between students and teachers has also been identified, and a limited number of examples can be found documented in the literature. One of the most widely-used social media tools is the 'microblogging' service Twitter. This research presents an analysis of nearly 19,000 tweets relating to 'engineering education' collected over a period of almost a year. Social network analysis is used to visualise the Twitter data. The Twitter social media communication is examined to identify who is active on this topic, who is influential, and what is the structure of the online conversations relating to engineering education. This work provides insights regarding how engineering education is currently represented in social media internationally, and offers a methodology to those interested in related future research.

Keywords: Engineering Education; Social Media; Twitter; Social Network Analysis.

1 Introduction

In the context of engineering education, the potential of social media to open new modes of communication, interaction and experimentation between students and teachers has been identified (Kamthan, 2010). Examples in the literature include: social media tools being used to link students with practicing industry professionals (Morgado et al., 2012); the use of Twitter to engage a large information literacy class (Morrow, 2010); the use of Twitter by engineering students on work integrated learning placements (Paku & Lay, 2011); the use of Twitter to send remote commands to a numerical computing environment (Judd & Graves, 2012); and students collaborating at two universities autonomously adopting Facebook for group communications (Charlton, Devlin, Marshall, & Drummond, 2010). Research on the use of social media by higher education institutions is still limited, and evaluation of the impact of social media activities is not straightforward, as few benchmarks exist. One approach to evaluation is social network analysis (SNA). The network data inherently created by social media tools represent the connections between participants as they interact, and can be used to make visible the social processes at play, to identify strategically important components and participants in the social network, and to show the development of the communication links over time (Smith et al., 2009).

One of the most widely-used social media tools is Twitter (twitter.com) (Bik & Goldstein, 2013; Himelboim, McCreery, & Smith, 2013; Naaman, Becker, & Gravano, 2011; Xu, Ru, Xiang, & Yang, 2011). Twitter is a popular 'microblogging' service where users can post quick and frequent short messages (up to 140 characters) called 'tweets', which may contain links to other online material such as photos and websites, to their 'followers' who have subscribed to their Twitter account. Tweets can be tagged with a searchable 'hashtag', and a user can 'retweet' to all of their followers a tweet that they receive from another user. Tweets can be directed specifically to other named user accounts, or broadcast generally to all followers of the sending account. Except for the content of tweets from protected (private) accounts, all tweets are effectively broadcast to the world and are publicly discoverable via a search. A growing number of academic units involved in engineering education internationally now advertise a link to a Twitter account on their Internet home page and/or use Twitter as part of their communication and marketing strategy. This research presents an analysis of nearly 19,000 tweets relating to 'engineering education' collected over a period of almost a year. Rather than describing educational

uses of social media, SNA is used to visualise the Twitter data. The Twitter social media communication is examined to identify who is active on this topic, who is influential, and what is the structure of the online conversations relating to engineering education.

2 Methodology

A ruling was obtained from the relevant institutional human research ethics committee that the collection and use of publically accessible Twitter data did not require formal ethics approval for research purposes. In the work presented here, popular public Twitter accounts are identified by name where relevant, but no accounts of private individuals are identified unless they expressly agreed to be named. The public application programming interface (API) provided by the Twitter platform allows data to be directly collected from the system (Miller, 2011). However, the Twitter system quickly archives data, such that there is a limit how far back in time a search or other data request will reach (Bik & Goldstein, 2013), and there may be other limits applied to the results of popular searches that are not predictable. By accessing the Twitter API, the NCapture program (QSR International, 2013a) is able to capture publicly available Twitter data at that point in time, including that arising from a keyword search. Over the period 30 March 2015 to 4 March 2016, tweets containing both of the keywords 'engineering' and 'education' were collected weekly. It is acknowledged that the Twitter data collected do not represent all tweets mentioning engineering education – the limitation on the depth of the publicly accessible Twitter data means that there are gaps in the data set, and there are likely to be other tweets related to 'engineering education' not captured by the basic keyword search strategy used. The NVivo program (QSR International, 2013b) was used to convert the captured Twitter data into Microsoft Excel (Microsoft, 2010) spreadsheets for further processing and analysis.

Bulk properties of Twitter data can be informative, such as the proportions of retweets and mentions, most active users, most followed users, etc. (Veltri, 2013). The captured Twitter data indicate whether a post is a tweet or a retweet – the proportions of each were calculated. The captured Twitter data indicate whether a tweet mentions any other user; if yes it is a directed or mention tweet; if not it is an undirected tweet – the proportions of each were calculated. Measures of reach and impact can be derived from the account statistics and activity of Twitter users (Veltri, 2013). The Twitter data were inspected to identify the most frequently tweeting users, the most retweeted users and the most mentioned users. In addition, for every uniquely identified user in the data set, their total number of tweets multiplied by their average number of followers, during the period under investigation, was computed as an empirical measure of potential Twitter influence.

Network visualisation of Twitter data can be a useful method to reveal the communication structures embodied in the data (Himelboim et al., 2013; Miller, 2011). The spreadsheet Twitter data were also exported in comma separated values (CSV) format, and then imported into the Gephi program (The Gephi Consortium, 2012) for network visualisation. As outlined in Figure 1, Gephi can be used to represent Twitter user accounts as 'nodes', and the communication path (representing one or more tweets) between two nodes as an 'edge'.

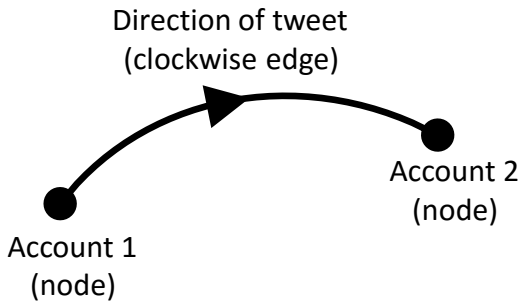


Figure 1. Twitter network visualisation schema used in this paper.

In the Twitter network diagrams used in this study, edges are presented as curved lines, the direction of tweets is clockwise around the edge, and the width of an edge is proportional to the total number of tweets recorded between the two nodes in that direction. The size of a node is proportional to the total number of edges

connecting to it (referred to as the node 'degree'). Twitter data will contain undirected tweets – those from a user not mentioning any other account, hence implicitly directed to the followers of the user, but also to the word at large. Because undirected tweets may represent a significant proportion of all tweets, a meaningful way must be found for dealing with them in analyses (Honeycutt & Herring, 2009). Not being explicitly directed to a named user, undirected tweets cannot automatically be formed into a network using the schema in Figure 1. In the analyses presented here, all undirected tweets are allocated as directed to a notional Twitter user identified as @undirected. While there is a single topological arrangement of the data for a given network, it can be visualised (laid out) in many ways. The Gephi program provides a range of algorithms for laying out networks. The Fruchterman-Reingold (F-R) layout algorithm (Fruchterman & Reingold, 1991) has a number of desirable characteristics (good node distribution, minimization of edge crossings, uniform edge lengths, reflection of inherent symmetries, etc.), and was chosen for use here.

3 Results and Discussion

For the period under investigation a total of 18973 tweets were collected. These originated from 7785 unique Twitter user accounts, and connected 8975 unique user accounts (nodes) via 13376 unique pathways (edges). Table 1 presents summary statistics for engineering education Twitter data.

Table 1. Summary statistics of engineering education Twitter data collected.

Variable	Count	Percentage
Total number of tweets	18973	100.0 per cent
Tweets	10676	56.3 per cent
Retweets	8297	43.7 per cent
Directed / Mention tweets	9954	52.5 per cent
Undirected tweets	9019	47.5 per cent

Table 1 shows that 56.3 per cent of the tweets collected were 'new' content from a user, while 43.7 per cent were retweets of a post from someone else. The level of retweets in general Twitter data has been reported as relatively low (3 per cent) (Boyd, Golder, & Lotan, 2010). However, higher proportions (29.3 per cent) have been reported in studies looking at the tweeting characteristics of individuals (rather than organisations) (Xu et al., 2011). Trends occur on Twitter when a topic of discussion becomes popular, and a trend is typically detected by the presence of a commonly occurring keyword/phrase. Naaman et al. (2011) propose two types of Twitter trend: i) exogenous – arising from an external event, such as an earthquake; and ii) endogenous – arising from groups of users deliberating sharing information on a topic. They found the proportion of retweets associated with trends to be much higher than general Twitter traffic – 32 per cent for exogenous trends and 47 per cent for endogenous trends. A low level of retweets has been taken to indicate largely one-way communication rather than conversation (Veltri, 2013); whereas higher levels of retweeting have been seen as indicators of a more active engagement and interaction in the Twitter environment (Himelboim et al., 2013). The tweets collected via the keyword search strategy used here probably results in a Twitter data set that synthetically exhibits characteristics much more like an endogenous trend than general Twitter traffic. The common, if largely asynchronous, interest in the topic of 'engineering education' embodied in the data collected may explain the high proportion of retweets observed. Table 1 shows that 47.5 per cent of the tweets collected were undirected (appearing in the Twitter timeline of those users following the sender, and discoverable in searches by other users), while 52.5 per cent were directed or otherwise specifically mentioned another user. The proportion of mentions in general Twitter data has been reported as 36 per cent (Boyd et al., 2010). High levels of undirected tweets could be seen as one-way communication, whereas the relatively high levels of directed/mentioning tweets observed here could again be taken as an indicator of a more interactive form of Twitter communication on the topic of engineering education.

Based on the schema presented in Figure 1 and using the F-R layout algorithm, Figure 2 presents an overall network visualisation of the large-scale structure of the engineering education Twitter data during the period under investigation.

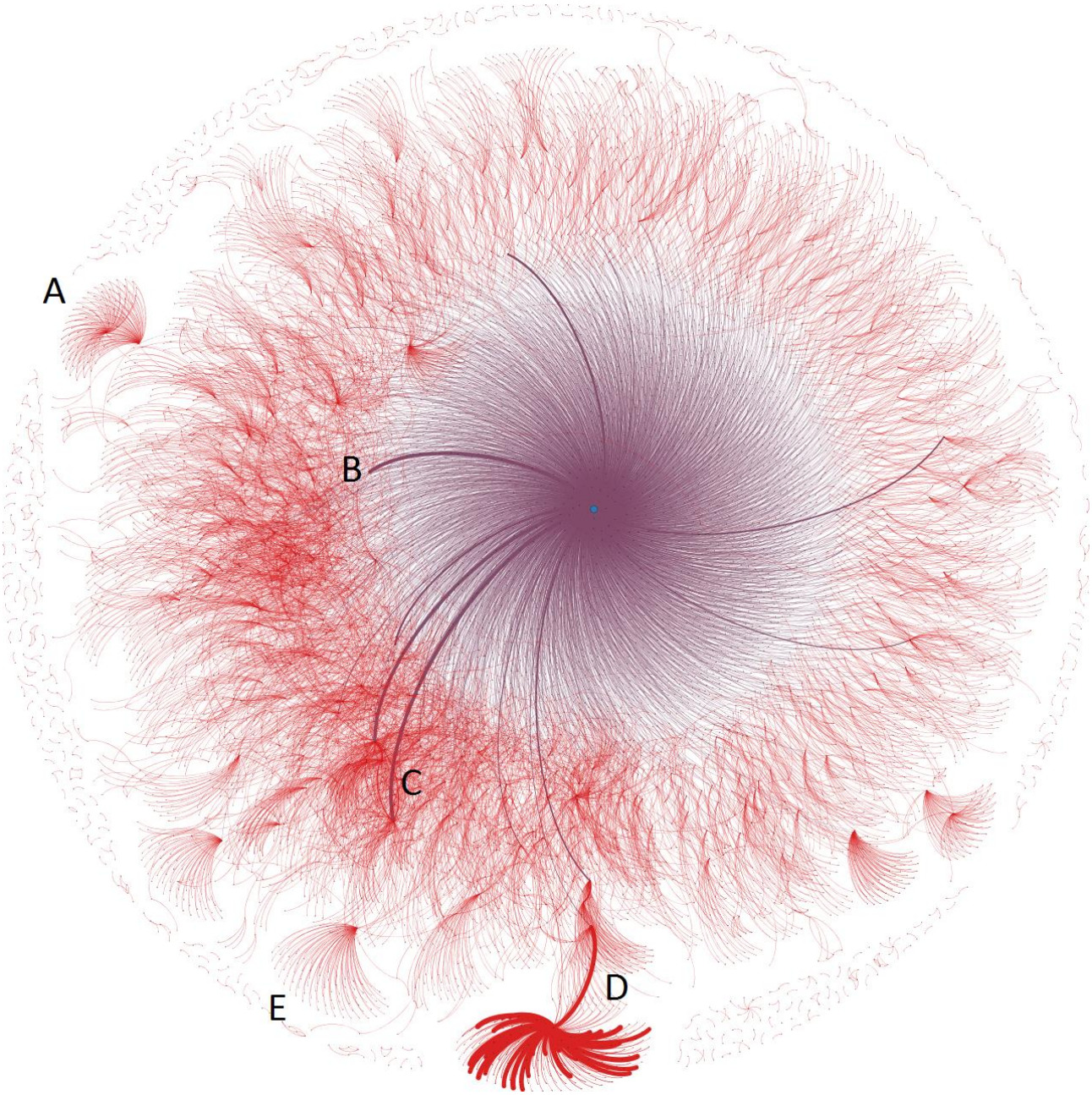


Figure 2. Overall 'engineering education' Twitter network visualisation.

The F-R layout algorithm produces a complicated network rich in features. The plume-like structures (such as point E in Figure 2) represent the Twitter mentions of a single user, located at the focus of the plume, by a relatively large number of other users, whom appear as the nodes within the plume. These mentions are represented by clockwise edges connecting inward to the user at the focus. These mentions include any tweets directed to the user at the focus point; however, the majority of these mentions are typically retweets of an initial tweet originating from the user at the focus point. There is a large whirlpool-like structure in the middle of Figure 2 that centres on a relatively large node. This structure arises from the method chosen to represent undirected tweets in the network – all 9019 connecting to the large 'undirected' node near the centre of the network. Outside of the central whirlpool there is a ring of more complicated connections – including edges representing retweets of undirected tweets, and/or interactions (Twitter conversations) between users. Finally, there is a thin halo of nodes around the outer edge of the network that have no connection to the main network proper. This outer region represents small groups of two or more users sharing tweets about engineering education – as exemplified by point H in Figure 3. The symmetry-emphasising characteristic of the F-R layout

algorithm is apparent in Figure 2 – the overall layout is approximately circular and balanced, with the principal regions in concentric rings.

A notable feature in Figure 2 is the spiral structure observed at point D – more detail can be seen at point G in Figure 3. Inspection of the tweets underlying this feature reveal that it is a series of 'robot' Twitter accounts systematically retweeting posts from the account at the centre of the spiral. Tweets from this central account are largely advertising engineering text books, and the whole structure is effectively an attempt at large-scale spam via Twitter. The structure at point D in Figure 2 accounts for 6679 tweets, which is 35.2 per cent of all tweets collected in this work. Spam is a common occurrence on Twitter, typically in the form of tweets designed to lure readers to a web site, and one study found that 8 per cent of general Twitter traffic was spam content (Grier, Thomas, Paxson, & Zhang, 2010). Spam on Twitter is often targeted at a theme or trend related to the item being advertised, so it is perhaps not surprising that the proportion of spam in tweets associated with a specific topic can be significantly higher than general Twitter content.

Figure 3 shows expanded details associated with point D in Figure 2. Figure 4 shows expanded details associated with point C in Figure 2. Additional features present in these Figures are discussed below.

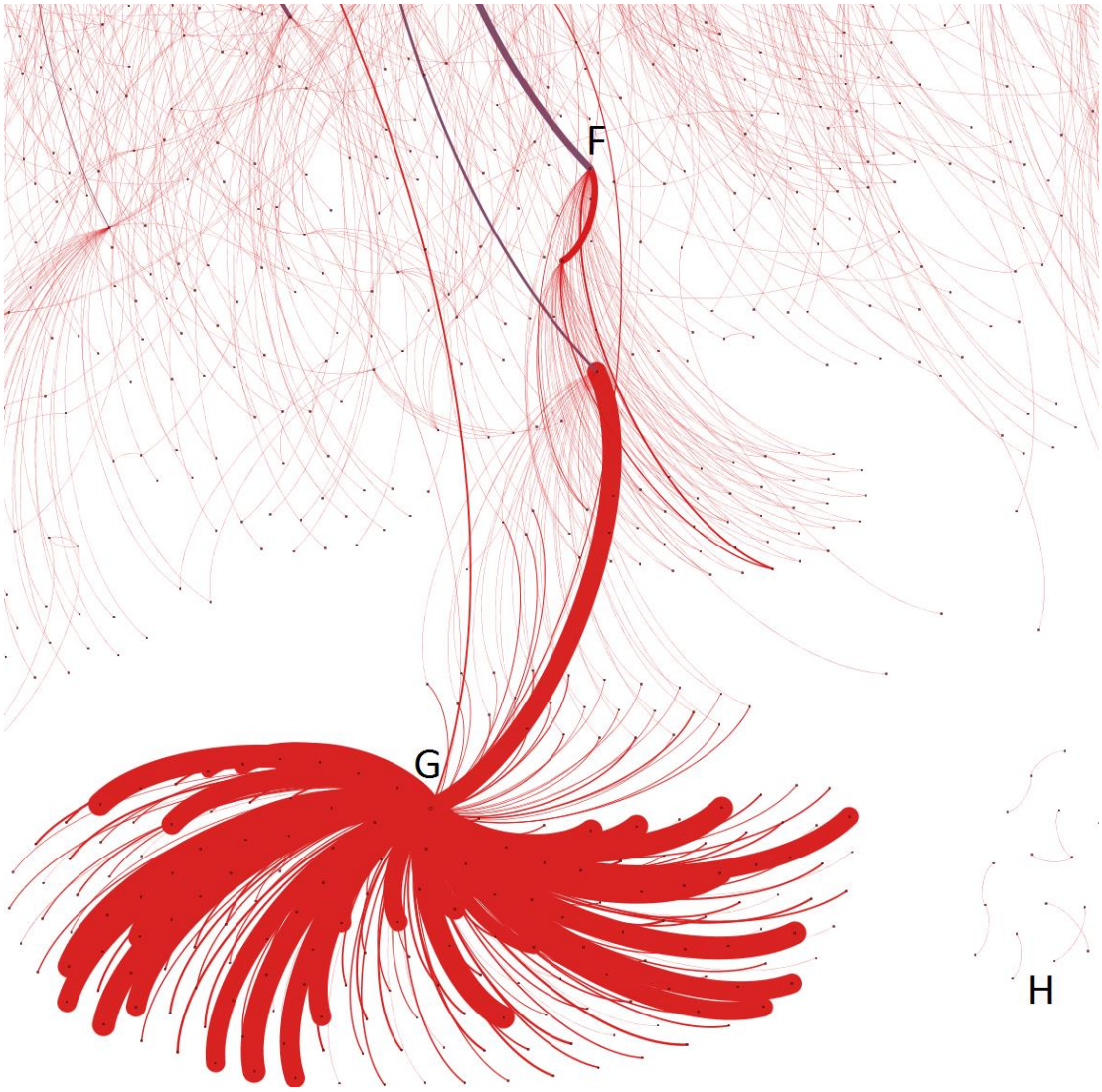


Figure 3. Selected 'engineering education' Twitter network visualisation – region D in Figure 2.

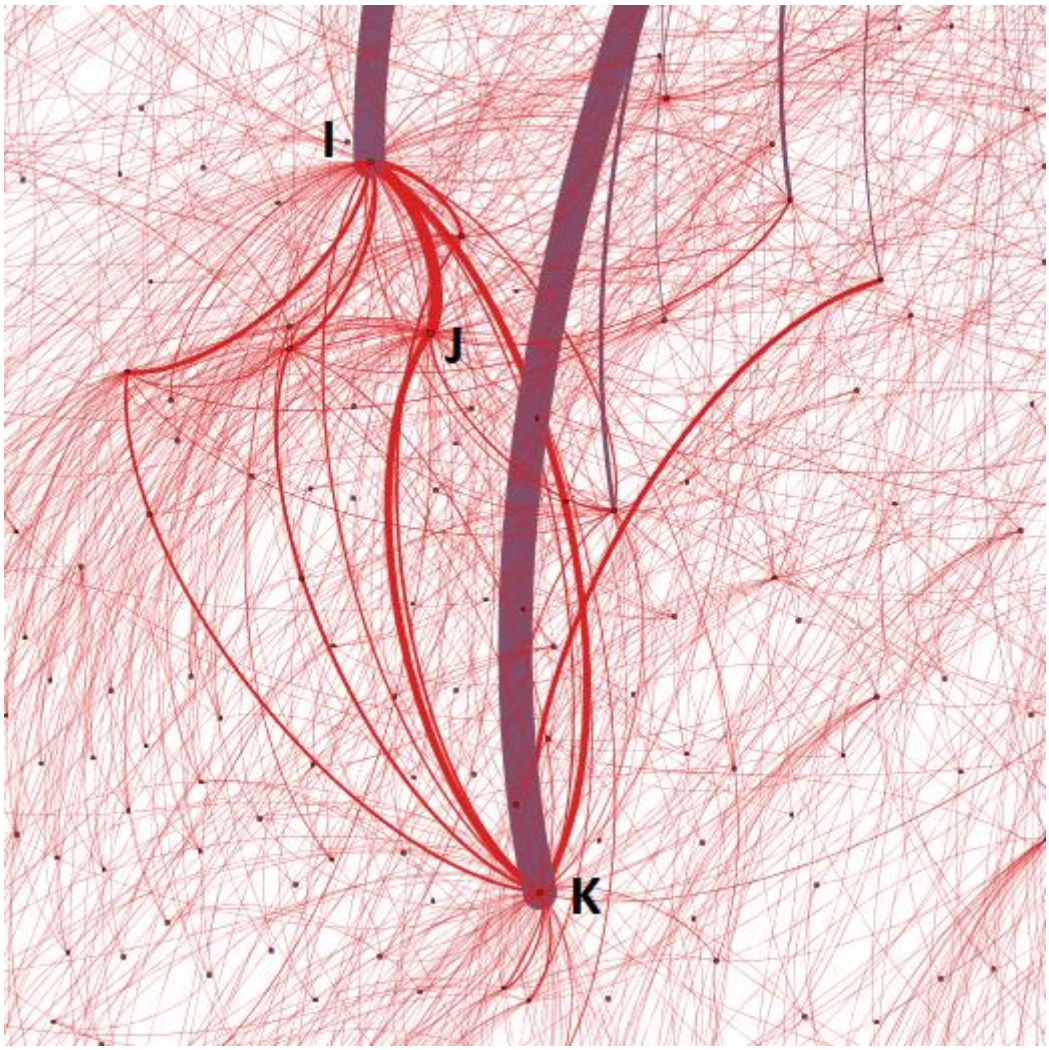


Figure 4. Selected 'engineering education' Twitter network visualisation – region C in Figure 2.

Table 2 presents the 'top' Twitter accounts based on a range of measures of impact.

Table 2. 'Top' engineering education Twitter accounts for various measures of impact.

Most prolific (number of tweets)					
@deg511	243	@BigBeacon	211	@campusmckvie	203
Spam account 1	179	Spam account 2	179	Spam account 3	179
Most retweeted (number of retweets)					
Spam account 4	6679	@ScotGovFM	86	@deg511	83
@HRDMinistry	83	@careersingov	82	@BigBeacon	57
Most mentioned (number of mentions)					
Spam account 4	204	@chronicle	107	@Forbes	100
@NSF	94	@OlinCollege	89	@CofGcollege	87
Most influential (number of tweets x average number of followers)					
@NSF	60153720	@careersingov	9948136	@deg511	5124749
Spam account 1	4492721	@BigBeacon	2650055	Spam account 5	1989000

Table 2 identifies the most prolific tweeters observed in the data set. The account with the most tweets is @deg511. This account belongs to David E. Goldberg, an emeritus engineering professor and founder of the organisation Big Beacon, which promotes engineering education reform. The second ranked account is the @BigBeacon account. @deg511 can be seen at point I in Figure 4, and @BigBeacon can be seen nearby at

point K. Both of these accounts have wide edges connecting them to the central @undirected node, which represent the relatively large number of tweets from these accounts. Edges connecting @deg511 and @BigBeacon can be seen, highlighting the 'real-world' links between these two accounts. The third most prolific tweeter is @campusmckvie, which can be seen at point B in Figure 2, again with a wide edge connecting to @undirected. @campusmckvie is an Indian engineering college that was relatively active on Twitter during the period under consideration. The next three highest tweeting accounts were all members of the outer spiral arms of the spam robot array at point G in Figure 3. Table 2 identifies the most retweeted accounts. The most retweeted account by nearly two orders of magnitude is the one located at the centre of the spiral at point G in figure 3, due the robotic spam operation. The second most retweeted account, @ScotGovFM, is the First Minister of Scotland promoting a new engineering program at City of Glasgow College, visible at point A in Figure 2 – further notes below. The third most retweeted account is @deg511, noted above. The fourth most retweeted account, @HRDMinistry, is the Indian Ministry of Human Resource Development promoting an engineering education symposium, visible at point E in Figure 2. The next most retweeted account, @careersingov, is an online recruitment site specialising in US government jobs, and can been seen at point F in Figure 3. The final most retweeted account is @BigBeacon – as noted above, this account is associated with @deg511, and it is likely that there is some level of mutual retweeting between these accounts.

Table 2 identifies the most mentioned accounts – Twitter mentions include retweets, so there can be some overlap with the previous category. As with retweets, the most mentioned account is the one located at the centre of the spiral at point G in figure 3. The second and third most mentioned accounts, @chronicle and @Forbes, are two specialised news publications with associated online presences. The fourth most mentioned account, @NSF, belongs to the US National Science Foundation, who might be expected to tweet messages about engineering education. The next most mentioned account, @OlinCollege, is an engineering school and can be seen at point J in Figure 4. Note that @deg511 (point I in Figure 4) is a former academic associate of Olin College, and strong network links can be seen in Figure 4 between @deg511, @OlinCollege and @BigBeacon (point K). The final most mentioned account, @CofGcollege, is the City of Glasgow College. As noted above, @ScotGovFM tweeted about a new engineering program at City of Glasgow College (including the account name @CofGcollege), and the relatively large number of retweets of that led to a relatively large number of mentions of @CofGcollege. This interaction can be seen at point A in Figure 2 – where the plume structure has two foci – one for retweets of @ScotGovFM, and one for mentions of @CofGcollege. Based on the empirical measure of their number of tweets multiplied by their average number of followers, Table 2 identifies the most influential tweeters observed in the engineering education Twitter data set. @NSF and @careersingov appear as first and second most influential due to their large respective follower bases. @deg511 and the associated account @BigBeacon appear as third and fifth most influential due to a combination of their relatively large follower bases and their relatively high level of tweeting. Two spam accounts round out the top six most influential accounts, again testament to the high proportion of spam activity observed here in the engineering education data set.

4 Conclusion

This paper presents an analysis of nearly 19,000 tweets relating to 'engineering education' collected over a period of almost a year. Descriptive statistic were compiled and social network analysis was used to visualise the Twitter data. Compared to studies of general Twitter traffic, relatively high proportions of retweets and mentions were observed. This suggests that engineering education is an active and interactive topic on Twitter, and this avenue for stakeholder communication should be of interest to all engineering academic units. The most prolific, most retweeted, most mentioned and most influential (based on the empirical measure of number of tweets multiplied by average number of followers) 'engineering education' Twitter accounts were identified. While some engineering colleges are apparent as active tweeters or as being frequently mentioned, the most influential accounts on the topic of engineering education are government institutions and individuals who are particularly active on Twitter and have a significant number of followers. This suggests that engineering academic units wishing to have influence on Twitter need to cultivate an audience of followers through both content and interaction relevant to the audience(s) targeted. A very high proportion of spam tweets were

observed. Spam in social media is a constant presence, and needs to be accounted for in institutional social media strategies, even in engineering education. A limitation of this study is that the data collection strategy and the operation of the Twitter public API mean that the data obtained are only a subset of all tweets related to engineering education. Additionally, space limitations meant that only the top half-dozen accounts in each category could be presented in Table 2. Finally, this study looked only at the structure of the network embodied by the Twitter communication, and not at the content of the tweets comprising the network. The tweet text content is a rich and valuable data set in its own right, and deserves a separate analysis. This work provides insights regarding how engineering education is currently represented in social media (specifically Twitter) internationally, and offers a detailed methodology to those interested in future research in this area.

5 References

Bik, H. M., & Goldstein, M. C. (2013). An introduction to social media for scientists. *PLoS biology, 11*(4), e1001535.

Boyd, D., Golder, S., & Lotan, G. (2010, 5-8 January). *Tweet, Tweet, Retweet: Conversational Aspects of Retweeting on Twitter.* Paper presented at the 43rd Hawaii International Conference on System Sciences, Hawaii.

Charlton, T., Devlin, M., Marshall, L., & Drummond, S. (2010, 14-16 April). *Encouraging interaction and status awareness in undergraduate software engineering projects: The role of social networking services.* Paper presented at the 2010 IEEE Education Engineering Conference, Madrid.

Fruchterman, T. M. J., & Reingold, E. M. (1991). Graph drawing by force-directed placement. *Software: Practice and Experience, 21*(11), 1129-1164. doi:10.1002/spe.4380211102

Grier, C., Thomas, K., Paxson, V., & Zhang, M. (2010, 4-8 October). *@spam: the underground on 140 characters or less.* Paper presented at the 17th ACM conference on Computer and communications security, Chicago.

Himelboim, I., McCreery, S., & Smith, M. (2013). Birds of a Feather Tweet Together: Integrating Network and Content Analyses to Examine Cross-Ideology Exposure on Twitter. *Journal of Computer-Mediated Communication, 18*(2), 40-60. doi:10.1111/jcc4.12001

Honeycutt, C., & Herring, S. C. (2009, 5-8 January). *Beyond Microblogging: Conversation and Collaboration via Twitter.* Paper presented at the 42nd Hawaii International Conference on System Sciences, Hawaii.

Judd, B. C., & Graves, C. A. (2012, 13-16 May). Cellular STEM: Promoting Interest in Science, Technology, Engineering, and Math Education Using Cellular Messaging, Cloud Computing, and Web-Based Social Networks. Paper presented at the 12th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing, Ottawa.

Kamthan, P. (2010). A Social Web Perspective of Software Engineering Education *Handbook of Research on Web 2.0, 3.0, and X.0: Technologies, Business, and Social Applications* (pp. 472-495): IGI Global.

Microsoft. (2010). Excel (Version 14.0.6112.5000). Redmond, Washington: Microsoft.

Miller, G. (2011). Social Scientists Wade Into the Tweet Stream. *Science, 333*(6051), 1814-1815. doi:10.1126/science.333.6051.1814

Morgado, L., Fonseca, B., Martins, P., Paredes, H., Cruz, G., Maia, A. M., . . . Santos, A. (2012, 17-20 April). *Social networks, microblogging, virtual worlds, and Web 2.0 in the teaching of programming techniques for software engineering: A trial combining collaboration and social interaction beyond college.* Paper presented at the 2012 IEEE Global Engineering Education Conference, Marrakech, Morocco.

Morrow, L. (2010, 7-9 June). "*Twitter... sick": evolution of an engineering information literacy session.* Paper presented at the 1st Canadian Engineering Education Association Conference, Kingston, Ontario.

Naaman, M., Becker, H., & Gravano, L. (2011). Hip and trendy: Characterizing emerging trends on Twitter. *Journal of the American Society for Information Science and Technology, 62*(5), 902-918. doi:10.1002/asi.21489

Paku, L., & Lay, M. (2011, 5-7 December). *Using Twitter to enhance reflective practice on work placements.* Paper presented at the 2011 Australasian Association for Engineering Education Conference, Fremantle, Western Australia.

QSR International. (2013a). NCapture (Version 1.0.136.0). Doncaster, Victoria: QSR International.

QSR International. (2013b). NVivo (Version 10.0.418.0 SP4). Doncaster, Victoria: QSR International.

Smith, M. A., Shneiderman, B., Milic-Frayling, N., Rodrigues, E. M., Barash, V., Dunne, C., . . . Gleave, E. (2009, 25-27 June). *Analyzing (social media) networks with NodeXL.* Paper presented at the Fourth International Conference on Communities and Technologies, University Park, PA, USA.

The Gephi Consortium. (2012). Gephi (Version 0.8.1). Paris: The Gephi Consortium.

Veltri, G. A. (2013). Microblogging and nanotweets: Nanotechnology on Twitter. *Public Understanding of Science, 22*(7), 832-849. doi:10.1177/0963662512463510

Xu, Z., Ru, L., Xiang, L., & Yang, Q. (2011, 22-27 August). *Discovering User Interest on Twitter with a Modified Author-Topic Model.* Paper presented at the IEEE/WIC/ACM International Conference on Web Intelligence and Intelligent Agent Technology.

Project-Based Learning: An Approach to one House Automation Design

Cleginaldo P. Carvalho[1]

[1] Centro Universitário Salesiano de São Paulo, UNISAL, Departamento de Engenharia Mecânica, Lorena, São Paulo, Brazil.
University of São Paulo - Lorena Engineering School, EEL-USP, Lorena, São Paulo, Brazil.
Faculdade de Ciências Humanas de Cruzeiro, FACIC, Cruzeiro, São Paulo, Brazil.

Email: cleginaldopcarvalho@hotmail.com

Abstract

Engineering is one sector dramatically affected by the changes in human activities. The technological revolution and the work market are demanding more flexibility, extra qualifications and more knowledge of specific areas from the upcoming engineers. Engineering universities intend to increase the efficiency in learning demanding methodological quality changes in the curriculum. The Project Based Learning (PBL) is a systemic approach, which consists of students to 'know how' and knowledge acquisition through the investigation of complex questions, tasks and products, and accurate planning focusing on efficient learning. In the PBL approach, the student is responsible for obtaining knowledge on their own. Domotic can be defined as the automatized services applied to one house. Under the technical aspects, one domotic network can be represented by one group the automated services that are linked and that realize several different functions. These functions can be connected through an external or internal communication net. The house automation functions as safety, children care, temperature control, entry access and lighting setting, all can be controlled by a microprocessor. The Arduino electronic board is a cheaper and more efficient solution which can be applied in a house automation design for the academic applications purposes. The purpose of this work is to analyze the performance of PBL as the foundation of a house automation design developed by Mechanical Engineering students. It commenced by explaining to the students the new learning methodology considering the input data. The class was divided in groups responsible of one house automation to handle anything. Each group created a timetable for all activities, the basic tasks being: key points in the house automation conception, project layouts, purchase, assembly, try run and presentation for final approval. Concluding this study, the results of the PBL efficiency measurement are presented as well as improvement recommendation for future projects.

Keywords: Project-Based Learning; Automation; Project Management; Engineering Learning Innovation; Arduino.

1 Introduction

The development of the learning methodology based on project begun in the 1900's, when the American philosopher John Dewey (1859-1952) proved that "learning under doing" was a revolutionary way of studying.

Constructivism explains that humans learn through interactions with the environment and this process is different for everyone. Therefore, a person is learning to build new knowledge based on the current knowledge he/she might already have (Markham, Lamer & Ravitz, 2008).

Constructionism examines an individual learning, step-by-step, and confirms that humans learn more when they are building something that can be shared with others (Grant, 2002).

Consequently, learning based in projects is related to the constructivism, where the know-how is not absolute, but built by the student through his knowledge and global perception, sizing the necessity of deeply understanding, amplifying and integrating the knowledge (Bolander, Fisher & Hansen, 2011; Crawley *et al.*, 2007).

According to the CDIO, we can define Project Based Learning (PBL) as an instructional method in which students learn a range of skills while, also, creating their own projects, which could be a solution to a real-world problem (CDIO, 2010).

The main characteristics of the PBL are (Niewoehner *et al.,* 2011; Wilkerson & Gijselaers, 1996):

- The student is the center of the process;
- Personal and professional skills;
- Communication;
- Attributes team work;
- Active process, cooperative, integrated and interdisciplinary and learning oriented.

The house automation is also known as domotic, which uses a technological base to do basic tasks, which in a conventional house are done by human beings, this can be seen in Figure 1, which illustrates a domotic. Using domotics, the tasks can be done by actuators. The automation brings security, cost savings and comfort to the house owner. In order to conduct this domotic project the Arduino electronic board is used with the "C+" language.

Figure 1. Domotic Illustration.

The conception of Arduino emerged in Italy in 2005, with the subject creating a device which could be used in projects and prototypes to be built as a cheaper alternative to the others in the market, focusing on the students and universities. Both hardware and the software are available almost everywhere.

The Arduino is a processor able to measure variables in the external environment and transfer electrical signals, using sensors in its input and then processing all the information supplying output signals (Mc Roberts, 2011).

This paper analyses the performance application of the Project-Based Learning as foundation of a domotic design to be developed by Mechanical Engineering students. It starts explaining the input data for the design and adopting the Arduino as the microprocessor. Afterwards, the students choose the automation conceiving, design, programming and implementation. As a result, the final conception is presented for the domotic and its features as well as the Project–Based Learning efficiency measurement. Finally, some recommendations for further projects are presented.

2 Materials

In this project, the main materials used were the microprocessor and the hardware for the house automation, which processed and transmitted the input and output data, and performed tasks in the house without human command, accordingly.

2.1 Microprocessor

The Family of the Arduino microprocessor used in the Project was the AT mega 2560, UNO version. This version has flash memory of 128KB and is indicated for robotic applications, because it has enough number of inputs and outputs. This Arduino Maga has 54 digital pins for I/O and 14 of the total for analogical output signals PWM and 16 pins for analogical input.

2.2 House Automation

Using the C+ language, codes were created and described as a function to be performed in one house automation system. The codes are integrated to one Arduino electronic board, which receives and process the data and start functions through the mechanism to be integrated by binary codes, which are protected by security systems. Afterwards, one operational system is integrated to the domotic system (Bolzani, 2004; Mariotoni & Andrade Jr., 2002).

Using the domotic concepts, the Arduino electronic board and C+ language for programming, the group of students planned to introduce the following automation functions:

- Electronic babysitter;
- Lighting automation;
- Camera systems.

3 PBL Methodology Applications

The methodology is divided in two topics: the first one regards the project time table, which adopted the development of the 5W2H tool; the second describes the procedure adopted to evaluate the PBL efficiency.

3.1 Project Time Table

The students were divided in teams and before they commenced, each team elaborated a time table following the 5W2H concept as shown in the Figure 2 below. The commitment to the schedule was submitted under assessment to evaluate the teams' abilities in terms of project management skills. Afterwards, each check point had a team meeting with the students presenting a new plan to correct the delays and the failure method analyze effect was introduced to each team in order to avoid that new problems appeared without any action to solve them.

5W2H Planning

Objective

Group: Student 1, Student 2, Student 3; Student 4, Student 5, Student 6, Student 7

What	Who	When		Where	How	Why	How	% Completed	Today	Situation
		Beginning	End							
Choosing the Project	Everyone	20-Aug	27-Aug	UNIVERSITY	Agreement	Starting Point	-	100%	100%	ok
Internet Research	Everyone	20-Aug	24-Nov	UNIVERSITY	Google, Mags	Concept (design)	-	100%	100%	ok
Theoric Research	Student 1, Student 4, Student 5	20-Aug	3-Sep	UNIVERSITY	Library, Google	Theoric Basis	-	100%	100%	ok
Project (Sketch)	Student 3, Student 6	27-Aug	10-Sep	UNIVERSITY	AutoCad	Sketch for assembly	-	100%	100%	ok
List of Material	Student 2	22-Aug	15-Oct	UNIVERSITY	Manual	To provide materials	-	100%	100%	ok
Prototype Assembly	Student 7	29-Aug	20-Oct	Student 7 House	Office	To prepare assembly	-	100%	100%	ok
Material Purchase	Everyone	2-Sep	2-Nov	UNIVERSITY	Manual or Tools	Prototype	-	0%	80%	not ok
Programming	Everyone	1-Sep	2-Nov	UNIVERSITY	Arduino	To move the arm	-	0%	60%	not ok
Prototype Testing	Everyone	2-Sep	24-Nov	University Lab	Function Test	To assure correct function	-	0%	50%	not ok
Final Assessment	Everyone	2-Sep	24-Nov	UNIVERSITY	MS Word	To show the professor	-	0%	30%	not ok
Presentation	Everyone	16-Sep	24-Nov	University Lab	MS Powerpoint	For final avaliation	-	0%	0%	not ok
Final Data	Everyone	14-Sep	26-Nov	UNIVERSITY	Written work and presentation	Avaliation	-	0%	0%	not ok

Figure 2. Time table of the main activities using 5W2H conception.

3.2 Methodology for the PBL Efficiency Measurement

In order to measure the PBL efficiency, the class was divided in eight groups composed by six students per group.

The original discipline was Computer Aided Manufacturing, however, the PBL application, focused on interdisciplinary activities and more disciplines were integrated in the project, such as: Project Management, Manufacturing Process, Team Working and Material Management. The assessment system was composed by grades from the check point meetings and by the final project evaluation. During the PBL implementation, the professor's roles were to consolidate the multidisciplinary theoretical concepts and coach the students through this new learning approach method. The project milestones were displayed on a timetable as shown in Figure 2 using the 5W2H concept.

The data was collected via an electronic survey, which can read and answer without the teacher's interference. The electronic survey generated statistical data and the results were imported to an Excel sheet. A proper

survey was applied to the students and it was composed by six questions to evaluate, the items were presented in the following order:

- The quality of the team job
- Level of commitment of the team with the results
- The prototype conception
- Team capacity in project management
- Capacity in team work
- Knowledge acquisition

4 Results

In this section, the results of the domotic application are presented considering the output from the eight groups involved in the PBL. Followed by the PBL efficiency measurement, also presented for each evaluated question and the results are commented.

4.1 Domotic Application Results

All groups involved in the PBL, presented the following results for their prototypes:

- Security System: Using one sensor (switch or microphone), when it captured one signal it was sent to the input slot of the Arduino board, which computed the signal and sent it to the emergency lighting system.
- Lighting: using one mobile phone the house lighting system was turned on.
- Babysitter system: The baby crying was simulated in the house and using the microphone the signal was sent to the Arduino following this information, a signal was sent to the mobile phone.

Figure 3 presents the back view of the prototype developed by the students. The main part of the hardware can be observed, which was used in the domotic application.

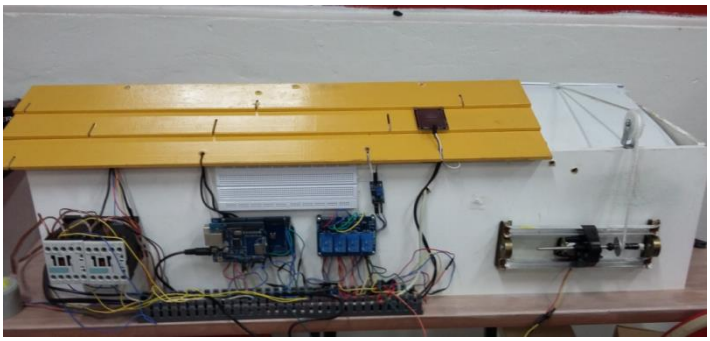


Figure 3. Back view of the prototype.

4.2 The Project-Based Learning Efficiency Measurement Results

The six-question survey was given to all students in an open question format. The students choose between five levels of specialization conformity and in accordance to the personal perception of the PBL methodology. The outputs are as followed with comments included:

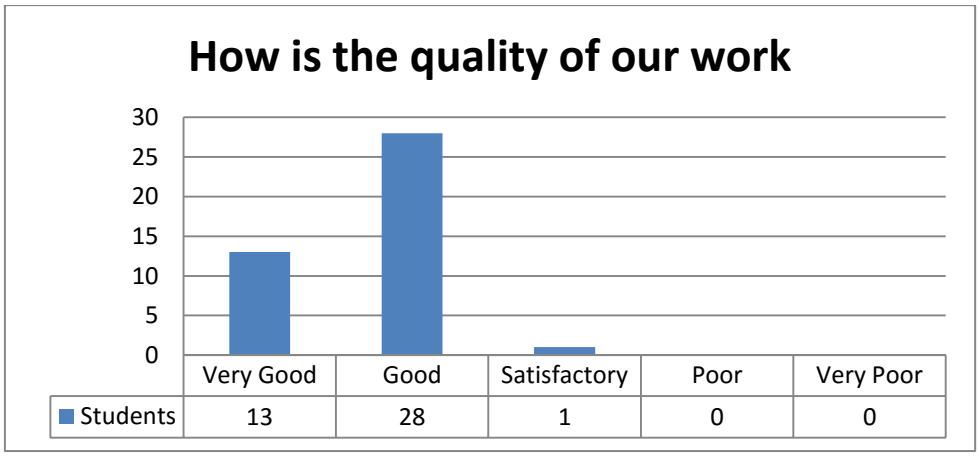


Figure 4. Evaluation of their work quality.

The majority of the students have the perception that their work was conducted according to the input data given to them in the beginning of the project and the quality of their work reached the established standards as shown in Figure 4. In fact, the students amplified their range of knowledge in terms of automation and domotic, using a multidisciplinary approach.

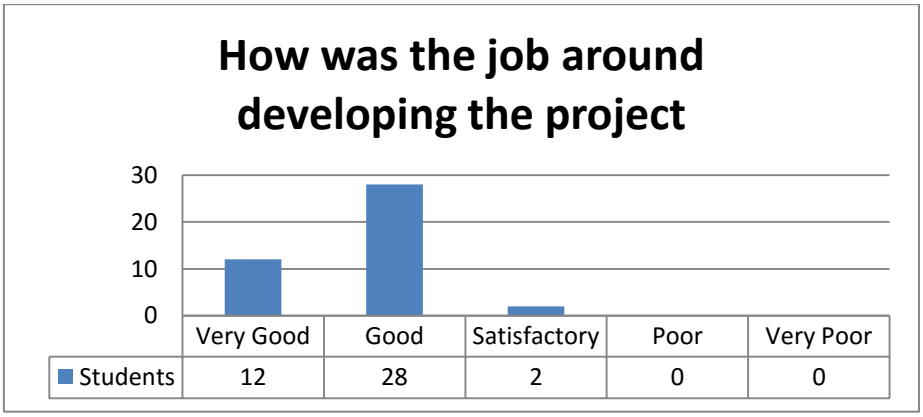


Figure 5. The results of the job around the project and their commitment.

As can be observed in Figure 5, almost all the students felt that they were responsible for the final results of the project. It shows that the PBL methodology gave them the sense of responsibility to conduct all the activities for the project success.

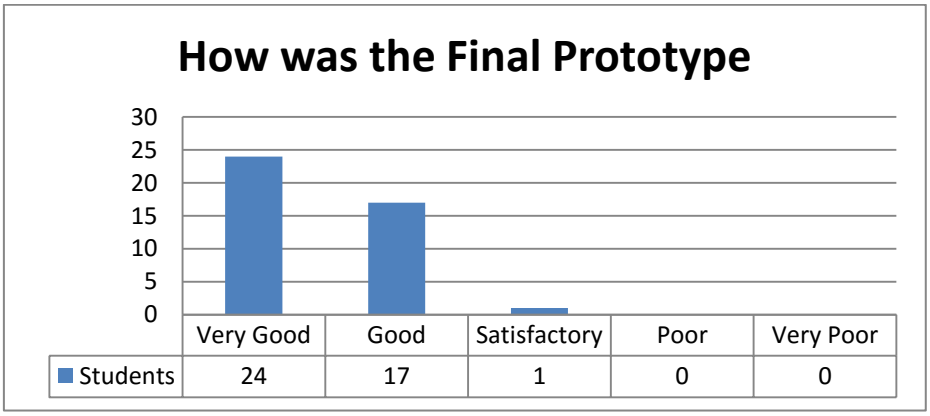


Figure 6. The final house automation performance evaluation.

The developed group methodology had the capacity to go over their limits and encouraged them to reach the goal established for the project. They worked in the conception, design, manufacturing, assembly and try run. All the house automation runs well under the specifications and on time as shown in Figure 6.

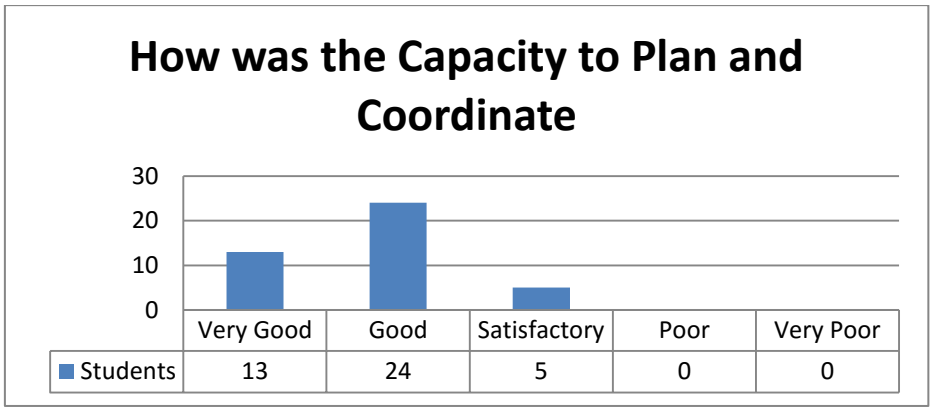


Figure 7. Project Management Abilities.

The Project-Based Learning gave the students the sense of planning and project management skills. Although the original discipline was related to Computer Aided Manufacturing the students learned deeply about management. Figure 7 shows how was their capacity to plan and coordinate.

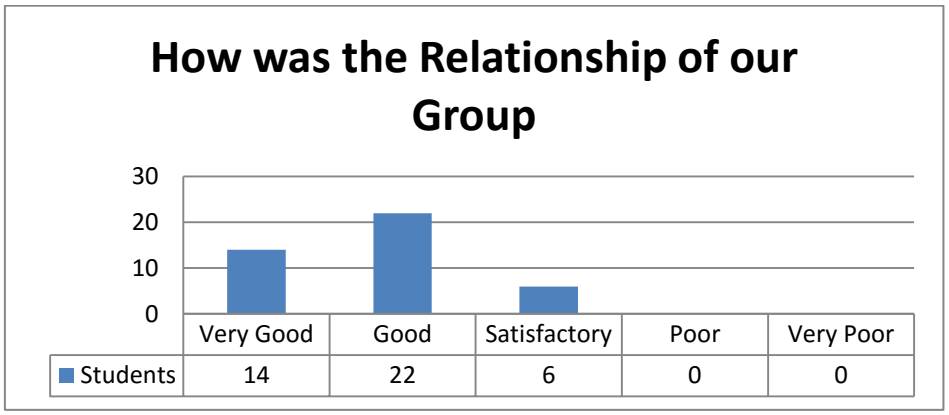


Figure 8. Capacity in team work.

By the end of the survey, it can be concluded that more than an interdisciplinary methodology, PBL motivated the students to work as a team, which is exemplified in Figure 8. This skill is essential for an engineer in the job market and sometimes is neglected in engineering curriculums.

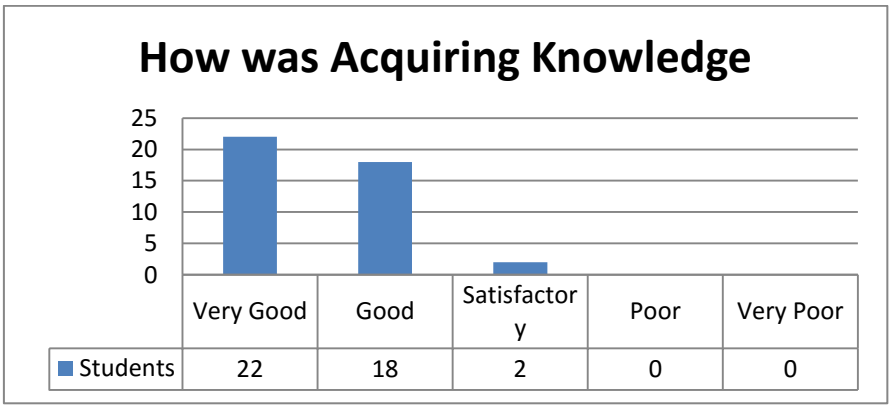


Figure 9. Knowledge acquisition using PBL as the learning methodology.

Finally, PBL, as shown in Figure 9, it is a strong tool when knowledge acquisition is demanded. The students faced many difficulties during the project development but solved all of them with the knowledge acquired in different fields.

5 Conclusion

In this paper, the Project-Based Learning application was evaluated. It was discussed the PBL conception as well as the concepts regarded to house automation as a mean to apply the innovation learning methodology.

Using the hands-on concept the students conceived, designed, assembled and implemented the domotic project. The automation features were measured and checked with the project input data specification. The students' skills in terms of project management were developed.

A survey was used to verify the efficiency of the PBL using the domotic project as the main students' motivation. The results of this innovative learning methodology were presented with great grades and vast comprehension with the majority of the students to which the survey was conducted. As a result, the perception of the teams regarding to their job quality, commitment, prototype building, planning capacity, team work spirit and knowledge acquire were conducted in an efficient way when the PBL was applied as the learning innovative methodology.

As for further research works, it is recommended that an individual assessment should be conducted and followed by a peer evaluation, in order to measure the level of assimilation of the multidisciplinary contents by each of the students as well as a way to also measure the efficiency of the Project-Based Learning that could be obtained by the results evaluation.

6 References

Bolzani, C.(2004) Residências Inteligentes: Editora Livraria da Física

Bolander, T., Fischer, P. Hansen, T. K. (2011). From Frustration to Success: A case-study in Advanced Design-Build Experiences. Proceedings of the 7th International CDIO Conference, Technical University of Denmark, Denmark, June 20-23.

CDIO (2010). The CDIO Standards V.2.0, www.cdio.org.

Crawley, E. F., Malmqvist, J., Oestlund, S. & Brodeur, D. R. (2007). Rethinking engineering education: The CDIO approach. New York: Springer.

Grant, M. M. (2002). Getting a grip on project-based learning Theory, cases. A Middle School Computer Technologies Journal. State University, Raleigh, Vol.5.

Markham, T. Larmer, J., Ravitz, J. (2008). A Aprendizagem Baseada em Projetos. Artmed Editora S/A, Porto Alegre.

McRoberts, M. (2011). Arduino básico. 1 º ed. Tradução e Rev. Rubens Prates, Camila Kuwabata, Rodrigo Stulzer, Marta Almeida de Sá Carolina Kuwabata, Rafael Zanolli, Edgard Damiani. São Paulo, SP copyright 2013 pela Novatec Editora Ltda.2011.

Mariotoni, C. A. e Andrade Jr., E. P.(2002) Descrição de Sistemas de Automação Predial Baseados em Protocolos PLC Utilizados em Edifícios de Pequeno Porte e Residências, Revista de Automação e Tecnologia de Informação. Volume 1, número 1.

Niewoehner, R. et al. (2011). A Learning Science Foundation for Project-Based Learning in Engineering. Proceedings of the 7th International CDIO Conference, Copenhagen, June 20-23.

Wilkerson, L, & Gijselaers, W. H. (1996).Bringing Problem-Based Learning to Higher Education: Theory and Practice. New Directions for Teaching and Learning, N.68, San Francisco, CA. Jossey-Bass.

Simulating a Business Competitive Environment in a Discipline of the Chemical Engineering Course

Domingos S. Giordani[1], Elisângela J. C. Moares[1]

[1] Department of Chemical Engineering, School of Engineering of Lorena, University of São Paulo, Lorena, Brazil

Email: dsgiordani@usp.br, elisangela.moraes@usp.br

Abstract

This paper reports the experience of two semesters of the execution of the discipline Industrial Chemical Processes in School of Engineering of Lorena, at the University of São Paulo, with the Project Based Learning approach. Both semesters were based on a set of rules which established the division of the class into groups to submit projects related to the syllabus of the discipline. The tasks of the groups were executed in the form of two semi projects, the first should address general aspects of the topic and the second should present a problem related to the theme and an innovative proposal for its solution. Two by two, groups competed each other for an investment to be determined by the rest of the class, who were the investors. Generally, students approved the method and were excited about the mood of competition. However, in the first experience, it was detected a limiting of learning related to the division of the subjects into groups, which forced the groups to have greater access to their own topics, so, in the second experience modifications in the rules were made, with the introduction of stakeholder groups, which resulted and increased access to global content of the discipline. The paper also reports other conclusions reached by the authors for this rich experience

Keywords: Active Learning; Engineering Education; Project Approaches; Business Environment Simulation.

1 Introduction

In recent years, engineering courses have been facing a double challenge; they must deal with the high velocity of technological changes and, at the same time, they must provide engineers with skills that some years ago were acquired from the professional experience, such as capacity of team work, leadership, communication and expression. These abilities are being called as soft skills (Lima et al., 2007).

Important studies associating the knowledge retention rate to the teaching method have reported that traditional classes present average rates of retention of only 5%, while discussion groups, practice by doing and teach others to do respectively show average rates of 50%, 75% and 90% (Singhal et al., 1997; Surgenor & Firth, 2006). Thus, it is clear that traditional forms of education, although still widely practiced, do not reach the expected role to the XXI century education.

The PBL method stands out for having the student as central and main figure in the learning process and to focus on the student and its performance in order to acquire the skills defined in the planning of the process (Lima, et al., 2005). According to Borges et al. (2011), the main characteristics of the method are: the student as the centre of the process; the development of the project in tutorial groups and to be an active, cooperative and interdisciplinary process.

The use of games and simulation of real life situations have been demonstrated to be useful tools to exploit its potential to present complex situations without discouraging students, allowing them to examine important elements of the professional field while they learn the elements of the syllabus (Braghirolli et al., 2016). Furthermore, gaming and simulation environments are excellent learning tools because they can replicate real contexts or even provide training situations that occur in very specific circumstances (De Carvalho, 2012).

Also seeking for the ability to simultaneously satisfy the demand for knowledge and motivation, Soares et al. (2013) have demonstrated that the competition among groups is positive, because they feel more responsible for the results and more motivated by the expectation of winning the competition, while they have improves in their creativity, as measured by Cascini et al., (2015).

Business game has been successfully used by Khrushchev et al. (2015) as a tool for simulating various aspects of professional environment, imitating the industrial process in a simplified reconstruction of real manufacturing situations, showing the potential of these simulations to enhance learning.

In this work, the authors show how two consecutive experiences, based on PBL principals, were used to simulate a business competitive environment with the students of a discipline called Industrial Chemical Processes aiming at the same time to promote the learning of the elements of the course syllabus and the acquisition of soft skills needed to the engineering professionals.

2 The method

2.1 The discipline

The discipline chosen to perform this experience is called Industrial Chemical Processes II. It is placed at the eighth semester of a ten semesters syllabus of the Chemical Engineering course at School of Engineering of Lorena, a unit of the University of São Paulo in Brazil. It is not a discipline of the main core of the syllabus, but it is important because it improves the overview that the student has on chemical engineering knowledge areas.

The program of the discipline consists of six themes: pulp and paper industries; sugar industry; alcohol industry; biotechnology industries; technology of fats and oils and manufacture of soaps and detergents. Its objective is to provide students with a current view of industrial processes that use chemical or biochemical conversion as a route of transformation of raw materials into products.

Up to 2014, the discipline was taught with traditional teaching method, that is, the professor prepared lessons in slides and passed the information to the students in lectures. They were evaluated through two written tests.

2.2 The new proposal

The new proposal to the course is based on a PBL approach. The classes were divided in groups. Each two groups were supposed to work on the same theme (their project) and they would compete against each other. The group should act as if it were a start-up company; the rest of the class should act as if they were investors, who should define what "company" would receive more investment, in terms of percentage.

The basic rules of the “game” were announced in the first week, after a motivational speech on the PBL method and its benefits to the learning process.

In the second week of the schedule, the students attended to a lecture about project management and had to prepare a basic project to attain their objectives, this project should be presented on the fourth week, after the third one, when they learned about presentations.

2.3 The stating rules

The rules that regulated the experiments have been compiled on 12 items, as described in Table *1*.

Table 1. The main rules.

1	The course will be based on a PBL approach, thus, all program content will be viewed by students within a scheme in which you will have to "get your hands dirty."
2	The central idea is that there will be working groups that will act as start-up companies that will present projects to investors.
3	The class will be divided in groups that will have the following positions: Manager, reporter, spokesman and co-workers.
4	Each two groups will work on one of the following themes: 1. pulp and paper industries 2. sugar industry 3. alcohol industry 4. biotechnology industries 5. technology of fats and oils 6. manufacture of soaps and detergents

5 The groups compete with each other in pairs, that is, a group has as an opponent the one who works on the same theme.

6 There will be a presentation schedule, divided into two blocks. In the first block, each group will present their area of knowledge, in the second; it will present a specific problem and its innovative solution for it.

7 Each group should prepare an "investment proposal" in its area of expertise to convince investors to allocate "funds" to the project. Since investors know nothing about the matter, in the first presentation the group must let them know the context of the subject; then, in the second presentation, the group have to present an innovative idea to be implemented, containing study of technical and economic feasibility and possible environmental impacts.

8 The investors are the students (except, of course, the assessed team and its opponent), so that the students decide what percentage of the available "funds" will be allocated to each project. The amount of available resources is imaginary and should be set in percentage terms for each team.

9 Each presentation must include:

1. A text, delivered at the presentation day in PDF format;
2. A slideshow of up to 15 minutes;

After each presentation, the opposing team will do a question to the presenting team. The team has five minutes to formulate and present the answer.

10 In the week between the two blocks of presentation, the groups may reorganize changing positions of each member. Each group may, only in this week, dismiss a member of the group, which will be "unemployed" and may get "job" in another group (provided that there is a place there). The firing and admission must occur by majority vote of the members of the group. To a member of the group is also possible to fire himself, which also leads him to the condition of "unemployed".

11 Students who remain in the condition of "unemployed" will have its grades calculated by the normal rule of assessment of the discipline, that is, two written tests, made in the middle and in the end of the semester. The subject of the tests will correspond to the content of the presentations made until the evaluation date.

12 Any additional demands and needs in order to enable the course to be applied properly will be adjusted during the semester by the professors.

2.4 The composition of individual scores

Also on the first day of the course, the rule of composition of individual scores was shown to the students, thus everyone knew how they would be evaluated and how their score in the discipline would be calculated.

The students had two grades in the semester, corresponding to the grades of the two written tests of the regular rule of the discipline. These grades were called as P_1 and P_2 and were calculated according to the equation (1)

$$P_x = G_{invest} + G_{att} + G_{peer} + G_{prof} \quad (1)$$

Where G_{invest} is the average of the investment received by the group, G_{att} is a grade proportional to the attendance to the presentations, G_{peer}. is the peer assessment of the student (attributed by its own group) and G_{prof} is the grade attributed to the group by the professors. The rule for each grade is shown in Table 2.

Table 2. The rule of composition of individual scores.

Grade	Points
Investment (G)	From 0 to 4 points (proportional to the investment)
Attendance in activities (I)	Up to 2 points (proportional to the amount of attendance)
Peer-assessment in the group (I)	Up to 2 points (specific rule)
Overall score - Professors (G)	From 0 to 4 points

(G) – Group (I) – Individual / Note. The sum cannot exceed 10!

As it can be seen in *Table 2*, if all the grades are the highest, the sum is 12, but the maximum score at the University is 10; this was intentional, because in case both opponent groups were very good and balanced and

had their investment divided in 50% for each, the grade of the professors could compensate a possibly unfair grade, making possible the highest score (10) to the student or group.

After each presentation all the "investors" received a card with statements about the quality of presentation, with responses scaled between strongly disagree and fully agree, according to the Likert scale (Likert, 1932), as it can be seen in Figure 1. They had to fulfil the card with the investment grade, in percentage.

Statement	Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree
The presentation was appropriate to the subject					
Presenters demonstrated to have adequately prepared to pass on their knowledge to you					
The topics of the presentation were well organized					
The oral presentation was clear					
The presenter made good use computational and audio-visual resources available					
The presenter made good use of time for presentation					
In the question section, the group presented their arguments clearly and rationally					
The presentation contributed to your learning					
The presentation sparked your interest to study more about it					
The presentation convinced you to invest in this company					
Knowing that there are two companies presenting on the same subject and you should invest all your resources in both and, based on your answers above, what percentage of your resources you decided to invest in this company?	Group A__% My Name:_____ My Group:____				

Figure 1. Evaluation and investment card.

The peer-assessment in the group had a specific rule. The group should attribute a grade for each member, according to the possible notes that are described in Table 3, so that the sum of the grades of the group result zero. Each grade corresponds to a number of points that contribute to the score of each student. The idea was to force the group to rank the quality of participation of each member.

Table 3. Range of possible grades in peer-assessment.

Possible Grades	Points
-2	0
-1	0,5
0	1
1	1,5
2	2

All the control of the process was implemented using Excel worksheets where the professors noted every week the presence, the investment given by each student to the groups and his own grade to each group. At the end of each block of presentation, they collected the peer assessment grades and the P_x grade was calculated and published.

2.5 The experiments

The experiments were conducted on the second semesters of 2014 and 2015. In the first time, the class had 66 students and in the second, 24.

There were some differences between the first and the second experiments. The first difference is related to organization of groups according to the number of students in two classes. In 2014, the course program was

organized in six topics, according to the shown in Table 1, but in 2015 it was reorganized into four topics. Thus, in 2014 there were twelve groups and in 2015 only eight.

There were also some changes in the starting rules, as the professors felt that they needed to be improved. The evolution of the rules, both during the year 2014 as those implemented only in the next semester will be discussed below.

3 Results and Discussion

3.1 The presentation environment

In the fifth week of the semesters the presentations were started. The first important behavioural point observed was the language used by the presenters; they have immediately grasped the idea of the business environment and they have addressed to the class as if they were talking to possible interested in their business, not as speaking to classmates, using a more formal language than that used colloquially.

The competition environment has brought seriousness to the process. It was observed that most teams have worked well in their presentations, trying to convince colleagues that their "companies" knew enough about the subject they worked.

The frequency in the classes was high, averaging 90% attendance at all sessions. Obviously a lot of this was due to the fact that part of the grade (up to two points) was proportional to the frequency, but the active participation of students in presentations could be observed in several occasions, with students asking questions and comments to presentations that did not concern with their specific themes.

3.2 Corrections in some rules during the first experiment

Over the first few weeks of work, some corrections had to be made in the rules to adjust the methodology to the proposed objectives of the course. Among them, stand out the following:

- Each week, two groups presented their work based on the fundamentals of their theme, and then the opponent team formulated their question to the group. Although the objective of this procedure was to show the "investors" the knowledge of the group on its subject, some opponent teams started to formulate questions as real traps, aiming to put the presenters in a difficult situation. So the professors started to judge questions before they were proposed and when they observed the destructive intention in some question, they asked the group to reformulate it.
- After a few weeks of work, it could be noticed some interesting facts on the behaviour of students. The main fact to be reported is that about the popularity of some individuals, who began lobbying for more invest in their companies, regardless of the presentation quality.

This fact could be observed when the professors noticed a discrepancy between their evaluation and the investment obtained by some groups that had clearly presented a job with lower quality. To eliminate the suspicion, the professors called some students to talk privately and asked if there was anything abnormal in the allocation of investment for that particular group. Then some students revealed that a group member, a very charismatic person, had asked colleagues to invest more in his group.

Despite of considering a serious fact, the case was seen as caused by the competitive environment that has been created, which has a whole positive aspect for promoting the quality of work, but, on the other hand, also has a negative side which can lead the unethical actions like this.

The means employed to correct this problem was to introduce an adjustment factor in the investment grade for each student. This factor was called "payback investment factor" and was calculated according to the success of their investments in groups who obtained higher average investments, ie, if the student systematically invested in groups that had low average investment, the factor would be less than one and his investment note would decrease slightly, but if the student invested in the best-evaluated groups, the factor would be greater than one and his investment note would increase slightly. So, equation (1) was replaced by

equation (2). After this change of rule, no more discrepancies were observed between the class average investments and professors' grades.

$$P_x = G_{invest} \times f_{payback} + G_{att} + G_{peer} + G_{prof} \quad (2)$$

Where f_{ret} is the factor of return on investment.

- Other correction that was necessary was related to the peer assessment grade. At the end of the first block of presentations, all the groups were instructed to rank their members according to the rule of peer assessment described in *Table 4*. But, 10 of 12 groups attributed the grade zero to everyone, what did not break the rule, but neither ranked the quality of the participation of each group member. So, for the next assessment it was prohibited zero attribution for all group members.

3.3 New rules added to the second experiment

Based on the experience gathered in the first experiment, some chances were implemented in the rules to improve the system.

- The first and most important change was the creation of the stakeholder groups. One of the problems pointed out by the students in the first experience was related to the fact that the groups become too restricted to the study of their own work issues. Then the figure of the **stakeholder group** was established, the interests of this group were in some way linked to the success of another group. Thus, the stakeholder group should help another group on their work and, on the day of their presentation, interact with the presenters in order to enrich the knowledge transmitted by them. The compensation for the work of stakeholder appears as an extra grade that can be added to the score assigned by professors to their group. This extra grade, called G_{stk}, is the difference between the score achieved by the group supported by the stakeholders and their own notes, whenever this difference is positive. So, a new term is added to the equation (2), that becomes the equation (3):

$$P_x = G_{invest} \times f_{payback} + G_{att} + G_{peer} + \left(G_{prof} + G_{stk}\right) \quad (3)$$

- A change was also made in the rule number 9 of Table 1, the presentation time has been increased to 25 minutes and the question asked by the opponent group was eliminated, being replaced by 15 minutes for the stakeholder group to present its contribution to the issue presented, after that, the questions were open to the entire class.
- A third change was made. In order to measure the knowledge acquired by students in each topic presented by the groups, before each presentation of the first block, it was distributed a questionnaire containing multiple choice questions on the subject of that week. The students had 15 minutes to answer it and they were told they did not need to be identified and that the result of that test would not influence in their grades. After the second presentation of each group in the second block of presentations, the same questionnaire was distributed and answered with the same instructions. The idea was to measure the increase of knowledge after the presentations. Unfortunately, presumably because the students did not identify themselves and the results did not change their grades, it was noted that many students did not answer the questionnaire seriously, especially in the second round. With a careful analysis of responses, those considered "not serious" have been eliminated, and it could be seen an average increase of 45% in the success rate of responses. Nevertheless, this result shows no statistical confidence and cannot be taken into consideration. For the next experiment, a new change in the rules is already stablished: students should be identified when answering these questionnaires. In addition, a way to get the increase in knowledge of the students into account on the composition of the final grade is being planned.

3.4 Transversal Skills observed

By working in groups with their organizational structure and leaders, students had the opportunity to exercise leadership and communication skills, sense of organization and responsibility for meeting schedules. The creativity and proactivity are other skills that have come with the PBL, since learning was focussed on the student, who became the main actor in the process of acquisition and manipulation of information. With the

presentations to the classmates, students exercised the ability to assemble a clear and succinct presentation, besides the control of time, a great difficult for those who are still inexperienced.

The management of internal conflicts in groups can also be highlighted as one of the skills exercised during the course. On many occasions, groups came to the professors to bring problems such as: a member who does not work, a member who wants to do everything by himself, a member who wants to fire himself to work with another group, etc. In all these cases, the professors' guidance was always in the sense that the problems should be resolved as if they were acting in a company, i.e. targeting the company's interests and not the particular interests of each member.

3.5 Evaluation of the course by participating students

In order to have a feedback from students about the methodology to which they had been submitted and to evaluate the acceptance of the method by students and also to understand to what extent the method contributes to the formation of the student, a survey was completed by the whole class on the last day of the course in both semesters. The survey consisted of statements to be classified according to the Likert scale. The statements are described in Table 4. The answers to the survey are compiled in Figure 2 for 2014 and in Figure 3 for the 2015 experience.

The results of the surveys show that most students consider that, although it is an innovative and more motivating method that traditional one, it did not bring losses to their learning. In addition, students consider that the course has a workload equivalent to the traditional course, which may contradict the tendency to think that these methodologies relieve students' workload.

Table 4. Statements to be evaluated by the students.

	Statements
1	The methodology used in this course is innovative
2	I think the learning method has brought losses to my learning
3	This way used in teaching the discipline was more motivating than the traditional way
4	This way used in the course of teaching resulted in a higher workload than the traditional way
5	I have reached to learn very well the subjects concerned to my group
6	I have reached to learn very well the subjects concerned to the other groups
7	I consider that the criteria for evaluation (grades) were righteous
8	There have been many attempts to circumvent the rules by the students
9	I wish more disciplines were taught this way
10	The competitive environment contributes to motivating the learning

Analysing the answers to statements 5 and 6 to the 2014 experience, it was observed that the students could better learn the items related to the subject of their work group than other matters, even considering that everybody had accessed all subjects through the critical analysis they needed to do to the work of other teams while acting as investors. This may be the most imperfect point of this experience. On the other hand, in the 2015 experience, when the stakeholder groups were created, it can be observed that the sum of agree and strongly agree responses changes from 91% to 100% (2014 to 2015) for the statement 5, but it increases from 42% to 60% (2014 to 2015) to the statement 6, what clearly means that the creation of the stakeholder groups was effective in increasing the access to the subjects related to other groups.

In general, students from both semesters considered the evaluation criteria were fair, and would like more disciplines were taught according to this PBL method.

Analysing the responses to the statement 8, the sum of strongly disagree and disagree changed from 55% to 93% from 2014 to 2015. Probably, this change is related to the creation of the payback investment factor, which acted only in the second half of the 2014 experience, but in whole 2015.

As a final point, the perception that the competitive environment contributes to motivating the learning, raised from 60% to 93% from 2014 to 2015, what can be seen as combined result of the changes brought to in the system and may be associated to the increase of the fairness of the evaluation's criteria.

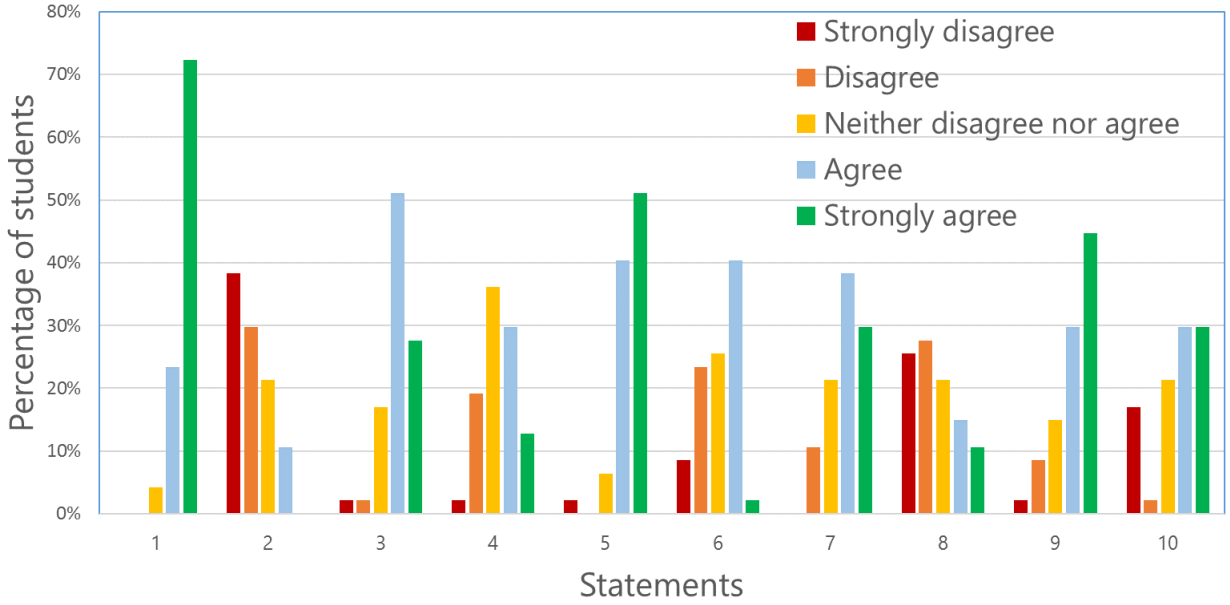


Figure 2. Compilation of the answers to the questionnaire in Table 4 – 2014.

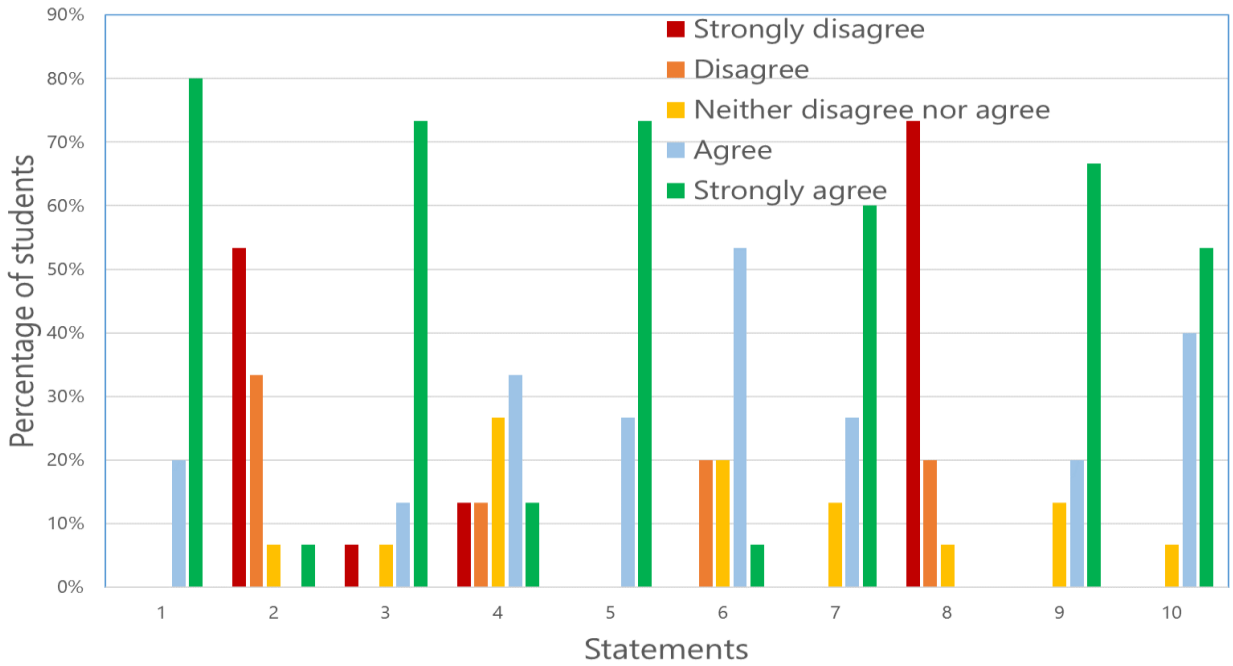


Figure 3. Compilation of the answers to the questionnaire in Table 4 – 2015.

4 Conclusions

This paper reports the application of a PBL method in a discipline of the course of Chemical Engineering in two experiences realized in 2014 and in 2015.

The rules created to conduct the experiment allowed the professors to simulate a business environment so that the students felt as if they were acting in their professional lives.

From the first to the second experiments, the rules have been improved, which increased student access to the contents of the discipline, enhanced the perception that the grading system is fair and declined attempts to circumvent the rules, in addition, the changes increased the motivation brought by competition between groups.

The solution of conflicts of interest and the achievement of goals and deadlines allowed students to develop important skills for their future professional activities while they learned the content of the syllabus.

Finally, the authors believe they have achieved success in their objectives of facilitating the learning of the course content and at the same time they have driven students to acquire some of the important soft skills.

The simulation of a business world proposed herein may be readily adapted for other situations, with minor changes in the basic rules proposed here, it is believed that the method can be applied to a wide variety of disciplines of the engineering courses.

5 References

Borges, S., Monteiro, S., & Quirino, M. G. (2011). Uma nova abordagem de ensino de Engenharia: Aprendizagem Baseada em Projetos (PjBL) na disciplina PSP1 do curso de Engenharia de Produção da UnB. *Anais Do COBENGE: CONGRESSO BRASILEIRO DE EDUCAÇÃO EM ENGENHARIA*.

Braghirolli, L. F., Ribeiro, J. L. D., Weise, A. D., & Pizzolato, M. (2016). Benefits of educational games as an introductory activity in industrial engineering education. *Computers in Human Behavior*, *58*, 315–324.

Cascini, G., Saliminamin, S., Parvin, M., & Pahlavani, F. (2015). OTSM-TRIZ Games: Enhancing Creativity of Engineering Students. *Procedia Engineering*, *131*, 711–720.

De Carvalho, C. V. (2012). Is game-based learning suitable for engineering education? *IEEE Global Engineering Education Conference, EDUCON*.

Khrushchev, Y., Batseva, N., Fix, N., Chesnokova, I., & Khar'kovskaya, V. (2015). Business Games in Training Engineering Students. *Procedia - Social and Behavioral Sciences*, *206*(November), 267–271.

Lima, R. M., Carvalho, D., Assun, M., Flores, A., & Van Hattum-Janssen, N. (2007). A case study on project led education in engineering : students ' and teachers ' perceptions. *European Journal of Engineering Education*, *32*(3), 337–347.

Lima, R. M.; Carvalho, D.; Flores, M. A.; Hattum, N. J., (2005) Ensino / aprendizagem por projecto: balanço de uma experiência na Universidade do Minho. Proc. of VIII Congresso Galaico-Português de Psicopedagogia, pp. 1787-1798.

Likert, R. (1932). A Technique for the Measurement of Attitudes. Archives of Psychology (140) 1–55.

Singhal, A. C., Bellamy, L., Mcneill, B., (1997). A new approach to engineering education, Arizona State University, Arizona, 88.

Soares, F. O., Sepúlveda, M. J., Monteiro, S., Lima, R. M., & Dinis-Carvalho, J. (2013). An integrated project of entrepreneurship and innovation in engineering education. *Mechatronics*, *23*(8), 987–996.

Surgenor, B., Firth, K., (2006) The role of laboratory in design engineering education, Proceedings of The third International Desing Conference on education, innovation and practice in engineering design, University of Toronto, Canada.

Learning Sustainability with EPS@ISEP – Development of a Water Disinfection System

Ádám Jenei[1], Aleksandra Bazylinska[1], Joanna Walczak[1], Sander Küttis[1], Benedita Malheiro[1,2], Cristina Ribeiro[1,3], Manuel F. Silva[1,2], Nídia Caetano[1,4], Paulo Ferreira[1], Pedro Guedes[1]

[1] ISEP/IPP - School of Engineering, Polytechnics of Porto, Rua Dr. António Bernardino de Almeida, 431, Porto, Portugal
[2] INESC TEC, Rua Dr. Roberto Frias, Porto, Portugal
[3] INEB, Rua do Campo Alegre, 823, Porto, Portugal
[4] CIETI & LEPABE, Rua Dr. António Bernardino de Almeida, 431, Porto, Portugal

Email: {mbm,mcr,mss,nsc,pdf,pbg}@isep.ipp.pt

Abstract

The European Project Semester (EPS) is a one-semester capstone project/internship programme offered to engineering, product design and business undergraduates by 18 European engineering schools. EPS aims to prepare future engineers to think and act globally by adopting project-based learning and teamwork methodologies. The EPS@ISEP programme – the EPS programme provided by ISEP – the School of Engineering of the Polytechnic Institute of Porto – started in 2011 and has since welcomed 3rd and 4th year mobility students during the spring semester. In particular, sustainable development is a pervasive concern within EPS projects. It was in this context that, in 2012, a team of EPS@ISEP students decided to develop a water disinfection system. While the technical goal of the project was to design and develop a fluid disinfection system for removing bacteria, viruses and seaweeds, the overall objective was far more ambitious: to help students learn, develop and adopt sustainable practices for their future professional life. The system was intended to be a simple and effective solution for water treatment and recycling. At a larger scale, the project contributes to the preservation of the planet's fresh water resources and to the improvement of the population's health by eliminating harmful microorganisms from the water. This challenge was, by itself, motivational and exposed the team to new learning experiences. The team found several approaches for water treatment and, after a detailed analysis, decided to adopt Ultraviolet (UV) irradiation for the removal of microorganisms. This multidisciplinary real world problem drove the team during the semester. The team surveyed and compared different methods for water cleansing and recycling, chose one approach and, then, designed, built and tested the prototype. In addition, the students also addressed marketing, sustainability as well as the ethic and deontological issues regarding the proposed solution while developing cross-cultural understanding, teamwork and communication skills. The project provided an excellent opportunity to foster the concept of sustainable development amongst students.

Keywords: Engineering Education; Sustainable Development; European Project Semester; Water Disinfection.

1 Introduction

The European Project Semester (EPS) is a one-semester capstone project/internship programme offered to engineering, product design and business undergraduates by 18 European engineering schools. EPS aims to prepare future engineers to think and act globally (Andersen, 2004), by adopting project-based learning and teamwork methodologies, fostering the development of complementary skills and addressing sustainability and multiculturalism. In particular, sustainable development is a pervasive concern within EPS projects.

The EPS@ISEP programme – the EPS programme provided by the School of Engineering – Instituto Superior the Engenharia do Porto (ISEP) – of the Polytechnics of Porto – welcomes engineering, business and product design students and includes six modules: Project (20 ECTU), Project Management and Team Work (2 ECTU), Marketing and Communication (2 ECTU), Foreign Language (2 ECTU), Energy and Sustainable Development (2 ECTU) and Ethics and Deontology (2 ECTU). These 2 ECTU modules are project supportive seminars oriented towards the specificities of each team project (Malheiro et al., 2015).

Every spring, EPS@ISEP proposes a set of projects (each one with a specific client, responsible for defining the project requirements and checking its compliance) with a strong focus on sustainability, to raise the students awareness to the problem. In the spring of 2012, a team choose to develop a Water Disinfection System, which

was proposed by the Chemical Engineering Department of ISEP. In accordance with the EPS 10 Golden Rules, the team was composed of four students with different nationalities and backgrounds (Malheiro et al., 2015). The goal of the disinfection system was to produce clean water (with no microorganisms) to be used in research experiments, using an automated system. The cleaned water was NOT intended for drinking. In the students' opinion, this project was an opportunity to contribute to clean / recycle already used water. Before building the product, the students studied and compared different solutions regarding water disinfection, developed a marketing plan with competitor and SWOT analyses and a marketing programme. Subsequently, they designed a solution, analysed its sustainability and specified a list of the materials, which they used to build and assemble the system. Finally, they carried out the necessary electrical simulations and experimental tests to verify the full operational capability.

Several approaches can be found nowadays for purifying water, such as using chemicals (chlorine, ozone), Ultraviolet (UV) lamps, reverse osmosis and filtering. The team decided to use UV radiation for removing microorganisms since they found it to be the most advantageous method to achieve the goal. As a result, the project's technical goal became to build and develop a disinfection system to remove bacteria, viruses and seaweeds from water using UV radiation, taking into consideration the requirements defined by the client: (*i*) the system should be able to provide 72 l/h continuous flow-rate; (*ii*) the treated water should not contain any viable cells of pathogenic (in particular bacteria, viruses, seaweeds, microalgae); (*iii*) the cleanness of water should be such that sun light can pass through the water layer, and reach about 15 cm depth of water with microalgae; (*iv*) the system should be controlled by a Programmable Logic Controller (PLC); and (*v*) the budget for developing the entire system is 400 €.

This paper presents in Section 2 a brief state of the art on methods for water treatment. Then, Section 3 introduces the system architecture proposed and Section 4 describes the implementation of the system and the tests performed in order to check the correct functioning of the device. Finally, in Section 5 the discussion and conclusions are presented.

2 Water Treatment

Water treatment is presently a very important topic since the world's fresh water resources are becoming limited (Water Facts, 2016). Every year millions of people die from water related diseases and others due to lack of access to clean water. Several companies and institutions are increasingly seeking different ways for disinfecting and cleaning contaminated water in order to re-use it. There are several applications and approaches for cleaning wastewater, namely using chemicals (chlorine, ozone), UV lamps and filtering. In the following subsections the main methods commonly used for water disinfection will be presented as well as some companies that sell products for this purpose.

Besides disinfection, which aims at reducing or eliminating the contents in pathogens, the water can also be submitted to several other different physical-chemical treatments, such as mechanical filtration, carbon filtration, removal of nitrates, decarbonisation and demineralisation, removal of iron and manganese, water softening (removal of components causing water hardness, involving the conversion of calcium and magnesium ions, responsible for hardness of water, into sodium ions), and the correction of pH. None of these treatments was addressed in this project.

2.1 Methods for Water Disinfection

2.1.1 Chlorination

Chlorination is the cheapest and most popular way to eliminate pathogens and disinfect water. The bacteria and viruses are destroyed by the action of chloride or pure chlorine gas to the water. Chlorine gas is the least expensive form of chlorine available, being the typical amount of chlorine gas required for water treatment ranges from 1 mg to 16 mg per litre of water. However, the most popular means of disinfection consists of using a solution of sodium hypochlorite (NaOCl), which is also the most efficient of the chlorinated disinfectants, with a recommended dosage from 0.2 mg to 2 mg of NaOCl per litre of water (SDWF, 2016).

The dose of chlorine should be selected according to the water quality. For the preparation and dosage of the solution, chlorinators are used (a chlorinator is typically composed of a diaphragm pump/suction-pumping engine, a polyethylene tank for the sodium hypochlorite solution, a suction pipe in the tank that contains the solution of disinfectant and a duct). The chlorinator must be installed in a separate room equipped with ventilation and as close to the receiver as possible. Sodium hypochlorite disinfection presents the disadvantage of deterioration of water odour and taste by chlorine. Despite its popularity, chlorine disinfection has gained several opponents since, not only, it is unable to kill some protozoan cysts, but produces trihalomethanes, a carcinogenic disinfection by-product (SDWF, 2016).

2.1.2 Ozonation

Ozonation consists of injecting oxygen enriched with ozone (O_3, triatomic oxygen) through the water. Ozone production is a local instant process generated by a silent, electric discharge in a high voltage alternating field, which affects the flow of clean, dry oxygen or air from the environment. Water ozonation stations consist of equipment for the production of ozone (ozonators) and contact tanks for dissolving ozone into the contaminated water.

Ozone has many advantages, which make it appropriate for application in water treatment: (*i*) ozone application improves the colour and taste of water; (*ii*) ozone oxidation trace contaminants such as pesticides and surfactants are destroyed; (*iii*) ozone is a powerful oxidizing agent that reacts directly with organic double bonds; (*iv*) ozone causes the biological disintegration of organic substances in wastewater which, in turn, when applied to a biologically active filter are further broken down to CO_2 and water; and (*v*) ozone causes the destruction of microorganisms contained in the water.

The disinfection of water by ozonation is most often used in swimming pool water, as well as in the case of large aquaria and fisheries. Ozone is also used for wastewater treatment such as surfactants and detergents from the laundry. As a basic principle widely applicable, the following requirement is applied: to get the highest degree of disinfection of drinking water, a residual ozone concentration of 0.4 mg/dm^3 must be maintained for a period of 4 min (Ozonia, 2009). However, although ozonation is an effective water treatment for aquaculture systems, ozone is also very dangerous and 5 ppm can be immediately life-threatening to personnel, which poses serious restrictions to its use (Summerfelt at al., 2009).

2.1.3 Ultraviolet Radiation

Solar disinfection takes advantage of UV radiation. However, only UV-A (400–315 nm) and UV-B (315–280 nm) reaches the Earth surface since the UV-C (280-100 nm) fraction of this radiation is almost totally absorbed by the atmosphere (WHO, 2016). Solar disinfection systems have long been used for water treatment (Kalt et al., 2014).

The fact that the UV-C light spectrum (280-100 μm) is absorbed through the structure of the DNA of microorganisms, stops their replication and constitutes a powerful chemical free bactericidal. By using a properly selected time and intensity, UV radiation can completely destroy microorganisms (Abbaszadegan et al., 1997) through the destruction of their DNA. Different organisms have different resistance to UV. In order to destroy a certain type of microorganism specific UV doses (mJ/cm^2) are applied (ClorDiSys, 2013).

The effectiveness of disinfection depends on the extent of the microbial contamination of the water. Usually it is defined for indicator bacteria, namely *Escherichia coli*. For the purpose of drinking water, disinfection in waterworks usually is taken to be effective for *Escherichia coli* at the level of 99.9 %, requiring a UV dose of 40 mJ/cm^2. The dose is adjusted depending on the application.

UV sterilization lamps are widely used to disinfect water without using heat or chemicals. UV lamps can replace pasteurizers in breweries, mineral water bottling plants, food processing plants at a fraction of operating costs. These devices provide a safe sterilizing system, disinfecting water in conventional greenhouses and closed loops with drainage. UV disinfection of water can be done at the location. Ultraviolet sterilization in the swimming pools results in the reduction of the amount of chlorine or even the total abandonment of chlorination. UV use in ponds and fountains protects water from organic matter rotting. UV lamps are also used for the destruction of ozone in ozone water.

The use of UV sterilization lamps presents the following advantages: (*i*) UV radiation of wavelength 254 nm damages DNA, which is lethal to microorganisms (Timmermann et al., 2015); (*ii*) does not alter the chemical composition of water; (*iii*) is overdose free; (*iv*) has low operating costs; (*v*) is free from the problems related with the use of chlorine (or other chemicals) and corrosion; and (*vi*) breaks down some pathogens such as *Cryptosporidium*, which are resistant to chlorination (Agrawal and Bhalwar, 2009).

Although UV irradiation provides a chemical free method of disinfecting soundproofing materials that are traditionally chemically incompatible and an effective method for inactivating pathogens resistant to chemicals, it presents the disadvantage of not being effective if the water has too many suspended particles that block the access of UV radiation, impeding its action (ClordiSys, 2013).

Solar water disinfection (SODIS) can be used both in bench-top facilities and in direct systems over the roof, is simple to use and inexpensive. This method of water sterilization has spread all over the developing world and is being used daily in more than 50 countries in Asia, Latin America, and Africa, where more than 5 million people get disinfected drinking water with SODIS technique (McGuigan et al., 2012).

2.2 UV-based Fluid Disinfection Products

There are several companies around the world that provide fluid disinfection services using UV technology. Those companies are mainly focused on worldwide service in industry and municipal environment. They provide services on an extremely big scale intended for different applications, mainly divided in two major areas: (*i*) industry: medical, pharmaceutical, industrial wastewater, aquaculture; and (*ii*) municipal: drinking water, beverage industry, swimming pool water treatment.

Examples of worldwide companies which provide UV technology are Atlantic Ultraviolet Corporation (Ultraviolet.com, 2016), Aquionics (Aquionics, 2016), Enaqua (Enaqua, 2016), Hanovia (Hanovia, 2016), and WEDECO (Wedeco, 2016). Each of these companies patented their own UV technology and method of application. Most of them use not only fluid disinfection by UV technology but also other methods like ozone systems or reverse osmosis. They provide different products for numerous different applications. Those companies, which are typically focused on mass production and distribution, have large budgets and broad teams of specialists and workers.

The problem of water disinfection for travellers has been addressed by a commercial device using UV-C radiation, the SteriPEN (SteriPEN.com, 2016), which was tested under different operating conditions. The device is able to sterilize water provided that the adequate bottle is used and that the device is conveniently applied (Timmermann et al., 2015).

3 System Architecture

Before defining the system architecture, EPS students have to study and define the environment in which their product will fit and the required restrictions that apply.

With this purpose, the team elaborated their marketing plan and analysed the sustainability issues of their solution. These topics are described in the next two subsections, after which, in the following subsection, is described the architecture the team proposed for the product.

3.1 Marketing Plan

After analysing the market for identical products and doing a Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis, the team performed a costumer segmentation, analysed the most relevant client's needs and defined the market positioning, objective and planning for the product to develop. In the sequel, they elaborated the marketing programme and the marketing mix.

According to this detailed marketing plan, they proposed the development of a product focused only on one specific area: fluid disinfection using a germicidal UV lamp. According to the students, their idea is not to create their own UV technology, but build a system with equipment available on the market and sell the service. This way, the parts can be defined and ordered for each client, allowing clients the possibility to choose the best

materials and technology depending on their budget and needs. They also propose targeting individual clients, such as chemical laboratories or small companies, keeping in mind that the clients can always count on their technical support to maintain the system. In comparison to larger companies, the price of such a company service would be lower.

3.2 Sustainability Issues

The students analysed, in the next stage, the eco-efficiency measures regarding the sustainability of the proposed product. The advantages of UV radiation for water disinfection were proven when compared with the use of chemicals and heat (energy consumption). The option for a modular system also presents advantages since it is only needed to replace the broken part in case of the malfunction or breakdown of a component.

3.3 Proposed Architecture

As verified during the state of the art research, there are several systems on the market for purifying contaminated water. Most of them are designed for industrial use, i.e., have large dimensions, process large fluid volumes and are expensive. There are also systems for cleaning the water in pools and ponds as well as systems for aquariums.

Based on these ideas, the team proposed to build a system differing from the existing commercial solutions in the sense that it should be compact, simple, small and modular. The idea to build a modular system implies that every part of the system can be changed easily and extra devices or equipment can be easily added, if needed (e.g., a chemical cleaning/filtering). The fact that the system is based on UV radiation is because this technology is sufficient, fast, environmentally safe and effective. Due to the small water volumes involved, the system should be small and compact to fit in laboratories. Besides that, it should be built according to the needs of the client. Furthermore, the system must be automated, meaning that the whole system should be controlled by a PLC. It should include an ON/OFF button, a START button and water level sensors, which will allow shutting down the system if the water level rises/drops above/below pre-defined levels.

Given these specifications, the team designed the UV-based water disinfection solution depicted in Figure 1 (left). The water is pumped from the container with contaminated water, pre-filtered, exposed to the UV radiation and is collected in the clean water recipient. As required, the entire system is controlled by a PLC.

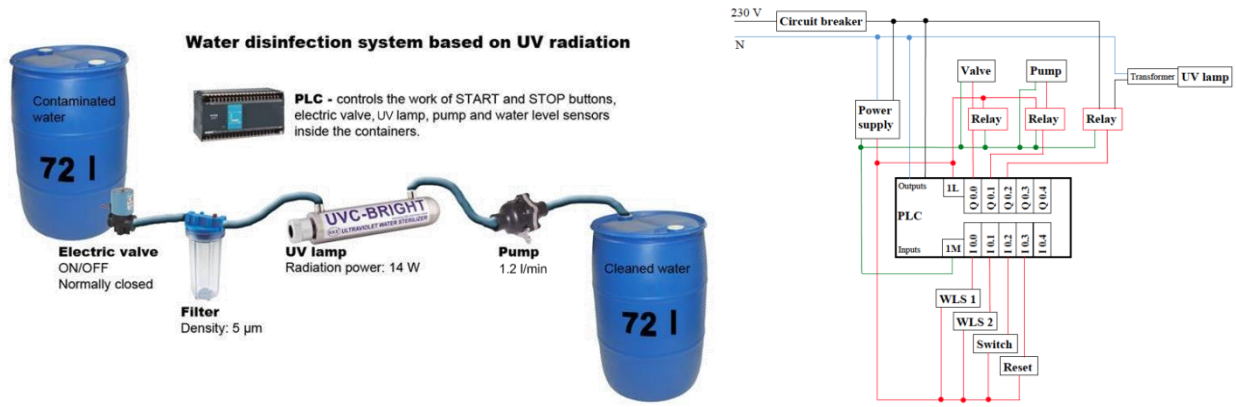


Figure 1. Project sketch of the water disinfection system based on UV radiation (left) and schematic of the water disinfection system electrical circuit (right).

This proposed architecture differs from the existing solutions in the sense that it is compact, simple, small and modular. Besides that, it is built according to the needs of the client. In this case the system is also automated, which means that the whole system is controlled by a PLC. To operate it, the system has an ON/OFF and a START button. The PLC will, based on the water level sensors, shut off the system if the water level rises above or drops below the pre-defined levels.

4 Implementation and Testing

4.1 System Main Components

For implementing the system depicted in Figure 1, the team performed the selection of materials and solutions while looking for a balance between quality, economy and ecology. The main principle adopted was to reuse resources which were already available at the client. In cases where it was possible, the team chose recyclable and environmentally friendly materials such as wood and metals. Whenever the technical requirements required purchasing plastic materials, long lifetime plastics were chosen.

The UV water sterilizer is the most important component of the system. It was chosen taking into consideration the specified water flow rate. Since the capacity of the pump is 1.2 l/min, the capacity of the water sterilizer should be higher to ensure proper sterilization. As a result, the team chose the 2G UV Water Sterilizer (220 V) Model A-140-6. There are cheaper UV systems with identical capacity on the market, but this sterilizer is more reliable and sustainable due to its stainless steel housing.

The team included an electrical valve (Solenoid Valve YCWS1) to control the water flow and a filter, placed before the UV lamp, to remove particles bigger than 5 µm from the water and improve the efficiency of the UV sterilizer.

To provide the adequate water flow through the UV sterilizer, the team selected a mini diaphragm pump. The pump's task is to extract the water from the first container (contaminated water), through the mechanical filter and the UV sterilizer, into the second container. Mini diaphragm pumps operate using two opposing floating discs with seats that respond to the diaphragm motion. This process results in a quiet and reliable pumping action and presents high efficiency, which results in longer life for the motor pump unit. Since, in these pumps, no metal parts come in contact with the materials being pumped, they have a good chemical resistance. Furthermore, the pump body contains no machinery parts, so it can be in dry running condition for a short while. The team chose the 6088 Aqua-Win pump Model C-152-6 because its low throughput matches the nominal capacity of the filter and of the UV sterilizer. A higher throughput implies higher capacity and robustness from the parts and, therefore, a higher price.

To control the system, and according to the client specifications, the proposed solution uses a Programmable Logic Controller. A PLC is an industrial digital computer typically used to control electromechanical devices such as industrial machinery, pumps, lighting, etc. The PLC, which is connected to the system sensors and switches, processes in real time the inputs and controls the outputs based on the defined logic (the user program). In this system, the PLC (SIMATIC S7-200, CPU 212) is used to read the ON/OFF and START buttons (inputs) together with two water level sensors (inputs) and to control 3 relays (outputs) connected to the main modules (pump, UV lamp and electrical valve). The user activates the system by pressing the ON/OFF button (power up), followed by the START button (startup). Once the system is activated, the electrical valve opens and the pump and UV light are turned on. The system shuts down automatically (when the water level sensors detect the pre-defined values) or at the user request (the user presses the ON/OFF button). After an automatic shutdown, once the water levels in the containers have been restored to appropriate values, the user may restart the system by pressing the START button.

As stated, the pump, UV lamp, and electrical valve are connected to the PLC through relays. A relay is an electrically operated switch where a low-power signal is used to control a circuit or several circuits, ensuring complete electrical isolation between control and controlled circuits. In this system, the relays are used to allow the outputs of the PLC to drive the power components. Finally, the system includes a 24 V DC power supply for the PLC, relays, level sensors, electrical valve and pump. Figure 1 (right) presents the schematic of the electrical circuit for this system.

4.2 Simulation Tests

In order to check if the electrical system works, two software applications were used: Simulador_S7_200_V2 Esp and MFC PC_Simu, version 1.0. The results of these simulations allowed concluding that the electrical schematics, including the components and circuitry, were correct and that the PLC logic was fully functional.

4.3 System Implementation

The final assembled prototype is presented in Figure 2 (left), including the water containers, the pump, filter, UV lamp and the control box. Figure 2 (right) illustrates the operation of the system.

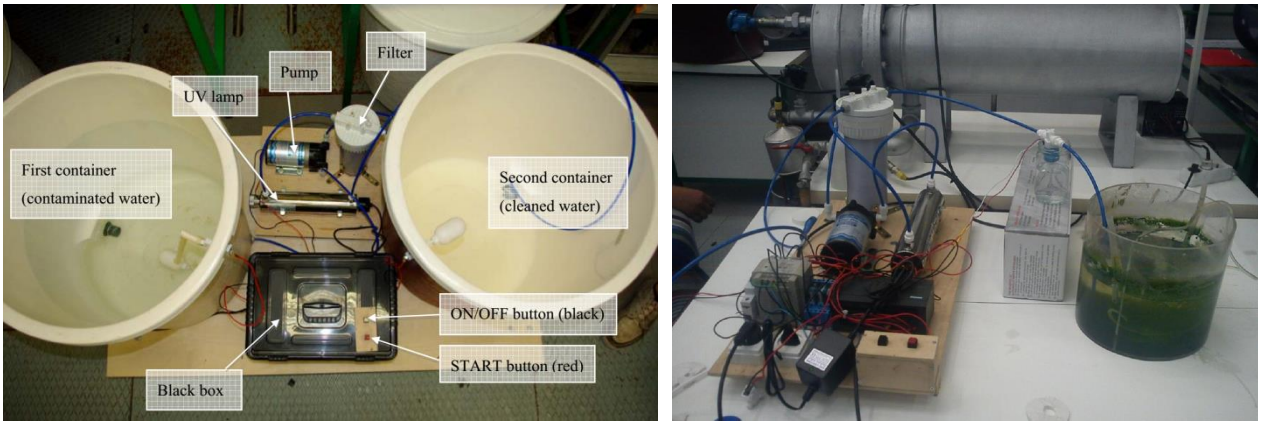


Figure 2. Assembled water disinfection system based on UV radiation (left) and water disinfection system tests (right).

Finally, after verifying that the system works in accordance with the pre-defined user requirements, the team developed an operating manual for the UV Fluid Disinfection System (Bazylinska et al., 2012b). This user manual, to be supplied to the client and to the system users, contains the system specifications, all components used (with their detailed specifications for component maintenance or repair) and the operating instructions. These instructions include the system operation as well the replacement of the relays and of the UV lamp.

5 Discussion and Conclusion

This paper presents the development process of the "Fluid Disinfection System Based on UV Radiation" prototype by a multinational team of students during the EPS@ISEP Spring 2012 edition. The objective of the prototype is to clean water, which has been used in the ISEP's chemical laboratory, based on UV technology. The whole system, which is controlled by a PLC, filters, exposes to UV radiation and drives the water using a small diaphragm pump. The mechanical and control parts of the system were successfully tested. The team was able to develop a fully functional prototype fulfilling the specifications.

The adopted learning methodology was project based learning with a strong emphasis on multicultural and multidisciplinary teamwork. A pro-active autonomous learning attitude was promoted among students as well as the development of critical thinking, collaboration, communication and creativity/innovation. During the project development, students had to define a work plan, identify and distribute the tasks, and autonomously decide the approach, the design and the technologies to use according to a budget previously specified as well as investigate alternative solutions for the proposed problem. The panel of supervisors with different fields of expertise acted not as directors but as a consulting committee. For each weekly supervision meeting the team had to specify the topics to be discussed.

The fact that the project was multidisciplinary together with the joint supervision provided students with the opportunity to develop solid scientific and technical competences, as well as transversal skills, as stated by the team members: "According to the team members, "*during these four months of work we have learnt many different aspects connected, not only, with mechanical, electrical and chemical knowledge but also teamwork. We improved our cooperation and communication as a team. Moreover, we dealt with the conflicts, restrictions and limitations we encountered on our way, namely, time, budget and knowledge limitations. To sum up, thanks to this project we improved our teamwork skills and got new knowledge, which can be useful in our future career. (...) We now can provide a service for different clients, taking into consideration low cost, good quality and sustainability.*" This testimony supports the idea that the challenge was, by itself, motivational and exposed the team to new learning experiences, namely, contributed to foster the concept of sustainable development amongst the students.

Acknowledgements

This work was partially financed by the ERDF – European Regional Development Fund through the Operational Programme for Competitiveness and Internationalisation – COMPETE Programme within project «FCOMP-01-0202-FEDER-023151» and project «POCI-01-0145-FEDER-006961», and by National Funds through the FCT – Fundação para a Ciência e a Tecnologia (Portuguese Foundation for Science and Technology) as part of project UID/EEA/50014/2013. Finally, the authors gratefully acknowledge the sponsorship of SOPSEC S.A.

6 References

Abbaszadegan, M., Hasan, M.N., Gerba, C.P., Roessler, P.F., Wilson, B.R., Kuennen, R., Van Dellen, E. (1997). The disinfection efficacy of a point-of-use water treatment system against bacterial, viral and protozoan waterborne pathogens, Water Research, 31 (3), pp. 574-582.

Agrawal, VK., Bhalwar, R. (2009). Household water purification: Low-cost interventions, Medical Journal Armed Forces India, 65 (3), pp. 260-263.

Andersen, A. (2004). Preparing engineering students to work in a global environment to co-operate, to communicate and to compete, European Journal of Engineering Education 29 (4) pp. 549–558, doi:10.1080/03043790410001711243.

Aquionics (2016). "Aquionics – UV that works" [Online]. http://www.aquionics.com/main/ [Accessed: 5-February-2016].

Bazylinska, A., Jenei, A., Walczak, J., Küttis, S. (2012a). "Fluid Disinfection System Based On UV Radiation – Final Report" [Online]. Available: http://www.eps2012-wiki2.dee.isep.ipp.pt/lib/exe/fetch.php?media=t2_final_report.pdf [Accessed: 5-February-2016].

Bazylinska, A., Jenei, A., Walczak, J., Küttis, S. (2012b). "Fluid Disinfection System Based On UV Radiation – User Manual" [Online]. Available: http://www.eps2012-wiki2.dee.isep.ipp.pt/lib/exe/fetch.php?media=t2_user_manual.pdf [Accessed: 5-February-2016].

ClorDiSys (2013). Ultraviolet Light Disinfection Data Sheet [Online], Available: http://www.clordisys.com/pdfs/misc/UV%20Data%20Sheet.pdf [Accessed: 3 March 2016.

Enaqua (2016). "Enaqua" [Online]. Available: http://www.enaqua.com/ [Accessed: 5-February-2016].

Hanovia (2016). "Hanovia UV – the power in UV technology" [Online]. http://www.hanovia.com/ [Accessed: 5-February-2016].

Kalt, P., Birzer, C., Evans, H., Liew, A., Padovan, M., Watchman, M. (2014). A Solar Disinfection Water Treatment System for Remote Communities, Procedia Engineering, 78, pp. 250-258.

Malheiro, B., Silva, M., Ribeiro, M. C., Guedes, P., Ferreira, P. (2015) The European Project Semester at ISEP: the challenge of educating global engineers, European Journal of Engineering Education 40 (3) (2015) 328–346, doi:10.1080/03043797.2014.960509.

McGuigan, K.G., Conroy, R.M., Mosler, J.-J., du Preez, M., Ubomba-Jaswa, E., Fernandez-Ibañez, P. (2012). Solar water disinfection (SODIS): A review from bench-top to roof-top, Journal of Hazardous Materials, 235–236, pp. 29-46.

Ozonia (2009). Ozonia North America Inc., Degremont Technologies. Application Brochure: Drinking Water Treatment Municipal Drinking Water – DIS02302EN-V2-02/2009

SDWF, Safe Drinking Water Foundation (2016). "Fact sheet: What is Chlorination?" [Online]. Available: http://www.safewater.org/PDFS/resourcesknowthefacts/WhatisChlorination.pdf [Accessed: 4-March-2016].

SteriPEN.com (2016). "SteriPEN" [Online]. Available: http://www.steripen.com/ [Accessed: 3-March-2016].

Summerfelt, S.T., Sharrer, M.J., Tsukuda, S.M., Gearheart, M. (2009), Process requirements for achieving full-flow disinfection of recirculating water using ozonation and UV irradiation, Aquacultural Engineering, 40 (1) pp. 17-27, doi:10.1016/j.aquaeng.2008.10.002.

Timmermann, L.F., Ritter, K., Hillebrandt, D., Küpper, T. (2015). Drinking water treatment with ultraviolet light for travelers – Evaluation of a mobile lightweight system, Travel Medicine and Infectious Disease, 13 (6), pp. 466-474.

Ultraviolet.com (2016). "Atlantic Ultraviolet Germicidal UV Equipment and Lamps" [Online]. Available: http://ultraviolet.com/ [Accessed: 5-February-2016].

Water Facts (2016). "Water Facts: Facts About Water and Sanitation - Water.org" [Online]. Available: http://water.org/water-crisis/water-sanitation-facts/ [Accessed: 5-February-2016].

Wedeco (2016). "Water purification" [Online]. Available: http://www.xylem.com/treatment/us/brands/wedeco [Accessed: 5-February-2016].

WHO (2016). World Health Organization, "Ultraviolet Radiation and Health". [Online]. Available: http://www.who.int/uv/uv_and_health/en/. [Accessed: 3-March-2016].

Characterising the Australian Engineering Workforce and Engineering Graduate Occupational Outcomes Using National Census Data

Stuart Palmer[1], Malcolm Campbell[1]

[1]Faculty of Science, Engineering and Built Environment, Deakin University, Geelong, Australia

Email: stuart.palmer@deakin.edu.au, malcolm.campbell@deakin.edu.au

Abstract

The purpose of undergraduate engineering education is to develop graduates who are capable of commencing professional engineering practice. Professional education should equip graduates with the skills, knowledge and attitudes required for their initial professional practice. It should also enable the capacity to continue the professional development required to refresh knowledge and skills as the graduates mature and the nature of professional engineering work develops. However, it is true that many graduates from professional engineering programs, either immediately or at some later time, pursue a career outside of professional engineering. The reasons for this are widely speculated upon, and are no doubt complex. In this regard, the professional engineering workforce, the undergraduate engineering education system, the links between them, and the occupational outcomes for engineering graduates in Australia are similar to many other developed nations. Using the latest Australian national census data we present a detailed analysis of the makeup of the professional engineering workforce and the occupational outcomes for graduates of undergraduate engineering programs in Australia. The data show that the Australian professional engineering workforce is comprised of people with a wide range of educational qualifications, and, even immediately post-graduation, many Australian engineering graduates pursue non-engineering occupations. This analysis presents important findings for those designing undergraduate engineering curricula that seek to equip students for the best employment outcomes, given the nature of the professional engineering work environment, and the short- and long-term occupations that engineering graduates actually pursue in Australia.

Keywords: Curriculum Design; Engineering Education Qualifications; Occupational Outcomes.

1 Introduction

A number of reviews of engineering education internationally, over an extended period of time, have concluded that there is a need to improve the quality, quantity, capability and employability of engineering graduates, and that design of undergraduate engineering curricula plays a central role in achieving this goal (Beanland & Hadgraft, 2013). Many prescriptions for achieving this improvement call for industry input into the design and review of engineering curricula to, "… enhance the industry relevance of engineering curricula." (Australian Workforce and Productivity Agency, 2014, p. 84) There are many means by which 'industry' input into undergraduate engineering curricula might be obtained, but industry advisory boards (IABs) are generally viewed as a key mechanism for providing this desired university-industry interface – "This relationship provides a way to monitor the effectiveness of curriculum by providing real-world assessment of coursework as well as scrutinizing the on-the-job performance of past graduates." (Genheimer, 2007, p. 18, citing Summers 2002) As a specific pedagogy, project-based learning (PBL) is often seen as an 'authentic' learning design in engineering education (Dym, Agogino, Eris, Frey, & Leifer, 2005), because the project-based organisation of work is common in engineering practice (Australian Workforce and Productivity Agency, 2014).

The regular appeals for engineering curricula to be more 'authentic', 'real-world', 'industry-relevant', etc. are almost always premised on a view that most, if not all, graduates from undergraduate engineering programs will go into professional engineering practice in 'industry'. However, the reality is that, internationally, many engineering graduates never work in professional engineering practice, or if they do, they do not remain in that sector very long (Choy & Bradburn, 2008; Palmer, Tolson, Young, & Campbell, in press). Even those engineering graduates that do work in an engineering role may find that their undergraduate education did not actually, "… present a realistic picture of what engineering is like 'on the job'." (Bailyn & Lynch, 1983, p.

264) Where engineering graduates do not practice in professional engineering, it is commonly framed as a 'problem' or 'wasteful'. The Australian Council of Engineering Deans refers to the 'loss' of engineering graduates, being a 'poor return' on the investment in their education (Australian Workforce and Productivity Agency, 2014). The Organisation for Economic Co-operation and Development refers to the natural inter-professional mobility of engineers as a 'concern' not only for engineers, but also for other professions and the wider economy (Lavoie & Finnie, 1998). The Roberts' Review investigating the supply of people with science, technology, engineering and maths (STEM) skills in the UK (Roberts, 2002), "… identified a number of *serious problems* in the supply of people with the requisite high quality skills." (p. iii) While part of the concern related to the declining number of students electing to study STEM, the report also noted, "… other sectors from which there is strong, and growing, demand for the skills and knowledge of science and engineering graduates (for example, financial services) tend to offer more generous pay and more attractive career structures … As a result, they have *taken increasing proportions of the best science and engineering students*." (p. 14)

Using the latest Australian comprehensive national census data we present a detailed analysis of the makeup of the professional engineering workforce and the occupational outcomes for graduates of undergraduate engineering programs in Australia.

2 The Professional Engineering Workforce

For an undergraduate engineering curriculum to authentically represent professional engineering practice, it is a necessary first step to understand the characteristics of professional engineering practice. Defining who is an 'engineer' has been a question debated internationally for a long time. As Parker (2004) notes, this question caused difficulty for the Superintendent of the US census in 1850, and continues to do so for those interested in labour market analysis today. Didier (1999) observes that a definitive meaning of the term 'engineer' in France has been an issue for more than two centuries. Bailyn and Lynch (1983) identify many definitions used in research relating to the engineering workforce, generally, "… based either on education or on current work activities." (p. 264) Parker (2004) asks:

> By what criteria should one judge whether someone is an engineer? His self-identification as such? Her job description and job title? Having an engineering degree? Having a degree in a related field? Indeed, does an engineer have to have a degree? Should someone still be counted an engineer if she has become a manager? (p. xiv)

Didier (1999) notes that, "In France, 'engineer' is both a job *and* a title." (p. 474) The job means being part of a profession requiring technical expertise, and the title is bestowed by earning an engineering degree. In Australia, the Australian and New Zealand Standard Classification of Occupations, "… counts all persons within a particular occupation as 'engineers' regardless of their level and nature of their qualifications." (Australian Workforce and Productivity Agency, 2014, p. 18)

Simply defining an engineer as a graduate from an accredited engineering program is also problematic, as many people who graduate as a qualified engineer never practice engineering, or if they do, they leave to pursue work in other fields, or leave the workforce altogether. In Australia, the Australian Workforce and Productivity Agency (2014) notes, "Engineering degrees include applied problem-solving, research skills and professional skills in addition to engineering science, which are skills that are extremely attractive to employers outside the field of engineering." (p. 94) In a previous investigation into where Australian undergraduate engineering graduates were working, the authors found that, overall, only a third were working in a professional engineering occupation, and even shortly after graduation this figure was only about a half (Palmer et al., in press). In the US, in 2011, only 26 per cent of science and engineering college graduates were working in a STEM occupation (Landivar, 2013). Specifically for engineering bachelor graduates in the US, in 1991 about 1.3 million of the 2.8 million (about 46 per cent) graduates were employed as engineers (Parker, 2004), and in a longitudinal investigation, Choy and Bradburn (2008) found that, ten years post-graduation, only about half of engineering majors were still working in a related field. It seems clear that in many countries, engineering graduates have a wide array of attractive career options beyond engineering open to them, in part because of their STEM skills are increasingly valued in many sectors (Lavoie & Finnie, 1998).

The confusion regarding who is an engineer results in part from the legal status of the occupational title in various jurisdictions. While there is legal protection for the occupational use of the title engineer in some countries, especially in Europe (European Council of Civil Engineers, 2005), in many other countries such protection is limited or non-existent. Spinden (2014) notes that while all states in the US require engineering practitioners to be licenced, around 80 per cent of those working in engineering roles do not pursue licencing, because they fall into one of the categories exempt from requiring a licence. Didier (1999) observes that in France, "The engineering profession itself is neither controlled nor regulated by French law." (p. 476) She also notes that those with a formal engineering education are only a subset of those working as engineers. In Australia, "… there is no legal ownership of the occupation title 'engineer'. Anyone can call themselves an engineer …" (Australian Workforce and Productivity Agency, 2014, p. 30) In many countries this results in an 'engineering workforce' composed of people with a range of qualifications, including non-STEM qualifications or none at all. In the US, in 1995, 400,000 of the 1.6 million people (approximately 25 per cent) employed in engineering occupations did not have an engineering degree (Lucena, 2003). In 1999 this proportion was still around 25 per cent (Parker, 2004). For all STEM workers in the US in 2011, around 30 per cent had less than a bachelor degree (Landivar, 2013).

Many people completing undergraduate engineering studies and qualified to enter the professional engineering workforce do not, or if they do, leave it after a short time, i.e., many 'engineers' work out of their field. In many countries, qualified engineers make up only a proportion of the professional engineering workforce. The nature of engineering work and the engineering workforce is often much more complex than the view presented to students (both those considering engineering study, and those currently completing undergraduate studies), and that upon which undergraduate engineering curriculum design is typically based. To gain an 'authentic' overview of the Australian professional engineering workforce, and where graduates of Australian undergraduate engineering programs fit in, here we analyse the latest Australian national census data covering educational qualifications and occupational roles reported by the Australian population.

3 Methodology

To identify which occupations Australian engineering graduates are working in, the Australian Bureau of Statistics census online TableBuilder service (Australian Bureau of Statistics, 2015) was used to cross-tabulate those respondents in the most recent Australian national census (in 2011) that reported a bachelor-level degree in engineering versus the occupations reported by respondents. The census data include 477 occupational classifications. These occupational classifications clearly identify 11 groups related to professional engineering, those not working, and those whose occupation cannot be classified. The remaining 463 non-professional-engineering occupational classifications were clustered into broad occupational groups – IT, general management, technical, marketing, etc. A discussion of this data set, including its limitations has been reported previously (Palmer et al., in press). Similarly, to identify what qualifications those working in professional engineering occupations in Australia have, the ABS TableBuilder service was used to cross-tabulate those census respondents that reported working in a professional engineering occupation versus the highest educational qualifications reported by respondents. The census data include 120 educational qualifications, based on eight levels (advanced diploma, bachelor, graduate diploma, etc.) across 15 broad discipline areas (engineering and related technologies, health, education, creative arts, etc.). The occupational classifications used to identify the Australian professional engineering workforce were the same 11 groups noted above. These two sets of cross-tabulated data were charted together to map out the relationship between those who graduate from bachelor-level undergraduate engineering programs, and those who work in professional engineering occupations, in Australia. The results obtained and their implications are discussed.

4 Results

Table 1 presents the census occupational classifications used to identify respondents currently working in a professional engineering occupation. In the 2011 Australian census data, 200,356 respondents reported a bachelor-level engineering qualification. The left-hand column in Figure 1 presents the numbers and

proportions of respondents who reported a bachelor-level engineering qualification, grouped by consolidated professional engineering occupations and the other principal broad occupational groups reported by respondents. In the 2011 Australian census data, 140,427 respondents reported working in a professional engineering occupation. The right-hand column in Figure 1 presents the numbers and proportions of respondents who reported working in a professional engineering occupation, grouped by the highest educational qualification reported by respondents. Australian census data reported publicly via the ABS TableBuilder service are subject to small random adjustments to avoid the possibility of categories with very small numbers of respondents possibly leading to the re-identification of individual respondents. Hence, the two lower column segments in Figure 1 (on the left - those bachelor of engineering graduates working in a professional engineering occupation, and on the right – those people working in a professional engineering occupation and holding a bachelor of engineering qualification) do not quite match in absolute numbers of respondents.

Table 1. Census occupational classifications relating to professional engineering.

Chemical and Materials Engineers	Civil Engineering Professionals
Electrical Engineers	Electronics Engineers
Industrial, Mechanical and Production Engineers	Mining Engineers
Other Engineering Professionals	Engineering Managers
Engineering Professionals (not further defined)	ICT Support and Test Engineers
Telecommunications Engineering Professionals	

5 Discussion

Figure 1 indicates that approximately half of all engineering bachelor graduates are not working in professional engineering occupations. Nearly 20 per cent of the balance are not working, and overall, about one third of all Australian engineering bachelor graduates reported working in a professional engineering occupation. A separate analysis of this data that considered respondents aged 20-24 years old (i.e., the age range covering most recent graduates from undergraduate programs) found that, even immediately post-graduation, less than half of Australian engineering graduates were working in a professional engineering occupation (Palmer et al., in press). In addition to the occupational groups explicitly identified in the left column of Figure 1, the 'All other occupations' group was made up of: marketing 3.1 per cent; construction 2.3 per cent; other professional 1.9 per cent; finance 1.6 per cent; science 1.1 per cent, unknown 1.0 per cent; education 0.9 per cent; and health 0.3 per cent. The related literature was examined for similar results. In a longitudinal investigation of US bachelor graduates, Choy and Bradburn (2008) found that, ten years post-graduation, only about half of engineering majors were still working in a related field. Using earlier Australian census data, Trevelyan and Tilli (2010) found that across the period 2001-2006, about half of all bachelor or higher engineering graduates aged 25-55 years were not working in engineering-related jobs. When census data for higher degree graduates were included in the analysis here for comparison, the total number of engineering graduates increased by about 25 per cent, but the proportions in Figure 1 did not significantly change.

Figure 1 indicates that bachelor of engineering graduates make up less than half of all Australians who reported working in a professional engineering occupation. An additional 11.6 per cent of respondents had a postgraduate engineering qualification (master or PhD level), so, slightly more than half of those in a professional engineering occupations had a bachelor degree or higher in engineering. However, the curriculum design of postgraduate engineering studies is typically very different to that of undergraduate programs – the latter being of principal interest here. Another 16.2 per cent of respondents reported sub-professional technical and trade engineering qualifications (certificate and advanced diploma). 6.5 percent of respondents reported no post-secondary school qualification at all. 2.4 per cent of respondents reported a postgraduate qualification in management. In addition to the educational qualifications explicitly identified in the right column of Figure 1, the 'All other qualifications' group was made up of: information technology 4.4 per cent; other management and commerce 2.6 per cent; architecture and building 2.4 per cent; other engineering and related technologies 2.3 per cent; natural and physical sciences 1.9 per cent; unknown 1.3 per cent; and a number of others all less than 1 per cent each, totalling to 2.6 per cent.

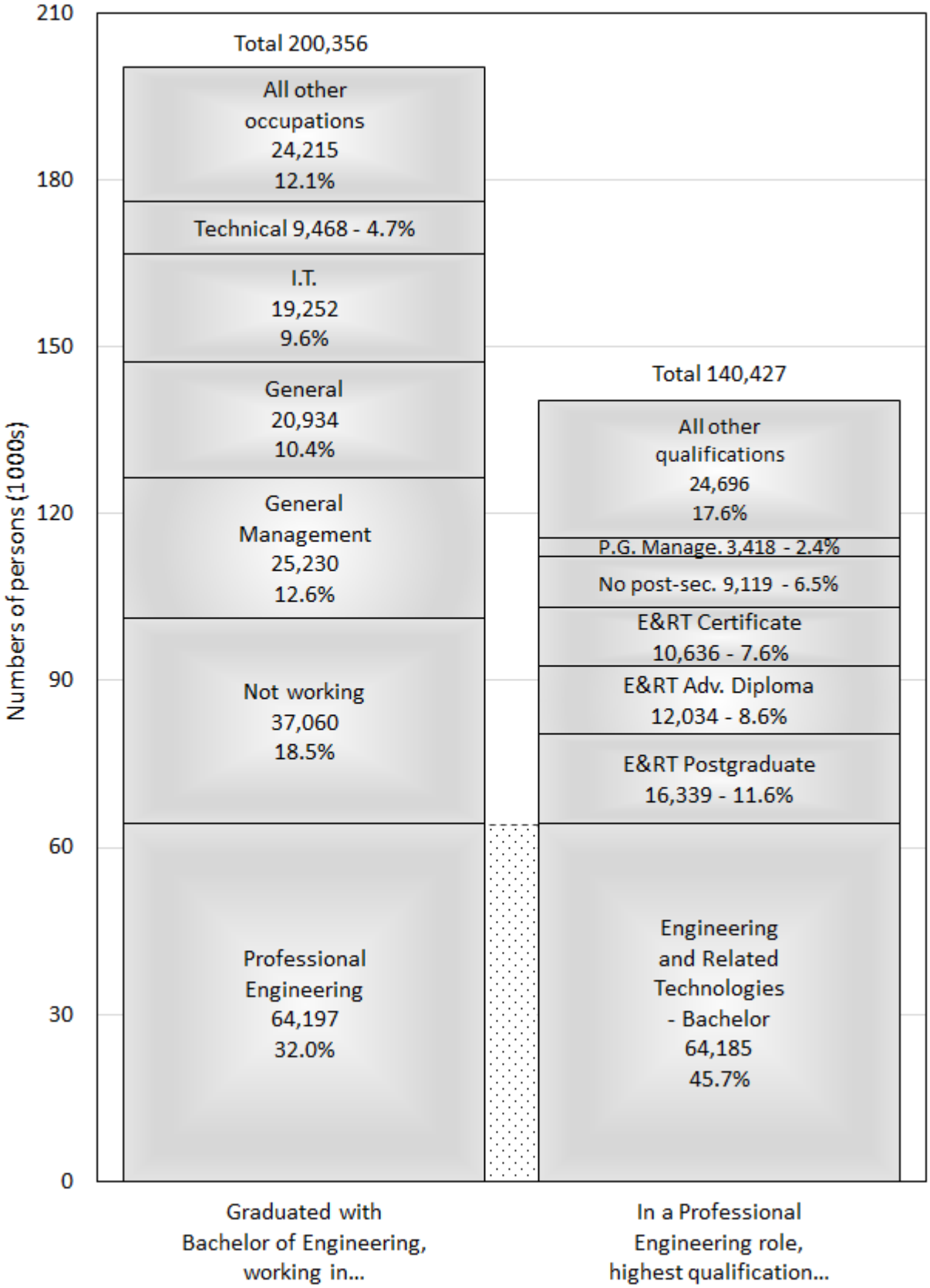


Figure 1. Summary of engineering qualification and occupation data from the 2011 Australian census.

In Australia, approximately 40 per cent of professional engineering roles are filled by people without at least a bachelor of engineering qualification. Lucena (2003) notes that perceived deficiencies in the management

skills of some engineers may be responsible for non-engineers in engineering management roles. More generally, Lucena (2003) observes that, in the US, competition may drive organisations to recruit on the basis of demonstrated skills rather than formal qualifications. In jurisdictions where an engineering bachelor degree is not a mandatory requirement for working in a professional engineering occupation then this option is open to employers. In Australia, when demand for skilled professional engineering employees outstrips those locally available, skilled migration (both temporary and permanent) is often used to meet this demand (Australian Workforce and Productivity Agency, 2014). As in the US, it is also possible that demand and competition for engineering skills drives the employment of non-engineers in professional engineering occupations.

Figure 1 indicates that, even allowing for the significant group of graduates not currently working, the number of Australians holding a bachelor of engineering qualification exceeds the number of people reporting working in a professional engineering occupation. Once the significant proportion of non-engineers currently filling professional engineering roles is considered, it is clear that it is a fundamental structural feature of the Australian employment market that many bachelor of engineering graduates will have to find employment outside of engineering if they wish to have a job. As noted above, some investigations of the engineering workforce describe engineering graduates working out of field as problematic (Australian Workforce and Productivity Agency, 2014; Lavoie & Finnie, 1998; Roberts, 2002). Other investigations don't appear to even countenance the possibility of bachelor of engineering graduates working outside of engineering. Romer (2001) presents a detailed analysis of the US job market for engineers and scientists that includes a schematic model of education pathways and work types (p. 236), and which provides no options for completing undergraduates other than graduate studies or employment in private sector research and development. Such a view is congruent with the dominant 'pipeline' model of engineering workforce development (Australian Workforce and Productivity Agency, 2014; Bhattacharjee, 2009) – where students study STEM subjects in school, study engineering at university and then work in a professional engineering occupation. However, there is a growing view that the pipeline model doesn't represent the reality of engineering workforce development, and its assumptions about student intentions and where people enter and exit need to be re-thought (Lucena, 2003; Mellors-Bourne, Connor, & Jackson, 2011).

A number of investigations have found that many students are not presuming a long-term career in engineering, and may hold only vague, or even no specific, career plans. Mellors-Bourne et al. (2011) surveyed 7000 UK STEM students and found that only 63 per cent of final-year engineering students definitely wanted a career in engineering. A survey of Australian engineering graduates found that, "Given the opportunity, most respondents would choose engineering studies again, however many were equivocal about staying in engineering in the medium to long-term." (Department of Education Employment and Workplace Relations, 2009, p. 24) Nearly half of the respondents saw themselves remaining in engineering for less than ten years. Benderly (2015) reports that around 25 per cent of new US engineering graduates were considering careers outside of engineering. Investigating engineering graduate unemployment in the UK, Atkinson and Pennington (2012) noted the emerging view that not all students studying STEM intend to work in STEM, and their advice to universities from employers included "Developing curricula to better reflect the realities of an engineering career" (p 13).

Robst (2007) observes that, while some view graduates working in jobs for which they are 'overeducated' as a labour market inefficiency, there is also a view that this is actually a feature of an efficient labour market, where the qualification plus, "[t]he training and experience gained through that position enables the person to find a better job." (p. 398) Submissions to a recent engineering workforce study in Australia noted that even where engineering graduates work out of their discipline, they, "… will continue to bring 'engineering perspectives and approaches to their work'."; that, "… the wide range of employment opportunities should be 'celebrated'."; and that, "… wherever they work, engineers will contribute their skills to benefit Australian business and the economy." (Australian Workforce and Productivity Agency, 2014, p. 94) Mellors-Bourne et al. (2011) observe that, in UK secondary education, the 'broadening' career benefit of studying STEM subjects is recognised in policy, and the full range of jobs open to STEM graduates, both in the STEM and non-STEM sectors, should be more widely acknowledged in higher education, and should be a key element of careers advice provided to students prior to higher and further education.

As noted above, industry advisory boards are generally viewed as an important mechanism for ensuring the relevance of engineering program curricula. Genheimer (2007) found limited research into the operation of engineering program IABs. Trevelyan and Tilli (2010) observe that the engineering school IABs that provide input to course curricula (and other matters) are typically comprised of representatives from traditional engineering industries. They note that the significant proportion of Australian engineering graduates employed outside of engineering has implications for the representation on IABs - "Given that so many graduates are employed outside engineering and related occupations, one can ask whether other employer groups should be represented ...") (p. 114). If authenticity in undergraduate engineering curriculum is one of the goals of an IAB, then the authenticity of the representation on the IAB of likely industries in which graduates of the program will work should be considered.

Parker (2004) notes:

> At the end of the 20th century, engineering practice was challenged by a proliferation of occupations requiring technical education; by rapidly changing technological advances; and by a perennial—if not heightened—concern with the relationship between engineering degree programs and occupational outcomes. (p. xviii)

Historically, in many countries, a bachelor of engineering has been the foundation for a range of well-paid careers, both within and beyond professional engineering. However, engineering education is comparatively expensive (Beanland & Hadgraft, 2013), so a potentially inefficient way to prepare graduates for some careers outside of engineering. As long as there are professional engineering roles to fill, there will be demand for bachelor of engineering graduates. However, with increasing demand and competition for STEM expertise from the non-engineering and non-STEM sectors of the economy (Bhattacharjee, 2009; Mellors-Bourne et al., 2011), it is possible that some other existing or new technology-related undergraduate program(s) might challenge undergraduate engineering programs in these graduate employment markets. Perhaps there will be a shift to engineering science or engineering technology qualifications that provide graduates with the traditionally valued general engineering skillsets more efficiently to build expertise that can service the non-engineering market needs and prepare students for the full range of career possibilities.

6 Conclusion

In Australia, as in many other countries, the stock and flow of human resources in the professional engineering workforce is complex. Using Australian national census data we find that the majority of people holding a bachelor of engineering degree do not work in a professional engineering occupation, and, that more than 40 per cent of the people working in a professional engineering occupation do not hold a bachelor degree or higher in engineering. In Australia, both the attractiveness of career options outside of professional engineering that use and value engineering and STEM skills, and the lack of legal protection for the occupational title of engineer are likely to contribute to these findings. While there are often calls for undergraduate engineering curricula to more authentically reflect the real world of engineering practice, such conceptions of authenticity generally do not reflect a reality where graduates are as likely to work outside of professional engineering as in it. A key reference point for curriculum design is often an industry advisory board. However, the composition of IABs typically does not reflect the likely full range of employers of bachelor of engineering graduates.

It is apparent that existing models of engineering education actually suit many employers, both STEM and non-STEM, and wholesale curriculum change is likely to be a disproportionate response to acknowledging the full spectrum of engineering careers beyond the traditional confines of the profession – to employ the apocryphal engineering maxim, "if it ain't broke, don't fix it." Additionally, undergraduate bachelor of engineering programs are typically accredited by the national engineering professional body, and dramatic curriculum revisions are unlikely to be approved for re-accreditation. However, as well as traditional engineering employers and the professional body, engineering students are also important stakeholders in curriculum design and program employment outcomes. Students – both those considering engineering study, and those currently enrolled in undergraduate engineering programs – would be better informed about, and equipped

for, the world of post-graduation work if they were exposed to the likely options for their career trajectory, as confirmed by this research. An authentic undergraduate curriculum would certainly incorporate and reflect the complex reality of the real world of professional engineering practice, the makeup of the engineering workforce, and the wide range of employment opportunities for engineering graduates in Australia.

7 References

Atkinson, H., & Pennington, M. (2012). Unemployment of engineering graduates: the key issues. *Engineering Education, 7*(2), 7-15. doi:10.11120/ened.2012.07020007

Australian Bureau of Statistics. (2015). Census TableBuilder. Retrieved from http://www.abs.gov.au/websitedbs/censushome.nsf/home/tablebuilder?opendocument&navpos=240

Australian Workforce and Productivity Agency. (2014). *Engineering workforce study*. Canberra: Commonwealth of Australia.

Bailyn, L., & Lynch, J. T. (1983). Engineering as a Life-Long Career: Its Meaning, Its Satisfactions, Its Difficulties. *Journal of Occupational Behaviour, 4*(4), 263-283. Retrieved from http://www.jstor.org/stable/3000315

Beanland, D., & Hadgraft, R. (2013). *Engineering Education: Transformation and Innovation*. Melbourne: RMIT University Press.

Benderly, B. L. (2015). Checkered Careers. *ASEE Prism, Online*(January), http://www.asee-prism.org/checkered-careers-jan/.

Bhattacharjee, Y. (2009). Study Finds Science Pipeline Strong, But Losing Top Students. *Science, 326*(5953), 654. doi:10.1126/science.326_654a

Choy, S. P., & Bradburn, E. M. (2008). *Ten Years after College: Comparing the Employment Experiences of 1992-93 Bachelor's Degree Recipients with Academic and Career-Oriented Majors. Postsecondary Education Descriptive Analysis Report. NCES 2008-155*. Washington DC: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education.

Department of Education Employment and Workplace Relations. (2009). *Labour Market Outcomes and Experiences of Recent Engineering Graduates*. Canberra, ACT: Department of Education Employment and Workplace Relations.

Didier, C. (1999). Engineering ethics in France: a historical perspective. *Technology in Society, 21*(4), 471-486. doi:http://dx.doi.org/10.1016/S0160-791X(99)00029-9

Dym, C. L., Agogino, A. M., Eris, O., Frey, D. D., & Leifer, L. J. (2005). Engineering Design Thinking, Teaching, and Learning. *Journal of Engineering Education, 94*(1), 103-120. doi:10.1002/j.2168-9830.2005.tb00832.x

European Council of Civil Engineers. (2005). *Civil Engineering Profession in Europe*. Athens: European Council of Civil Engineers.

Genheimer, S. R. (2007). *The Effectiveness of Industry Advisory Boards in Engineering Education.* (PhD), University of Oklahoma, Normanm, Oklahoma.

Landivar, L. C. (2013). *The Relationship Between Science and Engineering Education and Employment in STEM Occupations*. Washington: United States Census Bureau.

Lavoie, M., & Finnie, R. (1998). The occupational dynamics of recent Canadian engineering graduates inside and outside the bounds of technology. *Research Policy, 27*(2), 143-158. doi:http://dx.doi.org/10.1016/S0048-7333(98)00027-4

Lucena, J. (2003, 22-25 June). *Career Paths Of Non Engineers Into Engineering Practice In The Midst Of Globalization: Implications For Engineering Education.* Paper presented at the ASEE Annual Conference, Nashville, Tennessee.

Mellors-Bourne, R., Connor, H., & Jackson, C. (2011). *STEM graduates in Non STEM Jobs*. London: Department for Business, Innovation and Skills.

Palmer, S., Tolson, M., Young, K., & Campbell, M. (in press). The relationship between engineering bachelor qualifications and occupational status in Australia. *Australasian Journal of Engineering Education*, 1-10. doi:10.1080/22054952.2015.1092666

Parker, L. (2004). *Engineers in the United States: An overview of the profession*. Cambridge MA: Abt Associates Inc., for the National Science Foundation.

Roberts, G. G. (2002). *SET for success: the supply of people with science, technology, engineering and mathematics skills: the report of Sir Gareth Roberts' review*. London: Department of Trade and Industry and Department for Education and Skills.

Robst, J. (2007). Education and job match: The relatedness of college major and work. *Economics of Education Review, 26*(4), 397-407. doi:http://dx.doi.org/10.1016/j.econedurev.2006.08.003

Romer, P. M. (2001). Should the government subsidize supply or demand in the market for scientists and engineers? *Innovation Policy and the Economy, Volume 1* (pp. 221-252): MIT Press.

Spinden, P. M. (2014). The Enigma of Engineering's Industrial Exemption to Licensure: The Exception That Swallowed a Profession. *University of Missouri-Kansas City Law Review, 83*, 637-686.

Trevelyan, J., & Tilli, S. (2010). Labour force outcomes for engineering graduates in Australia. *Australasian Journal of Engineering Education, 16*(2), 101-122.

Using the Flipped Classroom Approach in Engineering Courses to improve Student Motivation and Learning Outcomes

Terry Lucke[1], Michael F. Christie[2]

[1] School of Engineering, University of the Sunshine Coast, Sippy Downs, Queensland, Australia.
[2] School of Education, University of the Sunshine Coast, Sippy Downs, Queensland, Australia.

Email: tlucke@usc.edu.au, mchristi@usc.edu.au

Abstract

Engineering students will approach their learning differently depending on the pedagogical models that their lecturers use. Lecturers who rely on one-way communication in lectures and tutorials, and test for declarative knowledge in end-of-course, closed-book exams tend to encourage students to take a surface or passive approach to learning. Those who require their students to actively participate in lectures and tutorials and problem solving projects, and who test students' deep understanding of the topic via exercises, quizzes and continuous and authentic assessment tasks, help instil a deep and active approach to learning (Biggs, 1999). One emerging pedagogical model that has been shown to successfully encourage a deep approach to learning and improved learning outcomes is the "Flipped Classroom" approach. This study investigated whether or not the flipped classroom model can be used to improve student motivation, engagement and learning outcomes for a group of second year engineering students in Fluid Mechanics course (n=66). A variety of techniques were used in the study to evaluate the effectiveness of the new flipped classroom teaching model. This paper defines what is meant by the "Flipped Classroom" approach, critiques some of its more ambitious claims, places it within the context of Project and Problem based learning pedagogies and provides a longitudinal case study to show some of the strengths and weaknesses of this emerging pedagogy. It does this by presenting the evaluation results from three different student cohorts studied over the last three years. The case study can be defined as a modified action research project in that the deliberate use of a flipped classroom approach was planned, discussed within a community of practice, trialled with an initial group of students and then the results of the intervention critically and reflectively analysed. Using this methodology three cycles of research were carried out.

Keywords: Ethical dilemmas in Engineering Education; Project management; Critical Incident Technique.

1 Introduction

In 2013 a modified action research project was begun in order to analyse the effectiveness of an emerging pedagogical model, currently called 'The Flipped Classroom'. This model is one of the more recent student centred initiatives that have gained acceptance in Engineering Education since the latter part of the 20th Century. The action research is on-going and now into a fourth cycle. Modifications have been made with each new intake of students and data continues to accumulate in the online learning management system that is used as one of the supports for this educational reform. The project focuses on a major modification that had been carried out in a second year engineering Fluid Mechanics course, in a small regional university in Queensland, Australia. In an earlier paper (Lucke and Christie, 2015) the authors explained how learning analytics could be best used to evaluate whether or not flipping the classroom could effectively motivate students to take a deep approach to their learning and in doing so improve their learning outcomes. Learning analytics is defined in general terms by George Siemens as the "use of intelligent data, learner-produced data, and analysis models to discover information and social connections, and to predict and advise on learning" (Siemens, 2005). In the second cycle of the project the first author used a new type of classroom response system (CRS) called Learning Catalytics (https://learningcatalytics.com/) which produced intelligent data from the online repository of pre-class, online exercises as well as mobile devices used in the classroom. The use of this system helped to produce more data about the pedagogical results that can accrue from 'Flipping the Classroom'. The most significant innovation in this new approach to teaching and learning is to systematize a change to the traditional lecture and tutorial/lab format that has characterized Engineering Education since it was first introduced into military academies in the UK and US in the early 19th Century. Good lecturers have

always urged their students to do their pre-reading so that they could get the most out of the lectures and be prepared to ask questions. This was also the case for tutorial or exercise work, but when students failed to do their homework lectures tended to consist of one way communication and tutorials often became mini lectures. The flipped classroom has many variations but in our case eLectures with accompanying exercises were put on line and the lecture was transformed into a series of active learning exercises where interaction became inevitable as groups competed with each other to assess the worth of the individual online answers and agree on solutions that were then be posted on screens at the front of a room. Instead of a traditional lecture theatre with a lectern and a semi circle of tiered, individual seats, the lecturer used a customized room that contained tables equipped with plugs for computers and wireless internet access that allowed students to send information from their laptops and mobile devices to large screens via the Learning Catalytics system.

In another paper from the 2015 PAEE conference Tavares and de Campos analyse an attempt to introduce a flipped classroom approach for by a Brazilian university engineering program. They admit that the experiment was not successful in its aim to provide evidence that this approach leads to better assessment results it did demonstrate a shift in attitudes and opinions regarding traditional forms of engineering education and opened the minds of both lecturers and students to an alternative and more interactive form of teaching and learning (van Hattum-Janssen et alia, 2015). Our action research project has been confined to one course rather than a whole curriculum and has had the advantage of an excellent online learning system and media-centre for posting interactive exercises and online lectures as well as a sophisticated classroom response system. Bishop and Verleger (2013) undertook a comprehensive survey of prior and ongoing research of the flipped classroom and concluded that it was very difficult to objectively show a connection between the use of the flipped classroom and improved learning outcomes. They recommend using controlled experimental or quasi-experimental designs, a point that we debate in our concluding section.

2 Methodology

Our investigation is best defined as a modified form of educational action research that is grounded in the philosophy of John Dewey (1916), that adheres to the action research principles of Kurt Lewin (1946), and follows the main methodological recommendations of Carr and Kemmis (1983). Kemmis and McTaggart (1988) subsequently developed a model of participatory action research but because we involve the students as informants rather than collaborators our research does not qualify for this category of action research. The intention of all action research is to make changes for the better. In this sense it is both partisan and transformative (Mezirow, 1991). Our intention was to help ourselves and our students become better learners. Since 1988 action research has become more and more relevant to educational improvement. The publication of a number of recent books and new editions (Spaulding & Falco, 2013 and McNiff, 3rd edition 2013) encourage teachers at all levels to instigate their own research as a way of improving the learning outcomes of their students. Action research involves a spiral process of planning, acting (implementing change), observing, analysing, reflecting and then evaluating. This completes one full cycle, which generally raises other issues that will be researched and acted upon in a new cycle. Our research into the educational value of the flipped classroom in fluid dynamics teaching began in 2013 and has undergone three cycles or iterations (2013, 2014 and 2015).

In our case the principal intervention has been to change the format from a traditional lecture plus tutorial/lab to a flipped classroom approach which involves "an educational technique that consists of two parts: interactive group learning activities inside the classroom, and direct computer-based individual instruction outside the classroom" (Bishop and Verleger, 2013). A typical online question is given below in figure 1.

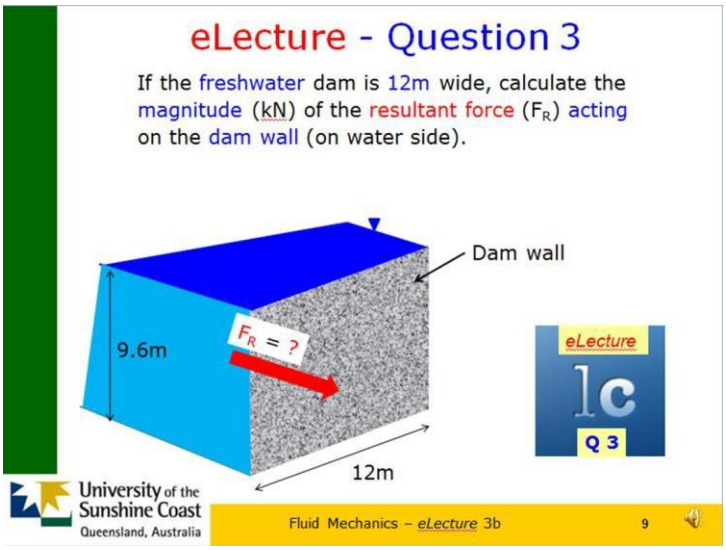


Figure 1 - Typical eLecture question (source: authors).

The students solved the questions and then submitted their answers on the website using their home computer or mobile devices (for example phones, tablets and laptops). There are, on average between 50 and 65 students in the second year fluid dynamics course which is the focus of this study and which takes place during the first semester (early March to late June). During the first cycle of this project in 2013 the lecturer made use of the university's learning management system (BlackBoard) which embodied synchronous and asynchronous tools such as Mediasite and Discussion Boards to provide online individual instruction and assessment outside of class time. In the first iteration (2013) he used a CRS called TopHat for the interactive sessions in class time. Students worked through narrated, weekly online lecture material (eLectures) prior to attending face-to-face class (workshop) sessions. The eLectures were recorded as Mediasite (http://www.sonicfoundry.com/mediasite) presentations and students viewed the eLectures through this online forum. The workshop sessions were then used to foster student engagement by working through typical problems, providing feedback, introducing advanced concepts, and facilitating student discussions and other collaborative learning activities (Lucke and Christie, 2015: Toto & Nguyen, 2009; Tucker, 2012). The eLectures were available one week before the workshop sessions and they were disabled again approximately two hours before the workshop sessions were scheduled to commence. This allowed students time to be able to absorb and process the information needed before it was be applied (Toto & Nguyen, 2009).

In the first iteration the student response questions were graded to encourage them to utilise and engage with the eLectures. The assessment schedule, designed in the first iteration of the action research project (2013), was as follows: 40% of their final mark was based on the online exercises, 20% was accorded for four reports of lab work (4x5% each) and 40% was for two in-class exams that were worth 20% respectively. The 40% for the online work was composed of 10% for the answers that followed questions attached to the eLecture material, 20% for the 'tutorial' quizzes and 10% for questions posed in the workshops. As a result of weaknesses in the TopHat CRS system, based on some of the data collection evidence mentioned below, the system was changed for the 2014 iteration. The Learning Catalytics system was chosen and has been used ever since.

3 Methods

Data was collected using mixed methods. Quantitative data was collected from an analysis of the online systems which allowed the lecturer/researcher to determine the amount of time that students spent on task, including viewing activity for each eLecture throughout the course. Figure 2 below provides an example of the type of informative graph that could be generated.

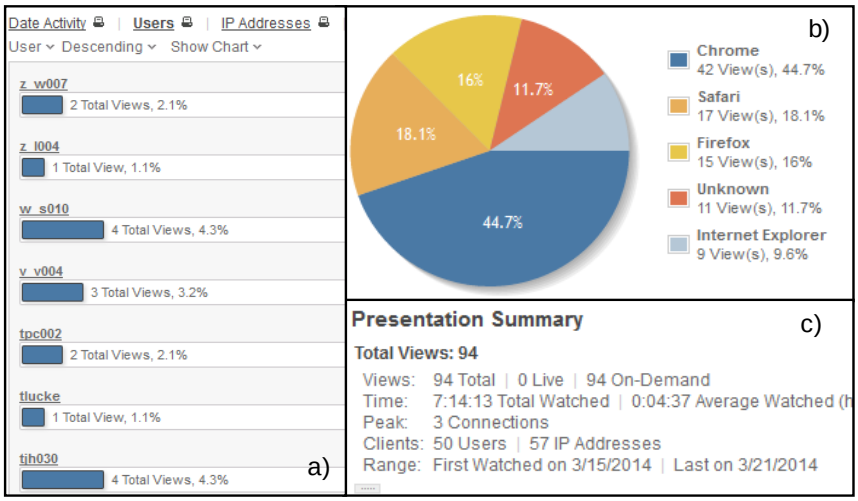


Figure 2: Various Mediasite Statistics Presentation Options: a) Views by User b) Platforms c) Viewing Summary.

The lecturer used classroom observations, student surveys, the standard end-of-year, online student evaluation reports (SETAC) for the course and unsolicited email responses from students to gather qualitative data. He ensure more objectivity and promote critical, analytical reflection at the end of each cycle of the action research project the author/researcher also made use of critical friends and a community of practice or COP (Wagner, 1996 & 1998). The COP was established by the university's Teaching and Learning Centre to assist staff interested in engaging with flipped classroom practice. Key insights that evolved in the reflective phase of each cycle are given in the results section below. Quantitative data from learning analytics was also analysed In an attempt to gauge whether or not the intervention had an effect on improving students' learning approach and understanding of the course material. The student's grade point average (GPA) was compared at the beginning and end of the course (see McKay et al., 2012); the amount of time a student spent studying the online material was compared with the student's total exam mark (/30) for that assessment item; the amount of time spent studying the online material before the two in-class exams (/50) and the total exam mark for that part of the assessment was also compared. The laboratory reports (/20) were not taken into account.

4 Results

The analysis of the learning catalytics as they applied to improved changes in grade point averages proved to be inconclusive. For more detail regarding the specific detail about our attempt to find clear evidence regarding the effect of flipping the classroom on improvements to grade point averages, it is best to refer to an earlier paper presented at the 2014 AAEE conference in Wellington New Zealand (Lucke, 2014). It was clear during this first cycle of action research cycle that the number of variables involved in the study would make it impossible to establish a causal link between the use of the flipped classroom approach and improvements in grades. Bishop and Verleger (2013) recommend a controlled experiment in order to discover such a connection and praise the study carried out by Day and Foley in which they compared two concurrent versions of a course and matched sections on topics, assignments, and time on task. Their study claimed that students in their experimental cohort, who studied in a flipped classroom environment, scored significantly higher on all homework assignments, projects, and tests. It is our considered opinion however, that, admirable though it is, such an experiment is unscientific, since it deals with different groups of human beings, learning in different places, at different times and with different approaches. Having come to this conclusion during the first iteration of our action research project we decided to concentrate instead on how the effect the flipped classroom intervention had on students motivation, approach to learning and their perception of how well they understood and could apply the course material after their flipped classroom experience.

The qualitative data was more unequivocal. For a clear majority of the students, flipping the classroom was seen as an overwhelming positive experience. Detailed data to support this conclusion has been presented in

the 2014 AAEE paper mentioned above. Evaluation results demonstrated that the new flipped lecture and CRS teaching format produced a substantial increase in the level of student engagement, motivation and attendance compared to previous cohorts (Toto & Nguyen, 2009; Demetry, 2010; Bakrania, 2012). As was pointed out in the 2014 paper, although the final student grades for the 2013 cohort were slightly higher than in previous years, this result was thought to be more due to the relatively high marks allocated to the CRS assessment questions (40% of final grade) than due to the results of implementing an effective flipped learning model. Students often worked in groups to solve their CRS questions and this probably increased the collective average student grades. New weightings for the course assessment items based on the online material were introduced in 2014 to try to reduce that effect. The worth of the online and interactive in class questions was reduced to 30% and the closed exam increased to 2x25% or 50%.

At end of the 2014 cycle it became evident that a reason why the students were doing better in their online section of the course was the possibility that there could be some collusion between groups of students who were perverting the formative learning intention of the individual quizzes and eLecture questions. For the 2015 cycle it was decided to monitor this during 2015 and unfortunately a form of cheating was discovered. The automated quizzes and questions provide feedback information about a student's answer once it was submitted by showing how the question should be answered correctly. If this information was shared with a group the individual might fail but the whole group could quickly and correctly do the online work. The group draw straws to decide who would take on the role of sacrificial lamb with each of the questions. This was a disappointing discovery and in the coming iteration (2016) of this longitudinal study no answers will be made available until the due date has been reached and the particular quiz or question closed.

5 Conclusion

The most important conclusion to draw from this study is there are positive benefits for university teaching and learning, and, in particular, Engineering Education, if lecturers are willing to engage in analytical and critical reflection on their teaching practice. To do so in a scholarly manner, using a simple methodology such as educational action research, benefits both teachers and students and provides important insights into the nature and purpose of Engineering Education itself. Ours is a profession where the quality of a graduate's attitudes, knowledge and skills and the ability to apply them in diverse social and cultural settings could be a matter of life or death. We have an obligation to know our students and what they know and can do. Three years of trialling the flipped classroom approach has demonstrated that making lectures more interactive and providing the students a chance to discuss and improve their knowledge and understanding during class time, rather than sitting passively in a lecture, is a very positive, pedagogical improvement. Unfortunately it has also revealed that it is very difficult to prove that one approach is more effective in raising grade point averages than another. To compound the matter higher education, seen through the student's eyes, is primarily a means to gain a qualification that will enable them to become a member of a profession. Students will take different approaches to their learning in such a situation. Because it is a graded system assessment becomes paramount. We have seen, from our own study, that even when provided with an opportunity to take a deep approach, receive formative feedback, learn in a way that fits an engineering ethos wherein problems are solved in conjunction with others, there is always the temptation to take a short cut. The dilemma we are left with in Engineering Education is how to encourage a deep approach to learning in our students but at the same time ensure that the less scrupulous do not succumb to the temptation of subverting the sort of teaching, learning and assessment that will inculcate the attitudes, knowledge and skills needed in an ethical, competent 21st century Engineer.

6 References

Biggs, J. (1987). Student Approaches to Learning and Studying," Melbourne: Australian Council for Educational Research. Available at: http://files.eric.ed.gov/fulltext/ED308201.pdf

Biggs, J. (1999) Teaching for Quality Learning at University. Buckingham, UK: SRHE and Open University Press.

Brown, M. (2012). Learning Analytics: Moving from Concept to Practice. ELI Briefs, EDUCAUSE Learning Initiative (ELI), 2012, available at: ttp://net.educause.edu/ir/library/pdf/ELIB1203.pdf

Day, J. & Foley, J. (2006). Evaluating a web lecture intervention in a human–computer interaction course. *IEEE Transactions on Education*, 49(4):420–431, 2006.

Demetry, C. (2010). An innovation merging "classroom flip" and team-based learning." *40th ASEE/IEEE Frontiers in Education Conference,* October 27-30, 2010, Washington, DC.

Elliot, A.J., McGregor, H.A. & Gable, S. (1999). Achievement goals, study strategies, and exam performance: A mediational analysis. Journal of Educational Psychology, 91(3), 549-563.

Harackiewicz, J.M., Barron, K.E., Tauer, J.M. & Elliot, A.J. (2002) Predicting success in college: A longitudinal study of achievement goals and ability measures as predictors of interest and performance from freshman year through graduation. Journal of Educat. Psych., 94(3), 562-575.

Kemmis, S. & McTaggart, R. (Eds.), (1988). The Action Research Planner. 2nd ed. Deakin University Press, Geelong.

Kennedy, G., Dalgarno, B., Bennett, S., Gray, K., Judd, T., Waycott, J., Chang, R., Bishop, A., Maton, K. & Krause, K-L. (2009). Educating the Net Generation: Implications for Learning and Teaching in Australian Universities: Final Report. ALTC.

Koehler, M. J., & Mishra, P. (2009). What is technological pedagogical content knowledge? Contemporary Issues in Technology and Teacher Education, 9(1), 60-70

Lewin, K. (1946). 'Action research and minority problems' Journal of Social Issues, 2(4), 34-46.

Lucke, T. (2014). Using learning analytics to evaluate the effectiveness of the flipped classroom approach. Proceedings of the AAEE conference, Wellington, New Zealand, 8-10 December 2014.

(Marton, F. & Säljö, R. (1976). On qualitative differences in learning. 1 – outcome and process. British Journal of Educational Psychology, 46, 4–11.

McNiff, J. (2013) Action research: Principles and practice (3rd edition) Abington: Routledge.

Mezirow, J (1991) Transformative Dimensions of Adult Learning. San Francisco: Jossey and Bass.

Punch, K. (2009). *Introduction to research methods in education*. New Delhi: Sage Publications.

Siemens, George. "What Are Learning Analytics?" Elearnspace, August 25, 2010. Retrieved from the following source on 23 February 2016: http://www.elearnspace.org/blog/2010/08/25/what-are-learning-analytics/

Toto, R. & Nguyen, H. (2009). Flipping the Work Design in an Industrial Engineering Course. 39th ASEE/IEEE Frontiers in Education Conference, October 18 - 21, 2009, San Antonio, TX.

Tucker, B. (2012). The Flipped Classroom-Online instruction at home frees class time for learning. Available at: http://educationnext.org/files/ednext_20121_BTucker.pdf

van Hattum-Janssen, N., Lima, R. M., Carvalho, D., Fernandes, S., M. Sousa, R., Moreira, F., ... Mesquita, . D. (Eds.) (2015). *Proceedings of Seventh International Symposium on Project Approaches in Engineering*. *Education*. Aalborg Universitetsforlag

Wenger, E. (1996). How we learn. Communities of practice. The social fabric of a learning organization. *Healthcare Forum Journal* 39:20-26.

Wenger, E. (1998) *Communities of Practice: Learning, Meaning, and Identity*. NewYork: Cambridge University Press;

Applying Problem-Based Learning in Laboratory Education

Nele Rumler[1], Susanne Staude[1]

[1] Institute for Energy Systems and Energy Business, Ruhr West University of Applied Sciences (GERMANY)

Email: nele.rumler@hs-ruhrwest.de; susanne.staude@hs-ruhrwest.de

Abstract

Thermodynamics is one of the core modules of mechanical and energy engineering degrees, dealing with very abstract concepts. A previous study revealed that more real-life problems should be integrated into the thermodynamics module to bridge the gap between theory and practical application. To do so, a laboratory session has been redesigned, using a problem-based approach. So far, experiments have been done at laboratory set-ups, guided by detailed instruction. A laboratory session has been redesigned in two different ways, both following a problem-based approach to engage students in learning. One half of the students got a real-life problem concerning the cooling system of a meeting room in the university. The other half of the students had to solve a problem by designing their own experiment. Two methods were used to evaluate the impact of these changes: Firstly, observations were made during the laboratory sessions. Secondly, questionnaires were developed to measure the impact on student's motivation and to find out more about the general motivation and learning personality of students. These were distributed at three different points in time and in three different study groups. The data from the questionnaires did not show a correlation between the learning personality of the students and their appraisal of the laboratory session. An effect on motivation could also not be shown. However, the observations during the laboratory sessions suggest that the new approaches were successful in engaging the students better in the laboratory tasks and there was more collaboration. With the new designs we could achieve our most important goal: leading students towards a working methodology of engineers.

Keywords: PBL; laboratory education; student engagement.

1 Introduction

Laboratory education is an integral part of all engineering degrees. Usually, it aims to show the students how theory is applied to the physical world, therefore hopes to assist the transfer from theoretical to real-life problems. However, often the laboratory set-up itself is more or less removed from a real-life situation: The equipment may be specifically designed for teaching, resulting in a less complex system. Even though this may be helpful for demonstrating purposes, it is not a realistic simulation of a possible real-life situation. As a result, students often fail to see the practical relevance of the given subject; this is especially true for fundamental subjects such as mechanics or thermodynamics. In addition, with these traditional, rather rigid laboratory set-ups students have very little freedom for "real" experimenting, i.e. trying things (and maybe even making mistakes to learn from them). Furthermore, in order to understand the relation between theory and real-life problem, reflection is needed. But Gunstone indicates an obstacle to this: *"In particular, the tasks of assembling apparatus and making required measurements can themselves become the prime, or even sole, focus for student actions. In these circumstances, student reflection on the nature and implications of the observations is extremely rare" (Gunstone, 1990, p. 74)*. And even though this publication is over twenty years old by now, it still holds true, because Sunal et al. found out that laboratory materials and exercises *"are still centred on traditional methods of the past decades"* (Sunal, Wright, & Sundberg, 2008, p. 18). Their advice is to restructure laboratory education from the "cookbook" nature into more inquiry-oriented investigations (*ibid.*).

Previous work on improving student learning in a thermodynamics module by the authors (Gerber, Rumler, & Staude, 2014) has shown that regular formative feedback should be planned in the course of a module. Otherwise students tend to overestimate their level of competence and fail to work sufficiently during the course of the semester and prior to the exam. In addition, it was found that more real-life problems should be integrated into the module to bridge the gap between theory and practical application.

This paper describes the changes that were made as a result to the laboratory sessions. The objective of this work was to improve the overall student learning in laboratory education. The aim was to increase the motivation of the students both for the laboratory itself as well as for the subject of the module. This was to be achieved by setting more realistic and interesting tasks and using a problem-based approach. With problem-based learning realistic tasks can be integrated in the education and the social-communicative and the technical-methodical competence is being supported (Dreher, 2012). In addition, a more open lab helps to teach students typical engineering skills like designing experiments and interpreting data (Shuman & Mason, 2012).

To evaluate the new approaches a longitudinal study was carried out at three different points in time during the semester. For the study, questionnaires were used which covered different aspects of motivation. They were distributed in one test group and two control groups.

2 Methodology

The thermodynamics module is part of the mechanical engineering, energy and environmental engineering and industrial energy engineering degrees. In the latter two courses it is a first year module (second semester), whilst in the mechanical engineering degree it is a second year module (fourth semester). It was decided to introduce the modified laboratory session in the industrial energy engineering degree and to keep the laboratory unchanged in the other two degree courses. Thus two control groups with a traditional laboratory experience guided by detailed instructions were available for comparison.

2.1 Redesign of the laboratory sessions

First, the intended learning outcomes of the laboratory sessions had to be formulated. This was done using a similar approach as described in the previous work (Gerber et al., 2014). Thus, the intended learning outcomes include aspects of thermodynamic knowledge and methodology as well as self-conception and psychological resilience. The main learning outcomes for the laboratory sessions were defined as:

- The students can apply the main thermodynamic concepts (i.e. first law of thermodynamics, behaviour of ideal substances, etc.) to real life situations.
- The students can reduce complex real systems to idealized models by identifying the appropriate assumptions.
- The students use experiments in order to answer (their own) research questions.
- The students critically assess measured data.
- The students work effectively in teams.

Two different approaches were taken in the redesign of the laboratory sessions. One half of the students got a real-life problem concerning the energy supply system of the building. The other half of the students was given a simple research-type task, which required them to solve a problem by designing their own experiment, similar to (Shuman & Mason, 2012). In both cases the problem presented to the students was formulated in such a way, that the specific questions to be answered by the experiment had to be formulated by the students themselves.

Two different problems concerning the energy supply system of the building were given to the students: one was dealing with the cooling system of a meeting room in the university and one was dealing with the ventilation system of a laboratory. The students got a problem statement, some technical specifications about the systems, a temperature sensor and they could access the building's system data. They had to work in groups of 4 – 5 students. The actual laboratory session was planned for 90 min. To solve the problem the students researched the aspects they did not understand in the problem statement and made a technical sketch of the thermodynamic problem. After this they obtained the relevant data from the building system and by measurement. A supervisor was present but only gave some guidance when it was really needed.

The research tasks given to the students were the following: Is the specific heat capacity for water a good approximation when it is used for beer? What is the efficiency of a halogen underwater lamp? For both questions the students were given some background information as well as a list of laboratory equipment they

could use. Before they were allowed to set up an experiment, the students were required to explain their experiment to the supervisor. Both the necessary equipment as well as the planned methodology had to be explained.

2.2 Evaluation

With the study the following research questions should be answered:

- Is there a difference between the student groups of the three degree courses with respect to their academic motivation and their personality?
- Is the new laboratory session perceived differently by students with different characteristics?
- Could the newly designed laboratory session increase the intrinsic motivation of the students?

There are different theories about motivation. Of particular relevance for this study is the self-determination theory of Deci and Ryan (Ryan & Deci, 2000). They divide the academic motivation into intrinsic and extrinsic motivation, the latter having four different degrees. According to Schiefele and Streblow (2006) intrinsic motivation can be increased by supporting the perceived competence, the perceived choice, the relatedness and the usefulness and importance. The new laboratory session were designed in such a way that students are actively involved, to support the perceived competence and perceived choice. They work in teams to increase the relatedness and by using realistic tasks it was intended to support the perceived usefulness and importance.

In order to evaluate the success of these measures, questionnaires were developed for three different points in time. The first questionnaire was distributed in the first lecture and comprised questions about the academic motivation to find out if it differs between the three groups. The adapted version of the self-regulation questionnaire of Ryan and Connell developed by Müller, Hanfstingl and Andreitz (2007) was used. With this, the level of intrinsic motivation and three of the four degrees of extrinsic motivation can be evaluated. Furthermore, questions with regard to flow (adapted from Engeser & Rheinberg, 2008) and usefulness with respect to the thermodynamics module were asked. Flow is described as a state, where a person feels motivated, happy and is committed to a task without obvious external rewards. The second questionnaire was distributed after all groups had completed the first laboratory session. For the test group, this was the modified laboratory session. In this questionnaire the Gesis short scale for need for cognition (gesis, 2015), self-efficacy (gesis, 2012) and a short scale for assessing the big five dimensions of personality (Rammstedt, Kemper, Céline, Klein, & Kovaleva, 2013) have been used. Need for cognition describes the differences in engagement and joy about cognitive tasks. Self-efficacy refers to the perceived competence of a person to successfully accomplish an activity. Finally, questions concerning the usefulness, interest, relatedness and flow with respect to the laboratory session were asked. These latter were posed in the third questionnaire as well, which was distributed after all groups had completed the second laboratory session.

In total 255 questionnaires were filled out (see Table 1). As we were interested for some of the aspects in the development over time on an individual level a code was used to guarantee anonymity. It consisted of the last letter of the first name of the mother, the first and last letter of the birthplace and the day of birth (without month and year).

Table 1: Overview about answered questionnaires.

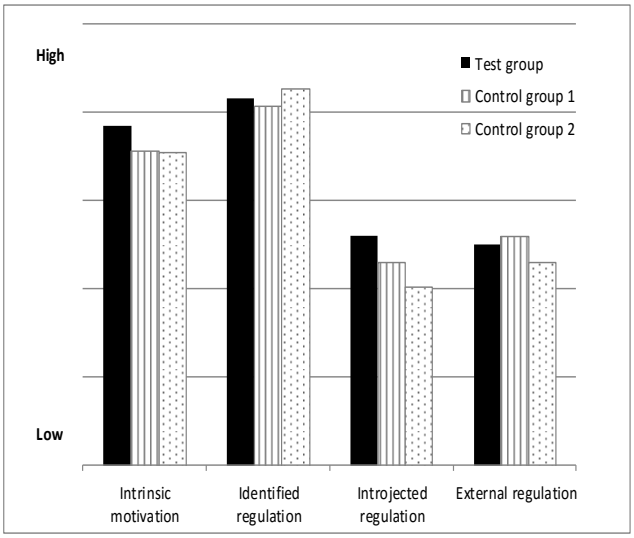
Point in time	Test group	Control group 1	Control group 2
t1	40	69	21
t2	22	20	20
t3	18	40	5

From the test group, only eight persons who filled the questionnaires at the second point in time, filled it also at the third point in time.

3 Results

3.1 Findings of the survey

The survey showed that our students are not motivated by an external reward or the avoidance of negative consequences, but are intrinsically motivated. Even more pronounced is the identified regulation, meaning that the students are motivated primarily because they see the personal relevance of their studies (see Figure 1). Figure 1 shows the big five traits of personality.



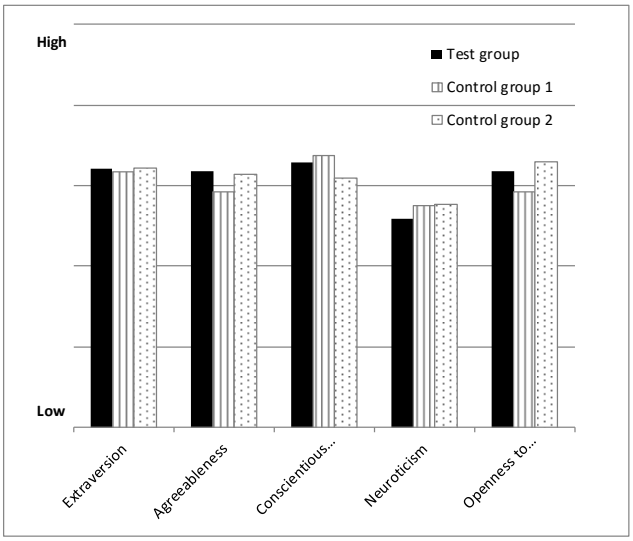


Figure 1: Academic motivation of the three study groups. Figure 2: Five dimensions of personality of the three study groups.

To determine whether the academic motivation differs between the three study groups a Kruskal-Wallis test for independent samples was conducted for the intrinsic motivation and three degrees of extrinsic motivation. No statistically significant difference was found. The same is true for the big five dimensions of personality (see Table 2).

Table 2: Results of the Kruskal-Wallis test for independent samples for the academic motivation and the Big Five dimensions of personality.

Variable		Statistical Significance
Academic motivation	Intrinsic motivation	0.105
	Identified regulation	0.637
	Introjected regulation	0.059
	External regulation	0.257
Big five dimensions of personality	Extraversion	0.961
	Agreeableness	0.840
	Conscientiousness	0.863
	Neuroticism	0.935
	Openness to experience	0.225

Next was analysed whether the new laboratory sessions are evaluated differently by students having high or low need for cognition, high or low self-efficacy and having a high or low fear of failure. As there was not one single item evaluating the laboratory session, an item analysis was done with the following five items: 1) The laboratory was fun, 2) I would like to do more such laboratories, 3) The laboratory provided interesting results, 4) To spend my time in the laboratory was meaningful, 5) Because of the laboratory I better understand the

theory from the lecture. It was found that the first four can be merged into one indicator, but the fifth one loads onto another factor. This new indicator for the evaluation of the laboratory was correlated to need for cognition, self-efficacy and fear of failure, but for none of them a statistically significant correlation was found (values for statistical significances 0.717, 0.463, 0.885).

To analyse whether the students perceived a difference in the two laboratory sessions the following items were analysed: 1) fun, 2) usefulness, 3) flow, 4) integration and 5) Would you like to do more laboratory session in your studies if time is provided. In Table 3 the mean values for the five items are listed. For the test group these were compared between the eight respondents who answered after both laboratory sessions. If all answered questionnaires are taken into consideration the trend in the difference between the mean values is the same compared to the eight respondents, only for the item fun it is slightly higher for the old laboratory design than for the new one. As the sample size of eight is very low, no significance test was conducted. But, as can be seen from the mean values, the difference in the evaluation of the new and old design is very small with the old design scoring slightly better.

Table 3: Mean values for the items fun, usefulness, flow, integration and more laboratories for all groups (scale: 1 "low" to 5 "high").

	Test group		Control group 1		Control group 2	
	New design	Old design	1st session	2nd session	1st session	2nd session
Sample size	8	8	20	40	20	5
Fun	3.5	3.25	3,5	2.98	3.05	3.0
Usefulness	2.8	3.3	3,37	3.48	3.77	3.87
Flow	3.63	3.81	3,7	3.64	3.69	3.25
Integration	3.88	3.92	3,53	3.38	3.78	3.87
More laboratories	3.5	3.63	3,25	2.93	2.85	3.0

3.2 Observations

For both new designs the supervisors of the laboratory sessions observed a more vivid discussion and more collaboration between students compared to traditional laboratory sessions.

As described before, some groups worked on two different tasks concerning a problem with the energy supply system of the building. For both tasks it was observed that students were first unsure how to deal with the new situation. In case of the problem concerning the decentralized cooling system of a meeting room, the students solved the problem without major problems after this first hesitation. However, in the case of the ventilation system, the students struggled even though the underlying thermodynamic problem was the same. They were clearly confused because of the more complex system, struggling to identify exactly which part of the system they needed to consider. The ventilation system has two separate heat exchangers, one for heating the air in winter and one for cooling the air in summer. Both groups struggled to work out that only ever one of those heat exchangers is active at any one time. This shows the difficulty and importance of designing a good problem. In this case the intended emphasis was on applying the student's new thermodynamic understanding. However, since they had not yet had enough practice in dealing with complex systems, their attention was diverted away from the thermodynamics and it is questionable whether the intended learning outcome was achieved.

The observations during the research-type lab showed a similar behaviour regarding the group dynamics and team work. Unlike during the more traditional labs, all students were actively taking part in the experiment. Particularly interesting was the resistance of all groups to actually plan and design their experiment before starting. Questions of the instructor were regularly needed to guide students to think about what they were

trying to achieve. The skills of phrasing a research question and also of questioning the measured data have yet to be developed. Hence, this type of lab is a very useful tool to train this and should be applied during the course of the studies more often.

4 Discussion and Conclusions

A problem of this study is the, in part, very small sample size. Because of this it was not meaningful to conduct a significance test for some of the analysed aspects. And even where it was done, care has to be taken when interpreting the results.

For the academic motivation and the five traits of personality of the three study groups no significant difference could be found. That indicates that the learning activities can be designed in the same way for the three study groups. Although no correlation between e.g. the self-efficacy and the evaluation of the new laboratory session could be found (which could be caused by the small sample size) the knowledge of how self-efficient the students are, helps in designing the right learning activities for them.

The evaluation of the students between the new and old laboratory design showed no difference, which could again be caused by the small sample size. But there is another aspect, which could cause this result. The second and third questionnaires were not distributed right after the respective laboratory session but in the lecture after every group had completed the laboratory session. That means that for some groups three weeks had passed so that their responses could be influenced by other experiences they have had in between. The observations made by the instructors during the lab further encouraged us to make the new design permanent. The collaboration within the groups was higher than were reported by the instructors of the traditional labs, which is an important factor for improved learning.

With respect to the evaluation methodology of this study it can be concluded that questionnaires should not be used as the only instrument. If the sample size is small either questionnaires should be used in conjunction with more structured observations or only observations or interviews should be used. It takes considerable effort to construct a good questionnaire; hence care should be taken to select the right method.

In conclusion it can be said that we could not answer all our questions with the available data. But our most important intended learning outcome was to lead students towards a working methodology of engineers. This could be achieved by both new designs, one representing the work of an engineer in a research laboratory and the other design representing the work of an engineer in a facility management department. This type of inquiry-oriented investigation should be integrated more often in engineering curricula. At the Ruhr West University of Applied Sciences this will be achieved in a number of ways. Firstly, the new laboratory sessions will be extended to the thermodynamics module of another degree course. In addition, a student engineering office is being developed as an elective module. The engineering office investigates the energy supply system of the campus to identify energy saving measures and students, who work as project engineers in this office get credits points for an elective module for it (see Rumler & Dreher, 2016).

5 References

Dreher, R. (2012). Von PBL zu PBE: Notwendigkeit der Weiterentwickllung des didaktischen Konzepts des problembasierten Lernens. In H. Hortsch, S. Kersten, & M. Köhler (Eds.), *Renaissance der Ingenieurpädagogik. Entwicklungslinien im europäischen Raum* (pp. 68–75). Dresden.

Engeser, S., & Rheinberg, F. (2008). Flow, performance and moderators of challenge-skill balance. *Motivation and Emotion, 32*(3), 158–172.

Gerber, J., Rumler, N., & Staude, S. (2014). Definition and Evaluation of Learning Outcomes for Definition and Evaluation of Learning Outcomes for an Enineering Thermodynamics Module. *INTED 2014 Proceedings,* 1276–1286.

gesis. (2012). Kurzskala: Selbstwirksamkeit. Retrieved from http://www.gesis.org/en/kurzskalen-psychologischer-merkmale/kurzskalen/selbstwirksamkeit/skalenkonzept/

gesis. (2015). Kurzskala: Need for cognition. Retrieved from http://www.gesis.org/en/kurzskalen-psychologischer-merkmale/kurzskalen/neu-need-for-cognition/skalenkonzept/

Gunstone, R. F. (1990). Reconstructing theory from practical experience. In B. Woolnough (Ed.), *Milton Keynes: Open University Press* (pp. 67–77).

Müller, F. H., Hanfstingl, B., & Andreitz, I. (2007). *Skalen zur motivationalen Regulation beim Lernen von Schülerinnen und Schülern: Adaptierte und ergänzte Version des Academic Adaptierte und ergänzte Version des Academic Self-Regulation Questionnaire (SRQ-A) nach Ryan & Connell.*

Rammstedt, B., Kemper, C. J., Céline, M., Klein, C. B., & Kovaleva, A. (2013). Eine kurze Skala zur Messung der fünf Dimensionen der Persönlichkeit. *Methoden, Daten, Analysen, 7,* 233–249.

Rumler, N., & Dreher, R. (2016). Living Laboratory plus Engineering Office – a new Approach to Engineering Education. *Proceedings of the 10. Ingenieurpädagogische Regionaltagung 2015 -Anwendungsorientierung und Wissenschaftsorientierung in der Ingenieurbildung Wege zu technischer Bildung, Eindhoven Nov. 2015. (to be published)*

Ryan, R. M., & Deci, E. L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary educational psychology, 25*(1), 54–67.

Schiefele, U., & Streblow, L. (2006). Motivation aktivieren. In Mandl, Heinz, and Helmut Felix Friedrich (Ed.), *Handbuch Lernstrategien* (pp. 232–247). Hogrefe Verlag.

Shuman, T. R., & Mason, G. (2012). *Novel Approach to Conducting Labs in an Introduction to Thermodynamics Course*. 2012 ASEE Annual Conference, Session: Energy Education Courses, Labs, and Projects (AC 2012-4999).

Sunal, D. W., Wright, E., & Sundberg, C. (Eds.). (2008). *Research in science education*. *The impact of the laboratory and technology on learning and teaching science K-16*. Charlotte, N.C.: IAP/Information Age Pub.

Collaborative Learning Experience of Students in Distance Education

Sivachandran Chandrasekaran[1], Parminder Singh Badwal[1], Gokul Thirunavukkarasu[1], Guy Littlefair[1]

[1]School of Engineering, Deakin University, Geelong, Australia

Email: siva.chandrasekaran@deakin.edu.au, pbadwal@deakin.edu.au, gthiruna@deakin.edu.au, guy.littlefair@deakin.edu.au

Abstract

Educational institutions recognised that the distance education mode is a preferred way to combine study with life, family and work commitments for distance learners. Distance education has played an important role in the provision of educational equity for distance learners who live in remote Australian communities. Engaging students and academic staff will always enhance student-learning outcomes to ensure a positive experience in distance education. It can be effectively achieved through collaborative learning. In distance education, academic staff and students face a number of challenges such as lack of student motivation, high student attrition rates, and a sense of isolation from a university community. Collaborative learning experience will enhance learner-staff and learner-learner interactions in distance learning, which can be achieved through developing a learning process. The learning process for distance learners involves student-learning strategy, Staff interactive sessions, peer-to-peer support, e-assessment, and self-realization of graduate learning outcomes. This distance learning process is confined for Deakin University learning environment, however the expectations is that the distance learning will be more mainstream in future of learning and teaching in Australian institutions. The focus of this research is to analyse and share collaborative learning experience of distance learners (off-campus) students in project management unit. It helps to analyse the barriers in distance education and finding ways to initiate collaborative programs in future. It also helps to fulfil the distance learners' expectations on program delivery.

Keywords: Collaborative Learning; Students learning experience; Distance Education.

1 Introduction

In Collaborative learning, students have the opportunity to interact and communicate with other peer learners to demonstrate their understanding of solving design problems. There are different ways to assess students learning capabilities, which are aligned to learning outcomes. Collaborative learning is an educational approach to teaching that involves groups of learners working together to solve a problem (Laal & Laal 2012). Collaborative learning is reforming the classroom learning. It enables the passive recipients of information (to whom education is provided by an expert teacher) to become active learners.

Collaborative learning has been gaining the interest of teachers since the 1970's (Bruffee, 1984; Gaillet, 1994). In early 1980's, it was the first time when the term collaborative learning appeared in the list of topics suggested by Executive Committee of the conference on college composition and communication (ECCC) for discussion at ECCC annual convention (Bruffee, 1984). In the following year, the collaborative learning effectiveness made its place from ninth place (last year) to first place on the ECCC topic list (Bruffee, 1984). At the same time, some shreds of evidences from previous literature started believing that this technique helps in engaging students more deeply with text and also in academics engagement with professional communities(Bruffee, 1984). However, the collaborative learning was started considering as the process constituting various disciplines of study and a working pedagogical tool in teaching composition(Bruffee, 1984). The focus of this research is to analyse and share collaborative learning experience of distance learners (off-campus) students in project management. It helps to analyse the barriers in distance education and finding ways to initiate collaborative programs in future. It also helps to fulfil the distance learners' expectations on program delivery.

2 Purpose of Collaborative Learning

In late 18th and 19th centuries, teachers realised the need of a practical method for handling instructions and evaluation of increasing number of students(Gaillet, 1994). Moreover, achieving the sense of community in the classroom was a substantial challenge(Gaillet, 1994). In past academic teaching, a newly introduced methods i.e. peer review and collaborative learning strategies proved to be very helpful to overcome those above challenges(Gaillet, 1994). Mary Beckham in a research study stated that students learn better when they work in a group(Beckman, 1990). Another research study conducted by Judith Lambiotte et al provides a hypothetical support to the fact that collaboration or working in groups promotes learning(Lambiotte, Dansereau et al. 1987). Besides those researchers views, Raudsepp et al mentioned that collaborative learning provides the students an opportunity to share their individual experience and trading of ideas within the group, which enhance the learning skills of students(Raudsepp, 1984).

In the early 20th century, the trend of delivering higher education has been changed particularly in Australia and also around the globe. Since last decade, the development of more flexible approaches to deliver higher education has been emphasised when considering the shifting characteristics of students which were making students less likely to come on-campus to visit traditional lecture theatres and classrooms(Jones, 2010). The decrease in funding in context of higher education (due to political and economic context) had also arisen the need of more cost efficient way of delivering education(Jones, 2010).

By analysing past literature, it is clear that collaborative learning was needed in order to handle increasing number of students in classroom; to spread sense of community in the classroom; to facilitate learning among students; to make learning and teaching a shared experience; and to obtain a cost efficient way of delivering education.

2.1 Importance of Collaborative Learning

The Importance of collaborative learning were depicted from the following aspects such as

- Collaborative learning provides students with the skills of working in private/public workplace(Beckman, 1990; O'Neill & Scott et al., 2011).
- Collaborative learning gives students an opportunity to share their individual experience and trading of ideas within the group. As a result of which students learn more with this learning technique(Raudsepp 1984).
- Students learn importance of team work through collaborative learning(Beckman, 1990).
- Collaborative learning develop social skills in students which are not very easy to learn from lecture-oriented classrooms(Soller, 2001).
- Collaborative learning makes teaching and learning a shared experience(Resta and Laferrière, 2007).
- In collaborative learning, students take responsibility of learning(Resta and Laferrière, 2007).
- Collaborative learning enhances critical thinking and problem solving skills(Gokhale, 1995).

2.2 Challenges to Collaborative Learning

Collaborative learning is beneficial only if there are well-functioning and active members in a group. The dysfunctional group activity can devalue the benefits of collaborative learning along with overall learning(Soller, 2001). Therefore the mutual understanding within the group is vital aspect, which is considered as the major challenge to collaborative learning process.

In order to achieve an effective collaborative learning, the process of teaching must include development and enhancement of student's ability to learn(Gokhale, 1995). In other words, role of traditional teacher must be changed from just information transmitter to learning facilitator(Gamson, 1994). Achieving this change in role of traditional teachers is another challenge to collaborative learning.

3 Collaborative Learning in Distance Education

Advancement of networking technology (distance education) has benefitted universities to reach out the students having schedule or location constraints(Soller, 2001). This technology enabled the students to take advantage of many educational opportunities which were previously unattainable(Soller 2001). In order to facilitate this networking technology, software was needed to support the structured on line learning activities. In early 19th century, computer supported collaborative learning (CSCL) system has been developed to support distance education(Guzdial & Hmelo et al., 1997; Jermann and Dillenbourg, 1999; Singley, Fairweather et al., 1999). The CSCL system initiated the provision of shared online workspaces, online lecture notes, online presentation and the most important tool for online communication i.e. chat tools and bulletin boards. The online communication tools along with other online tools enabled the students to participate in online discussion and provide directions or guidance to their peers(Bruckman and De Bonte, 1997; O'Day, Bobrow et al., 1998). The overall higher education system have promoted and enabled collaborative learning in distance education.

Garrison et al found that computer-mediated communication (CMC) system had the potential to change the nature of distance education by blending the features of collaborative learning with online/distance learning(Garrison, 1993). Kaye et al believed that computer mediated communication to bring a new paradigm in distance education(Harasim, 1990). In year 1999, Elizabeth Stacey conducted a study aimed to observe the effects of computer-mediated communication on online collaborative learning. Stacey observed that CMC maintained environment for social construction of knowledge by empowering collaborative learning process(Stacey, 2007).

In addition to the above systems, in 2007 wiki (another computational system) was launched to facilitate collaborative learning in distance education. This system enabled all the off-campus students to interact with each other via taking part in online discussions and sharing their experiences with each other(Lamb and Johnson, 2007; Jones, 2010; Chawner and Lewis, 2013). The wiki process was meant to facilitate online collaborative learning. Peter in his research study found that wiki offered a mechanism for promoting collaboration among online students and benefited the off-campus students by enabling them working collaboratively(Jones, 2010).

Deng et al and Elgort have found that web 2.0 application, blogs, podcasts along with social networking or internet based activities which promotes online collaborative learning has brought a dramatic revolution in the higher education system(Deng and Yuen, 2007; Elgort, 2007).

The above literatures reveals that just after implementation of collaborative learning over the traditional lecturing system, the efficiency (in terms of effective learning) of collaborative learning encouraged the education providers to introduce collaborative learning in distance/online education as well. For the same reason various computational systems were developed. Thus each computational system (e.g. CMC, CSCL, wiki etc.) was proved to be very efficient in spreading collaborative learning trend in online learning system. From the overall discussion, collaborative learning technique was proved to be the most efficient technique of delivering education in distance education system.

4 Design Methodology

The online survey questions covered were designed to determine the students' level of experience on collaborative learning from undergraduate engineering. The views of students' on collaborative learning in a particular third year engineering unit called 'Project Management'. From the quantitative and qualitative analysis performed, the results are analysed and presented from a students' perspectives. The survey is paper based which was conducted by a third person not involved in the teaching. The survey was given to 35 students in the third year of engineering class, which was anonymous and non-identifiable. These results are from students' own experiences and the results present various views, which include students' knowledge and expectations in collaborative learning. The survey questions used in this research were given in Appendix A.

The third year unit 'Project Management' was a core subject where students need to undertake after passing the professional practice subject as a prerequisite. The scope of this unit focuses on engineering project management, which teaches knowledge skills and competencies relevant and commonly required to proficiently manage projects that typically involve or are encountered in professional engineering practice. It also concentrates on three main concepts such as preparation and planning required for a project; the activities associated with managing the project including resource management and human management; and the evaluation of project status and completion of a project.

5 Student perceptions

In order to have a better understanding of the outlook of collaborative learning technique at undergraduate level, it was essential to conduct a research on impact and comfortability of the students in using the existing system of collaborative learning techniques. A total number of 35 students where requested to answer a questionnaire with 9 distinct questions which were put forth to collect the data at the end of the semester. Out of which, 18 completed the initial survey and this explorative research aimed at discovering the perception of students about the comfort level, the impact of using cloud based technologies/activities, and personal preferences of working in a team and about factors affecting the engagement of off-campus learning.

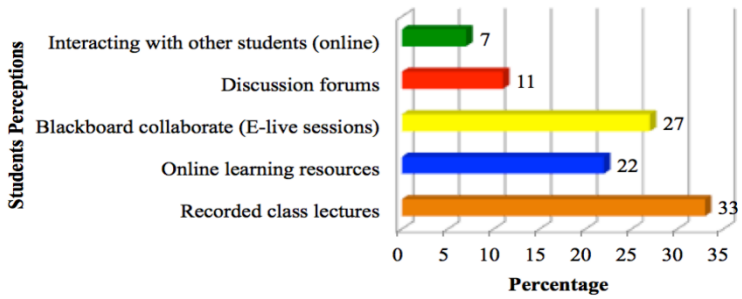


Figure 1. Perception of students on the impact of the learning resources.

When students where asked about the resources that had major impact on their learning outcomes during their learning process. From the responses obtained it is clear that 33% of the students mentioned using recorded class lectures and 27% of the students mentioned on blackboard collaborate (E-live sessions), about by 22% of the students mentioned on online learning resources. Whereas 18% of the students are in a mixed mode of using discussion forums and interacting with other students online (11% and 7% each), as shown in Figure 1. It is worth to notice that most of the students preferred recorded lectures and collaborating black board sessions.

The students are also asked about their perceptions on collaborative learning. Table 1 shows the responses that indicate that majority of students described that collaborative learning is an interactive approach to teamwork (67%) and the active involvement in explorative learning (33%). Table 1 also clearly depicts that the aspects of learning in team and peer-to-peer learning where not preferred by the students. The past literatures prove that the positive impact of this collaborative work enhances the fact of learning in groups [1] and to perceive the usefulness of the explorative learning with peer support [2].

Table 1. Student's Perceptions on collaborative learning.

Perceptions	Percentage
Interactive approach to teamwork	67
Learning in teams	0
Active, involved, exploratory learning	33
Peer to peer learning	0

When students are asked about the comfortability of collaborative learning. It is clearly shown in Table 2 that around 67% of the students revealed that collaborative learning does help in distance learning and 33% of students revealed that it is necessary for distance learning. From this cohort of students' perceptions from third year undergraduate engineering, it is evidently shows that students interest in learning teamwork skills and are becoming ready for future career.

Table 2. Comfortability of collaborative learning in distance education.

Students Perceptions	Percentage
Is necessary	33
Does helps	67
Possible helps	0
Is not necessary	0

Figure 2 shows Student's perceptions on their experience with the cloud based technologies/activities in Distance education. It is clearly shows that the use of and usefulness of blackboard collaborator for inter and intra team communication in cloud based technologies/activities in distance education has an equal value in being efficient, very efficient and somewhat efficient with an aggregate of 33%. On the other hand, sufficient interactivity with staff/students, Ease of use and quality of access has their distribution in being effective (67%) and very effective (33%). It is evident from the observations that the students' perception on the various scales of measuring collaborative learning technique proves to be efficient.

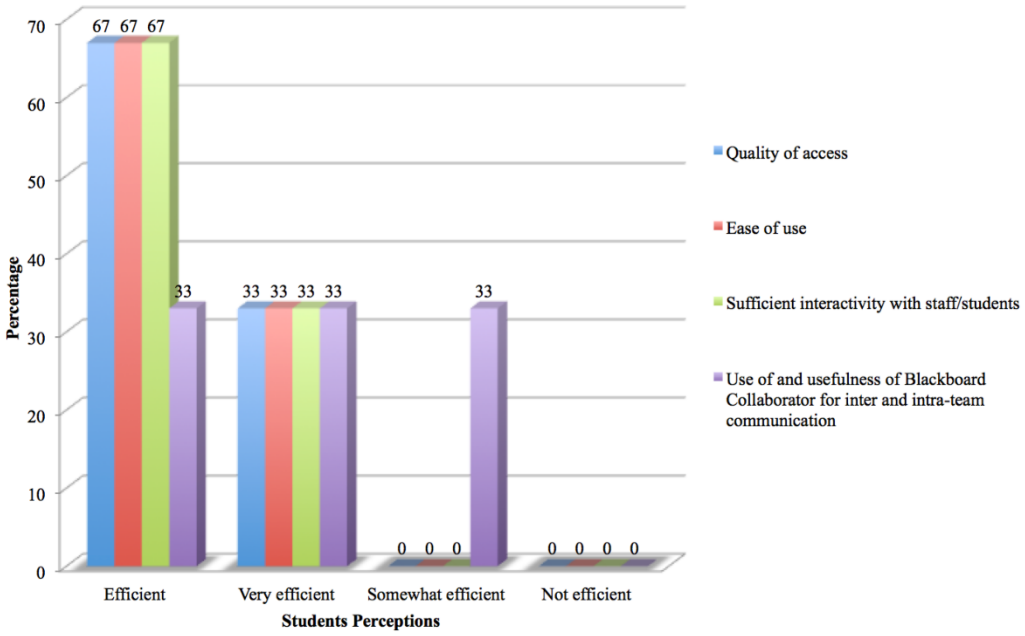


Figure 2. Student's perceptions on their experience with the cloud based technologies/activities in Distance education.

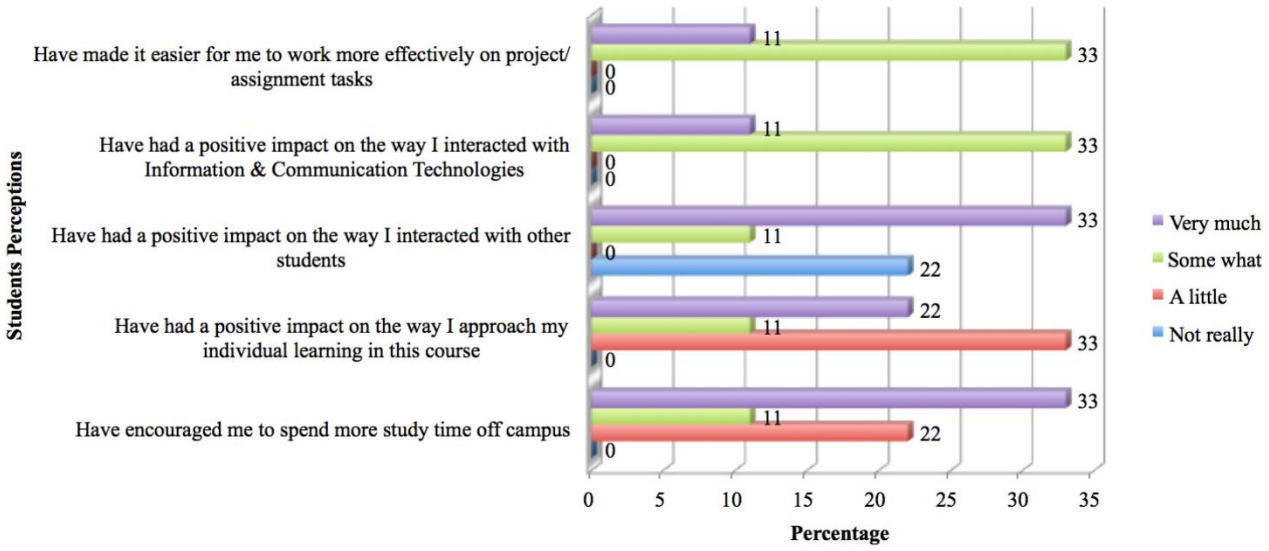


Figure 3. Perception of student's on how collaborative learning affects their ability to achieve your graduate learning outcomes (GLO).

Figure 3 clearly depicts that it is really important to understand the affect of collaborative learning with the ability of the student to achieve their graduate learning outcomes. Based on the perceptions of students on how collaborative learning affects ability to achieve GLO, it is clearly shows that the positive impact on the interactions with information and communication technologies and the easiness of working more effectively on project/assignment tasks is very much useful (11%) and 33% of students say that it is somewhat useful. Followed by the encouragement to spend more study time off campus having an equally distributed opinion of 33% deciding that it is very much useful, 11% of students say for somewhat useful. The approach of individual learning which enhanced the freedom of learning at students pace, around 22% of students revealed that it is very much useful and 44% of students reveals that it impact is less (11%-little and 33%-somewhat). Also, very few students judges that the impact of interacting with other students helped in achieving the learning outcomes. Around 22% of students mentioned that interacting with other students is not really positive. One of the Deakin graduate learning outcomes (GLO7) is teamwork skill, the collaborative learning in teamwork will enhances problem solving, analytical thinking, communication, working through difference of opinions, negotiating issues and perspectives in a team.

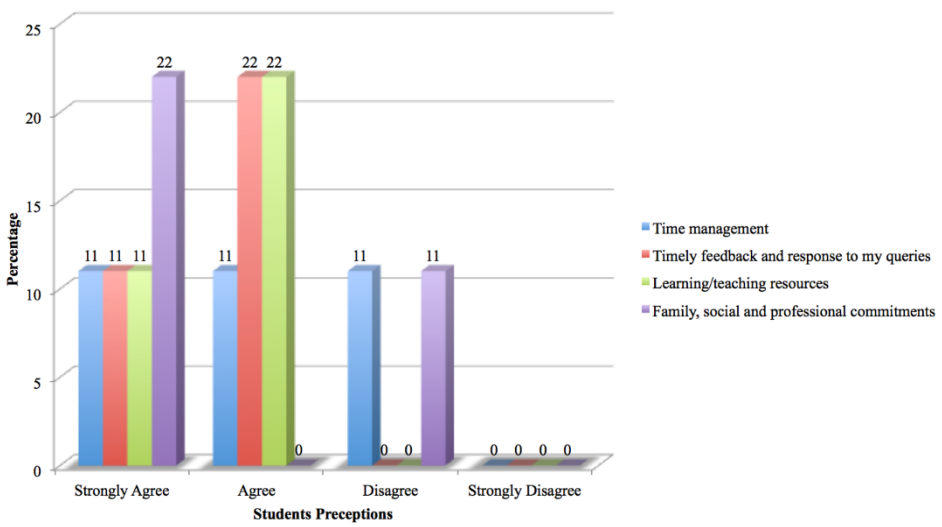


Figure 4. Students Perceptions on the factors affecting their engagement in off-campus learning.

Figure 4 shows that Time management was a dominating factor affecting the engagements of the distance learners. Most of the students (22%-44%) agree that the influence of other factors such as Family, social and professional commitments, learning teaching resources, timely feedback and response to queries are affecting the engagement of off-campus learners. Some of the student (11%) are aware of managing work, family and study in a balanced way. When students are questioned about their preference in assessments, about 67% of the students preferred to have 80% individual and 20% group assessments (table 3). Table 4 shows that 100% of students preferred to be in a group of 3 persons when the students are asked about the grouping.

Table 3. Students Perceptions on assessments in collaborative learning.

Students Perceptions	Percentage
0% group (peer assessment) / 100% individual	0
20% group (peer assessment) / 80% individual	67
50% group (peer assessment) / 50% individual	33
80% group (peer assessment) / 20% individual	0
100% group (peer assessment) / 0% individual	0

Table 4. Students Perceptions on grouping.

Students Perceptions	Percentage
1 (individual only)	0
3 students in a group	100
5 students in a group	0
Group randomly	0
Group by student own preference	0

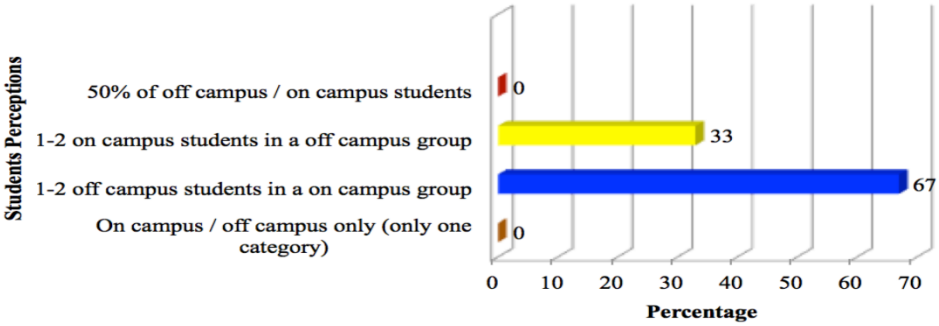


Figure 5. Students Perceptions on grouping.

Given the fact that the collaborative learning technique involves a lot of group assessments, it is important to know the experience of students with respect to on/off campus students in a team. It is clearly shown in figure 5 that the preferences of the students are towards having a mixed team with both on and off campus students as in Figure 5. 33% of students prefers 1-2 on campus in an off campus group where as 67% of students prefers 1-2 off campus students in an on campus group. Overall students' perceptions reveals that both on-campus and off-campus students experienced and revealed that collaborative learning is essential for life-long learning and problem solving which develops shared understanding between the team.

6 Discussion

From the overall analysed survey results, students reveals the use of online recorded lectures followed by the blackboard sessions (online collaborative session) are more supportive in learning resources. The blackboard session is an online classroom environment, which enables students and teachers to communicate synchronously with audio, video, text messaging, and a white board with file/screen sharing. Majority of students describes collaborative learning is an interactive approach to teamwork and the active involvement

in explorative learning. Around 100% of the students revealed that collaborative learning does help and is necessary for distance learning. It is also evident that Student's have very efficient experience with the cloud-based technologies/activities used in distance education. Figure 3 shows the positive impact on the interactions with information and communication technologies and the easiness of working more effectively on project/assignment tasks. It clearly depicts the experiences of student's on collaborative learning which helps to enhance their ability to achieve graduate learning outcomes such as teamwork, communication, critical thinking, problem solving. Most of the students revealed that the time management is a biggest affecting factor with family, social and professional commitments during their studies. The students wants to be assessed more on their individual effort and less on their team work which resembles the students comfort of undertaking the responsibility of submitting work for assessments. The collaborative learning is a positive approach for all students in a classroom where on/off campus work together with other team members and enhance their learning capabilities.

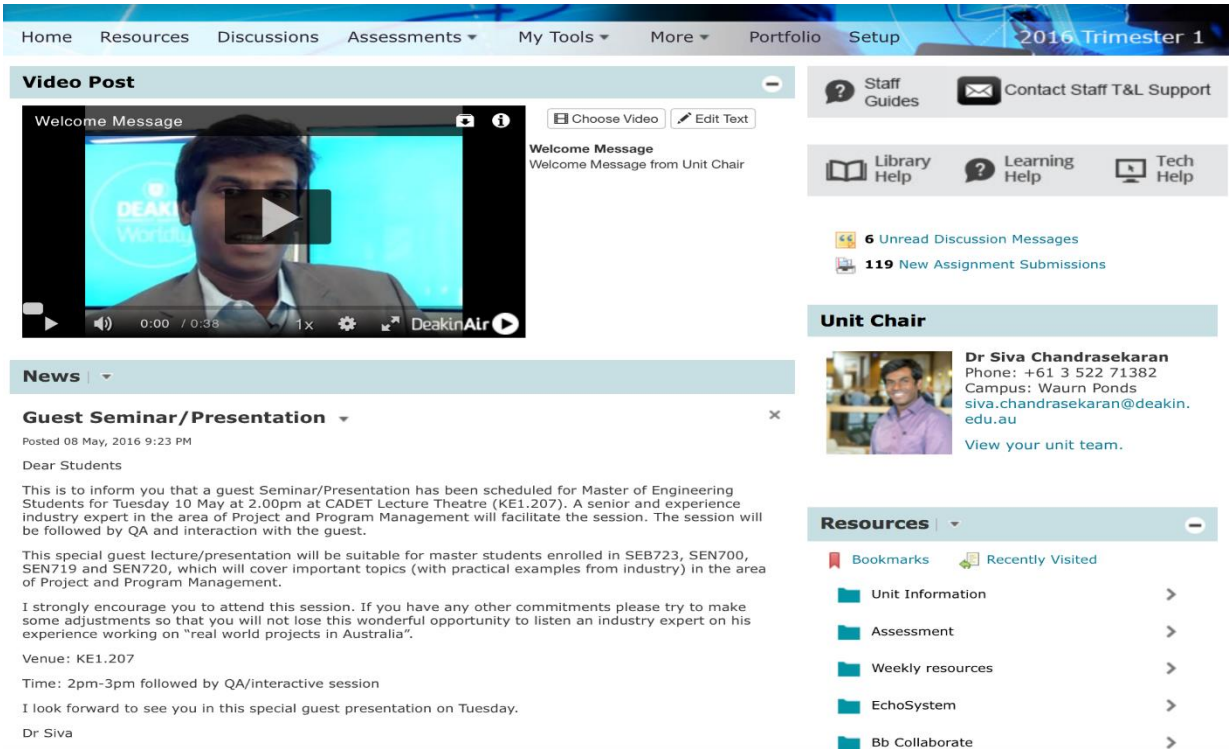


Figure 6. Cloud Deakin Learning Environment.

Figure 6 shows an example of cloud learning environment (Cloud Deakin). The learning and teaching activities, learning resources, assessment design and measures must support the on/off campus learners in order to achieve learning outcomes. Engineers Australia policy on Accreditation of engineering programs offered in distance mode guidelines states, " Electronic and face-to-face opportunities must be provided for distance mode learners to interact, particularly to ensure that group and team based learning experiences are equitable for both on-campus and off-campus students". Deakin University has provided Cloud Deakin (Cloud learning environment) to incorporate a range of spaces and tools to enable interactive and engaging learning for on/off campus learners. Cloud learning environment allows students to access unit content and course information including assessment items, support materials, engage with lecturers and other students using Bb collaborate (virtual classrooms), listen to recorded lectures, join live streaming events and create student personal portfolio for highlighting their learning achievements.

7 Conclusion

This research study is focused on analysing students' perceptions on collaborative learning. From the analysed survey results, it is clearly highlighting that students learn differently in teams, the students also learn from the experiences of their peers. Collaborative learning gives an opportunity for assessing the team member's

strengths and weaknesses where students have peer-peer learning pressure makes the learning process active. This collaborative learning requires students to act in new ways, which is an excellent opportunity to work and share their knowledge with peers. This research study is an evidence for the academics to understand how collaborative learning works for students in different learning environments. Through collaborative learning, distance learners able to receive the same level of learning and teaching support, course resources, peer-peer interaction and staff interaction, assessment feedback by using Cloud Deakin as an feasible online learning environment.

8 References

Beckman, M. (1990). "Collaborative learning: Preparation for the workplace and democracy?" *College teaching*, 38(4), 128-133.

Bruckman, A. and De Bonte A. (1997). MOOSE goes to school: A comparison of three classrooms using a CSCL environment, In Proceedings of the 2nd international conference on Computer support for collaborative learning, *International Society of the Learning Sciences,* 20-27.

Bruffee, K. A. (1984). "Collaborative learning and the" conversation of mankind", College English, 46(7), 635-652.

Chawner, B. and Lewis, P. H. (2013). "WikiWikiWebs: New ways to communicate in a web environment", *Information technology and libraries*, 25(1), 33-43.

Deng, L. and Yuen, H. K. (2007). Exploring the role of weblogs in supporting learning communities: An integrative approach, In ICT: *Providing choices for learners and learning. Proceedings ascilite Singapore* 2007, Citeseer.

Elgort, I. (2007). "Using wikis as a learning tool in higher education", ICT: Providing choices for learners and learning, *Proceedings ascilite Singapore*, 233-238.

Gaillet, L. L. (1994). "An historical perspective on collaborative learning", *Journal of Advanced Composition*, 93-110.

Gamson, Z. F. (1994). "Collaborative learning comes of age", *Change: The Magazine of Higher Learning*, 26(5), 44-49.

Garrison, D. R. (1993). "A cognitive constructivist view of distance education: An analysis of teaching-learning assumptions", *Distance education*, 14(2), 199-211.

Gokhale, A. A. (1995). "Collaborative learning enhances critical thinking".

Guzdial, M., Hmelo, C., Hübscher, R., Nagel, K., Newstetter, W., Puntambekar, S., Shabo, A., Turns, J., and Kolodner, J. L. (1997). "Integrating and guiding collaboration: Lessons learned in computer-supported collaborative learning research at Georgia Tech", Proceedings of the 2nd international conference on Computer support for collaborative learning, *International Society of the Learning Sciences*, 95-105.

Harasim, L. M. (1990). "Online education: Perspectives on a new environment", *Greenwood Publishing Group Inc*.

Jermann, P. and P. Dillenbourg (1999). "An analysis of learner arguments in a collective learning environment", Proceedings of the 1999 conference on computer support for collaborative learning, *International Society of the Learning Sciences*.

Jones, P. (2010). "Collaboration at a distance: Using a wiki to create a collaborative learning environment for distance education and on-campus students in a social work course" *Journal of Teaching in Social Work*, 30(2), 225-236.

Laal, M. and Laal, M. (2012). "Collaborative learning: what is it?", *Procedia-Social and Behavioral Sciences,* 31, 491-495.

Lamb, A. and Johnson, L. (2007). "An information skills workout: Wikis and collaborative writing", *Teacher Librarian*, 34(5), 57.

Lambiotte, J. G., Dansereau, D. F., Rocklin, T. R., Fletcher, B., Hythecker, V. I., Larson, C. O., and O'Donnell, A. M. (1987). "Cooperative learning and test taking: Transfer of skills", *Contemporary Educational Psychology*, 12(1), 52-61.

O'Day, V., Bobrow, D., Bobrow, K., Shirley, M., Hughes, B., and Walters, J. (1998). "Moving practice: From classrooms to MOO rooms", *Computer Supported Cooperative Work (CSCW)*, 7(1-2), 9-45.

O'Neill, S., Scott, M., and Conboy, K. (2011). "A Delphi study on collaborative learning in distance education: The faculty perspective", *British Journal of Educational Technology*, 42(6), 939-949.

Raudsepp, E. (1984). "Effective teamwork", *Manage,* 35, 18-22.

Resta, P., and Laferrière, T. (2007). "Technology in Support of Collaborative Learning" *Educational Psychology Review*, 19(1), 65-83.

Singley, M. K., Fairweather, P. G., and Swerling, S. (1999). "Team tutoring systems: Reifying roles in problem solving", Proceedings of the 1999 conference on Computer support for collaborative learning, *International Society of the Learning Sciences*.

Soller, A. (2001). "Supporting social interaction in an intelligent collaborative learning system", *International Journal of Artificial Intelligence in Education (IJAIED),* 12, 40-62.

Stacey, E. (2007). "Collaborative learning in an online environment" *International Journal of E-Learning & Distance Education*, 14(2), 14-33.

9 Appendix A: Questionnaires

1. Based on your own experiences, which of these learning resources is most impactful?
2. What is collaborative learning?
3. How comfortable do you feel collaborative learning in distance education?
4. What is your experience with these following cloud based technologies/activities in Distance education?
5. In terms of your own experiences, how do collaborative learning affect your ability to achieve your graduate learning outcomes?
6. Which of these factors affecting your engagement in off-campus learning?
7. For collaborative learning which one of these options do you prefer for assessment?
8. Which one of these listed options do you prefer for grouping and How? Please click one option in each column
9. Which composition of group do you prefer with respect to off campus and on campus students?

SCS (Social and Communication Skills)

Rosalie van Baest[1]

[1]Fontys University of Applied Sciences, Eindhoven, Holland

E-mail: r.vanbaest@fontys.nl

Abstract

The SCS (Social and Communication Skills) module is an experiential, student-centred lecture series that seeks to stimulate the receptiveness of Mechanical Engineering students to their own personal development. The choice of stimuli used in the SCS lectures and the way students respond to these, are critical to the success of the module. The objective of the SCS module is: to contribute to the development cycle of the personal attributes of Mechanical Engineering students and their receptiveness to their individual strengths and weaknesses, as well as those of others. The SCS module is primarily focused on intrapersonal development. At the same time, the development of interpersonal skills is of importance. Reflection, through writing a reflective piece in a workbook after every SCS lecture, serves as a link between lectures. Students complete a written evaluation after every period. The attitude and communication skills of the SCS lecturer have a strong influence on the pace of lectures. (The SCS module forms the first part, the foundation, of a more extensive research in the practice of Higher Technical Education in Holland).

Keywords: Intrapersonal development; interpersonal skills; receptiveness; reflection; experiential education.

1 Introduction

The experiential SCS module is part of the first year foundation programme for the Mechanical Engineering field of study (1998 tot 2006). The introduction of the concept of teamwork to Engineering studies requires the commitment of Mechanical Engineering students in terms of developing teamworking skills. Conscious reflection on personal attributes is important in order to gain an insight into oneself, as well as the attributes of team members. The focus in the module is on personal development, teamwork and partnership and.

During SCS lectures, Mechanical Engineering students are continually exposed to new experiences related to their personal attributes and they reflect on these experiences through writing a reflective piece in order to expand their ability for self-reflection and to gain new insights into themselves. (Kolb, 2005). Over the years, the SCS module has undergone numerous name changes. For example, in the quotes from students (see quotes under SCS glossary), there are references to the abbreviation PCS (Professional Communication Skills). The objective and format of the SCS module are identical.

The SCS module was also part of the first year foundation programme for Orthopaedic Engineering. The module is still part of the first year foundation programme for the Automotive field of study. All fields of study are offered by in Eindhoven.

2 Objective

The objective of the experiential SCS module is as follows: "to contribute to the development/development cycle of the personal attributes of Mechanical Engineering students and their receptiveness to their personal strengths and weaknesses, as well as those of others".

The SCS module provides an opportunity to learn with others, from an educational concept that focuses on personal development (Kolb, 2005), as well as the opportunity to attribute meaning to it (Weick, 1979). In this educational context interaction with continually changing participants means that different situations are created continually, "thus, something can be created which has never existed before". (Senge et al., 2004, Korthagen, 2009). This offers Mechanical Engineering students the opportunity during the lectures, to make independent choices when carrying out tasks focused on the development of their personal attributes. They are encouraged to be receptive and to become motivated in relation to their personal development. By completing their tasks during SCS lectures, students gain an insight into the quality of their social and communication skills, as well as those of their fellow students.

- The SCS module is primarily focused on intrapersonal development and the quest for internal reflection (Kolb, 2005). The module is focused on the affective development of Mechanical Engineering students.

- Interpersonal skills are also of importance: sharing collective experiences to reflect on personal behaviour and attitude and to learn from the behaviour and attitudes of fellow students.

- The shared SCS learning experiences are relevant to all team members, working on a project in the context of team building, during project work and getting to know fellow students better on a personal level. (See quotes under SCS glossary). In this respect, engagement in SCS lectures is essential.

Each student participates in the SCS module from the perspective of his/her own personal background and is given the opportunity to follow his/her individual development path within a safe environment.

3 Methodology

"The stimulation of new educational concepts better suited to our multi-disciplinary society demands a dynamic setting that is difficult to pre-define in literature. Which educational methodology is most appropriate for stimulating the desired learning process? How do people learn self-management? How do you facilitate reflection? Which learning processes ensure that people become more motivated? These learning processes involve behavioural change, personal development and emotions. Changing concepts and visions require more than just the ability to reproduce existing knowledge. These types of change processes are far more complex than traditional knowledge transfer" (Shulman, 2000; Kock, 2004).

Receptiveness to personal development is not straightforward in the context of Engineering studies. Therefore, an entirely different approach was chosen for the SCS module.

- The approach is demonstrated through use of experiential stimuli, amongst others: Mechanical Engineering students identify which emotions, related to a personal quality, they experience during SCS tasks. The students cannot apply these stimuli directly to their Mechanical studies. It offers the opportunity to step back from the usual elements of their studies.

- The SCS module offers the opportunity to engage in a cyclical learning process: after every lecture, students reflect on their learning experience and write a reflective piece on the lecture. At the end of the course, students reflect on the entire SCS course and summarise their thoughts, ideas and opinions of the SCS lectures. They note what they found to be the positive and negative points. Recurring themes of reflection in the Mechanical Engineering students' reflective passages form a continual thread that links the SCS lectures to one another. Justification remains an important element.

- The format and content of SCS lectures are not entirely set in stone, however there is a framework for each lecture. It is essential that the SCS lecturer is able to respond flexibly to situations that arise.

- The SCS module also offers a cyclical learning opportunity for the SCS lecturer. A positive attitude of the SCS lecturer to the Mechanical Engineering students' reflections and evaluations is of importance. It brings the opportunity of modifying the SCS module in subsequent lectures.

- During the learning process, the lecturer develops sensitivity to the perspectives of the Mechanical Engineering students. This sensitivity can be utilised to facilitate receptiveness amongst Mechanical Engineering students in terms of the quest for internal reflection.

3.1 Receptiveness

The SCS lecture series progresses well if Mechanical Engineering students are receptive to the methodology of the SCS module. This means: students have a flexible attitude and actively engage in SCS lectures. They subsequently carry out a reflection exercise according to their own insights, which they write in a reflective piece in their workbooks. Some students find it very difficult to get used to this style of teaching and reflection: they will require additional time and space. In addition to receptiveness to their own insights, they develop receptiveness to their fellow students. The shared learning experience provided by SCS lectures and the insights

that are developed as a result, may provide a positive contribution to an enjoyable teamwork experience during the projects.

3.2 Stimuli

The reflection exercises and evaluations will indicate whether stimuli are resonating during SCS lectures and which stimuli are working well, or not. In that respect, for the SCS lecturer the first years of the SCS module are a quest for the right way, afterwards it becomes easier to make changes. Over time, a number of lecture ideas and tasks are developed that can be incorporated into SCS lectures in a flexible way. The continual quest for relevant and meaningful SCS stimuli requires reflective skills on the part of the SCS lecturer: self-reflection, reflection on the stimuli provided and on progress of the SCS lectures.

The students' evaluations and reflections as captured in their reflective pieces, provide an insight into how the students are finding the SCS lectures and interpreting them. This provides a contribution to the lecturer's learning process and pointers for changes to the SCS module.

Over the years, virtually all tasks have been amended numerous times, as well as the content and format of the SCS lectures, in order to better align with the lecture theme. The stimuli are considered meaningful if they are clearly understood by the students and they complement the objective and narrative of the relevant SCS lecture. The students' reflections and evaluations provide continual feedback for improvement.

3.3 SCS themes

SCS themes include, amongst others: self-esteem, ambition, resistance to stress, capacity for motivation and encouragement, integrity, responsibility, creativity. Each theme represents a personal attribute. (Gramsbergen et al., 1999).

Each SCS lecture focuses on a different theme. The idea is that students are exposed to an unexpected experience related to the relevant SCS theme of that lecture, so that the experience is better retained. It is useful for students to be aware of the way in which their personal attributes come across to other students during the SCS lecture, as well as demonstrating a willingness to discuss and reflect on these. What are each student's thoughts, ideas, emotions about their behaviour during the SCS lecture and how do they respond to feedback from and on fellow students?

It is not the intention to teach students a number of tricks, but to encourage them to reflect, to make them aware of their social and communication skills in relation to their personal attributes. Developing self-awareness, reflecting on their individual roles, and acquiring experience and knowledge about the personal attributes of fellow students within the context of SCS. Self-awareness and an insight into personal attributes are not achieved without effort. "The trick is to gain an awareness of your own abilities and personal attributes and to implement these". (De Valk, M. 2006). The SCS module offers students an opportunity to achieve this.

3.4 Reflection workbook

At the start of the academic year, students receive a reflection workbook. The reflection workbook serves as a personal log and provides exercise material for the duration of the SCS course. It is a document that provides both the student and the SCS lecturer with an insight into the SCS experience. The reflection workbook is a personal document in progress. Students generally hand write their reflective pieces. Sometimes students will complete a task on the computer and paste their work into the reflection workbook. All workbooks are different: well cared for, untidy, scant in content, such comprehensive entries that a second workbook is required, with or without images and drawings.

After the SCS lecture, students write out their reflections and submit the workbook. If the SCS lecturer evaluates the papers in a timely fashion and returns them to students at the start of the next SCS lecture, the reflection workbooks become meaningful and students will treat them with care. In completing the reflection exercise after the initial lectures, students sometimes have the tendency to describe the lecture content; they require time and space to achieve the ability to reflect. The SCS lecturer's invitation to reflect once again on the previous SCS lecture and to provide justification for statements, may offer a learning experience. By going through the reflective pieces before each lecture, the SCS lecturer can provide timely guidance if students keep

describing the content of the lecture. If reflection is left to a later stage, the memory of their perceptions of the lecture would have faded and any reflection will be less current.

There will be variance amongst students with regard to orientation of development of their personal attributes. Some students have never actively worked on their development, others are more advanced in that respect. However, each lecture is a new experience, students share that experience with one another and can learn from one another. The students' approach to tasks and their reflections on tasks varies for each SCS group. By writing reflections in a reflection workbook, students are able to review their reflective pieces. This can contribute new insights that can be utilised when students complete their written evaluation at the end of a SCS period. Writing about one's reflections on the SCS lecture stimulates articulation of personal thoughts, feelings and ideas. Continually being exposed to new lecture experiences and (consciously) writing about reflections, supports the continuous SCS thread and contributes to internalisation of SCS themes.

3.5 Evaluation of reflective pieces

Feedback after evaluation of the reflective pieces is based on the subjective viewpoint of the SCS lecturer, using a system of lines. For example, one line: this is clear. Two lines: this is very clear. Students are familiar with this system. It is not about attributing a mark or a score, but whether students have written down their reflections on the SCS lecture and undertaken action during the SCS lecture. Only when elements of a reflective piece raise questions or contain contradictions, the lecturer adds a comment in the student's workbook.

At the start of the lecture, students look at the number of lines beside their completed tasks in the reflection workbook. At that point, there is an opportunity to answer any questions from students regarding any comments. The most important aspect is that students reflect on their ideas, thoughts and emotions and record those reflections in their workbooks. Students appreciate timely evaluation of their reflective pieces, which is communicated via the line system: it demonstrates the lecturer's engagement.

3.6 Evaluation

After every lecture, students complete a short written evaluation of the last lecture, with supporting statements. They indicate the strong and weak points of the SCS lecture and note any points for improvement. The instruction for them to justify their views and statements is essential. This way, students are encouraged to identify the thoughts that underpin their views and to reflect consciously on reasons for making specific statements. (See quotes under SCS glossary). The reflection exercise does not specify which topics should be discussed. Students note down their own views, thoughts and feelings spontaneously in their reflective pieces.

3.7 Completion of the SCS module

The SCS methodology describes completion of the SCS module as follows: if students have attended lectures, engaged in SCS lectures, written a reflective piece in their reflection workbooks after every SCS lecture, and completed a written evaluation of the SCS module, they are awarded a credit for the module.

3.8 SCS lecturer

The SCS lecturer's attitude and communication skills form part of the methodology of this study. What approach can lecturers use to encourage receptiveness to personal development amongst students? It is essential for the SCS lecturer to have personal experience of, and to develop SCS skills. The lecturer must seek to gain an insight into personal development in order to be able to offer support to students in developing their personal attributes. This process of identifying, of gaining experience and making choices in terms of implementing changes, takes a few years. The learning process facilitated by repeatedly gaining SCS experience with different students and of utilising the feedback in their reflective pieces and evaluations has resulted in the SCS module being modified on numerous occasions over time.

In the SCS lecture, students are exposed to the SCS lecturer's style of working, in which there is space for the receptiveness and personal learning processes of the students. The role and the attitude of the lecturer during SCS lectures determine how SCS lectures progress. If the SCS lecturer has internalised the SCS core values and core themes, the lecturer is less likely to revert to the traditional style of teaching. Facilitating experiential learning is not straightforward.

"*Harrelson and Leaver –Dunn (2002) suggest that experiential learning requires that teachers assume a facilitator mindset, which might be a difficult mindset for some. Lipshitz (1983) underscores the complexity of the role of an experiential teacher who needs to have a firm grasp of the relevant conceptual material and also develop sensitivity and skill in managing students' emotional reactions to the learning process*". (Kolb & Kolb, 2005, p. 35).

In addition to experience with, and theoretical knowledge of SCS themes, a focus on the personal development of young people and the creation of a supportive environment during SCS lectures is of primary importance for the SCS lecturer. The SCS module is not intended to encourage competition, but rather to stimulate internal reflection. "Getting to know" yourself and the space to learn within a safe environment in which mutual respect is a priority. Letting go of the "traditional" style of teaching sometimes also means letting go of one's own educational paradigm.

3.9 SCS for lecturers

In addition to SCS lectures for Mechanical Engineering students, experiential SCS lectures have been provided to six Engineering lecturers for sharing practical SCS experience. That way, these lecturers acquire SCS experience that they can share with students in turn. Receptiveness to experiential and student-centred SCS teaching is essential.

4 SCS tasks

During SCS lectures, the question is always whether the stimuli, the style of presentation of the tasks and the content of the tasks offers sufficient motivation for students to complete their tasks with personal commitment. Are the stimuli contributing to the quest for internal reflection? The stimuli may resonate with one group of Mechanical Engineering students and generate receptiveness, while another group of students may not be stimulated into action. To ensure an element of surprise, SCS lectures always start with a task, with as little explanation given as possible, which students must then undertake. Students make their own choices in terms of format of the task. After completion and discussion of the task, an explanation about the objective of the task takes place. The stimuli are critical to success of SCS lectures: are the stimuli contributing to receptiveness of the Mechanical Engineering students?

Below are a number of SCS tasks that were included in the module for some time. First, Kolb's Learning Styles.

4.1 Kolb's Learning Styles

Completing Kolb's Learning Styles test provides a learning experience in the initial phase of the first year foundation programme for the Engineering field of study. By recognising and identifying individual learning styles, students gain a deeper insight into themselves. They are encouraged to engage in reflection on themselves and the way in which they function as learning individuals. Recognition of one's personal learning style makes it possible to link it to recurring issues caused and experienced by oneself, for example during teamworking exercises. This creates an opportunity to make changes to one's own behaviour. (Kolb, 2005).

Filling out and completing Kolb's Learning Styles test during the SCS lecture helps students identify their personal learning styles, an intrapersonal process, and to become familiar with the learning styles of fellow students. The test is simple and can be completed without a great deal of additional explanation.

First, students complete the test. The learning styles test consists of nine lines of four words each. It is essential that students understand the meaning of the words. On each line, students intuitively attribute a number between 1 and 4 to the words, each of which represents a learning style. They award four points to the word that most resonates with them and one point to the word that least resonates. After filling out the form, they calculate the score by adding the numbers in the vertical columns. There are four columns. Each column represents a learning style. Students then enter the scores into a diagram that represents a cycle of learning, entitled "Your preferred learning style". The diagram is part of the learning style test. The continuum of the cycle provides an overview of the preferred learning style or styles. Finally, students are given a written description of the learning styles. It is essential that every student agrees with the results of his learning styles

test. Only the student himself can sense the learning style in which he recognises himself and which learning style he could develop. For example, because he keeps encountering the same problems in teamwork exercises caused by the fact the student has not (yet) developed a learning style. Occasionally, the learning style is not a good "fit" and the student repeats the learning styles test when convenient.

4.2 Receptiveness

The perception that the attributes of their own learning styles need not be exhaustive in a new situation, for example, in a different project group, offers students the opportunity to be receptive to conscious development of (one of) the other learning styles. Besides exposure to the attributes of their own learning styles, students are also exposed to the attributes of the learning styles of others, during completion and discussion of the Learning Styles test in the SCS lecture. If students share their experiences with one another during the SCS lecture, it is useful for facilitating mutual understanding when working as a team on projects.

Because students identify the type or types within the learning cycle with which they are most comfortable and the way in which they approach their activities, they gain a greater insight into themselves. Particularly where this insight is supported by the evaluations of fellow team members. Thus, students are able to consciously assess their own styles of approach and consciously develop their strong and weak points if desired. Completion of the learning styles test offers an insight into the relationships between the different learning styles and the opportunities for teamwork. (Kolb, 2005,p. 8, Objectives of the learning styles test).

4.2.1 Feedback

It is essential that students receive clear and substantiated feedback on the results of the learning styles test. For example, feedback on the relationship between students' learning styles and teamwork on projects, is motivational and insightful. In order to provide clear feedback, the SCS lecturer needs to have experience of, and an insight into his own learning style.

4.2.2 Internalisation

Kolb's Learning Styles test is taken once at the start of the first year foundation programme for the Engineering field of study and is not followed up in the course. Thus, there is no other point at which students again consciously consider and interpret their own learning style. Internalisation, making one's personal learning style one's own, does not happen often: after a while, students can no longer remember what their personal learning style is.

" *When it is used in the simple, straightforward, and open way intended, The LSI usually provides valuable self-examination and discussion that recognizes the uniqueness, complexity, and variability in individual approaches to learning. The danger lies in the reification of learning styles into fixed traits, such that learning styles become stereotypes used to pigeonhole individuals and their behaviour*."(Kolb 1981 a: 290-291).

A number of tasks are gradually being incorporated into SCS lectures. The success of the SCS lecture is determined by the choice of stimuli. Another SCS tasks is included below to illustrate the SCS approach.

4.3 Picture paradigm

Lecture notes comprising different, carefully selected pictures of paintings provide students with the opportunity to reflect and formulate their thoughts on these paintings during the SCS lecture. The students are given the notes and tasked with first taking their time to look at the paintings individually. Then, they choose the most beautiful and the ugliest of the paintings from the notes and justify their choices. Subsequently, they discuss their thoughts, ideas and feelings about the pictures with a fellow student. The fellow student listens without judgement and notes what is discussed.

Subsequently, the student who took the notes reads his notes to the class. He discusses his fellow student's choice and justification. The student whose choice and justification is being read out, indicates whether the interpretation was formulated correctly.

The students are surprised at how differently a picture of a painting can be perceived. Often, the emotions generated by an image, for example a childhood memory, play a part. Each student's emerging paradigms of

the paintings and the differences in these, are relevant to this SCS exercise. Furthermore, active listening and communicating the view of a fellow student without including one's own views, is important. Students also find it interesting to get to know one another better by listening to the experiences and memories of fellow students.

5 Glossary of SCS terms

While writing their evaluations of the last SCS period, students again reflect on their experience of the SCS lectures. By means of a review, Mechanical Engineering students communicate their vision of the SCS lectures they have attended. A number of terms emerge.

Reflection (as in ponder): to reflect on teamwork, to reflect on communication, to reflect on and consider relationships, to reflect on perceptions of lectures by completing the reflection exercise.

Self-awareness: self-knowledge, personal development, self-confidence, insight, paradigms,

Motivation and humour: useful, informative, fun subject, with the greatest of ease, simplicity

Development: learning, a change of attitude, personal development, team building

In the below-mentioned, after elaboration of each SCS term, a number of quotes from Mechanical Engineering students' reflective papers are listed in order to highlight the subjective perceptions of students.

5.1 Independence

The freedom to act independently during SCS lectures is essential to stimulate Mechanical Engineering students to take action on their personal development: to make independent choices while carrying out SCS tasks and to make independent choices in terms of approach to reflective practice. The SCS lecturer assures students act independently during SCS lectures. The independence of each student is manifested in a different way: through the attitude and communication displayed during SCS lectures and in the way the reflection exercise is carried out. The concept of "independence" is demonstrated in students' reflective pieces. Acting independently and making individual choices during SCS lectures is essential. Contributing actively and shaping the SCS experience requires making personal choices.

5.2 Reflection

By writing reflective pieces and evaluations of their SCS lecture experiences, recognition and acknowledgement of their personal attributes is established, and thus, how this personal attribute relates to daily life. (see Kolb). Students are challenged to engage actively in self-reflection. Not all students have reached the point yet where they are able to consciously record their thoughts on SCS lectures. No internalisation has yet taken place.

"*The transfer of knowledge, skills and attitude (competence) seldom happens spontaneously and requires space for conscious development*" (De Corte et al., 1991, Bolhuis & Simons, 1999). Encouraging awareness strengthens the process of spontaneous learning or experiential learning. (Kolb, 2005).

(Note: The SCS module has undergone numerous name changes during the course of time. For example, in the early years, the SCS module was called PCS, Professional and Communication Skills).

- "I found it incredibly useful to complete this workbook. It is a good way of reflecting on how people are communicative and social beings in practice. Besides, it is fun to work on it in class, knowing that there is a purpose behind it.

- I found PCS really helpful to do, particularly writing pieces in the workbook. What you learn in the lectures through tasks, is reflected in the workbook. It makes you reflect more deeply on certain things.

- It was actually good to write all those pieces in the workbook. It made me see the world in a different way.

- By paying close attention to the task and reflecting on the objective of the task afterwards, you certainly consider a number of things. You reflect on these concepts the context of daily life. How do you approach things and how

could you do it better? It is important to write a piece on this every week, because it makes you put extra thought into it.

- By having to write a page every week about subjects related to communication, you are forced to look at yourself. You become more aware about what you think about certain things and how you perceive things. I enjoyed the lectures and that had a positive effect on the learning process".

5.3 Teamwork

In addition to intrapersonal development, it is important to gain insights into interpersonal relationships. SCS does not just identify personal attributes, but also the personal attributes of fellow students. Completing tasks as a team during lectures facilitates reflection on one's own behaviour and mirroring and learning from the behaviour of fellow students. This way, shared experiences are created, which can be utilised later in teamwork scenarios.

- PCS made me reflect on how I behave towards others and how I interact with others. It is useful to reflect on this. You can avoid many problems this way.

- I think it is important that everyone now reflect on their role in the team. That way, you look at yourself too and you may realise that you can do certain things better.

- PCS taught me that it is best to say some things straight away in a group, rather than wait until things go wrong. It is interesting, because it involves a degree of psychology in terms of the way people behave and how you behave in a group. And how you can improve your own role within the group, if desired".

5.4 Self-awareness

During the SCS module, there is an opportunity for Mechanical Engineering students to gain experience and develop insights into their social and communication skills. The experience is always related to personal attributes. Conscious development of "self-awareness" requires receptiveness to an individual's personal attributes. The ability to reflect consciously, to take a step back and consider an experience consciously is essential to the learning process of developing self-awareness: gaining an insight into oneself, an insight into personal strengths and weaknesses that emerge through behaviour and attitude demonstrated in the SCS lecture.

The next step in developing self-awareness is to gain an insight into the consequences for oneself and one's environment of one's own behaviour and attitude. At the same time, developing an insight into the personal attributes of fellow students increases insights into oneself through the mirroring of one's personal attributes with those of fellow students. The experiential SCS lectures contribute to the development of self-awareness, as well as conscious performance during teamwork and projects (Everwijn, 1996). Breaking free from fixed patterns, recognising that there are other ways of approaching things and the ability to apply these.

- "In my opinion, PCS is not like traditional learning. They enable you to reflect on things on which you normally would not. This increases your self-awareness. And this self-awareness may, for example, enable you behave differently in certain situations.

- I found PCS1 a useful and fun subject. It contributes greatly to your personal development. You perceive life more consciously and are suddenly able to analyse complicated issues reasonably easily.

- At the start of the first lecture, I thought: "how on earth is PCS relevant to me? ". Later, I started enjoying it more and more and I gained a greater insight into my own skills. For example, I know I can come across as very overpowering. I think that is simply the nature of the beast.

- My personal experience of PCS is that it was of great value. Because after all these weeks, as you noticed, it was difficult for me to express my feelings and views in the beginning, but the more I gained self-confidence in that respect, the easier it became for me to express my feelings and opinion.

- Establishing my paradigm was an entirely new experience, because you share feelings about yourself and that makes you feel very vulnerable.

- Monitor yourself, explore why you do the things you do (or make decisions) a certain way. You act the way you think is best, but you also realise that if people have a completely different view of things, your way is not the only correct way. Others perceive things differently and therefore they opt for different solutions".

5.5 Motivation and humour

The SCS lecturer contributes to creating a feeling of wellbeing amongst the students by creating a safe environment that inspires trust: it is OK to make mistakes. Feeling vulnerable becomes less threatening then. Students are more likely to be motivated to work on SCS tasks in a safe environment. Working on SCS tasks as a team with fellow students often offers the opportunity to laugh together at situations. Laughing together puts things into perspective and contributes to receptiveness to the emotions generated during the lecture and it provides motivation to engage actively in the lecture.

- "I was just talking about laughter and we laughed a great deal in PCS, and that is a very positive point.

- In a fun way, you discover, indeed you suddenly realise, what is important in our society. That is the fun part, you suddenly acquire that knowledge, which is not theoretical, but has to be transferred.

- I hope that more similar subjects will be offered over the coming years, in which we are taught in an enjoyable way and in which we are not always dealing with material that needs to be processed, but with other things too.

- With the greatest of ease, we learn to communicate well, which I think is a really good approach".

5.6 Personal development

Personal development is an intrapersonal process of change, which becomes recognisable and visible in the behaviour and attitudes of Mechanical Engineering students. Recognisable to themselves and visible to their environment. Consciously recognising one's own development is critical to gaining an insight into the process of personal development. Reflecting on one's own initiative and learning to look at oneself critically are essential skills in achieving self-development and awareness.

- "In SCS, you learn to know and develop yourself.

- I think that in future, everyone will benefit from the PCS lectures we received. You learn to reflect on your actions, that is always good for personal development.

- Usually, you do those things unconsciously, but the PCS lectures teach you awareness. Once you are aware, you are sometimes able to respond better to certain situations".

6 References

Barker, J. (1996). Paradigma`s. Mentale modellen voor de toekomst. *Scriptum Books*. Hoofdstuk 7, 11 en 12.

Bolin, A.U., Khramtsova, I., & Saarnio, D. (2005). Using Student Journals to Stimulate Authentic Learning: Balancing Bloom`s Cognitive and Affective Domains. *Teaching of Psychology*. 32 (3), 154-159).

Denton, D. (2011). Reflection and Learning: Characteristics, obstacles, and implications. *Educational Philosophy and Theory*. 43 (8), 838-852.

Goleman, D. 1999. Emotionele intelligentie in de praktijk. *Uitgeverij Contact.*

Gramsbergen- Hoogland,Y, e.a. (1999, 2005). Persoonlijke kwaliteit. *Uitgeverij Wolters Noordhoff.*

Kolb, A. & Kolb, D. (2005). The Kolb Learning Style Inventory-Version 3.1. 2005 Technical Specifications. *HayGroup. LSI Technical Manual.*

Kyprianidou, M., Demetriadis, S., Tsiatsos, T. & Pombortsis, A. (2012). Group formation based on learning styles: can it improve students` teamwork? *Education Technical Research Development*.60, 83-110.

Masui, C.& De Corte,E. (2005). Learning to reflect and to attribute constructively as basic components of self-regulated learning. *British Journal of Educational Psychology.* 75, 351-372.

Rogers, C. (1979). Leren in vrijheid. *Uitgeverij De Toorts*.

Seligman, M. & Csikszentmihalyi, M. (2000). Positive Psychology, An Introduction. *American Psychologist*. 55 (1), 5-14.

Zhao, K., & Biesta, G. (2012). The Moral Dimension of Lifelong Learning: Giddens, Taylor, and the "Reflexive Project of the Self". *Adult Education Quarterly.* 62 (4), 332-350.

Learning Sustainability with EPS@ISEP – Development of an Insectarium

Anthony Fountain[1], Bartosz Kuron[1], Carina Bentin[1], Eughan Davies[1], Kristjan Suits[1], Paloma del Toro[1], Abel Duarte[1,2], Benedita Malheiro[1,3], Cristina Ribeiro[1,4], Fernando Ferreira[1], Luís Lima[1,3], Paulo Ferreira[1] and Pedro Guedes[1]

[1] ISEP/IPP – School of Engineering, Polytechnics of Porto, Rua Dr. António Bernardino de Almeida, 431, Porto, Portugal
[2] REQUIMTE/LAQV, Rua Dr. António Bernardino de Almeida, 431, Porto, Portugal
[3] INESC TEC, Rua Dr. Roberto Frias, Porto, Portugal
[4] INEB, Rua do Campo Alegre, 823, Porto, Portugal

Email: {ajd,mbm,mcr,fjf,lul,pdf,pbg}@isep.ipp.pt

Abstract

Sustainability plays a key role in EPS@ISEP programme - the European Project Semester programme at the School of Engineering of the Polytechnics of Porto. Not just the environmental, but also economical (marketing) and social (ethics) perspectives are explored by multicultural teams during this one semester capstone/internship programme. In 2015, a team of EPS@ISEP students choose to design and develop an insectarium to grow insects for reptile feeding. The team, after exploiting the topic, contemplated growing insects not only for animal feed, but also for human food. Their motivation resulted from the fact that insects, when compared with traditional sources of protein, are more sustainable, i.e., require considerably less resources per kg of protein. This approach, in the current Earth's population growth scenario, contributes to minimise the resources required for meeting food needs. The main goal of the proposal was to raise the awareness of the participants regarding sustainable development while creating a functional, cost-effective, eco-friendly and attractive prototype. The team, driven by this multidisciplinary problem, performed: (*i*) a survey of competing products; (*ii*) a selection of the insect species to grow based on the study and comparison of the life cycle and habitat requirements of different species of insects; (*iii*) a marketing plan; (*iv*) a sustainability and an ethic and deontological analysis of the proposed solution; and (*v*) the design, assembling and testing of the prototype. Furthermore, the students also developed cross-cultural understanding, teamwork and communication skills. The project provided an excellent opportunity to foster the concept of sustainable development amongst the students.

Keywords: Engineering Education; Sustainable Development; European Project Semester; Insectarium.

1 Introduction

The European Project Semester (EPS) is a one-semester programme offered to engineering, product design and business undergraduates by 18 European engineering schools. EPS aims to prepare at the capstone project/internship level future engineers. EPS aims to prepare future engineers to think and act globally, by adopting project-based learning and teamwork methodologies (Andersen, 2004), fostering the development of complementary skills and addressing sustainability and multiculturalism.

EPS@ISEP – the EPS programme implemented since 2011 at ISEP – the School of Engineering of the Polytechnics of Porto – welcomes 3rd and 4th year mobility students during the spring semester. The structure of the EPS semester at ISEP includes one Project (20 ECTU) and five project supportive seminars modules oriented towards the specificities of each team project – Project Management and Team Work (2 ECTU), Marketing and Communication (2 ECTU), Foreign Language (2 ECTU), Energy and Sustainable Development (2 ECTU) and Ethics and Deontology (2 ECTU) (Malheiro et al., 2015). In particular, Energy and Sustainable Development and Ethics and Deontology, ensures every project has a strong focus in sustainability, as a way to raise the student's awareness to this problem. In terms of pedagogy, EPS@ISEP implements project based learning with a strong focus on multicultural and multidisciplinary teamwork. The project module is assured by a team of supervisors, from distinct scientific areas and with different backgrounds, and adopts a coaching approach, leaving teams in charge of their projects. Assessment occurs twice during the semester and has two components: self and peer (S&P) and supervisor/teacher assessment. The S&P assessment takes into account

the quality and quantity of the technical contribution, openness to others ideas, teamwork performance, leadership, attitude and initiative shown.

One of the project proposals offered in the spring of 2015 was the development of an insectarium, encompassing two goals: (*i*) to raise student awareness to the problem of sustainable food production; and (*ii*) to design and develop an insectarium. As all EPS projects (each one with a specific client, responsible for defining the project requirements and checking its compliance), the objectives of the insectarium proposal were broad: "*This project addresses the problem of how to produce food to feed the world's population. Since recent figures indicate that there are more than 200 million insects for each human on the planet, the challenge is to build an enclosure with the appropriate conditions to grow insects (e.g. mealworm or Tenebrio). This insectarium should be inexpensive, productive and have an elegant and functional design*." (Insectarium, 2015).

The team that choose this project was composed, according to the EPS 10 Golden Rules (Malheiro et al. 2015), of six students from different nationalities (Belgian, Polish, German, Spanish, Estonian and Scottish), and backgrounds (Digital media and graphic design, Computer science, Marketing, sales and purchases, Building engineering, Environmental engineering and Electronic engineering). The technical objective of the project was to create a functional, cost-effective, eco-friendly and attractive insectarium prototype. The team, driven by this multidisciplinary problem, performed: (*i*) a survey of competing products; (*ii*) a selection of the insect species to grow based on the study and comparison of the life cycle and habitat requirements of different species of insects; (*iii*) a marketing plan; (*iv*) a sustainability and an ethic and deontological analysis of the proposed solution; and (*v*) the design, assembling and testing of the prototype. This paper aims to provide an insight on how a project about home insect farming can simultaneously alert towards and motivate for the adoption of sustainable development practices.

One of the major issues for humanity is the lack of sustainable good quality food sources. The Food and Agriculture Organization (FAO) estimates that the world needs to increase its food production by 70 % by 2050 in order to serve a global population of 9 billion. Insects form part of the traditional diets of at least 2 billion people, mainly in the Asian and African regions. In the remaining regions of the world, the main use of insects is for animal feeding. More than 1 900 species have reportedly been used as human food (FAO, 2014). Furthermore, the standard food production model is unsustainable in terms of resources required (energy, soil, water) and by-products produced (emissions). Research is forcing people to re-think food production and recommending the adoption of specific insect species as a higher source of nutrition.

This paper presents in Section 2 insect farming, in Section 3 introduces the team's solution, in Section 4 describes the implementation and the functional tests, and, finally, in Section 5 draws the main conclusions.

2 Insect Farming

The concept of insect farming is relatively new. Insects are reared in a confined area (i.e. a farm) where the living conditions, diet and food quality are controlled. Farmed insects are kept in captivity and are thus isolated from their natural populations (FAO 2013). One of the advantages of insect farming is the relatively small ecological footprint compared to conventional livestock farming in terms of: (*i*) land use, (*ii*) the efficiency in converting feed into high value animal protein; and (*iii*) greenhouse gas and ammonia emission.

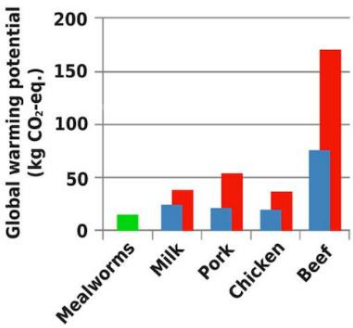


Figure 1. Greenhouse gas emissions for different protein sources production (Stromberg, 2012).

Studies conducted in the Netherlands, where mealworms are often cultivated as food for reptile and amphibian pets, concluded that insects, like mealworms, can help to solve this problem. Researchers, which analysed every input used in the process of breeding the worms, show that worms are a protein source considerably more eco-friendly than conventional protein sources. Insect farming requires less energy and produces less carbon dioxide into the atmosphere when compared with the production of milk, pork, chicken or beef (Figure 1). Pound for pound, mealworm protein (green) produces much lower amounts of greenhouse gas emissions than both the high (red) and low (blue) estimates for conventional protein sources (Stromberg, 2012).

2.1 Mealworm

Although the insectarium may be used to house different insects because of the controllable temperature and humidity, the focus is on production of mealworms since they can be eaten by animals and humans. Moreover, compared to other insects, they contain a high level of protein and are one of the easiest insect species to grow.

2.1.1 Life Cycle

Mealworms are the larval form of the mealworm beetle, *Tenebrio molitor*, a species of darkling beetle. Like all holometabolic insects, they go through four life stages: egg, larva, pupa and adult (Figure 2).

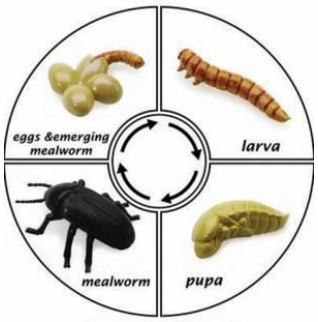


Figure 2. Four life stages of *Tenebrio molitor* (Super Teacher Tools, 2016).

The life cycle takes around a year to complete the four stages of metamorphosis. The egg is white and takes around one to four weeks to hatch and the larva to emerge. The larval stage may molt ten to twenty times before reaching the pupa stage. As a pupa, it changes colour, starting white and darkening before the beetle emerges, and grows from a length of 1.25 cm to 1.90 cm. The adult beetle is black with hardened front wings and lasts one to three months. When they reach one to two weeks of adult life, the beetles begin to mate and reproduce. A few days after mating, female beetles will burrow into soil or substrate and lay the eggs. The second stage of the insect life lasts about eight to ten weeks and is spent as a brown larva called mealworm. When first hatched, it is quite small, but will grow up to 3.8 cm long. Since it has a hard exoskeleton, the worm will need to molt and shed its hard outer shell in order to grow. Molts will occur ten to twenty times during this stage of life. A recently molted worm will be soft and white, but the exoskeleton will quickly harden. A mealworm spends its time eating and growing in order to save up energy for the next transformation.

2.1.2 Habitat and Growth Conditions

Mealworms live in areas surrounded by what they eat under rocks, logs, in animal burrows and stored grains. They clean up after plants and animals and, therefore, can be found anywhere where there are such leftovers.

Raising mealworms is fairly easy since they are prolific breeders and are hardy insects. Their growth is affected by the temperature and humidity. The ideal temperature and humidity for growing a colony is around 25-27 ºC and 70 % humidity, respectively.

2.1.3 Home Farming

Domestic *Tenebrio molitor* colonies usually hatch and live in standard plastic containers. The container should be kept away from windows and direct sunlight to prevent the temperature from rising (Figure 3a). The daily light cycle is adequate, i.e. the process does not require artificial lighting. A colony of mealworms will reproduce faster with a higher humidity, but, in most cases, the natural humidity in the air will be sufficient. In a dry

climate, it may be necessary to raise the humidity. The substrate of the container will be the food - wheat bran, oatmeal, cornmeal, wheat flour, ground up dry dog food or a mixture of these dry foods. Slices of potatoes, apples, carrots, lettuce, cabbage or other fruits and vegetables are used to supply water to the worms. Potatoes are often preferred since they last a while and do not mold quickly.


(a)

(b)

Figure 3. Insect Farming: DIY kit sold by Tiny Farms (Tiny Farms, 2016) and Kreca insect farm in Ermelo (Kreca, 2016).

2.1.4 Industrial Farming

In Europe insect farming is at an early stage. The European Commission is currently co-financing a research project to explore the feasibility of using insect as a protein source, following a recommendation of the European Food Safety Authority (Finke, M. D. et al., 2015). The European Union prohibits the use of insects to feed livestock. Nevertheless, there are large companies investing in the sector like Proti-Farm, a producer of insect ingredients for the food and pharmaceutical industry based in The Netherlands. In 2014, it acquired Kreca, a company with in-house knowledge of breeding and rearing 13 different species of insects. Kreca's production, which includes 12 different insect species, is intended for human food (5 %) and pet food (95 %). The farm consists of eight barns where the temperature varies between 25 ºC and 30 ºC, depending on the insect species. The insects are fed on corn or *groat* meal obtained from local providers. Inside the barns, racks of boxes hold hundreds of kilograms of insects (Figure 3b), eating several tonnes of meal and producing a few tonnes of insects per week. Proti-Farm sells whole insects, protein powders (isolated, concentrated, hydrolysed) and (refined) lipids.

3 System Architecture

Before defining the system architecture, EPS students have to study and define the environment in which their product will fit and the restrictions that apply.

3.1 Marketing Plan

During the elaboration of the marketing plan, the team identified the strengths, weaknesses, opportunities and threats regarding the potential market – market SWOT analysis, performed market segmentation and defined the marketing programme for the product. During this study, the team concluded that the market offers many different types of bug-specific farming structures. However, it is lacking a general solution for household users, i.e. a solution for farming different species of insects. As a result, the team decided to create a home insectarium to house different species. For example, Space for Life (2016) suggests and provides instructions for raising ants, house crickets, mealworms, praying mantids and monarch butterflies at home. Since the light, temperature and humidity requirements differ from species to species (Space for Life, 2016), such a product must be reconfigurable. Ideally, the insectarium should include a control system to operate the heating, cooling and lighting subsystems in accordance with the readings from the installed temperature, humidity and light sensors. In addition, since it is intended for the domestic market, it should be attractive and easy to maintain. Figure 4 shows the initial structure drawings and the brand logo INSECTO, which were defined together with the marketing plan (Bentin et al., 2014).

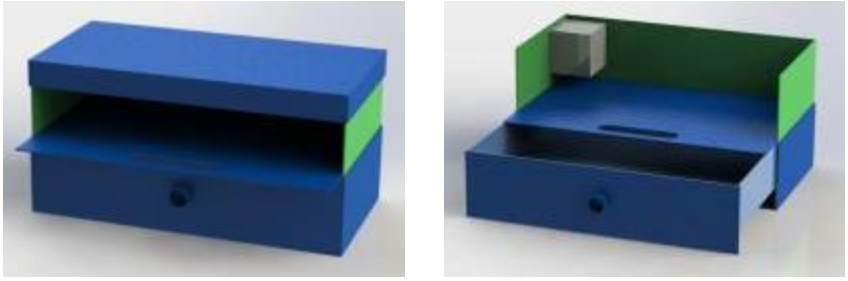


Figure 4. First sketches and INSECTO brand logo.

3.2 Sustainability Issues

There is no universal definition of sustainability. For the team, sustainability is "*a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations.*"

In terms of the structure, the team chose to keep the manufacturing, assembling and maintenance simple and easy. The result was INSECTO – a boxy, modular insectarium composed of a reduced number of parts – which allows stacking for larger production schemes. The team selected acrylic glass – polymethyl methacrylate (PMMA) – to build the structure of the insectarium since it is a durable material with a long life cycle and a good temperature and sound isolation. The PMMA temperature insulation maintains the insects at a comfortable temperature with low power consumption. The electronic components were chosen according to their energy consumption (sustainability) and the selected software was open source (cost).

3.3 Proposed Architecture

The air conditioning of the insectarium (temperature and humidity) is the main technical aspect of the project. Air conditioning can be divided into heating, cooling, humidification and dehumidification processes with specific energy demands. Since the simultaneous control of temperature and humidity is rather complex and exceeds the pre-defined budget (100 €), the team decided to incorporate in the insectarium two additional elements: an air heating resistor and air renewing fan. This approach uses the resistor to raise the internal temperature and the fan to reduce both the internal temperature and humidity.

To control automatically the temperature and humidity inside the insectarium, the team selected an Arduino microcontroller, a humidity sensor, a temperature sensor, a resistor, a fan and, for the user interface, a Liquid Crystal Display with a keyboard (Figure 5). The microcontroller is connected to the humidity sensor (input), temperature sensor (input), the keyboard (inputs), the LCD (output), the resistor (output) and to the fan (output). The microcontroller controls the fan speed and the resistor power through pulse width modulation (PWM), i.e. the fan and resistor are connected to the microcontroller via PWM outputs.

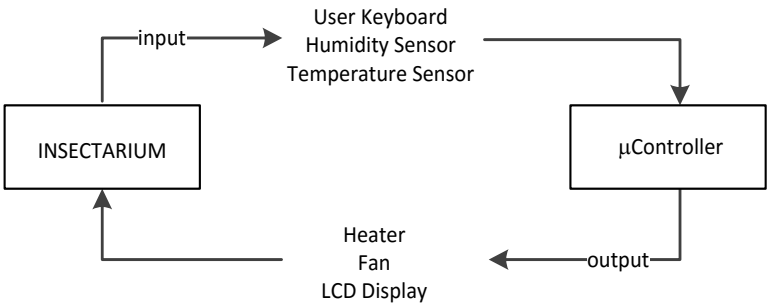


Figure 5. Control system diagram.

The proposed system differs from the Dot It Yourself (DIY) home solutions because it is modular, reconfigurable (via the user interface) and automatically controls (via the control system) the most relevant environmental parameters (temperature and humidity) for breeding different species of insects at home. This approach meets the client requirements and extends further the spectrum of possible clients.

4 Implementation and Functional Tests

4.1 Main Components

The team performed the selection of materials and solutions, analysing the quality, economy and sustainability aspects. For the structure, the team opted for PMMA plastic due to its durability and resistance. The structure was built with existing PMMA leftovers (reuse). The team, for the control system and according to the comparative study undertaken, chose: (*i*) an Arduino Uno microcontroller; (*ii*) a DHT22 humidity and temperature sensor with an accuracy of ±2 % for the humidity and ±.5 ºC for the temperature; (*iii*) a 28 Ω resistor (reused from a toaster); (*iv*) a 12 V 0.13 A fan (reused from a Personal Computer); (*v*) a ULN2003A high-current Darlington transistor array to boost the current for the fan and resistor; (*vi*) an Itead 1602 LCD shield with keyboard; and (*vii*) a power supply AC/DC 230 V AC/12 V 2 A (Bentin et al., 2105). The cost of these components was 60 €. Figure 6 presents the electrical circuit of the control system (left) and the flow chart of the controller software (right).

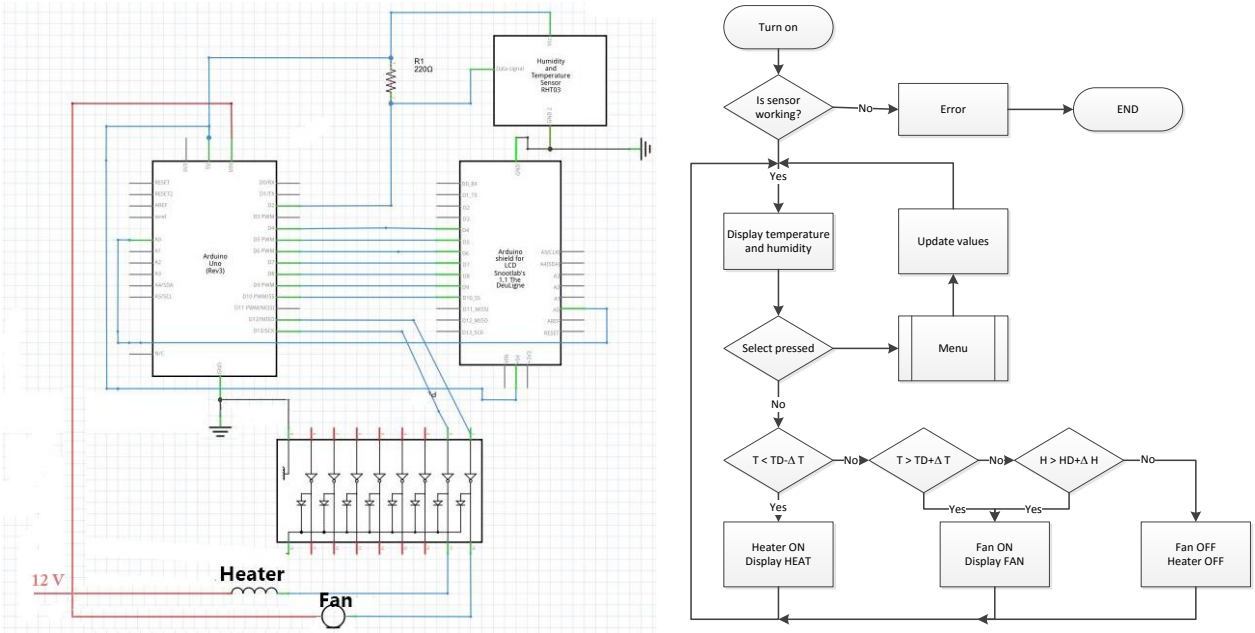


Figure 6. Electric schematic (left) and software flow chart (right).

4.2 User Interface

The main function of the insectarium is to provide different species of insects with an appropriate environment to grow and reproduce. This was achieved by creating a configurable automatic humidity and temperature control system. Figure 7 (left) presents the structure of configuration menu implemented in the user interface (right). The user can specify the desired temperature (ºC) and humidity (%), the maximum temperature (ºC) and humidity (%) variation, the percentage of heat power and the fan speed.

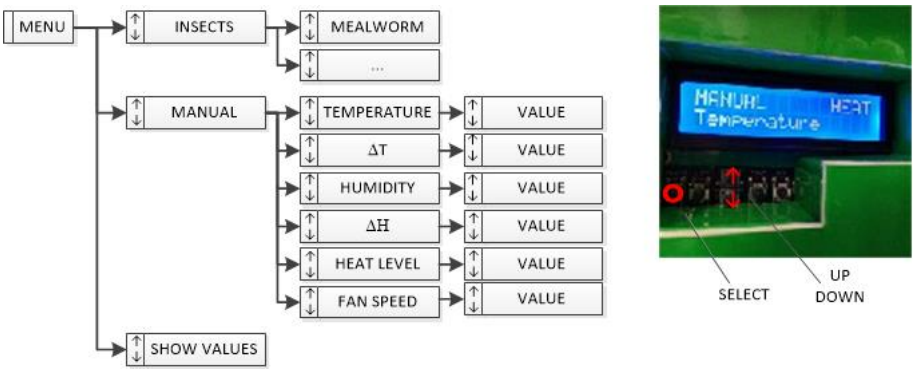


Figure 7. Menu system (left) and user interface (right).

4.3 Power Consumption

The power consumption estimation (in the most demanding scenario) of any electric appliance is a sustainability indicator. In a continuous operation scenario, the Arduino, LCD shield and the double sensor are always on. In addition, in the worst case scenario, the heater or the fan will be on, but not simultaneously.

Table 1 presents the estimated power consumption of the main system components. In the best case, when only the Arduino, LCD shield and sensor are on, the estimated annual power consumption is 7.6 kWh. In the worst case, when the heater is also on, the estimated annual power consumption reaches 49.6 kWh. This results in an estimated annual average power consumption of 26.5 kWh (equivalent to a 3 W lamp).

Table 1. Estimated power consumption.

Equipment	Voltage (V)	Current (A)	Power (W)
Heater	12	0.400	4.800
Fan	12	0.140	1.680
Arduino Uno	12	0.050	0.600
LCD shield	5	0.050	0.250
Sensor	5	0.025	0.013

4.4 Tests and Results

Initially, the team undertook basic tests regarding: (*i*) the heating and cooling functions (to determine the maximum attained temperature and the fan ability to renew the air) without control; and (*ii*) the debugging and validation of the control code. With the resistor connected to 12 V, it took in average 227 min to raise the internal temperature from 24 ºC to 31 ºC and, once it reached this maximum value, it stabilized. With the fan connected to 12 V, the temperature inside diminishes until it reaches the external room temperature. For example, lowering the internal temperature from 31 ºC to 27 ºC (room temperature) took 50 min.

Finally, with the insectarium assembled, the team conducted the functional tests and measured the actual power consumption. Figure 8 depicts the assembled prototype. The functional tests were defined together with the requirements and use cases during the design phase, a mandatory step of any EPS project.

Figure 8. Photograph of the assembled insectarium.

These tests contemplated the normal operation of the insectarium, i.e. the maintenance of the temperature and humidity parameters within the user specified values. The user interface menu was fully functional, allowing the user to specify the desired input parameters. The control system was able to maintain the internal temperature and humidity within the user specified values. Table 2 presents the power consumption measured in the three operation modes (idle, air heating and air renewal), resulting in an average annual power consumption of 24.1 kWh (< than the estimated 26.5 kWh).

Table 2. Measured power consumption.

Operation mode	Current (A)	Power (W)
Arduino, LCD shield and sensor	0.093	1.116
Arduino, LCD shield, sensor and fan on	0.170	2.040
Arduino, LCD shield, sensor and heater on	0.425	5.100

5 Conclusion

This paper reports the development of INSECTO – an attractive, configurable, modular domestic insectarium for growing different insect species – by a multinational and multidisciplinary team of students within EPS@ISEP. The team perceived the project development process as *"a fun and exhilarating challenge from which we benefited greatly as an experience for our careers by living in a different country and working with people from all over Europe.*", and the INSECTO prototype as "*a product that provides sustainable food for now, but, more important, for the future*", while aiming "*to be as sustainable as possible (...) and innovative compared to other insectarium products."* These views illustrate the relevance the team attributed to this project in terms of multicultural teamwork and sustainable development practices. The functional tests showed the effectiveness of the configurable temperature and humidity control system. Further studies should be done to compare the performance of the system with traditional uncontrolled DIY systems, e.g. using mealworms, as well improve the validation of INSECTO with different room conditions.

EPS@ISEP acted as the framework to promote cross-cultural communication, multidisciplinary teamwork, ethical and deontological concerns, sustainable development practices as well technical and scientific competences within this team composed of design and engineering students.

Acknowledgements

This work was partially financed by the ERDF – European Regional Development Fund through the Operational Programme for Competitiveness and Internationalisation – COMPETE Programme within project «FCOMP-01-0202-FEDER-023151» and project «POCI-01-0145-FEDER-006961», and by National Funds through the FCT – Fundação para a Ciência e a Tecnologia (Portuguese Foundation for Science and Technology) as part of project UID/EEA/50014/2013.

6 References

Andersen, A. (2004). Preparing engineering students to work in a global environment to co-operate, to communicate and to compete. *European Journal of Engineering Education*, *29*(4). 549–558. doi:10.1080/03043790410001711243.

Bentin, C., Davies, E., Fountain, A., Kuron, B., Suits, K. & Toro Ronda, P. (2015). Insecto [Project Report]. Retrieved 15 February, 2016, from http://www.eps2015-wiki3.dee.isep.ipp.pt/lib/exe/fetch.php?media=reportpdf.pdf.

FAO (2104). Insects to feed the world [Conference Report]. Retrieved 15 February, 2016, from http://foris.fao.org/meetings/download/_2014/insects_to_feed_the_world/misc_documents/summary_report_and_abstract_book.pdf.

FAO (2013). Edible insects – Future prospects for food and feed security [FAO Forestry Paper 171]. Retrieved 27 February, 2016, from http://www.fao.org/docrep/018/i3253e/i3253e.pdf.

Finke, M.D., Rojo, S., Roos, N., van Huis, A. & Yen, A. (2015). The European Food Safety Authority scientific opinion on a risk profile related to production and consumption of insects as food and feed. *Journal of Insects as Food and Feed*, *1*(4), 245–247. doi: 10.3920/JIFF2015.x006.

Insectarium (2015). Insectarium Project Proposal – EPS@ISEP Spring 2015 [Project Proposal]. Retrieved 5 February, 2016, from http://www.ave.dee.isep.ipp.pt/~mbm/PROJE-EPS/1415/Proposals/EPS_PROJECT_2015_T3.pdf.

Kreca (2016). Kreca Living and freeze-dried insects [Webpage]. Retrieved 12 March, 2016, from http://www.krecafeed.com.

Malheiro, B., Silva, M., Ribeiro, M. C., Guedes P., & Ferreira, P. (2015). The European Project Semester at ISEP: the challenge of educating global engineers. *European Journal of Engineering Education*, *40*(3), 328–346. doi:10.1080/03043797.2014.960509.

Space for Life (2016). Raising insects [Webpage]. Retrieved 20 February, 2016, from http://espacepourlavie.ca/en/raising-insects.

Stromberg, J. (2012). The Sustainable Meat of the Future: Mealworms? [Smithsonian.com article]. Retrieved 27 February, 2016, from http://www.smithsonianmag.com/science-nature/the-sustainable-meat-of-the-future-mealworms-168571999/.

Super Teacher Tools (2016). Mealworm life cycle [Image]. Retrieved 27 February, 2016, from https://www.superteachertools.net/jeopardyx/uploads/20141006/14122713461412616887.jpg.

Tiny Farms (2016). Tiny Farms – Pioneering the industrial production of edible insects [Webpage]. Retrieved 20 February, 2016, from http://www.tiny-farms.com/.

Engendering Diversity in Engineering Education and Other STEM Areas: a Case Study in Sustainability

Michael F. Christie[1], Maureen O' Neill[1], Kerry Rutter[2], Graham Young[3], Angeline Medland[3]

[1] School of Education, University of the Sunshine Coast, Sippy Downs, Queensland, Australia, 4556
[2] TPP, University of the Sunshine Coast, Sippy Downs, Queensland, Australia, 4556
[3] Gympie campus, University of the Sunshine Coast, Sippy Downs, Queensland, Australia, 4556

Email: michael@cwrite.net, moneill@usc.edu.au, KRutter@usc.edu.au, amedland@usc.edu.au

Abstract

In 1996 S.L. Hanson pointed out that young women were under represented in Science, Technology, Engineering and Mathematics (STEM) courses in tertiary education. Today, the participation rates of young women in these subjects continues to be comparatively low and their attrition rates high. The overall ratio of male to female students in western universities of technology has typically been 80% men and 20% women. During the same period (1996-2016) the numbers of students entering Engineering Education courses have been falling in developed countries. One way to solve the recruitment problem and to improve the quality of Engineering Education is to attract more women to study in this area. In 2016 the authors undertook a case study in a small, regional university in Queensland, Australia, to find out why so few young women enrolled in Engineering Education and other STEM subjects. The female students in our study, were enrolled in more traditional female courses such as nursing and education. The participants were asked if they had considered engineering or other STEM areas, and if they had, why had they decided to settle for nursing or teaching. A critique of the literature helped us develop a survey, focus group and interview schedules which we used in collecting data. This paper analyses the problem of how to engender more diversity in Engineering Education and makes some specific recommendations about ways of increasing female participation rates. Our study found that many of the factors that helped or hindered young women from applying for Engineering and other STEM courses twenty years ago, still apply today. In our case study, factors that were perceived to assist young women in undertaking Engineering Education included encouragement from teachers and parents, assistance from more competent peers and mentors and the use of Project Based and Active Learning pedagogies.

Keywords: Diversity in Engineering Education; Sustainability in Engineering Education; Gender Balance.

1 Introduction

Twenty years ago Hanson (1996) argued that although female students have demonstrated interest and aptitude in Science, Technology, Engineering and Mathematics (STEM), they were under represented in STEM subjects at both secondary and tertiary levels of education. Female students who graduated from university in these subjects were also found to be more poorly paid and did not do as well in terms of their career as did their male counterparts. Eisenhart and Finkel (1998) conducted an extensive review of US women in science and found that females tended to have lower status and more marginal positions in engineering and science. They argued that women who enrol in science subjects and start science careers are attracted jobs that involve social, political or environmental areas of employment (Eisenhart & Finkel, 1998, p.204). They also suggest that women tend to be more comfortable in these areas because the work environment is friendlier even though the pay and status attached to them are lower. These findings were backed up by other research studies on the gender gap in STEM subjects in the United States. The National Centre for Education Statistics (NCES) concluded that "girls are less likely than boys to aspire to careers in science and engineering" (NCES, 1997, p.27). The NCES noted that the maths and science proficiencies of boys and girls are similar to the age of nine but then a gap appears at age thirteen (NCES, 1997, p.1). By seventeen the gender gap in maths and science narrows slightly but because of the fairly radical change in the attitudes of boys and girls after grade 8 (age thirteen) the gap is never bridged (NCES,1997, p.17). The 1997 report listed many factors associated with this persistent gap between boys and girls in terms of STEM subjects. They included location, particularly remote locations, varying education systems (i.e. Catholic, independent, state), and low social-economic background (SES). The NCES cited enrolment statistics for tertiary intake of men versus women which indicated that "men

outnumber women in mathematics, statistics, sciences (particularly physics), engineering, manufacturing, construction and computing, while women outnumber men in the study of health, welfare, education, humanities, arts, agriculture, life sciences, services, social sciences, business and law" (NCES, 1997, p.27). One might imagine that in the two decades after this report was published a great deal would change, especially as there was already a perceptible fall in enrolments in STEM subjects at the university level in the US, the UK, Australia and other developed countries. The fall in student enrolments was particularly prevalent in Engineering Education.

2 The current state of the gender gap in STEM

Nearly two decades after its 1997 report the NCES (2013) made it clear that the gender gap in STEM subjects at the university level remained. The same can be said for other developed countries. When one compares US data from NCES between 1997 and 2013 with data from Australia for the same timeframe, the common theme that emerges is that women are under-represented in STEM fields throughout their education and career (NCES, 1997; NCES, 2013; ACOLA, 2013, p. 134). One note of optimism is that there has been some gradual improvement. According to Freeman (2004, p.30) in the early 1970s in the US, females accounted for less than 1% of undergraduate degrees conferred in engineering. Data from ACOLA (2013) showed that the same figure was true of Australian female graduates in engineering degrees in the early 1970s. Two decades later, in 1996, the number of Australian female engineering graduates was 5.2% (ABS 2001). Roberts and Arye (2002) noted that Australia trailed both the UK and the US in the percentage of women engineers that they graduated. In 1996, in the UK, women represented 7 per cent of professional engineers and technologists (Glover, 2002). The US National Science Foundation (NSF 1998) found that 9% of graduate engineers were women in 1998, while Lal, Yoon and Carlson (1999) found that in 1999 women held 10% of professional engineering jobs in the US. ACOLA (2013) reports that in Australia, women's participation in STEM has improved over the two decades since 1993, but that there is a case to be made for re-invigorating the agenda on women in STEM (ACOLA, 2013, p.153). Today that number of female engineering graduates has risen to 20% in Australia which is the same figure for the US a decade earlier (Freeman, 2004; National Science Foundation, 2004). In Australia national estimates suggest that gender disparities, specifically in engineering, are largely driven by "inadequate enrolment (not inadequate retention) of women" (ACOLA, 2013, p. 211).

Inadequate enrolments are also the main reason for gender disparities in US Engineering universities. A longitudinal study conducted by National Science Board (2010) that used primary sources from the American Society for Engineering Education (ASEE), the Engineering Workforce Commission (EWC), and Engineering Trends found that the under-representation of women in Engineering Education for the academic years 1999–2000 through 2004–2005 was predominantly due to low enrolments in Mechanical, Computer, and Electrical Engineering programs. The female enrolment in those subjects was between 12% and 14% compared with the national average for female enrolment in engineering courses, which was 20 to 22%. The disciplines where women were, on average, over-represented, when compared to the national average, included Bio-engineering (38%), Environmental Science (37%), Chemical Engineering (35%), Industrial, Management and Manufacturing, and Architecture (29% each). A key question is whether retention in engineering is lower among women than men. The above study shows that female students comprised 20% of national engineering enrolments between 1999 and 2004 and during the same time women represented 22% of degree recipients (National Science Board, 2010). This indicates that issues of female under representation, especially in the field of engineering, is not due to drop-out rates of female engineering students but rather low enrolment rates. The earlier Australian study by Roberts an Arye (2002) found that this is also true of Australian Engineering Education. They point out that there is little or no difference in retention rates between men and women in engineering and that the proportion of women and men who begin working as engineers after graduation is almost equal - 85% for women compared with 89% for men. The number who subsequently left these jobs is also very similar. Women engineers in the 30-39 age bracket who stopped working as engineers made up 45% of the total. Another 17% left the job after they turned 40 years of age or more. The percentage of males who stopped working in the 20-29 age bracket was 40%. Those who left after 30 years of age made up 20% or less of the total (Roberts & Arye, 2002, p.7).

3 Gender Equality

In a number of OCED countries measures have been implemented to ensure a more equitable percentage of women in STEM disciplines such as engineering (OCED, 2014, p.6). One measure that universities worldwide are attempting to institute, involves scholarships and fellowships specifically targeted at female students and researchers in areas such as engineering. Another scheme introduced by Ghent University, Belgium, in 2009, was to provide young female PhD researchers with mentors. Increasing the visibility of female role models in engineering and other STEM subjects is another way to highlight the presence, excellence and outstanding contributions of women in STEM fields. The Gender Equality Observatory publishes documents that highlight how the "presence of women in the various sciences has been undervalued" (p. 7). To raise the visibility of some of these outstanding women, a calendar dedicated to women in various scientific fields is published every year. In 2010 the calendar focussed on women in the field of Chemistry: http://www.urv.cat/media/upload/arxius/any_ciencia/pdfcalendari.pdf

In Australia the government, via its Department of Education Science and Training (DEST), has introduced a Maths and Science partnerships Program (AMSPP) project worth $16.4 million available over three years to enable universities across Australia to deliver innovative math and science projects to increase participation of both males and females in STEM. The main purpose is to improve student engagement in maths and science courses through innovative partnerships between universities, schools, and other relevant organisations. Despite these initiatives falling interest in STEM subjects generally, and gender inequality in Engineering and Science Education in particular, persists. Strachan, Whitehouse, Peetz, Bailey & Broadbent (2008 p. 323) argue that "gender equity is yet to be achieved with significant remaining barriers in academic and senior positions". Reports from the OECD (2013) and from (DEST, 2006 and 2015) make the same point.

Australian universities tend to have a strong record on positive gender policies but inequitable practices are hard to change. In fact universities continue to allow unequal outcomes for men and women in terms of pay and status (Probert, 2005, p.50). Dariusz & Krzysztof (2013) show that the situation Probert described a decade ago has not changed and that there continues to be a slow evolution of women into senior academic positions. Female academics are concentrated in lower job classifications, receive less than average pay and are more often employed in casual positions (EOWA 2005, pp. 30-35). DEST (2006 and 2015) confirmed this lack of progress in terms of gender equity in two reports written a decade apart, showing that women in Australian universities are under-represented in full- time and on-going positions and in senior roles. Similarly in the UK two reports published in 2013 and 2015 showed that although approximately 55% of all UK first-degree students were female this percentage does not subsequently translate in terms of those graduates who eventually become academics in that discipline. Biosciences, for example, has over 60% female students but only 15% of their professors are women. Four years ago the House of Lords Science and Technology Committee (2012) completed an inquiry into STEM in higher education that identified a need for increased numbers of employable, skilled STEM graduates as a matter of urgency for the economic health of the UK. This report highlights the need to increase the number of students who might go on to take STEM related subjects at university in general but also stresses that a low female uptake in stem subjects in compulsory schooling will only compound the current problem of gender inequality in these subjects at the university level. The need to increase female numbers is crucial in areas such as the Built Environment (Fielden et al., 2010), Engineering (Wallace and Sheldon, 2014), Mathematics (Boaler et al., 2011) and Physics (McCullough, 2004). One way forward is to find more creative ways to recruit and teach women in STEM subjects such as engineering.

4 Strategies for engendering diversity in Engineering Education

Another group that does not usually make up a significant proportion of students in Engineering Education and other STEM subjects at university are students with low socio-economic status (SES) backgrounds. Thomas (2014) has argued that particular strategies can be adopted by regional universities to recruit, teach and retain such students. He argues that students from this type of background encounter greater challenges and barriers in adapting to university and in particular to those subjects that are deemed hard, such as mathematics and engineering. He points out that this group has fewer 'encouragers' and suggests that the pathways and pedagogies that universities adopt need to be modified for such students. From what we have presented above

we feel that the same can be said for young women who may aspire to undertake an engineering or mathematics degree but all too often lack encouragement to do so. In his study Thomas interviewed 19 teachers and leaders form 12 regional Australian universities and concluded that the strategies that could be advantageously employed to retain students from low SES background could include active learning pedagogies. In our own case study we looked not only at possible male students from low SES background but also women who were enrolled in more traditional female courses, such as nursing and education. A critique of the literature helped us develop surveys, focus groups questions and selected interview schedules which we could use in the collection of data regarding their recruitment and retention. Like Thomas we found that many of the factors that helped or hindered young women from applying for Engineering and other STEM courses twenty years ago, and hinder the recruitment and retention of SES background students, still apply today. Our case study revealed that the young women and men we interviewed had lacked both encouragement and confidence to take on courses in engineering and mathematics. They felt that there were a number of factors that might have boosted their confidence. These included greater encouragement from teachers and parents, assistance from more competent peers and mentors, and the use of Project Based Learning and other Active Learning pedagogies. Our findings were backed up by other scholars who have undertaken similar research in this area.

Authors such Green, 1997; Galton et al., 2000; West et al., 2010; Tobbell, O'Donnell and Zammit, 2014 have all researched early educational transfers and transitions into STEM. Like us they have concluded that the successful transition of students into STEM degrees, and their eventual retention and success, is greatly dependent on the type of pathways and support that are offered prior to and early in the students' move to university from secondary education. Such support is not only a key to the success of individual students but also an important strategy to adopt for economic and social reasons. Today developed countries, are, to some extent, faced with a STEM crisis (Morley & Lugg, 2009; Hulme & Wilde, 2015). It is essential to assist students early on with a correct choice of university subject if we are to engender more diversity in subjects such as Engineering Education and ensure the sustainability of the discipline. As Yorke and Longden found from their quantitative and qualitative based survey of first-year university students' experiences across twenty five institutions and nine broad discipline areas, an important reason for "withdrawal by some students was wrong choice of field of study" (Yorke & Longden, 2008, p 52). In our own case study we found that many of students of this type had difficulty getting information from their family or friends. We established, as did other scholars, that understanding and tackling transition from pre-tertiary education into higher education was important if students were to make the right choice of subject, including the possibility of enrolling in courses such as engineering, maths, science and technology (Hume & Wilde, 2015). In the focus group discussion that we held we learned that our informants were affected by psychological factors, such as low self esteem when it came to their belief that they had the skills and abilities to undertake study of STEM subjects and that they felt nervous about such a choice because they lacked mentoring towards the end of their secondary schooling.

5 Conclusions and recommendations

The steps the student makes while transitioning from pre-tertiary to higher education are the beginning of a difficult educational journey (Wakeling & Hampden-Thompson, 2013). A successful transition requires students to understand the nature of their chosen academic discipline. There appears to be a mismatch in the way that STEM subjects are presented during the students' pre-tertiary phase compared to when they begin higher education (Hulme and Wilde, 2015, p.15). Based on our own study we agree with the suggestion that students can have unrealistic expectations in relation to the nature and extent of "autonomous learning, the teaching methods they would encounter within higher education, and levels of achievement" that academics in STEM subjects often demand (Hulme and Wilde, 2015, p.6). Because of these unrealistic expectations students question their own ability to make a successful transition and this results in academic disengagement (Rowley, Hartley and Larkin, 2008, p.11). Our research was preparatory in nature but indicated that more work needs to be done to develop a better understanding of student expectations of tertiary study (Johnson, 2003). We also recommend that more work be done on the importance of helping to establish and make more visible strong female role models in STEM. This is a point that the 2014 OECD report on Fostering Equity in Higher Education

emphasized. The fact that Higher Education and industry lack sufficient strong female role models is, unfortunately, all too patent. Huhman (2016, p.1) points out that "today, women hold only 27% of all computer science jobs, and that number isn't growing". Those who do make it into computer science and engineering need mentoring. The OECD report stresses that mentoring programs prior to and during the first year at university have had an effect on student intentions to pursue a university education and complete it. It identified that there was a higher intention to attend university among those students who received mentoring in comparison to those who did not (OECD, 2014, p. 26 and DuBois et alia, 2011). There is an urgent need for STEM providers within the higher education sector to better inform those involved in pre-tertiary policy and practice in terms of curriculum, skills, active learning and teaching approaches. Engineering Educators can also assist by lobbying for resource sharing, smaller class sizes, greater visibility of female role models and a proactive approach to preparing students for transition from secondary schooling to tertiary study. Our study and other action research initiatives, such as the study carried out by the Royal Melbourne Institute of Technology (ACOLA, 2013), suggest viable ways of engendering diversity in Engineering Education and other STEM subjects by increasing the recruitment of women and applicants from low SES backgrounds. Such studies also demonstrate how in addition to recruiting such students Engineering Education and similar subjects can become more sustainable by not only recruiting a broader spectrum of students but also ensuring that they succeed in their studies.

References

Australian Bureau of Statistics [ABS]. (2001). Australian demographics statistics. ABS Cat. no. 3101.0. Canberra: Australian Government.

ACOLA. (2013). Stem country comparisons: International comparisons of science, technology, engineering and mathematics (STEM) education. Final Report.

Boaler, B., & Mckenna, T. (2011). *Engaging the disengaged*. New York: Cambridge University Press.

Bracket, M., Rivers, S.E., & Salovey, P. (2011). Emotional intelligence: implications for personal, social, academic, and workplace success. *Social Personality Psychology Compass*, 5(1), 88-103.doi:10.1111/j.1751-9004.2010.00334.x

Department of Education Science and Training [DEST]. (2006). Careers and Transition: Employability skills. Victoria: Australia.

Department of Education Science and Training [DEST]. (2015). Australian Maths and Science Partnerships Programme (AMSPP). Victoria: Australia https://www.education.gov.au/australian-maths-and-science-partnerships-programme-amspp.

DuBois, D. L., & Karcher, M, J. (2011). *Handbook of youth mentoring. Washington* D.C: Sage Publications.

Engineering UK. (2015).

Eisenhart, M, A., & Finkel, E. (1998). *Women's Science: Learning and succeeding form the margins.* Philadelphia: Temple University Press.

Equal Opportunity of Women in the Workplace Agency.[EOWA]. (2005), Annual Report 05-06. North Sydney: Australia. 30-35.

Hanson, S, L. (1996). *Lost talent: Women in the sciences.* Philadelphia: Temple University Press.

Hulme. J. A., & De Wilde, J. (2015). Tackling transition in STEM disciplines: Supporting the Science, Technology, Engineering and Mathematics (STEM) student journey into higher education in England and Wales. The higher Education Academy. ISBN: 978-1-907207-56.

Hugo, H. (2005). Education in Brazil: Access, quality and STEM. University of Lisbon: Australian Council of learned Academies.

Huhman, H. R. (2016) STEM fields and the gender gap: where are the women? http://www.forbes.com/sites/work-in-progress/2012/06/20/stem-fields-and-the-gender-gap-where-are-the-women/#2ead5b3b33a9.

Fielden, S.L., & Davidson M, J. (eds) (2010). *International Research Handbook on successful women Entrepreneurs*, Cheltenham, UK & Northampton, MA, USA: Edward Elgar.

Freeman, B. (2004). Women in Engineering Science and Technology. Education and Career Challenges. New York: Engineering Science Reference.

Galton, M., & Blachford, P. (2000). *The Class size debate. Is small better?* Philadelphia: Open University Press.

Glover, J. (2002). Women and Scientific Employment: Current Perspectives from the UK. *Scientific Studies.* 15(1), 29– 45.

Green, L. (2007). *Music, Gender and Education*. Cambridge: Cambridge University Press.

Johnson, B. (2003). *The first year at university: teaching students in Transition*. New York: McGraw Hill.

Lal, B., Yoon, S., & Carlson, K. (1999). How large is the gap in salaries of male and female engineers? National Science Foundation, Division of Science Studies issue brief. Accessed from: http://www.nsf.gov/sbe/srs/issuebrf/sib99352.pdf.

Lima, R. M., Carvalho, D., Flores, M. A., & van Hattum-Janssen, N. (2007). A case study on project led education in engineering: students' and teachers' perceptions. *European Journal of Engineering Education*, 32(3), 337 - 347.

Macaskill, M., & Denovan, S. (2013). *Stepping up to the second year at university*. New York: Routledge.

Marginson, S. (2006). Dynamics of national and global competition in higher education. *Higher Education*, 52, 1–39. doi: 10.1007/s10734-004-7649-x .

McCullough, P. (2004). 2004 Physics Education Research Conference. American Institute of Physics. Sacramento, California. August 4-5.

McKenzie, A., & Schweitzer, R. (2001). *Researching Higher Education*. London: McGraw Hill.

Morley, L., & Lugg, R.(2009). Mapping Meritocracy: Intersecting Gender, Poverty and Higher Educational Opportunity Structures. *Higher Education Policy* 22, 37–60. doi:10.1057/hep.2008.

National Science Board (2010) Science and Engineering Indicators 2010. Higher Education in Science and Engineering USA: Chapter 2, 2-41. National Science Board. 2010. Arlington, VA: National Science Foundation (NSB 10-01)

National Science Foundation. (2004). Science and Engineering Indicators 2004. Vol 1. NSB 04-1; Arlington, VA: National Science Foundation.

National Centre for Education Statistics [NCES]. (1997). Findings from the condition of education (1997) no. 11 women in mathematics and science: U.S. Department of Education Office of Educational Research and Improvement. Document No:97-982 1997,14-20.

National Centre for Education Statistics [NCES]. (2013). STEM Attrition: College Students' Paths Into and Out of STEM Fields Statistical Analysis Report. U.S. Department of Education. NCES 2014-001.

OECD. (2014). Fostering Equity in Higher Education Compendium of Practical Case Studies: Promoting female participation in STEM.

Powell, P. C., & Weenk, W. (2003). *Project-Led Engineering Education*. Utrecht: Lemma.

Probert, B. (2005). I Just Couldn't Fit It In: Gender and Unequal Outcomes in Academic Careers. *Gender, Work & Organization*, 12 (1), 50–72. doi: 10.1111/j.1468-0432.2005.00262.x

Roberts, P., & Arye, M. (2002). Counting the losses…….The Careers Review of Engineering Women: an investigation of women's retention in the Australian engineering workforce. The National Women in Engineering Committee: Engineers Australia.

Rowley, J., & Hartley, R. (2008). *Organizing knowledge*. Hampshire: Ashgate Publishing.

Strachan, G., Whitehouse, G., Peetz,D., Bailey,J., & Broadbent, K. (2008). Gender equity in universities: should we be worried? *Gender and Education*, 11 (3), 323-342.

The House of Lords Science and Technology Committee. (2012). *Behaviour Change*. Authority of the House of Lords. London : The Stationery Office Limited.

Thomas, G. (2014). Closing the policy-practice gap for low-SES students in higher education: the pedagogical challenge. *Higher Education Research & Development*, 33(4). 807-820. DOI: 10.1080/07294360.2013.863846.

Tobbell, J., O'Donnell, V, L., & Zammit, M. (2014). Exploring transition to postgraduate study: shifting identities in interaction with communities, practice and participation. *British Educational Research Journal*, 36(2), 261-278.

Universities UK. (2013).Patterns and trends 2013 in UK higher education: higher education: a diverse and changing sector. Universities UK: HESA.

Wakeling, P., & Hampden-Thompson, G. (2013). Transition to higher degrees across the UK: an analysis of national, institutional and individual differences. York: Higher Education Academy.

Willmott, P. (1995). *Understanding, Managing and Implementing Quality: Frameworks, Techniques and cases*. London: Taylor and Francis.

Wallace, N ., & Sheldon, M. (2014). *Enhancing career pathways*. SA, Australia: Springer.

West, P., Sweeting, H., & Young, P. (2010). Transitions matters: Pupil's experiences of the primary-secondary transition in the West of Scotland and consequences for wellbeing and attainment. *Research Papers in Education*. 25 (1), 21-50.

Wingate, W. (2007). *Focus on first year success*. London: Sun Press.

Yorke, A., & Longden, M. (2008). *How to Recruit and Retain Higher Education Students: A Handbook of Good Practice.* New York: Routledge.

Project Management in Engineering Education: Key Issues in Supervising PhD Students in Project Based Learning

Michael F. Christie[1],Terry Lucke[2]

[1] School of Education, University of the Sunshine Coast, Sippy Downs, Queensland, Australia.
[2] School of Engineering, University of the Sunshine Coast, Sippy Downs, Queensland, Australia.

Email: michael@cwrite.net, tlucke@usc.edu.au

Abstract

Harmer (2014) surveyed 59 articles related to Project Based Learning (PjBL) and concluded that PjBL has been trialled worldwide in the last decade and adopted across a diversity of educational institutions. PjBL has been defined as problem based learning that usually involves a prolonged activity resulting in a product, presentation, or performance (Donnelly and Fitzmaurice, 2005). Although engineering educators use PjBL mainly at the undergraduate or masters by coursework level we argue that the engineering PhD can also be categorised as a form of PjBL. We contend that the PhD process would be much improved if in fact the definition, philosophy, pedagogical practices and project management principles of PjBL were applied to aspects of PhD project management, teamwork, supervisor and student roles, as well as evaluation and assessment. The PhD as a form of PjBL aims to produce engineering improvements and to do this effectively good project management is essential. It is increasingly common that a PhD is assessed on the basis of published or submitted journal articles authored by the student, alone or with others. Often supervisors and fellow students can be included as co-authors because engineering PhDs tend to work on improving a project or process as part of a collaborative team. Our research makes use of Flanagan's *Critical Incident Technique* (1954) to gather and analyse data about the issues that can affect the quality of project management and other related issues in the PhD process. Although there are different levels of project management our focus is at the PhD supervisory level. Our paper presents a case study that was carried out at a prominent European university of technology. Flanagan's technique is explained briefly and the case study data is analysed to reveal key issues that can make a difference in terms of good project management.

Keywords: Ethical dilemmas in Engineering Education; Project management; Critical Incident Technique.

1 Introduction

The most difficult and sophisticated form of project management in teaching and learning at the university is, arguably, managing the PhD project. As Sinclair (2004) notes in his commissioned report on the PhD process there are clear differences between the disciplines when it comes to managing the PhD. The PhD culture in the natural sciences tends to be collaborative in terms of research and publishing whereas the arts and humanities (and to a lesser extent the social sciences) are often more individualistic. Natural science supervisors, especially in an applied science like engineering, generally manage teams working on projects that they themselves have found funding for. Governing bodies and professional associations in the engineering profession have agreed on a set of protocols for determining what should be expected of engineering graduates in terms of their professional knowledge, skills, and attributes. National bodies, especially in developed countries, have come together to forge international agreement on this and the Washington, Sydney and Dublin Accords demonstrate that there is now an international consensus on the sorts of skills, competencies and professional and personal attributes that a graduate needs if he or she wants to be placed on an international register of engineers (IEA, 2013). The IEA's comparative paper on professional competencies and graduate attributes makes it clear that graduating engineers must be problem solvers capable of applying their knowledge and skills in new and unexpected circumstances. It also emphasises that they should possess the sort of professional and personal attributes listed in the table below. Given such strong international agreement on this and the similarity between the IEA's recommendations and the principles and practice of PBL, either in the form or problem or project based learning, it is surprising that PBL and PjBL are not even more widespread in engineering courses at both the undergraduate and postgraduate level.

We argue that the duty of PhD project managers is not only to ensure that their PhD students possess the

above mentioned competencies and attributes before beginning their research studies, but that they also, as experienced academic engineering educators, lead by example and demonstrate that they too possess them. In the context of this paper we emphasise the third set of competencies, namely, the 'professional and personal attributes' of the graduate engineer, and their importance in project managing the PhD. If it is true, as Sinclair (2004) points out, that the scientific PhD is characterised by collaboration in terms of problem solving, knowledge building and the publication of results, then the need to embody the attributes laid out in the table below is paramount since all of them are important ingredients of project based learning.

Table 1. Engineers Australia: Stage One Competencies and Elements of Competencies (2005 & 2011)

Competency 3	Professional and Personal Attributes
Competency 3.1	Ethical conduct and professional accountability
Competency 3.2	Effective oral and written communication in professional and lay domains
Competency 3.3	Creative, innovative and pro-active demeanour
Competency 3.4	Professional use and management of information
Competency 3.5	Orderly management of self, and professional conduct
Competency 3.6	Effective team membership and team leadership

In our study we used Flanagan's Critical Incident technique (CIT) to investigate different aspects of project management in the PhD process. Our approach was quite straightforward. We asked PhD supervisors to think back over their experience as supervisors and as former PhD students and to write down two separate incidents. The first should be told from their perspective as a supervisor. The second as a former student. We indicated that the incidents could be positive or negative, important or trivial, but the key was to specify what had occurred and say why it was so memorable. Many of the incidents related to behaviour that demonstrated both good and bad examples of the professional and personal attributes that are given in the table above.

2 The PhD as a form of project based learning

In an earlier conference paper given at the 2015 combined IJCLEE conference we compared and contrasted Project and Problem Based Learning and argued that these two types of PBL complement each other (Christie and Lucke, 2015). In that paper we pointed out that problem based learning, which we will refer to as PBL, begins with an issue or problem that students need to solve or learn more about. Project based learning, which we will refer to as PjBL, usually begins with the design and creation of a product or an artefact in mind. In both PBL and PjBL tasks can be staff or student driven or a combination of both. Above all both are characterised by active learning on the part of the students. Sometimes the tasks require wider field experience in a workplace but even when simulation or virtual reality is used the emphasis in terms of assessment is that it be active, authentic and, where possible, formative as well as summative. The following figure taken from Brundiers and Wiek's article (2013) that compared PBL and PjBL not only provides a simple way of distinguishing between these two pedagogical models but provides a basis for our claim that the PhD can be seen as a form of project based learning.

As we note in the abstract a survey of the literature shows that both forms of PBL tend to occur mainly in undergraduate degrees if we use published papers as an indicator. They are used to a lesser extent in Masters by coursework and rarely in the PhD. We undertook a search of publications in Scopus for the period 2006-2016 using three different search phrases. The first 'PBL in undergraduate courses' gave 145 results with over 30 each in Engineering, Medicine and Computer Science and 19 in Nursing. Of the total 96 were articles, 35 conference papers and the rest consisted of a few books, book chapters and reviews. A search of 'PBL in Masters' produced a total of 65 publications more evenly spread between articles and conference papers. The most publications per discipline (22) was in Engineering. Using the search term 'PBL in PhD' resulted in 6 publications. Of these only two articles were relevant - the other four tended to be articles about undergraduate PBL based on PhD thesis work. We acknowledge that good PhD coursework will include PBL approaches but Scopus, at least, does not show any articles that focus on its specific use there.

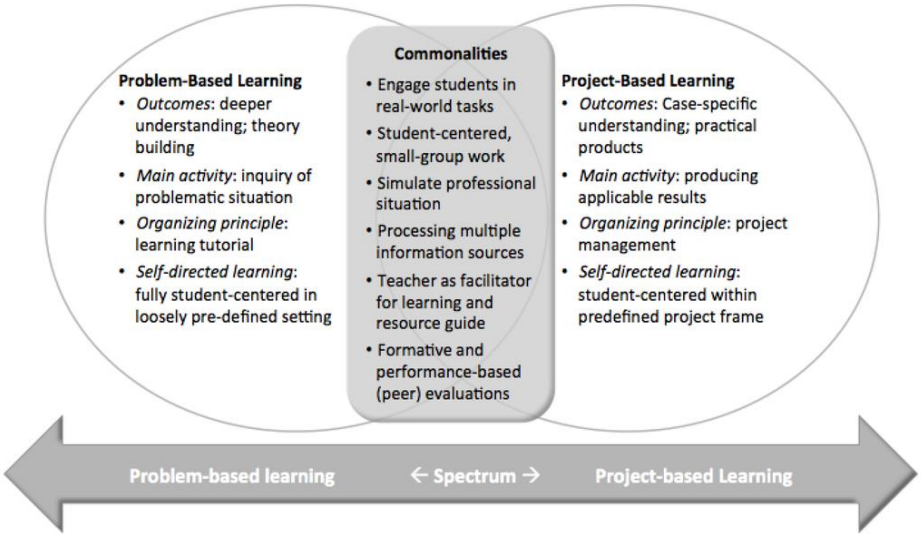


Figure 1. A comparison of PBL and PjBL. Source: Brundiers and Wiek (2013: 1727).

More importantly there does not appear to be any literature that specifically argues our point that the engineering PhD is by its very nature a form of PjBL. When we look at the figure above we postulate that all of the points made in the Commonalties column and the right Venn diagram under PjBL apply to a majority of engineering PhDs. Doctoral students in engineering almost always are engaged with real world tasks, tend to work in small student centred learning groups, are clearly becoming fully fledged researchers either in simulated or real world situations, process multiple information sources, have supervisors who act as their guides, and are regularly involved in formative and peer based evaluations. The PhD (like PjBL) is concerned with case specific understanding and outcomes and often results in improvements to or the creation of practical products or processes. The main purpose of the PhD is to come up with applicable results. The organising principle of the PhD process is an hierarchical project management structure with the Research Office and Dean of Research managing the bureaucratic side of the PhD and the Supervisor taking care of managing the particular project that his or her students are working on according to a strict framework and timeline. Finally there is no other form of education at the university that is more student centred.

3 Methodology

The purpose of our research was to better understand the PhD process as a form of project based learning by focusing on key elements in each. These included including project management, teamwork, the role of supervisor and student, effective communication, ethical and professional behaviour and evaluation and assessment. We used Flanagan's Critical Incident Technique (CIT) to gather and analyse data which were collected during professional development courses for supervisors over a five year period at a prominent European university of technology. In addition to our research aim there was also a pedagogical purpose for getting the participants to write the incidents. The aim of the courses were inform participants about rules and regulations, encourage networking and to provide the supervisors with an analytical, critical reflective tool that they could use to improve the doctoral experience. The incidents became the basis for small group discussions on issues deemed important by the participants. The plenary session, facilitated by the course leader (the first author) provided a forum for sharing key issues and obtaining information and help with matters of concern. The participants wrote the incidents prior to class. As we note above we generally asked them to write down something memorable about their PhD experience either from their current perspective as a supervisor or as a former PhD student. To help prod their memory we suggested that the incident could be either positive or negative and might relate, for example, to issues or problems that arose in the areas mentioned above. Fifty three incidents were randomly chosen from three hundred incidents, using the length of the written incident as a randomizing factor. The incidents were then analysed to determine common themes and issues. In Flanagan's critical incident technique (1954) the key steps in using the technique are to define the general aim

of the activity being investigated, specify the way in which the incidents are to be collected, and then categorize and analyse the incidents according to a predetermined set of criteria. The results are presented in a report that clarifies the research method and indicates any limitations that were imposed on it (Christie and Young, 1997).

Our general aim is best summed up by the title of this paper. We wanted to know what are some of the key issues affecting the quality of project management at the supervisory level in the PhD process, a process that we defined as a type of PjBL. In analysing the data we used the professional and personal attributes list from the Stage One Competencies and Elements of Competencies developed by Engineers Australia as a way of determining when an incident provided evidence of good versus poor project management. Our thesis is that a good quality project manager or supervisor of the PhD process should ideally be able to display the six behaviours in that list. We have numbered them again below using a C to show that they refer to a competency or element of a competency. In our analysis of the incidents each narrative was read carefully to determine if it related to any of the six competencies. Since the narratives could address both manager or student behaviour and deem it as positive or negative we used the abbreviations MC and SC followed by a number and a plus and/or minus sign to code the type of behaviour that occurred in each of the incidents. By using the list below we were able to make a number of conclusions about the key issues that were of concern to 53 supervisors of PhD students, who we argue, are engaged in a learning process that can be characterised as an extended project based learning project. Those concerns relate to the following desirable attributes that professional bodies of Engineers around the world expect that an engineering graduate, let alone a qualified and experienced engineer who supervises engineering PhD students, should possess:

C1. Ethical conduct and professional accountability
C2. Effective oral and written communication in professional and lay domains
C3. Creative, innovative and pro-active demeanour
C4. Professional use and management of information
C5. Orderly management of self, and professional conduct
C6. Effective team membership and team leadership

The more the above criteria were addressed in a positive manner in an incident the higher it rated as an example of quality management and vice versa. Naturally each incident had a specific focus and commonly related to only one or two types of behaviour. The limitation in our methodology was that judging the categories addressed in each incident was carried out by the authors alone. With more funding it would have been possible to employ the Delphi Method whereby a panel of experts judged the incidents independently over two rounds, thereby providing a more objective assessment of the categories evident in each incident. Even so a certain degree of subjectivity is inevitable especially when incidents generally involve the behaviour of at least one supervisor and one student but typically can include co-supervisors and more than one student depending on the composition of the research team.

Judging the most relevant competency expressed in the incident is also difficult. For example one incident (no 31), told from a student perspective, dealt with how a mature student's positive progress in the PhD was derailed by a difficult divorce. Because of the supervisor's active, intuitive and timely intervention the student was able to regain focus and finish the PhD. The supervisor's management of this situation could be seen to cover all six of the desirable professional and personal attributes mentioned above. However some might question if it is the role of a supervisor to provide such support to a student whose problem is personal rather than an academic while others could argue that because the student's divorce and its consequences was adversely affecting the PhD process it was up to the supervisor to step in. It might have been enough to recommend an expert counsellor rather than intervene. In another incident (no 34) a principal supervisor who was very good at the job was promoted and did not have the time to supervise as well as was required. This was never really acknowledged or communicated to the student. Again this situation demonstrated a lack of many of the criteria mentioned above. In this instance we were guided by the narrator's own assessment of the incident. Remembering this situation as a student the participant said: 'I was not really angry about my supervisor's "absence" – at least I had my co-supervisor and myself. What made me angry was that the

supervisor never said that he hadn't time to read the paper and that he was not well prepared for the meetings, i.e., the main problem was the lack of open and clear communication'. Interestingly this negative experience had a positive outcome. The narrator of the incident said that because of the principal supervisor's lack of interest: 'I became a very good project manager even if the time for "real" research got more limited'.

When the participants wrote incidents from a supervisor's point of view their memory of the incident was fairly recent. When they, on the other hand, wrote an incident from their time as a PhD student, there is a greater chance that the story has been rehearsed in their mind and that details have been lost or altered. This is a not a problem if we maintain, as we do, that the incidents are individual perceptions of what occurred rather than an objectively recorded event that endeavours to capture an historical truth.

4 Results

The results of the analysis are given in the table 2 below:

Table 2. Incident number, description and the competencies, both positive and negative, demonstrated by the incident.

No of Incident	Description and coded competencies
Incident 1	Giving and receiving feedback on presentations. Defensive and offensive student response to constructive feedback on presentation. SC4-
Incident 2	Giving and receiving feedback on writing. Being aware of one's body language and how students can be sensitive to it in critiquing their work. MC2+, MC5+
Incident 3	Creative criticism. Breaking a negative cycle in the collaborative writing of a publication (co-supervisor, supervisor plus 3 students). MC3+
Incident 4	Co-supervision and cooperation. Male student picks male co-supervisor's plan over female co-supervisor's. Female supervisor wonders why. MC5+, MC6-
Incident 5	Freedom to research. External funding and need for results means co-supervisor does work while student on parental leave. MC1-, MC2-
Incident 6	Forced student collaboration. Creative solution to problems in paired project. MC3+
Incident 7	Misunderstandings about a co-supervisor's desire to be involved with the student's PhD research – student concern about the first author 'problem'. No early or clear communication about the problem. MC2-/SC2-, MC5-/SC5+
Incident 8	One-way communication in a vital introductory discussion concerning a PhD project. Body language being misinterpreted. MC2-/SC2-
Incident 9	The supervisor's need for a balance between being directive or letting the student decide key issues. Advice not taken. A gender issue? MC2-/SC2-
Incident 10	The supervisor's responsibility to ensure that the PhD student's work is original. The promising Diploma work is not so promising as an extended work and original paper because of previous publications that come to light. MC2-, MC4-
Incident 11	Failing to get through to a student. Student blames himself and refuses help. SC2-, MC5+
Incident 12	Credit for work done. The first author dilemma. MC1-/SC1-, MC2-/SC2-
Incident 13	Publishing pacts. MC1-, MC5-
Incident 14	Winning the confidence of one's PhD student in an unstable environment. MC5+, SC2-
Incident 15	Keeping secrets to protect 'the innocent'. What do students need to know about inappropriate behaviour on the part of supervisors. MC1+/-, MC5+/-,
Incident 16	Two types of PhD student motivation and ways of enhancing them: a) an interest in the field (quality) and b) generating results (quantity) MC3+, MC6+
Incident 17	Answering questions on behalf of less experienced co-workers. MC2+,MC6+
Incident 18	The danger of bending rules. Losing one's temper. MC1-. MC5-
Incident 19	The importance of careful recruitment and early intervention when things go wrong with a PhD candidature. SC1-, SC5-

Incident 20	Walk a mile in the PhD's shoes. Changing demands of the PhD. MC2-/SC2-, MC3-/SC3-
Incident 21	Who should help the inexperienced supervisor understand her/his role and how to do it best? SC3-, SC5-
Incident 22	Negotiating and accommodating different supervisor and student 'research horizons'. MC4+, MC6+
Incident 23	Early intervention can alleviate disputes over research ideas and authorship of articles. MC1-, MC5-, MC6-
Incident 24	Not reading early drafts well enough. MC5-, MC6-
Incident 25	Being aware of the complexities of supervising interdisciplinary research without being too frightened to attempt it. MC4-, MC6-
Incident 26	Making sure you listen to all sides of the student story M&SC2-, MC6-
Incident 27	When communication gets difficult between supervisor and student a neutral observer can help. MC2+, MC5+, MC6+
Incident 28	Student perspective on disagreement among supervisors. Co supervisor was right about inappropriate topic. MC6-
Incident 29	Scientific cultural differences among supervisors – from a student perspective. MC6-
Incident 30	Troubles with a sick supervisor who seems to lack academic judgement. MC5-, MC6-
Incident 31	Support from the research group in hard times. The importance of solidarity among the team. MC6+
Incident 32	Seeking advice in planning the direction of cross disciplinary research. MC6+
Incident 33	How not to supervise a PhD – minimal and negative supervisor input. MC6-
Incident 34	Learning from the mistakes of others. Engaging your students so that they do not suffer the sort of neglect you experienced as a PhD student. M&SC2-, MC6-
Incident 35	Lack of supervision and the failure to communicate that there would be little time to read papers or supervise. MC2-, MC5+, MC6-
Incident 36	Communication breakdown between supervisor and PhD student. MC2-/SC2-
Incident 37	Using colleagues and fellow students to overcome difficulties as a PhD student. MC6+, MC5+/SC5+, MC2+
Incident 38	The importance of collegial communication when recruiting new students. MC2-
Incident 39	The importance of supervisor-student communication when submitting the PhD thesis. MC6-
Incident 40	The first author problem – tradition and power versus ethics. MC1-, MC2-
Incident 41	Who has the responsibility for deciding who should be first author? MC1-, MC2-
Incident 42	Being assertive as a PhD student when a supervisor acts inappropriately. MC1-, MC3-, MC5-
Incident 43	Appropriate and inappropriate ways to give feedback. A supervisor's power is to be used (wisely) not abused. MC2-, MC6-
Incident 44	Being ready to call in outside expertise when a difficult supervision situation calls for it. MC3+, MC4+
Incident 45	Standing up to one's supervisor on the issue of authorship. MC1-
Incident 46	The importance of encouraging student initiatives, and in particular, those that help build a collaborative spirit within the research group. SC3+, MC6-
Incident 47	The art of finding good problems to solve. Should PhD students be trained for this? SC3+, SC4+, MC6-
Incident 48	The responsibility of giving constructive, timely feedback on drafts of the thesis. MC2-
Incident 49	The importance of building rather than undermining the self confidence of students. MC5+
Incident 50	The importance of supervisors providing genuine academic critique of their students' work. MC3-, MC6+
Incident 51	The need to encourage students to be self critical about their own work. MC2-, MC6-
Incident 52	How not to manage and supervise an industry related project MC3-, MC5-, MC6-

Sinclair's report (2004) argues that in Australian universities at least supervision in the natural sciences appears to be more successful than in the Social Sciences and the Humanities. He uses completion figures to support his argument. He also points out that Postdoctoral positions are more common in the Sciences and that this leads to more experienced younger supervisors in the natural sciences. He goes on to argue that competent young co-supervisors and a teamwork ethos can partially explain the 25% difference in completion rates (Sinclair, 2004, 24). Although our research cannot be compared with Sinclair's large survey it does suggest that there might be a less positive sides to supervision in the natural sciences. Younger supervisors are often more active because the team leader (generally a Professor and, on paper, the principal supervisor) is too busy seeking funding and building networks and as a consequence may not have time left over for hands-on supervision or laboratory work (Christie and Garrote, 2013).

This is borne out by a number of incidents in our study that revolved around the fact that senior supervisors did not give sufficient support, knew little about the specific areas that individual students were working on, or, in the worse cases, ignored students except when they wanted their name, or a friend's name, on a publication (incidents 3, 13, 21, 22, 23, 30, 33, 37, 39, 40, 53). This project was initiated in order to improve the conduct of a course in supervision and, hopefully, disseminate research results that could help others improve similar courses. The authors were interested to find out to what extent supervisors felt that the quality of project management or supervision matched the specified competencies for professional and personal attributes as laid out in the Stage One Competencies and Elements of Competencies of Engineers Australia (2005 & 2011). Table 3 below provides a summary of issues that concerned the participants both as supervisors and former PhD students.

Table 3. Quantitative summary of competencies revealed in the incidents.

A: From a Manager/Supervisor (M) perspective						
Competency	C1	C2	C3	C4	C5	C6
MC+	1	4	2	2	6	4
SC+	0	0	0	0	1	0
MC-	6	7	1	3	4	6
SC-	2	8	2	1	2	0
Subtotal A	9	19	5	6	13	10
B: From a PhD Student (S) perspective						
MC+	0	4	3	3	2	5
SC+	0	0	2	1	1	0
MC-	4	13	4	3	7	12
SC-	0	9	1	1	0	0
Subtotal B	4	26	10	8	10	17
Subtotal A	9	19	5	6	13	10
Total	**13**	**45**	**15**	**14**	**23**	**27**

5 Conclusions

This project was initiated in order to improve the conduct of a course in supervision and, hopefully, disseminate research results that could help others improve similar courses. Our research showed that an analysis of the 53 incidents revealed that the most common issues in terms of positive and negative managerial/supervisory competencies were in the area of communication(45), with effective team membership and team leadership being the second most common (27). A clear third related to the orderly management of self and professional conduct (23) with the other three competencies, namely, creative, innovative and pro-active demeanour (15), professional use and management of information (14) and ethical conduct and professional accountability (13) being almost of equal importance. Unfortunately there were more examples of negative than positive behaviour in relation to the six competencies. In the case of ethical and professional behaviour (C1) there were

12 negative versus 1 positive example; for effective oral and written communication in professional and lay domains (C2) there were 37 versus 8; in the area of creative, innovative and pro-active demeanour (C3) there were 8 versus 7; for professional use and management of information (C4) there were 8 versus 6; in the area of orderly management of self, and professional conduct (C5) there were 13 versus 10; and, for the last competency of effective team membership and team leadership (C6) there were 18 versus 9. What is significant in the case of first competency is that almost all of the incidents that dealt with unethical and unprofessional behaviour were connected to disputes over authorship of papers. Finally there were some clear differences between the incidents told from a current supervisor perspective and those that were remembered from the time when the supervisors had been PhD students themselves. The most obvious was that issues relating to the competencies of effective oral and written communication (C2) appeared in incidents told from a student perspective 26 times versus 19 from a supervisor perspective, and, in the case of effective team membership and team leadership (C6) there were 17 versus 10 references. Since the repercussions for poor communication and team leadership are most likely to adversely affect students more than supervisors it is understandable that students desire both clear communication and good team leadership on the part of those who manage their project based learning.

This case study has shone light on a wide variety of issues that need to be addressed in the PhD process if it is to function as an effective form of Project Based Leaning. Given that the relationship between project managers or supervisors and their PhDs is meant to be collegial, at least in the European tradition, it was surprising to see a large number of incidents that were related to power issues between co supervisors, between students and their supervisors and among the students themselves. In some of the incidents issues of sexism arose as well as cultural differences, both in terms of one's discipline and ethnic background. Many incidents revolved around a lack of support for the PhD student. It would be useful if future research on this topic obtained critical incidents from current PhD students who are at different stages of their candidature since not only do different types of students need different sorts of support but also the level of support can change depending on the stage of the PhD. A comparison between the number and type of incidents from current students and supervisors, as opposed to incidents that are remembered by supervisors from their own time as students, would also improve any future study. A very satisfying aspect of this study was that it not only gave us new insights into the engineering PhD as a form of project based learning but it was also efficacious for those who participated in the research. The discussions that followed the narration of the incidents in both the small groups and the subsequent plenary sessions were robust, informative and, according to the participants themselves, extremely helpful as a professional development exercise.

6 References

Brundiers, K and Wiek, A. (2013) Problem- and Project-Based Learning Courses. Sustainability. 3, *1727*.

Christie, M., and Young, R. (1997). Critical Incidents in Vocational Teaching. Darwin: NTU Press.

Christie, M. (2008). Using critical incidents to improve the supervision of PhD students. Pedagogical Papers Series Winter Edition. Gothenburg: IT University Press.

Christie, M. and Garrote, R. (2013). Using communicative action theory to analyze relationships between supervisors and PhD students in a technical university in Sweden. Högre utbildning, 3 (3), 2013, 187-197.

Delamont, S., Atkinison, P. and Parry, P. (2004). Supervising the doctorate: a guide to success. Milton Keynes: Open University Press.

Donnelly, R. & Fitzmaurice, M. (2005). Collaborative project-based learning and problem-based learning in higher education: A consideration of tutor and student roles in learner-focused strategies'. Emerging Issues in the Practice of University Learning and Teaching. Dublin: AISHE, pp 87-98.

Flannagan, J. (1954). The critical incident technique. Psychological Bulletin, 51, 327-358.

Gatfield, T. (2005). An investigation into PhD supervisory management styles: Development of a dynamic conceptual model and its managerial implications. Journal of Higher Education Policy and Management, 27(3), 311-325.

Harmer, N. (2014). Project based Learning Literature Review. Unpublished ms. Plymouth University.

Lima, R. M., Carvalho, D., Flores, M. A., & van Hattum-Janssen, N. (2007). A case study on project led education in engineering: students' and teachers' perceptions. European Journal of Engineering Education, 32(3), 337 - 347.

McMorland, J., Carroll, B., Copas, S. and Pringle, J. (2003). Enhancing the practice of PhD Supervisory Relationships through first and second person action research/peer partnership inquiry. Quality Social Research, 4(2)

Mezirow, J. (1991). Transformative Dimensions of Adult Learning. San Francisco: Jossey-Bass.
Powell, P. C., & Weenk, W. (2003). Project-Led Engineering Education. Utrecht: Lemma.
Punch, K. (2009). Introduction to research methods in education. New Delhi: Sage Publications.
Sinclair, M. (2004). The pedagogy of 'good' PhD supervision: a national cross-disciplinary investigation of PhD supervision. Canberra: Australian Government, Department of Education, Science and Training.
Tripp, D. (1993). Critical incidents in teaching: Developing professional judgment. London: Routledge.
Wilkinson, D. (2005) The essential guide to postgraduate study London : SAGE ISBN 1-4129-0062-X (hbk.)
Wisker, G. (2005) The Good Supervisor: Supervising Postgraduate and Undergraduate Research for Doctoral Theses and Dissertations. Basingstoke: Palgrave Macmillan. ISBN 1-4039-0395-6.

Active Learning with the Use of MOOCs at Chalmers University of Technology – Experiences, Challenges and Future

Elisabeth Saalman[1]

[1] Department of Engineering Education Research, Applied Information Technology, Chalmers University of Technology, Sweden

Email: saalman@chalmers.se

Abstract

Chalmers University of Technology (Chalmers) has joined the MOOCs movement and is from 2014 a partner of the edX platform. The first MOOC that Chalmers offered (2015) was a course about the material graphene "Graphene science technology". The second MOOC offered at Chalmers was the MOOC "Sustainability in everyday life" (2015). This year 2016 Chalmers University of Technology is offering a MOOC "Sensing the planet". This MOOC is an energy and earth science course in two parts which aims at answering questions like What do your senses tell you about planet Earth? and Do we know enough about our planet? The aim of this paper is to report from Chalmers experiences of, and research on MOOCs and to discuss how MOOCs can be used to support active learning in engineering education. If we think of active learning as an approach to instruction in which students engage the material they study through reading, watching, listening, writing, discussing and reflecting it is natural to think of a MOOC as a valuable resource for active learning. Chalmers' research regarding MOOCs is presented and discussed. Chalmers conducts a strategic venture with MOOCs, opening for enhanced cooperation with other universities to achieve high quality in online web-based education, both on campus and at a distance. Chalmers basic assumption is that MOOCs of good quality, pedagogically well-planned and with engaging learning resources should have the potential to support active learning in engineering education. Several other universities in Sweden and the Nordic countries are now offering MOOCs and explore the opportunities and challenges with MOOCs. A conference "MOOCs in Scandinavia" was arranged in Stockholm 11 - 12 June 2015 (Karolinska Institutet, 2015). The 2nd MOOCs in Scandinavia Conference, June 9-10th 2016, is arranged by Chalmers University of Technology in Gothenburg.

Keywords: Active Learning; Engineering Education; MOOCs; blended learning; ICT.

1 Introduction

For a number of years higher education institutions in many countries have been offering open online courses that are freely available on the Internet, known as Massive Open Online Courses, MOOCs. Anyone with access to a computer connected to the Internet can take part in these courses. The international pace of development and interest in MOOCs is substantial. The number of MOOCs has increased dramatically in recent years (Open Culture, 2016; Open Education Europa, 2016; Bates, 2015). MOOCs of today deliver high quality content from some of the world´s best universities for free to anyone with a computer and an Internet connection.

A MOOC is open with no barriers to entry or leave and there is no limitations in number of students. A MOOC is flexible in time, place and resources. It gives the participant possibility to choose between learning resources and to make own choices how to learn and engage. A MOOC is often organized with video lectures, quizzes, dialogue, interactivity through questions and discussion forums. MOOCs has also been reported as interesting for research communication, continuing education, lifelong learning among people, for increasing visibility, marketing and recruitment. Additional aspects on the impact of MOOCs is the possibility to support international collaborations and cross-cultural issues.

In several countries, as in Sweden, higher education is provided free of charge and Internet-based distance teaching and learning has been an established phenomenon for many years. In Sweden higher education offers a wide range of freestanding courses which can be studied in the context of lifelong learning. Continual professional development and other forms of continuing education therefore form part of the normal higher education system in Sweden and are, according to the legislation, free of charge. Higher education in Sweden is thus already relatively open and flexible.

Chalmers has joined the MOOCs movement and is from 2014 a partner of the edX platform (edX, 2016) Chalmers offered two MOOCs in 2015 and is offering two new MOOCs during 2016 and another new MOOC is planned to be released autumn 2017. The hypothesis is that MOOCs of good quality, pedagogically well-planned and with engaging learning resources have the potential to foster active learning.

This paper reports from and discusses the Chalmers experiences, challenges and future plans for using MOOCs to support active learning. Chalmers University conducts a strategic venture with MOOCs to gain further experience in developing, implementing and evaluating methods for teaching and learning within the MOOC format. At Chalmers there is an expressed need to focus even more on quality and modernization that meets expectations of individualized education and to develop the pedagogy in existing courses using modern educational technology and Internet in MOOCs, blended learning, flipped classroom and other innovative forms of education. Chalmers has a desire to, in a greater extent than today to become a modern edge cutting technical university with a global view on education and opening for enhanced cooperation with other universities to achieve high quality in online web-based education.

From a higher education perspective - pedagogical perspective - there are clear benefits for universities to work with the MOOCs concept. Spread of knowledge and marketing MOOCs contribute to the development of pedagogy for online education and teachers involved will learn and improve skills for educational development and blended learning. Knowledge of how students learn will increase from studies on students´ learning online which can be used in research on web-based teaching and learning. MOOCs also contribute to the development of technology in education. The technology level in a MOOC must be relatively high compared to conventional online courses enabling technological and methodological development. The underlying web-based technology contributes to the development of pedagogical methods of on-campus education and in blended learning (Bates, 2015). This is in consistency with other studies for example Garrison (Garrison, 2004) who concludes that blended learning is consistent with the values of traditional higher education institutions and has the proven potential to enhance both the effectiveness and efficiency of meaningful learning experiences.

The research question is how MOOCs – but also other web-based forms for teaching and learning; blended learning, flipped classroom etc – can foster active learning. Pedagogical aspects on the use of MOOCs are discussed and the paper tells about ongoing development and research at Chalmers regarding web-based/online teaching and learning including MOOCs and blended learning.

2 MOOCs at Chalmers University of Technology

The **1st MOOC** that Chalmers offered (2015) was a course about the material graphene "***Introduction to Graphene Science and Technology***". The background to developing this first Chalmers MOOC offered globally is that Chalmers is the coordinator of the Graphene Flagship in EUs huge research initiative on graphene. Excerpts from the description of the MOOC content at the Chalmers web (Chalmers MOOC, 2016, ChalmersX, 2016)**.**

Previous knowledge needed to be able to benefit from this course is that the participants have an adequate knowledge of general physics and university level mathematics.

The participants are expected to devote 6 hours weekly to the course. Each week features a series of lecture sequences supported by interactive video tutorials and interspersed exercises or problems. Students will work on a homework assignment or quiz each week.

9600 participants/students from 127 countries all over the world registered on the MOOC 2015.

The **2nd MOOC** that Chalmers offered (2015) was the course "***Sustainability in Everyday Life***". Excerpts from the description of the course content at the Chalmers web **(**ChalmersX, 2016).

Previous knowledge needed to benefit from this course is that the participants should have passed compulsory school of at least 9 years and be comfortable working with a computer.

9000 participants/students from 156 countries all over the world registered on the MOOC 2015.

The **3rd and 4th MOOCs** which Chalmers offers 2016 are connected to each other, they are both about sensing planet earth. The two MOOCs are ***"Sensing Planet Earth – from Core to Outer Space"*** (started February 1st 2016) and "***Sensing Planet Earth – Water and Ice"*** (starts March 21st 2016). The content is split in two courses with a length of four weeks each. Each course has an introduction that provides the necessary mathematical and physical background and a summary at the end will put together a complete picture of how we can monitor and measure the complex Earth systems. The MOOCs are run globally and are produced in a format suitable for smartphones thus allowing flexible studies. The MOOCs are customized to smartphones since the availability of smartphones is much bigger than the access to computers.

Previous knowledge needed: The target groups are high school teachers, high school students, the public and decision makers or professionals who are relying on Earth observations. High school students (and also much of the public) are expected to appreciate the MOOC and have sufficient knowledge of mathematics and physics to manage to follow the MOOCs. In the MOOC some of the homework/assignments are about collecting own data (temperature, weather, water levels etc) and practice active learning. The MOOCs are produced in a format suitable for smartphones thus allowing flexible studies.

Description of the course content in "***Sensing Planet Earth – from Core to Outer Space***" and the content in "***Sensing Planet Earth – Water and Ice***" can be find at the Chalmers web **(**ChalmersX, 2016):

Another **5th MOOC** at Chalmers about logistics is planned for a global release autumn 2017.

Thus, Chalmers today have experiences from producing four MOOCs and a fifth is on its way and will be offered globally 2017 (Chalmers MOOCs project, 2015). The MOOCs offered 2015 are now being evaluated and data and statistics are being compiled spring/summer 2016.

3 Chalmers perceived opportunities and challenges in providing MOOCs

Teachers involved in the planning – pedagogical and technical - designing, organizing, producing and implementation of MOOCs report of a lot of work but also competence development and enrichment of their teaching experiences which can be used at campus and in blended learning.

There are several steps in producing a MOOC; planning, structuring, designing, coordinating, producing and implementing the course. These steps include a lot of tasks that need to be thought through and decided about: the pedagogical concepts; the course content including the learning objectives, course moments, homework, quizzes, hands-on exercise and interaction/communication in the MOOC. Concepts of letting students carry out experiments and submitting their results via the MOOC platform may be desirable and need to be planned and decided how to carry out and follow-up. The way in which students will be examined in must also be decided and produced.

When planning and creating a new MOOC there is often no teaching material that can be used unchanged. The teachers have to rethink the pedagogical setup and the course material, learning resources have to be arranged and put together in a new way in order to adapt to the digital components used in the MOOC. The tasks of creating, structuring, writing and presenting the content have to be done in the same way one would create any new course. The teachers have to plan and coordinate lectures and course moments and decide about all MOOCs resources needed to give the course. In the planning the teachers have to take into account the heterogeneous MOOC student groups: high school students, high school teachers, decision makers etc. and it has to be thought throw how to manage to keep students´ interest, to retain students in the MOOC.

Additionally the MOOC communication is challenging. The challenges are how to manage and support valuable communication in student-teacher, student-student, student group interaction etc. Possible ways for interacting with MOOC students could be: e-post, social media, online forums, chat forums etc. However e-post is not possible when there are a large amount of students, social media needs to be directly embedded in the MOOC platform and it requires resources in terms of moderation and thus skilled moderators. At Chalmers among others graduated students were/are trained and educated and are the persons who will take the role of forum moderators in the MOOC forums in order to find out where students had problems with the MOOC content.

Thus, substantial time allocation is needed by core staff, which means that a considerable amount of teacher´s resources and time is needed.

In building the MOOCs a considerable amount of content production, recorded/filmed lectures and other learning resources/educational materials have to be produced and of high quality. A lot of videos have to be produced – teaser videos, course content/knowledge videos, follow-up videos that provide a summary of the most frequent questions related to a course moment in order to meet the students´ activity and questions in the MOOC forums.

Since a MOOC requires well-prepared content of high quality the teachers´ benefit from a production support team. At Chalmers there is a support team for blended learning. During 2014 Chalmers set up a central support team to promote and facilitate information and communication technology components in teaching. The Chalmers Engineering Education Research department, the Chalmers library and the Learning Centre (a Chalmers network) work together in this team (Chalmers support for blended learning, 2015). The team offers support to teachers who want to work with MOOCs and/or blended learning and the support includes both technological and pedagogical aspects on the MOOC content and how the content is communicated to course participants.

The Chalmers teachers report that the development of MOOCs benefits from the possibility to discuss and get help from the pedagogical and production support team at Chalmers.

Chalmers teachers/researchers involved in the MOOCs production and/or in blended learning have started to report of their findings at a yearly Chalmers conference (Chalmers conference on teaching and learning KUL, 2016) and at some other national or Scandinavian conferences on teaching and learning (Swedish Development conference for engineering education, 2015; MOOCs in Scandinavia conference, 2015, Sweden´s conference for the development of higher education NU2015).

Conference contributions from Chalmers during 2015 are *Developing a MOOC at Chalmers: Motivation and first experiences from a teacher´s perspective* (Janssen and Stöhr, 2015), *Flipping a PhD course using movies from a MOOC* (Svensson et al, 2015) and *Using learning analytics in virtual learning environments* (Demazière et al, 2015). The first conference paper describes an action research program aimed to evaluate the benefits and challenges of MOOCs for teachers at Chalmers. The second conference paper is about flipping a course using MOOC videos and the paper reports that students experienced the MOOC videos and learning activities as very useful for their learning. The third conference paper discusses the use of learning analytics in virtual and blended learning environments.

4 Discussion

The Chalmers experienced possibilities and challenges with MOOCs is the subject of this paper. However parallel to the work with MOOCs at Chalmers there is also since some years an ongoing Blended learning initiative/project at Chalmers (Chalmers support for blended learning, 2015).

There are two main educational/pedagogical issues, which are related to the restrictions that accompany any online course. These issues are communication and interaction which relate to teacher-student communication and the way how students can be actively involved in the lectures. How student support should be given is also often discussed.

The communication/dialogue differs from direct communication in a physical classroom, where students can ask questions/comments directly during or after the lecture, lecturers in online course can take questions/comments only after a certain time delay. In some online courses it is possible that students contact the lecturer directly, but given the large number of students in a MOOC, effective handling of questions and comments can only be achieved via forums. Because of the very large numbers participating and commenting, moderation of individual comments by the instructors offering the MOOC is rarely possible. This requires that user-forums are being moderated; the most frequent questions being filtered out and answered in dedicated follow-up videos which have to be recorded while the course is running.

Considering that a student of a MOOC will watch (video) lectures alone it is obvious that the communication from the teacher to the student is basically a one-to-one communication. This differs from usual classroom teaching, where the lecturer tries to address the group and (in some cases) can even approach sub-groups individually by flexibly selecting educational approaches depending on how well students receive that form of input. Thus, not only scripts and lecture notes of the MOOC need to be written under the consideration that one needs to address a single person, but also the way how lectures are organized and filmed needs careful planning.

Computer-marked assignments where students complete an online test and receive immediate computerized feedback are often used in MOOCs. These tests are usually offered throughout the course, and may be used just for participant feedback.

Examinations in MOOCs are based on computer automated testing - multiple-choice, computer-marked questions etc - but sometimes peer assessment has been used and/or in addition. In connection with examination identifications of students over the internet demands extra efforts. Examinations need to be performed in a legally and fair manner. The identification is often carried out using electronic identification systems**.**

MOOCs normally award some kind of recognition when a participant has completed the course, often based on a final computer-marked assessment.

Active learning is learning which engages and challenges students thinking using real-life and imaginary situations. It takes advantage of the opportunities for learning, investigating and exploring, events and life experiences and focused learning and teaching.

In particular, students must engage in such higher-order thinking tasks as analysis, synthesis, and evaluation. Active learning engages students in two aspects – doing things and thinking about the things they are doing (Bonwell and Eison, 1991). In active learning environment learners are immersed in experiences within which they are engaged in meaning-making inquiry, action, imagination, invention, interaction, hypothesizing and personal reflection (Cranton, 2012).

Further the educational methods, technology and web-based course moments used need to be pedagogically well thought out to meet the students´needs for active, engaging, interactive and collaborative learning. If we think of active learning in this way then it is natural and logic to think of a MOOC as a possible resource for active learning. Montgomery et al (2015) report from a three-year action research study where the purpose was to explore the digital challenges of student engagement in higher education using blended learning. The study report of four pedagogical opportunities for digital intentionality in virtual spaces and which they suggest could be used for future innovation: designing digital resources, scaffolding student learning, learner customisation and promoting the lived experience. The authors tells that intentionality regarding learner engagement is critical in the design of virtual spaces, since with the privileges of student flexibility in learning time and space, comes increased responsibility for individual student motivation. The authors suggest that lessons learned could be effective in the development of higher educational experiences for on-campus students as well as promoting greater engagement in online formats involving more global populations in e.g. MOOCs.

As mentioned a MOOC is open to everyone with the possibility to use a computer and/or a smartphone. No registration is needed. This fact means that being the teacher you can encourage students to study selected parts of an existing MOOC as a way to awake interest/get them interested in your subject and/or prepare for class, to start discussions etc. It is not necessary to follow the whole MOOC – the teacher can advise the students in how they can choose to take part in what they find interesting without any obligations. This is a way to share and reuse already produced learning resources of good quality. The two Chalmers MOOCs *Sensing Planet Earth* which are offered spring 2016 are aimed to be used by college teachers in this way. In the way the MOOC is structured makes it possible for high school teachers to choose and work with selected parts, certain course moments, videos etc of the MOOC advising their students to engage in active learning with selected material in the MOOC as a complement to the face-to-face teaching and learning at campus.

According to above a MOOC of good quality, pedagogically well-planned and with engaging learning resources has potential to support active learning. If a student's interest and engagement can be captured at depth this is an important foundation for the student's continued learning; the students´ creativity and willingness to learn.

Regarding research there are so far relatively few research publications on MOOCs. There is need for more research on factors that influence student learning in virtual learning environments e.g. a MOOC.

Quantitative studies are needed that seek to quantify learning gains. There has not been a great deal of published information about the use of learning analytics (Bates, 2015) but learning analytics have the capacity to collect and analyse large amounts of data about participants and their performance, enabling for feedback to instructors about areas where the MOOC content or design needs to be improved.

Qualitative studies are needed that describe the experience of learners within MOOCs, which indirectly can give insight into what they have learned. To develop deep, conceptual learning, there is a need in most cases for intervention by a subject expert to clarify misunderstandings or misconceptions, to provide accurate feedback, to ensure that the criteria for academic learning, such as use of evidence, clarity of argument etc are being met, and to ensure the necessary input and guidance to seek deeper understanding (Harasim, 2013). Further, Firmin et al (2014) have shown that when there is some form of instructor encouragement and support of student effort and engagement, results improve for all participants in MOOCs.

What students do in a MOOC is interesting and crucial for their learning: which forums do the participants visit, how do they engage in different forums, how do they use the learning resources - for example how many times do they look at the videos - what "tracks" do the students leave in the MOOC. To research and get knowledge of how students actually learn in a MOOC is urgent.

As reported in the previous section "Chalmers perceived opportunities and challenges in providing MOOCs" Chalmers has started several research initiatives on MOOCs.

Concerning the MOOCs development and research several tracks can be discerned: How the MOOCs developing process including teachers, developing team, production team etc proceeds; How do teachers experience to teach with MOOCs, positive experiences/pedagogical challenges; How find out and understand what the students do in the MOOCs and how do they learn; How succeed in getting valuable interactivity supporting student learning in the MOOC; How manage the moderation in a good way to support students and How manage to keep, retain students in a MOOC.

A positive fact that have potential to promote the Chalmers and Swedish MOOCs development is a recent report from the Swedish Higher Education Authority. In the spring of 2015 the Swedish Government gave the Swedish Higher Education Authority (UKÄ) (The Swedish higher education authority, 2016) the task of analysing the possibilities and potential obstacles to the introduction of open online education (MOOCs) in Swedish higher education. This task also included proposing whether, and if so how and to what extent, MOOCs could be included in Swedish higher education and what consequences this could have. According to UKÄ's proposition, all state universities and several other higher education providers should have the opportunity to organise open online courses. Several higher education institutions would need extra funding to be able to offer these courses and UKÄ proposes that the state allocates special funds to be used for the development of digital teaching and learning in higher education.

UKÄ considers that Swedish higher education institutions should, like their counterparts in other countries, be given the possibility of arranging open online courses (MOOCs). It is UKÄ's opinion that these courses would, among other things, offer new possibilities of providing knowledge to large groups in the community and that they can help to deal with major social challenges. At the same time the international visibility of the higher education institutions would be raised.

There are also international initiatives and several organizations (EADTU European Association of Distance Teaching Universities, 2015; EADTU:s HOME-project, 2016; EUA European University Association, 2015; MOOCs worldwide use, 2016; MOOCKnowledge, 2015; Open Education, 2015) occupied with the possibilities of MOOC:s, and in a broader perspective blended learning, web-based learning, e-learning. For example the

European commission 2013 launched a comprehensive initiative regarding open education (Opening up Education, 2013). This initiative is intended to promote digital competence, the use of open learning resources and education and access to digital resources in both schools and universities. The MOOC consortium Openup Education is coordinated by the European Association of Distance Teaching Universities, EADTU, and is growing rapidly.

5 Future plans for the use of MOOCs at Chalmers

The MOOCs offered so far at Chalmers have had a focus to attract participants from a broad and global arena.

Chalmers will continue to follow the development of MOOCs and how they can be used online and/or in blended learning at campus. There is obvious advantages following the development thus supporting and encouraging competence development about blended learning among teachers at Chalmers.

Experiences and findings from the MOOCs project and blended learning project are communicated at conferences - at Chalmers internal KUL conference, national and international higher education, pedagogical conferences. In addition publications in scientific journals will help sharing experiences and further knowledge building about teaching and learning in MOOCs and other forms of web-based teaching and learning and how they can be used foster active learning in higher education.

Several other universities in Sweden and the Nordic countries are now offering MOOCs and explore the opportunities and challenges with MOOCs. A conference "MOOCs in Scandinavia" was arranged in Stockholm 11 - 12 June 2015 (Karolinska Institutet, 2015). The 2nd MOOCs in Scandinavia Conference, June 9-10th 2016, is arranged by Chalmers University of Technology.

6 References

Bates, A.W. (2015). Teaching in a digital age – guidelines for designing teaching and learning, [e-book version] Retrieved from https://opentextbc.ca/teachinginadigitalage/

Chalmers (2016). MOOCs in Scandinavia conference. Retrieved fromhttp://www.chalmers.se/en/conference/moocs2016/Pages/mis2016.aspx

Chalmers (2016). Chalmers internal conference on teaching and learning KUL. Retrieved fromhttps://www.chalmers.se/sv/konferens/KUL/KUL2016/Sidor/default.aspx

Chalmers (2015) Chalmers MOOCs project. Retrieved from http://www.chalmers.se/insidan/EN/education-research/project-chalmers-mooc

Chalmers (2015) Support for blended learning. Retrieved from http://www.chalmers.se/insidan/EN/education-research/education/development-teaching/support-for-blended

Demazière, C., Stöhr, C., Adawi, T. (2015). Using learning analytics in virtual learning environments. Paper presented at Swedish Development conference for engineering education. http://www.teknat.uu.se/utvecklingskonferens2015/. Abstract retrieved from http://publications.lib.chalmers.se/publication/226112-using-learning-analytics-in-virtual-learning-environments

EADTU European Association of Distance Teaching Universities. (2015). Institutional MOOC strategies in Europe. Status report based on a mapping survey conducted in October– December 2014, EADTU, February 2015.

EADTU:s HOME-project. (2016). Higher education online: MOOCs the European way. Retrieved from http://home.eadtu.eu/ (14 januari 2016).

edX. (2015). Retrieved from http://www.edx.org

EUA European University Association. (2015). Trends 2015: Learning and Teaching in European Universities, EUA Publications 2015, Andrée Sursock.

Firmin, R. et al. (2014). Case study: using MOOCs for conventional college coursework, Distance Education, 35 (2)

Garrison, D. R. & Kanuka, H. (2004). Blended Learning: Uncovering its Transformative Potential in Higher Education, Research Gate. Retrieved from https://www.researchgate.net/publication/222863721

Harasim, L. (2012). Learning Theory and Online Technologies, New York/London: Routledge

Janssen, M., Nyström Claesson A. & Lindqvist, M. A. (2015). Design and early development of a MOOC on "Sustainability in everyday life": Role of the teachers. Paper presented at Chalmers internal conference on teaching and learning KUL. Abstract retrieved from

http://publications.lib.chalmers.se/search/index.xsql?start=0&doSearch=true&query=de veloping+a+mooc&submit01=S%C3%B6k

Janssen, M. & Stöhr, C. (2015). Developing a MOOC at Chalmers: Motivation and first experiences from a teacher´s perspective. Paper presented at Chalmers internal conference on teaching and learning KUL. Abstract retrieved from http://publications.lib.chalmers.se/publication/210895- developing-a-mooc-at-chalmers- motivation-and-first-experiences-from-a-teachers-perspective

Karolinska Institutet. (2015). MOOCs in Scandinavia conference. Retrieved from http://ki.se/en/lime/moocs-in-scandinavia-conference

MOOCs worldwide use. (2016).Retrieved fromhttp://www.openeducationeuropa.eu/en/european_scoreboard_moocs

MOOCKnowledge (2015). Establishing a large-scale data-collection about participants of European Open Online Courses (2015). Joint Research Centre, The European Commission´s in-house science service. Retrieved from http://www.openeducationeuropa.eu/en/project/moock

Montgomery A.P. et al (2015). Blending for Student Engagement: Lessons Learned for MOOCs and Beyond, Australasian Journal of Educational Technology, 31(6)

Open culture. (2015). http://www.openculture.com/2015/02/200-moocs-getting-started-in- february-enroll-in- one-today.html

Open Education. 2015. Retrieved from http://www.openeducationeuropa.eu

Svensson, L., Hammarstrand, L. & Stöhr, C. (2015). Flipping a PhD course using movies from a MOOC. Paper presented at Swedish Development conference for engineering education. http://www.teknat.uu.se/utvecklingskonferens2015/. Abstract retrieved from http://publications.lib.chalmers.se/search/index.xsql?start=0&doSearch=true&query=fli pping+a+phd+course+using+movies&submit01=S%C3%B6k

Swedish Higher Education Authority. (2016). MOOCs report to Swedish Government (English summary). Retrieved from http://english.uka.se/higher-education-system/massive-open- online-courses-moocs.html

Sweden's conference for the development of higher education, NU2016. (2016). Retrieved from http://www.nu2016.se/app/attendee/default.asp?LanguageId=2&ProjectId=5953&PageI d=39103

Innovative Experiences and Proposals in Engineering Education for Sustainability: Application to the University of Brasilia Undergraduate Production Engineering Program

João Mello da Silva[1]; Marcia Longen Zinden[1]; Andréa Cristina Santos[1];Carlos Henrique Rocha[1]; João Carlos Felix Souza[1]; Simone Borges Simão Monteiro[1]

[1] Department of Production Engineering, Faculty of Technology, University of Brasília, Campus Darcy Ribeiro, Brasília-DF, Brazil

Email: joaomello@unb.br, marcialz@unb.br,andreasantos@unb.br,chrocha@unb.br, jocafs@unb.br, simoneborges@unb.br

Abstract

Considering the problem-based learning with solutions via projects, the contents of the curriculum guiding line of the Undergraduate Production Engineering Program at University of Brasilia (CGEP/UnB) comprise six blocks, as follows. (S1)- Conceptual Nucleus in Production Systems, encompassing six courses of the initial semesters; (S2)- Eight Projects for Integration of the Curriculum (PIC1 thru PIC8), each one structured according to a model based on four anchors (project methodology courses, technical contents courses, real-life problem situations and possibilities of enrichment), in this paper named as "the 4 Anchor Model"; (S3)- Required Supervised Internship; (S4)- Graduation Project 1; (S5)- Graduation Project 2; and (S6)- Complementary Activities. Taking the 4 Anchor Model as background, this article presents results and proposals for some components of the above listed blocks S1 and S2. With respect to Block S2, in ten semesters there were 1,320 registrations in the eight project methodology courses (PSP1 thru PSP8 corresponding to PIC thru PIC8), forming 243 teams. Regarding PSP1, the first in the sequence of the eight project methodology courses, there were 368 enrolled, 75 teams in the same ten semester period. In PSP1 many projects contemplated aspects of production systems sustainability, with very good results. From now on all PIC1 projects will have at least a mandatory appendix on sustainability. In relation to Block S1, due to the structure of the two courses (Value Formation in Production Systems – FVSP and Production Systems Project Methodology – MPSP) it has been noted an increasing interest in sustainable projects. Activities of both, FVSP and MPSP courses include the preparation of publications reviews, developed as team projects, with deliverables in written, graphical and oral languages. Since the first offer, which occurred in semester 1/2010 (FVSP) and semester 2/2010 (MPSP), every semester several publications reviews have focused on aspects of sustainability. Due to the results linked real problems, sustainability will become the driver of all publications reviews of FVSP (sustainability in production systems value formation) and MPSP (examples of sustainable projects).

Keywords: Sustainability in Engineering Education; Problem-Based Learning via Projects; Publications Review.

1 Introduction

The University of Brasilia's Production Engineering Undergraduate Program (PEUP/UnB) is an evening program, with a normal flow of twelve semesters, for a total of 3,600 hours of activities. Since the second semester of 2009, when the program began, 50 new students are admitted each semester, which will result in a steady student body of about 600 students.

According to a problem-based learning focused on project activity, the curriculum follows the national curriculum guidelines established by the Brazilian National Board of Education. As Figure 1 shows, the contents of Synthesis, Integration and Entrepreneurship (blocks S1 to S6) comprise the backbone of the program.

The Core Concept in Production Systems (Block S1) covers basics of production engineering, value formation, human behaviour, project management and sustainable development.

Block S2 is focused on a set of projects to be developed in the context of sustainability. Starting at the fourth semester of the normal coursework, students develop up to eight Projects for the Integration of Curriculum (PIC1 thru PIC8), with complexity growing period by period, seeking to consolidate the methodological aspects with issues addressed in disciplines of technical contents, with the reality brought about by External Agents (EA) linked to each project theme.

The Graduation Project (Blocks S4 and S5), aiming at facilitating (i) the scientific initiation, (ii) the acquisition of experience in literature, (iii) the writing of technical reports, (iv) the preparation and oral presentation, and (v) the ability to work both in a team and individually, encompasses two courses: Graduation Project 1 (Block S4) and Graduation Project 2 (Block S5).

The Required Supervised Internship (S3) consists of field work to gain experience in a real production engineering environment. This activity should be preferably developed in association with the Graduation Project 1 (Block S4), in order to align the Graduation Project with the Required Supervised Internship activities.

The Complementary Activities (Block S6) encompass student participation in undergraduate research projects, multidisciplinary projects, community projects, technical visits, participation in events, outreach projects, prototype development, participation in junior companies, elective internships and other entrepreneurial activities.

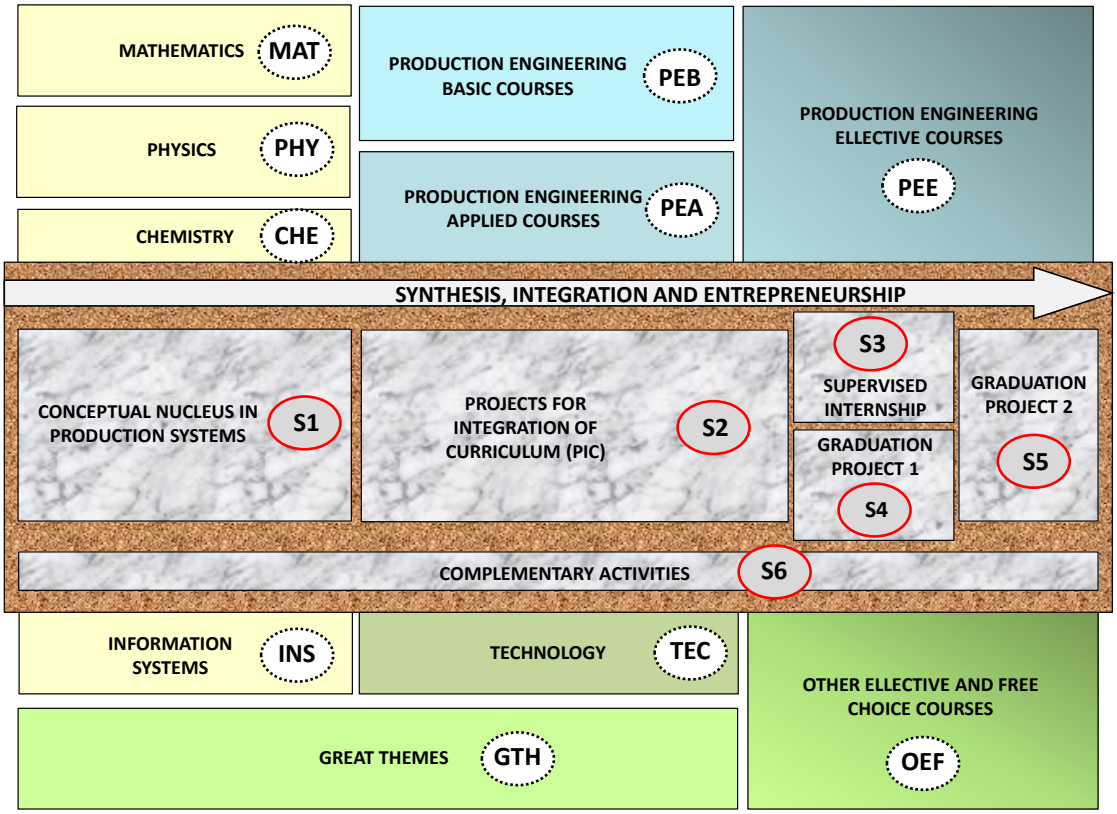


Figure 1 – PEUP/UnBCurriculum Blocks.

According to the 4 Anchor Model, the projects associated with Block S2 of the curriculum have four anchors as its basic pillars: (A1)- Project Methodology, with eight Production Systems Projects courses, PSP1 thru PSP8, where PSP3 and PSP8 are elective and the other six are required courses; (A2)- Technical contents, related to production engineering areas; (A3)- Reality, with real problems brought on by External Agents (EA); and (A4)- Possibilities of enrichment related to courses with specific interests in the problems being solved.

With an expected demand of about 300 students per semester, the model of anchors A1 to A4 currently uses the settings that follow for the eight PIC. **PIC1➔** A1: PSP1, A2: Probability and Statistics (PS), A3: External Agents with access to databases; A4: Defined By Demand; **PIC2➔** A1: PSP2, A2: Engineering Economics, Information Systems in Production Engineering; A3 and A4: DBD; **PIC3➔** A1: PSP3, A2: Required or elective initial Production Engineering courses; A3 and A4: DBD; **PIC4➔** A1: PSP4; A2: Production Planning and Control, Systems Simulation, Health and Safety at Work; A3 and A4: DBD; **PIC5➔** A1: PSP5; A2: Production Quality Management; A3 and A4: DBD; **PIC6➔** A1: PSP6; A2: Product Engineering, Logistics and Supply Chain; A3 and A4: DBD; **PIC7➔** A1: PSP7; A2: Strategic Management; A3 and A4: DBD; and **PIC8➔** A1: PSP8; A2: Required or elective advanced Production Engineering courses; A3 and A4: DBD.

Students enrolled in each PSP are divided into groups, each one developing a specific topic, aimed at learning: (i) Methodology for Sustainable Projects; (ii) Technical Contents; (iii) How to solve real problems via projects; and (iv) Enrichment in specific topics. To this end, each group will make use of written, visual and oral languages, contemplating deliveries associated with preliminary, intermediate and final phases of the project. In the ten semester period from 1/2011 thru 2/2015 there were 1,320 enrollees in 243 teams ofthe eight PSP.

Based on the 4 Anchor Model, it follows results and proposals for some components of blocks S2 and S1.

2 PIC1 of Block S2

PIC1 plays a fundamental role as part of the initial basis for the implementation of all Block S2 activities. As shown in Figure 2, the general PIC1 framework put into action during the semester 2/2015 brought some innovations in all four PIC1's anchors.

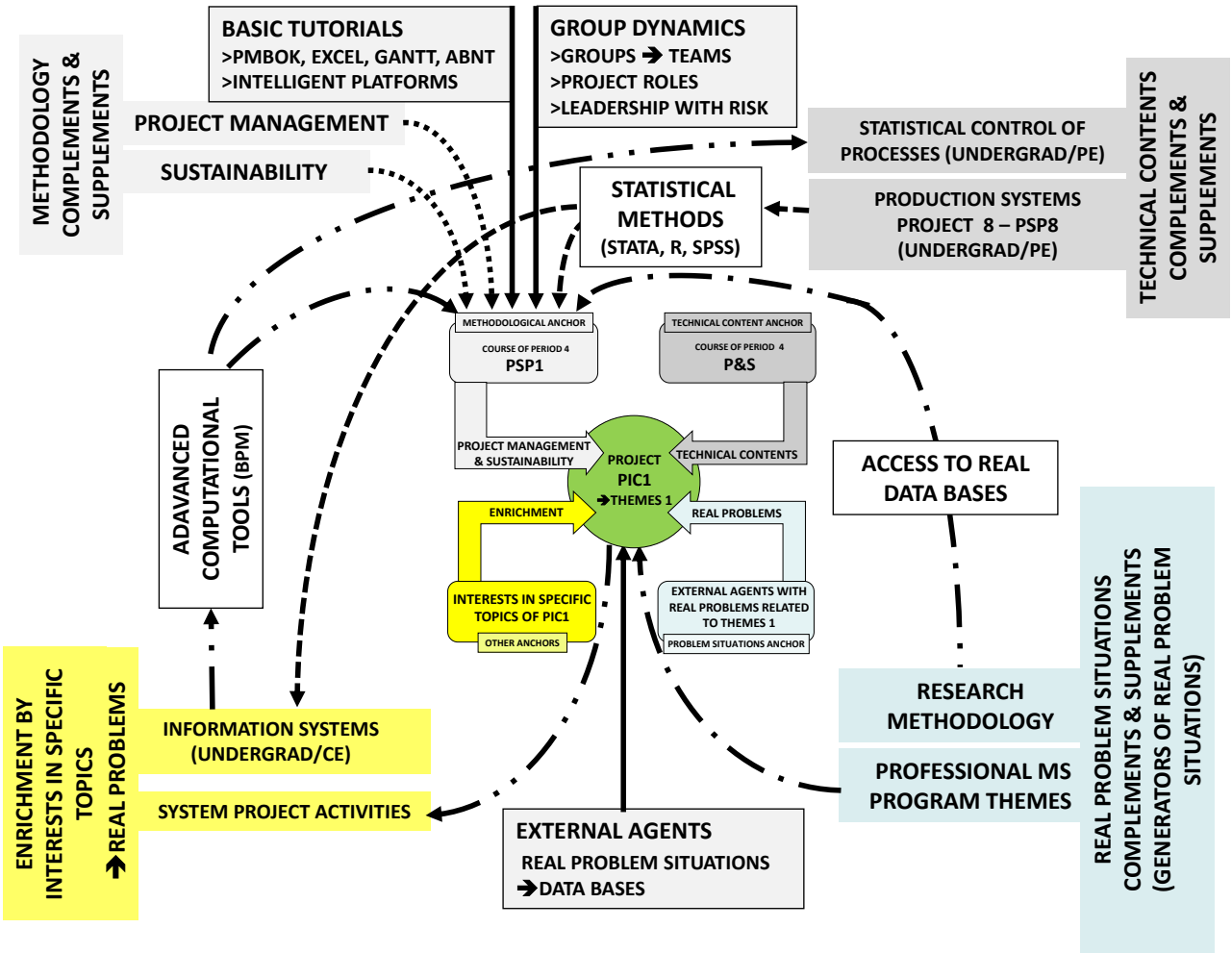


Figure 2 – PIC1framework in the2/2015 semester.

2.1 Anchor A1: Methodology

The PSP1 course is the only one of the PSP that, in addition of being a methodological anchor, includes conceptual complement and supplements in project management and sustainability. In this regard, PSP1 covers topics in systems and models, human interaction, searches in data bases, team behaviour in sustainable projects, including definition of project roles, and tutorials in PMBOK, Excel data functions, scheduling softwareand norms for technical writing (ABNT standards). Taking into account the relevance of intelligent platforms for all PSP, the PSP1 classes are being oriented to start using these platforms during the execution of the projects. During the ten semester period from 1/2011 thru 2/2015 there were 368 enrollees in PSP1,

divided into 75 groups. In semester 2/2015 there were 44 enrollees, designated to 11 groups of 4 students in each one.

The 2/2015 semester PSP1 project management activities were grouped under the titles: (i) Problem situations brought on by EA; (ii) Characterization of themes to be designated to Groups; (iii) Students designation to Groups; (iv) Groups evolution to Teams; (v) Rising of Team Leaderships; (vi) Establishment of College of Leaders; (vii) Emergence of Theme Leaderships; and (viii) Consolidation of a General Leadership.

The first two titles (problem situations and the characterization of themes) are treated in item 2.3.

The designation of the enrollees in PSP1, PSP8 and Information Systems (IS) to Groups was made according to criteria of gender, either had coursed or be coursing the PS course, and either had coursed or be coursing the Introduction to Research Methodology in Production Engineering course. In each one of the 11 Groups there were 4 PSP1 enrollees, at least one PSP8 enrollee and up to 3 IS enrollees.

The evolution of Groups to Teams resulted from group dynamics classroom sessions conducted by a professor of the Department of Production Engineering with background in Psychology and Production Engineering. After the sessions, the 11 groups evolved to 11 teams, with the identification of 11 Team Leaders, responsible mainly for the teamwork systematization tasks.

The Team Leaders also represented the Team in the 4Colleges of Leaders created in the context of the 2 EA, both UnB's entities: the University Hospital (HUB) and the Undergraduate Education Dean (DEG). For HUB were created the Pathological Anatomy Exams, and the Surgical Queue colleges, while the 2 colleges created for DEG were Retention and Evasion Indicators for the Faculty of Technology Undergraduate Programs, and Retention and Evasion Indicators for the Center of Information and Computing Undergraduate Programs. Each Team Leader participated of the consolidation of the teamwork within the corresponding Theme College of Leaders, as well as broughton the Theme College of Leaders decisions to his or her Team. The consolidation work in the Theme College of Leaders involved basically the systematization of the tasks of common interest to the Teams.

In each Theme College of Leaders emerged a Theme Leader, mainly responsible for the preparation and presentation of an executive summary of all work developed by Teams of the corresponding theme. The General Leader for each EA was responsible by the coordination of the executive summaries of the corresponding EA themes, in terms of a general executive summary presented at the PIC1 project final meeting. It was also responsible by the consolidation of all the PIC1 project final meeting presentation files, as well as the consolidation of all lessons learned and the elaboration of a set of 10 multiple choice questions aimed at verifying whether or not the class apprehended contents of the final presentations. Table 1 shows the deliverables associated to the several PSP1 project activities described above.

Table 1.PSP1 Deliverables in semester 2/2015.

Responsible	Deliverables
➔Teams (Projects) 11 Teams: 7 HUB; 4 DEG	Written Report; Presentation File; Poster; Class Presentation; Individual participation
➔Team Leaders 11 Team Leaders	Teamwork Consolidation; Draft of Poster; Participation in the Theme Consolidation work
➔Theme Colleges of Leaders 4 Colleges: 2 HUB; 2 DEG	Common Theme work systematization; Choice of the Leader for the Theme work consolidation
➔Theme Leaders 4 Leaders: 2 HUB; 2 DEG	Theme work consolidation; Draft of the Theme Executive Summary; Draft of the Theme Presentation File; Draft of Theme Poster; Participation in the General Consolidation work
➔Themes General Leaders 2 Leaders: 1 HUB; 1 DEG	General Theme work consolidation; Draft of the General Theme Executive Summary; Draft of the General Theme Presentation File; Draft of the General Theme Poster; Participation in the General Consolidation work

2.2 Anchor A2: Technical Contents

The Technical Contents of PSP1 is a basic PS course. Having the Statistical Control of Processes course as its Technical Contents, the first offer of PSP8 occurred in the semester 2/2015, with 11 enrollees. Instead of the standard format of a PSP in terms of having its own EA problem to be solved, all PSP8 enrollees were designated to the 11 PSP1 teams, complementing and supplementing the basic Technical Contents of PSP1 Anchor's PS course in terms of advanced statistical methods, such as control charts. The PSP1 students, acting as project coordinators, had the opportunity of a first contact with statistical control of processes tools. On the other hand, the PSP8 students had real problems to apply statistical control of processes.

2.3 Anchor A3: Reality brought by External Agents

As stated before, the EA in the semester 2/2015 were HUB and DEG, both UnB's entities. After meetings with personnel of these entities, four themes were chosen and the corresponding eleven projects established.

HUB (2 themes, 7 projects): (i) Pathological Anatomy Exams (5 projects: Pathological Anatomy Exams Files; Traceability of Current Pathological Anatomy Exams; Statistics of Current Year Pathological Anatomy Exams; Statistics of 2010-2014 Pathological Anatomy Exams; Traceability of Past Pathological Anatomy Exams); and (ii) University Hospital Surgical Queue (2 projects: Surgical Queue Priorities; Patients Files).

DEG (2 themes, 4 projects): (i) Retention and Evasion Indicators of the Faculty of Technology Undergraduate Programs (2 projects: Production Engineering Program; Other Engineering Programs); and (ii) Retention and Evasion Indicators of the Center of Information and Computing Undergraduate Programs (2 projects: Computing Engineering Program; Computing Sciences Programs).

Continuing the previous semesters approach, three graduate students of the Professional MS Program in Applied Computing with interests in developing their MS dissertations in these themes served as PSP1 tutors. Under this approach, the PSP1 students performed essentially activities of data consolidation under the supervision of the graduate students. The graduate students, besides having the results of the data consolidation for their research, were also involved in the fundamental activity of undergraduate tutoring.

2.4 Anchor A4: Enrichment possibilities

Also in the semester 2/2015 occurred the first case of Enrichment through the participation of Information Systems course students in PSP1 projects. A total of 27 students of the undergraduate programs in Computing Engineering and Computing Sciences were designated to the 11 PSP1 teams, complementing and supplementing the basic Technical Contents of PSP1 Anchor's Probability and Statistics course in terms of advanced computational tools. As in the case of Anchor 3, the PSP1 students, acting as project coordinators, had the opportunity of a first contact with computational tools. On the other hand, the IS students had real problems to apply information systems project tools.

2.5 Sustainability

During the ten semester period ranging from 1/2011 thru 2/2015, many PIC1 projects contemplated aspects of sustainability, for example, Green jobs in Brazil (ILO/UN),Social Security topics (INSS/MPS), Public transportation (CEFTRU/UnB), Human Development Index (UNESCO/UN), Public Health topics (HUB), Garbage Collection (SLU/GDF), and Evasion and retention of university students (DEG). Due to the results obtained, from now on all PSP1 projects will have at least a mandatory appendix on sustainability.

Taking as a basic premise that the formation of value, regarded as the ultimate purpose of any System of Human Activities (SHA), encompassing both the generation of value and the appropriation of this value to all stakeholders (Guarajedagui and Ackoff, 1996), the System of Multiple Levels of Learning developed by Wasdell (1993), considers an SHA as a purposeful open system.

The SHA Learning Level Zero corresponds to a system without feedback loop. At this Learning Level, despite eventual changes in the environment, an SHA has no feedback informationto adaptor change its behaviour and performance.Climbing to Learning Level 1, the SHA incorporates the Learning Cycle 1, with the possibility of adapting the behaviour depending upon the feedback information. This SHA Evolution 0/1 ranges from mere adjustments up to a full SSHA behaviour transition.

Rising to Learning Level 2, Cycle 2 of learning is incorporated, in which the possible of changes in the behaviour of SHA may occurs due to the feedback received not only on the results obtained by Cycle One of the learning system, but also on the results of Cycle One itself. This SHA Evolution 1/2, which has the Evolution 0/1 immersed in it, ranges from mere adjustments to the transition to a new system behaviour, now also in terms of learning. Continuing in this embodiment of learning cycles, the SSHA progress from Level n-1 to Level n, called Evolution (n-1)/n, which has the set {Evolution 0/1, Evolution 1/2, Evolution2/3, Evolution 3/4, ...} immersed there in, includes from mere adjustments to complete the transition to a new behaviour of the system in terms of learning. As this merger can theoretically continue indefinitely, there is no limit to the SHA in learning. As shown in Figure 3, due to the unique features of the first four cycles of learning in terms of SHA excellence indicators, this set of cycles gets a special attention.

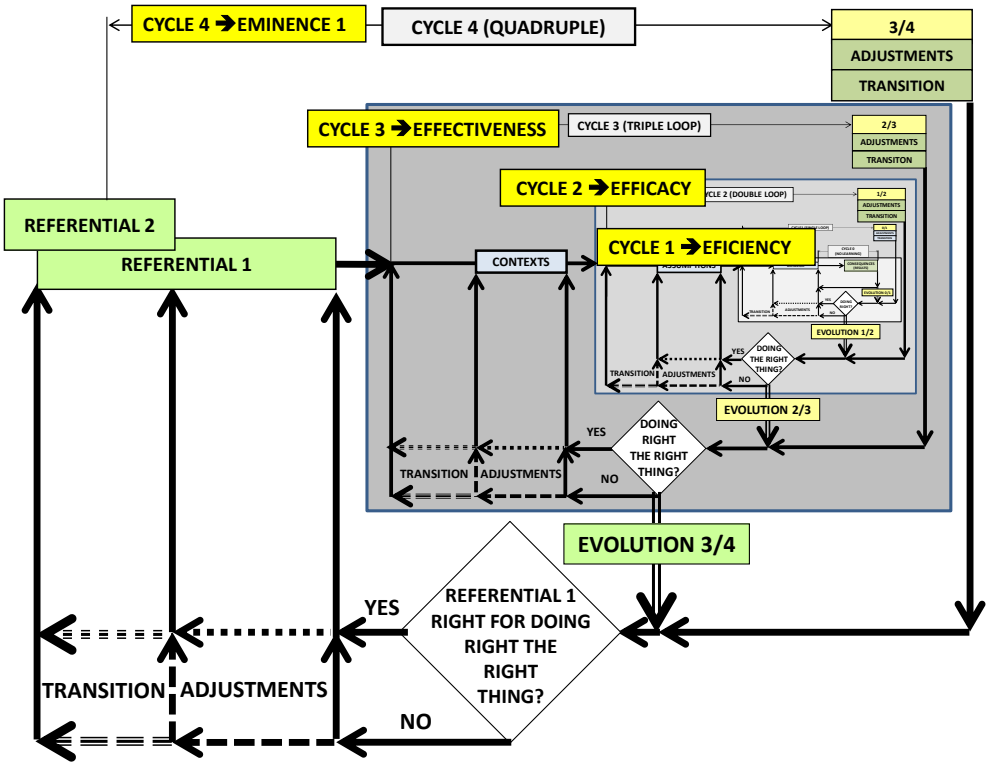


Figure 3 – Wasdell multiple levels of learning

As shown in Figure 3, these four cycles can be linked to four indicators of excellence: (i) Efficiency ("Doing Right") ➔ Simple Cycle; (ii) Efficacy ("Doing the Right Thing") ➔ Double Cycle; (iii) Effectiveness ("Doing Right the Right Thing") ➔ Triple cycle; (iv) Eminence ("Right Referential for Doing Right the Right Thing") ➔ Quadruple Cycle. The socio-environmental responsibility incorporates the essential attributes of sustainability to SAH with multiple levels of learning, resulting in the Sustainable Systems of Human Activities (SSHA).

According Silva et al. (2013), the set of eight PEUP/UnB's PIC defines a framework of increasing knowledge for both students and teachers that allows the application of the model of multiple levels of learning in a modular fashion. Efficiency, Efficacy, Effectiveness and Eminence measures will result from the application of the model. From now on, having PIC1 as the starting point, the PIC projects preferably will have as a main objective the effective implementation of sustainability principles contained in these "four Es" of excellence, in a gradient complexity. It is expected that this will be accomplished through systemic performance questions associated with sustainability, applied by validation procedures developed for each step of the set PIC1 thru PIC8.

3 MPSP and FVSP of Block S1

Block S1 covers the Production Systems core concepts through six basic courses: (i) Introduction to Production Engineering; (ii) Introduction to Sustainable Development; (iii) Ergonomics and Human Behaviour at Work; (iv)

Value Formation in Production Systems ➔FVSP; (v) Production Systems Project Methodology ➔MPSP; and (vi) Introduction to Production Engineering Research Methodology.

The structure of the FVSP and MPSP courses, required courses of the second and third semesters, respectively, has resulted in student interest in sustainable projects, particularly in PSP1. Activities of FVSP and MPSP include the preparation of publications reviews, developed as team projects, with deliverables in written, graphical and oral languages. As in PSP1, among the course activities are team, theme and general leaderships. Taking the PIC1 4 AnchorModel as background, both MPSP and FVSP team projects have similar Anchor A1 and A2. Regarding Anchor A3, the teacher plays the EA role, bringing "reality" to the FVSP and MPSP projects through the proper choice of the publications to be reviewed.

Every semester several FVSP and MPSP publications reviews have focused on aspects of sustainability. Due to the results obtained in terms of this reality searching, from now on sustainability will become the driver of all reviews of FVSP (sustainability in production systems value formation) and MPSP (examples of sustainable projects). The PIC1 Anchor 4 Model does not apply to either MPSP or FVSP.

3.1 MPSP and FVSP project methodology aspects (Anchor A1)

In semester 2/2015, MPSP had 53 enrollees, designated by lottery to five Groups of 5 students and to seven Groups of 4 students. Regarding FVSP, its 65 enrollees were designated to 13 Groups of 5 students each. As shown in Table 2, the MPSP project activities and its corresponding deliverables are very similar to PSP1. It is worthwhile to emphasize the tutorial in GanttProject, as well as the general consolidation work in terms of the common points found in all publications reviews.

For both, MPSP and FVSP the teacher handles a generic draft version of the project Work Breakdown Structure to all Groups. In relation to the FVSP deliverables, besides the poster draft the semester 2/2015 Team Leaders have only the teamwork consolidation as a specific task.

Table 2.MPSP Deliverables in semester 2/2015.

Responsible	Deliverables
➔Teams (Projects) 12 Teams: 4PIN; 4 KPP; 4 EPO	Written Report; Presentation File; Poster; Class Presentation; Individual participation
➔Team Leaders 12 Team Leaders	Teamwork Consolidation; Draft of Poster; Participation in the Theme Consolidation work
➔Theme Colleges of Leaders 3 Colleges: 1 PIN; 1 KPP; 1 EPO	Common Theme work systematization; Choice of the Leader for the Theme work consolidation
➔Theme Leaders 3 Leaders: 1 PIN; 1 KPP; 1 EPO	Theme work consolidation; Draft of the Theme Executive Summary; Draft of the Theme Presentation File; Draft of the Theme Poster; Participation in the General Consolidation work
➔Themes General Leader 1 Leader: HUB &DEG& EPO	General Theme work consolidation; Draft of the General Theme Executive Summary; Draft of the General Theme Presentation File; Draft of the General Theme Poster; Participation in the General Consolidation work

3.2 MPSP and FVSP technical contents (Anchor A2)

In addition to the project teamwork publication review, the MPSP course includes technical contents on project management best practices, in terms of project, program and portfolio management. Regarding FVSP, the technical contents cover Projection, prospection and vision modelling horizons; Spaces for value formation; Sustainable systems of human activities; Performance in trajectories of excellence.

3.3 MPSP and FVSP real problems (Anchor A3)

In semester 2/2015, 3 publications reviews, designated to 12 Groups covered the MPSP reality aspects: (i) Project Intelligence (Rechenthin, D., 2013); (ii) Refining the Knowledge Production Plan (Floricel S. et al., 2011); and (iii) Sustaining and Developing Disciplinary Expertise in Project-Based Organizations (Enberg, C. and Bredin,

K., 2015). For FVSP, 3 publications were allocated to 13 Groups: (i) Project Categorization Systems (Crawford, L. et al., 2005); (ii) Researching the Value of Project Management (Thomas, J. and Mullaly, M., 2008); and (iii) Valuation: Métricas de Valor &Avaliação de Empresas (Assaf Neto, A., 2014). Focusing on results linked to real problems, from now on sustainability will be the driver of all publications reviews of FVSP (sustainability in production systems value formation) and MPSP (examples of sustainable projects). For semester 1/2016 Project Management & Sustainable Development Principles (Gareis, R. et al., 2013) has already been chosen as publication to be reviewed in MPSP.

4 Conclusion

Sustainability is a fundamental aspect to be dealt with in all phases of lifecycle of any production system. Particularly in Project Management, any PBL approach should emphasize this aspect. All innovations in the context of the PEUP/UnB relative to the PSP1 project management activities during the 2/2015 semester were segmented acording to the general PIC 4 AnchorModel (**A1:** Methodology; **A2:** Technical contents; **A3:** Reality; **A4:** Possibilities of enrichment). Starting at 1/2016 semester, all PIC1 projects will have Sustainability as a mandatory Appendix. Moreover, having PIC1 as the starting point, all PIC project preferably will have as a main objective the effective implementation of sustainability principles contained in the "four Es" of excellence. Also taking the PIC 4 Anchor Model as background, both MPSP and FVSP projects had innovations related to Anchor A1 and A2. Regarding Anchor A3, it was described the External Agent role played by the teacher in terms of bringing "reality" to the FVSP and MPSP projects through the proper choice of the publications to be reviewed. From now on sustainability will become the driver of all publications reviews for both, FVSP and MPSP.

5 References

Ackoff, R. L. and Gharajedagui, Reflections on Systems and Their Models, Systems Research, March, 1996

Argyris, C., Social Science Approaches to Business Behavior, Garland Publishing, 1987

Argyris, C. and Schön, D., Organizational Learning II: Theory, Methods and Practice, Addison-Wesley, 1996

Assaf Neto, A., Valuation: Métricas de Valor & Avaliação de Empresas, Atlas, 2014

Crawford, L. et al., Project Categorization Systems, PMI, 2005

Enberg, C. and Bredin, K., Sustaining and Developing Disciplinary Expertise in Project-Based Organizations, PMI, 2015

Floricel S. et al., Refining the Knowledge Production Plan, PMI, 2011

Garavan, T., The Learning Organization, A Review and Evaluation, The Learning Organization, Vol 4, No. 1, 1997

Gareis, R. et al., Project Management & Sustainable Development Principles, PMI, 2013.

Rechenthin,D., Project Intelligence, PMI, 2013

Romme, A. G. L. and Witteloostuijn, Arjen van, Circular Organizing and Triple-Loop Learning, Journal of Organizational Change Management, Vol 12, No. 5, 1999

Silva, J. M. et al., Maturity Model Based on Multiple Levels of Learning: Proposal for Application in an Institution of Engineering Education, with a Focus on Sustainable Based Learning, PAEE2013, Eindhoven, 2013

Thomas, J. and Mullaly, M., Researching the Value of Project Management, PMI, 2008

Wasdell, D., Learning Systems and the Management of Change, Meridian Monograph 1993:1, (http://www.meridian.org.uk/_PDFs/Learning% 20Systems.pdf, accessed October 2011)

The Construction of an Analog Vocoder as a Hands-on Introductory Course in Electrical Engineering

Ignacio Irigaray[1], Martín Tarragona[1], Jimena Arruti[1], Pablo Zinemanas[1]

[1] Instituto de Ingeniería Eléctrica, Facultad de Ingeniería, Universidad de la República, Montevideo, Uruguay

Email: irigaray@fing.edu.uy, tarragona@fing.edu.uy, jarruti@fing.edu.uy, pzinemanas@fing.edu.uy

Abstract

This paper describes the Tallerine-Vocoder; a hands-on course for Electrical Engineering (EE) freshman students. This course aims to motivate students and stimulate their creativity meanwhile the objects, topics, methodologies and actors of the EE program are also introduced. Throughout the course, students build and test all the necessary modules to assembly an analog Vocoder. The Vocoder modules are briefly explained and the course methodology exposed. Finally, the main goals of the course are objectively evaluated by a student survey and discussed in the results.

Keywords: active learning methodologies; hands-on; electronics and music; Vocoder.

1 Introduction

The Electrical Engineering program of Universidad de la República, Uruguay lasts five years, and is structured in three vast consecutive blocks: (1) the basic skills in Mathematics and Physics are concentrated in the first two years, (2) the basic technological skills are concentrated in the third year, (3) the specific technological contents are in the two final years. With the syllabus organized in this way, the students have their first approach to more tangible topics related to electrical engineering only from the third year onwards. Furthermore, technical subjects are generally taught with strong emphasis on theoretical aspects. All this has a high contrast with the students' expectations, who frequently expect to have direct contact with practical tasks since the beginning of the career. In this context, it is usual to have students reaching the end of their undergraduate education without a basic notion of practical issues such as circuits designing, soldering, testing, etc. Therefore the EE program faces some difficulties:

1. A scarce freshmen visibility of the EE program among all the Engineering programs (mechanical, civil, chemical, computer science, etc.).
2. Serious difficulties with student motivation, social integration and evasion.
3. The number of freshmen EE students descending from 240 to 120 in seven years.

To overcome this, the EE program offers the Tallerine course since year 2013. The main goals of Tallerine are: to motivate the students, stimulate their creativity, integrate them socially, that the students identify themselves with the University and the program, and to introduce the objects, topics, methodologies and actors of the EE program (Giusto, 2014). Each edition of Tallerine consists in various EE projects among which the students can choose according to their interests and preferences. Projects must meet the following requirements: the students have to build a prototype; are representative of EE applications and have ludic and motivating aspects.

In this context, members of the Open Electronic Workshop[3] (TEL) and the Audio Processing Group[4] (GPA) propose EE projects with musical applications. In the first two editions of Tallerine, one of those projects was an analogue synthesizer (Tarragona, Davoine, & Eirea, 2014). This experience yield good results and showed various advantages when using audio applications:

- The modular synthesizer enables students to build, understand and test the modules by stages.

[3] http://iie.fing.edu.uy/tel/

[4] http://iie.fing.edu.uy/investigacion/grupos/gpa/

- The skills and tools needed for building each module are very basic and do not require previous experience.
- Only standard electronic components and tools are needed and these are low in budget.
- No special workspace is required: students can even work in their own homes.
- The synthesizer is a musical instrument that can be played by controlling electrical signals, enabling students to link electronic operation with sounds; they can also demonstrate it to non-technical public such as their friends and families, rising their motivation.
- The students can link engineering and musical concepts. For instance, the link between amplitude and frequency modulation with tremolo and vibrato.

2 Vocoder

In the first semester of 2015 the audio related project was the Tallerine-Vocoder, which involved the building of an analog Vocoder. The Vocoder was original developed as a speech coder for audio data compression, and then utilized during the WWII as part of the SIGSALY encryption system (Boone, & Peterson, 2000). In the sixties and seventies the Vocoder was applied in artistic contexts, and was widely utilized by musicians such as Wendy Carlos, Kraftwerk, and Laurie Anderson (McClary, 1989). The Vocoder is also used today in movies and music, such as in the voice of the robot "EVE" in the movie "WALL-E" (Rowe, 2010) or by musician from Phil Collins to Daft Punk.

The Vocoder (Dudley, 1936) has two inputs: namely program and carrier, and one main output. The spectral envelope of the program is extracted and then applied to the carrier. The block diagram of Figure 1 depicts the process. Both input signals are filtered to perform a sub-band processing. In each sub-band, an envelope-follower estimates the amplitude of the filtered program signal. Then, each carrier sub-band is amplified by a Voltage Controlled Amplifier (VCA) with gain given by the previously estimated amplitude. Finally, all the sub-bands are recombined by a summing amplifier.

For example, when the program signal is speech and the carrier a keyboard, this results in a talking keyboard effect. This allows the expansion of the expressive possibilities of an instrument with some voice characteristics. To efficiently capture the voice formants at least 10 bands are needed. In short, each band process has four modules: two pass-band filters, an envelope follower and a voltage controlled amplifier.

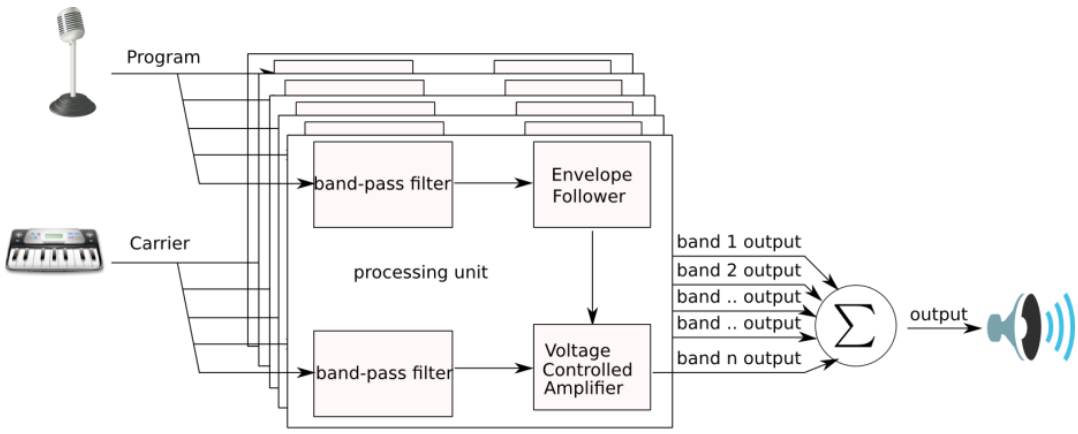


Figure 1. Vocoder block diagram.

Band-Pass Filter (BPF)

As previously mentioned, the band-pass filter modules allows the sub-band processing. The filters are standard 4-pole active Butterworth band-pass filter with constant quality factor Q. Two matched filters are needed per band. Filtering, invariant linear systems, and frequency response are the topics introduced in this module.

Envelope Follower (EF)

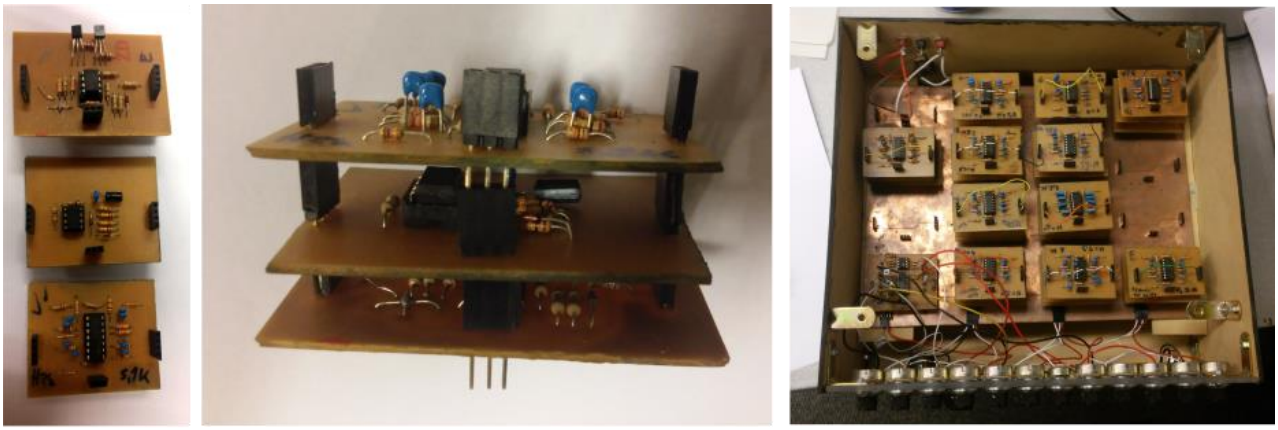
The Envelope Follower consists in a half-wave rectifier that drains current into a capacitor. Then, the capacitor voltage follows the signal peaks. This voltage results in an estimation of the program sub-band amplitude. Amplitude dynamics varies with frequency, so the capacitance value has to be adjusted for each band. Non-linear elements (diodes), rectifiers, capacitor natural response, and amplitude modulation are presented in this module.

Voltage Controlled Amplifier (VCA)

This module has two inputs, the signal and the control voltage. The VCA amplifies the carrier filtered signal (input signal) with gain given by the EF output (control voltage). As a result, the amplitude of the carrier in this band is determined by the amplitude of the program signal in the same band. The spectral envelope of the processed carrier approximately matches the spectral envelope of the program when all the sub-bands are processed. Transistors and the differential pair are introduced in this module.

Main Board (MB)

The four modules of each sub-band are interconnected via a predefined pinout, forming a processing unit as depicted in Figure 2. The main board accomplish different tasks: distribute the input signals across the processing units, sums all the processing units outputs, dispatches the power supply, act as mechanical holder for the units and interconnects the front panel with the modules adjustable controls.



a) b) c)

Figure 2. a) From top to bottom: VCA, EF and BPFs modules. b) Assembled processing unit. c) Main board with processing units.

3 Methodology

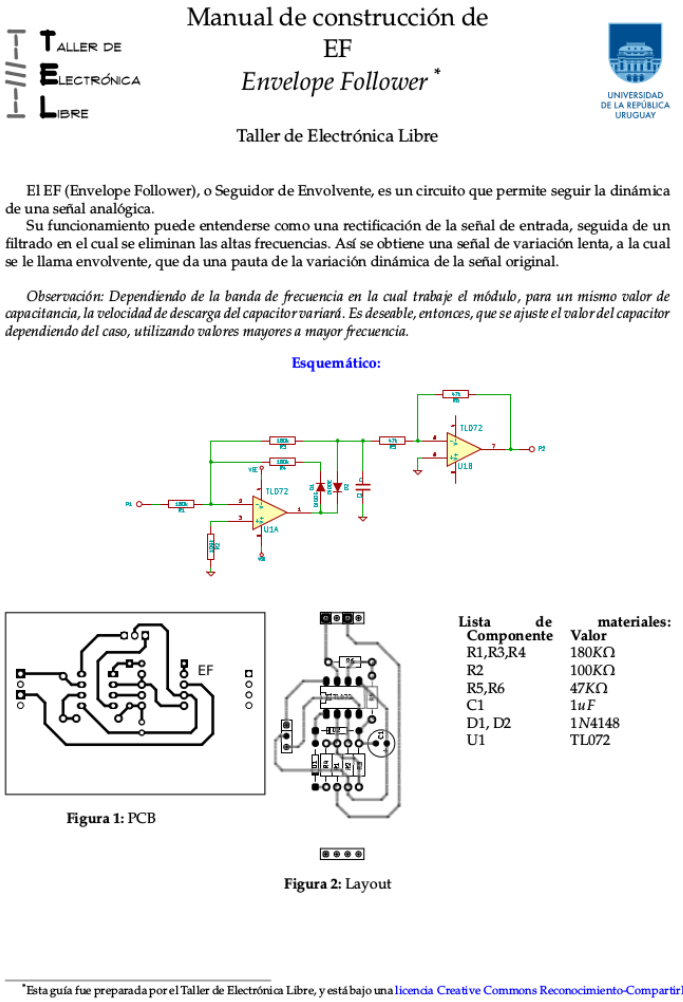
The first half of the course deals with the introduction of basic aspects of electronics, electrical components, signal processing and circuit theory. As a general rule of the course, from the beginning the students are divided in groups of six, in order to enable reasonable task divisions as well as for integration purposes (Giusto, 2014). The teachers calibrate the scope of the topics to be understandable for first grade student. The modules of the Vocoder are then presented, emphasizing the related concepts of electrical engineering. After that, the student assemble the modules on protoboard and evaluate them with a testing and debugging procedure. Laboratory devices such as multimeters, oscilloscopes, signal generators and power supplies are introduced at this stage. All of these activities are done by each group promoting peer learning and the increase of motivation. The first part ends with a written report and a presentation. This is the first time the students face this kinds of evaluations at the University. Corrections and comments are made to improve their skills in this area.

The next stage consists in a lecture about the Vocoder, including general subjects such as: operating principles, historical perspective and different applications. This lecture attempts to bring an integral approach of the project, showing the relation between Engineering and other disciplines.

Finally, the groups build the processing units of the Vocoder. This consists in making the Printed Circuit Board (PCB), mounting and soldering the different components and testing the modules. Once the building process is explained, the students receive a chart (see Figure 3) with the necessary information summarized. It consists in a brief description, circuit schematic, layout, footprint and bill of material.

The evaluation process is done taking into account several inputs collected all along the course:

1. Written reports. This reports show the team involvement in the course and serve as a practice of writing technical reports.
2. Oral presentations. Each group choose a specific topic related to the Vocoder and make an oral presentation to teachers and classmates.
3. Class observation. Group work, equal participation and solidarity between team members are evaluated by the teachers.
4. Co-evaluation. Each student has to evaluate the others group members in punctuality, complying with stipulated deadlines, quality of work, proposing ideas and compliance with group agreements. Then, each student receives the average result of his evaluation. This tool is very helpful to prevent an unfair distribution of tasks and responsibilities inside the student teams. This coevaluation is inspired in (Alonso, 2001; Míguez & Loureiro, 2012).



Manual de construcción de EF

Envelope Follower *

Taller de Electrónica Libre

El EF (Envelope Follower), o Seguidor de Envolvente, es un circuito que permite seguir la dinámica de una señal analógica.

Su funcionamiento puede entenderse como una rectificación de la señal de entrada, seguida de un filtrado en el cual se eliminan las altas frecuencias. Así se obtiene una señal de variación lenta, a la cual se le llama envolvente, que da una pauta de la variación dinámica de la señal original.

Observación: Dependiendo de la banda de frecuencia en la cual trabaje el módulo, para un mismo valor de capacitancia, la velocidad de descarga del capacitor variará. Es deseable, entonces, que se ajuste el valor del capacitor dependiendo del caso, utilizando valores mayores a mayor frecuencia.

Esquemático:

Figura 1: PCB

Figura 2: Layout

Lista de materiales:

Componente	Valor
R1,R3,R4	180KΩ
R2	100KΩ
R5,R6	47KΩ
C1	1uF
D1, D2	1N4148
U1	TL072

*Esta guía fue preparada por el Taller de Electrónica Libre, y está bajo una licencia Creative Commons Reconocimiento-CompartirIgual 3.0.

Figure 3.Chart of the Envelope Follower given to the students.

4 Results

At the end of the semester the Vocoder was assembled, tested (Figure 3) and used in a music live performance at the Tallerine final fair (Figure 4). Input instrument is an electric guitar which is modulated by the singing voice[5].

The course was evaluated by the students through a final survey. The results of the final survey shows that the main goals of the course were achieved. In brief:

- 90,5% of the students answered affirmatively to the question "Did you participate with enthusiasm?"
- 81% of the students answered affirmatively to the question "Did you find the methodology appropriate?"
- 71,4% of the students answered affirmatively to the question "Did the Course improve your initial perception of the methods and contents of the program?" .

The survey was completed by 21 students at the end of the semester and presents comparable results to the others projects involved in Tallerine course.

All the supplies generated in this course are available as an open educational resource with a creative commons license. This includes the modules schematics, layouts, course slides and charts. The material is available at the TEL webpage (http://iie.fing.edu.uy/tel).

Figure 4.Vocoder assembled and tested.

Figure 5. Vocoder at live performance.

5 Conclusions and future work

Active Learning and hands-on methodologies showed that can be effective to motivate the freshman students and introduce some of the main topics of the EE program. The Vocoder proved to be a good tool to introduce various EE topics. Also, their units and module structure brings the possibility to keep the complexity level bounded.

Electronic musical instruments can be used as an active learning tool. Students experiment with practical electronics meanwhile the theoretical background is presented. This process includes the development of transversal skills like project management, teamwork, and creativity. Working with music and engineering is very motivating and allows the students to find links between them.

[5] This performance is available at: https://www.youtube.com/watch?v=2a7Ey2_1Mlg

A textbook as an educative resource was elaborated collecting the experience generated in all the audio related projects. This book is in review process and its release is planned to the end of this year. It contains audio applications projects with their links to the different EE courses. This book could be useful for EE students of all degrees.

Finally, the GPA and the TEL are generating educative resources for a new course intended to third year students. It is planned for the second semester of this year and to build a Theremin (Moog, 1996) is the proposed project. Students of the third year have already acquired a theoretical background that allows a more in-depth analysis of some of the topics covered by the course. Our expectation is that students work independently and pro-active searching solutions for problems that arising from the project.

6 References

Giusto, A. (2014). Tallerine: a hands-on course for motivating freshmen for Electrical Engineering. *12th Active Learning in Engineering Education Workshop, Caxias do Sul, RG, Brasil*, 191-202.

Tarragona, M., Davoine, F., & Eirea, G. (2014). The Synthesizer: a versatile active learning tool for electrical engineering. *12th Active Learning in Engineering Education Workshop, Caxias do Sul, RG, Brasil*, 218-226.

Dudley, H. (1936). Synthesizing speech. *Bell Laboratories Record*, 15, 98-102.

Boone, J. V., & Peterson, R. R. (2000). The Start of the Digital Revolution, SIGSALY: Secure Digital Voice Communications in World War II. *Center for Cryptologic History, National Security Agency*.

Rowe, D. A. (2010). From Wood to Bits to Silicon Chips: A History of Developments in Computer Synthesized Speech Technologies: Tools for Aiding Impairment.

McClary, S. (1989). This is not a story my people tell: musical time and space according to Laurie Anderson. *Discourse*, 12(1), 104-128.

Míguez, M. & Loureiro, S. (2012). El trabajo colaborativo como estrategia de enseñanza y de aprendizaje. *UEFI, Facultad de Ingeniería*.

Alonso Tapia, J. (2001). Motivación y estrategias de aprendizaje. Principios para su mejora en alumnos universitarios. *Enseñanza y estrategia de aprendizaje en alumnos universitarios*, 79-111.

Moog, R. (1996). Build the em theremin. *Electronic Musician*, 12(2), 86-100.

Team–Based Serious Games and Useful Mathematics in Engineering Education

Fares Ben Amara[1], Walid Ayari[1]

[1] Esprit School of Engineering, Tunis, Tunisia

Email: fares.benamara@esprit.tn, walid.ayari@esprit.tn

Abstract

Serious games are considered as pedagogical tools that have been introduced in the teaching process in order to help the learners to enhance their specific skills. In fact, their use has been proven promising in numerous educational fields (information technology, mechanics,..).When developing the serious games for academic purposes, the challenge involves the theoretical domains or fundamentals such as teaching of mathematics for the future engineers. In this paper, we will examine in details the learning process of the fundamental notions such as, divisibility, congruence, prime number, n modular inverse, these arithmetic notions are regarded as key to future engineers in information technology via two team-based serious games, with regard to cryptation and decryption and sending of encrypted message. We will also describe the major players and their roles in the course of the game, as well as the target skills which have to be assimilated by the players. The use of such a pedagogical approach has required the establishment of an active pedagogical method that we have initiated since three years in our Engineering School ESPRIT, first by the establishment of a team-based teaching method, a dynamic method of exchange and assistance, in addition, by the shift from classical courses to problem-based courses in line with the needs of the other taught disciplines or, at best in line with the professional life and the real world. This paper is a testimony of our application of the team-based serious games in the teaching of several notions of fundamental mathematics.

Keywords: Serious Games; Team Work; Team Based Learning; Mathematic Courses.

1 Introduction

For many years, the teachers and all the people involved in the pedagogical field have recognized that the tools of the experience and the alternative learning environments have been revealed useful to help students to better learn and store the information. According to the proponents of the activity theory (Gros, 2003), (Engstrôm, 1993), the learning process is not only designed on the basis of the game itself, but rather as a transformation which occurs due to dynamic relations between and among the players, the game and the people involved in the process. Knowing the Engineering IT students' reluctance towards the theoretical mathematics courses, we have examined the efficiency of the innovative learning method by applying an active pedagogy in ESPRIT, during three years, firstly, by the implementation of a team and peer-based dynamic learning method (Louati ; Bettaieb ; Derbel, 2014) ,then by the courses shift ,into problematized courses in relation with the needs of the others disciplines or at better in relation with the professional life and the real world (Akrout; Ben Amara; Ayari, 2015) in order to motivate students.

A decrease in reluctance of students towards mathematics may lead to an increase in the transfer of knowledge. In fact, certain innovative learning methods such as the method of serious games could have the added value to enhance the participatory learning process. Others studies have also shown that the serious games may present very efficient alternative activity, which may offer students educational and recreational learning environment (Wouters; van Nimwegen; van Oostendorp ; van Der Spek, 2013). In order to expand our teaching methods so as to better teach our students, we will focus on the method of serious games, whose utility has been proven efficient, in the learning process of students (Gloeckner ; Love ; Mallette, 1995).

It is in this sense that we will present two serious games made in team with regard to sending encrypted and interception messages, in order to introduce purely theoretical aspects in arithmetic.

2 Used Tools

The principle objectives of this experience which consists of introducing the method of serious games in the teaching of mathematics is, first to address the two encountered principle difficulties, namely the demotivation of students and the abstract content of the lessons, and second to enhance the work in team of students by improving the participatory aspect.

Our approach is to achieve four goals:

- The transmission of the content, the learners will participate in the process of learning.
- Establish bonds between the teacher and the learners, the teacher will help the students to solve the problems raised.
- Commitment of learners, the students are invited to take initiative in the frame of the course program, with regard to down-to-earth situations
- The autonomy of the learners, the aim is to motivate the students to develop their own research, the teacher as a resource person

By applying the active pedagogical method TBL and by introducing the down-to-earth examples in the teaching of mathematics in order to motivate students, we will experiment; for three years, the method of serious games, in fact such a method will provide a great deal of advantages on the pedagogical level such as, the efficiency of the course, the cooperation and communication among and between students ,a significant increase of the motivation, the acquisition of cognitive skills and positive attitude, the structuration of knowledge with respect to assimilation of the information during the learning process, and the development of ability to understand a given problem (Sauvé; Louise; Renaud; Lise; Gauvin; Matthieu 2007).

3 The game

In such games, we will first divide up the students in three groups of five to six students, two groups will be called Allies A1, A2, and an enemy group E( ). the group A1 begins with encrypting the message and send it to group A2, this message will be intercepted by the group E. The aim of this game is that the goup A2 decrypt the message before group E, otherwise the allies will lose the battle.

Figure 1. Two allied groups A1, A2 and the enemy group E.

3.1 CESAR's spy (affine cipher)

The aim of this game is to understand the notions of congruence and to manipulate the calculation modulo a positive integer n.

In this game, we will first give the students the twenty six letters of the alphabet in Table 1, numbered from 0 to 25, in the order by ignoring the punctuation marks.

Table 1. Numbered affine cipher alphabet.

A=0	B=1	C=2	D=3	E=4	F=5	G=6	H=7	I=8	J=9	K=10	L=11	M=12
N=13	O=14	P=15	Q=16	R=17	S=18	T=19	U=20	V=21	W=22	X=23	Y=24	Z=25

We will give also a set of numbers (a, b). To encrypt the message, at each letter of the rank x in the alphabet $(0 \leq x \leq 25)$, we correspond the letter of the rank y

$$y \equiv ax + b\ [26]$$

We will introduce then to our students the notion of congruence and calculation in the cyclic sub group $Z/26Z$.

We will explain to the students of group A1 and A2 that the set of (a, b) is the secret-key cipher, it is only known from the sender and the recipient. We will choose the set (a, b) = (3, 5) and we will provide the group A1 with the message "ASSAULT" that they will be required to encrypt and send the encrypted message to the group A2.

First, the students of the group A1 encrypt the message which becomes "FHHFNMK": it is an occasion for them to master the calculation of congruence.

After encrypting the text, the students of the group A1 will send the key-message to the students of the group A2.Knowing the secret-key cipher, the students of the group A2 proceed then to the decryption of the sent message. They will notice that, to express x in function of y, they will have to determine an integer c, reverse of number 3 modulo26 i.e.

$$3c \equiv 1\ [26]$$

The students will notice that the knowledge of the set (a, b) will allow to decrypt the message. This justifies the term "secret key".

In the meanwhile, the group E intercepts the message, they will notice, after a statistical analysis, that the most used letters in the encrypted message are F and H, knowing that the most used letters of the alphabet are A and S, the students of the group E will deduct the following system:

$$\begin{cases} b \equiv 5[26] \\ 18a + b \equiv 7[26] \end{cases}$$

They will then determine the set (a, b), the secret-key cipher. They will notice that to decrypt the message, they will have also to determine the reverse of the number 3 modulo 26.

We will introduce then to students the theoretical notions of the reverse of a number and prime numbers in a cyclic sub-group Z/nZ

Finally, a race against the clock will begin between the groups A2 and E to decrypt the message. A bonus will be awarded to the winning group.

3.2 RSA spy

This game aims at enhancing the knowledge in arithmetic and introducing new results regarding the prime number and the notions of divisibility. In this game, we will begin by presenting to students of the group A two prime numbers (p, q). We will choose, for example p = 3 and q = 5 and we for the integer n=3*5=15. Then we give them the twenty six letters of the alphabet in Table 2.

Table 2. Numbered RSA alphabet

␣␣=00	A=01	B=02	C=03	D=04	E=05	F=06	G=07	H=08	I=09	J=10	K=11	L=12
M=13	N=14	O=15	P=16	Q=17	R=18	S=19	T=20	U=21	V=22	W=23	X=24	Y=25
Z=26												

The students will be asked to choose a prime number with $(p-1).(q-1)$, they will choose e=5, and we will explain that the set (n, e) will be called ''public key''. They will be assigned to share the results with the groups A2 and even the group E, hence came the name of the 'public key'. We will introduce then the theorems and the definitions regarding the prime numbers, the notions of divisibility and common dividers, and the theorem of Bezout.

The game begins by asking the students of the group A1 to find a relative integer d, called private key, verifying the theorem of Bezout i.e. $e.d = m(p-1)(q-1)+1$ they will verify that d=13. By explaining the RSA encryption protocol and the notions of Euclidian divisions and congruence, we will ask then the students of the group A2 to encrypt the secret message 'SOS'', which becomes '' D␣␣D'', they will send then the encrypted message to the group A1,the latter will use their private key to decrypt the message.

In the meanwhile the students of the group E intercept the message, they will try to decrypt the message, for this, they will have to obtain the private key d=13, for this purpose, they will have to decompose n in prime factors, which will be very easy with n=15

After that, we will choose two other greater prime numbers p and q and the game starts. The students of the group E will notice that the determination of the secret key becomes more and more easy. This allows us to prove the efficiency of this encryption system and the support of the arithmetic in this field.

4 Results

The introduction of these two examples of the serious game in the chapter of arithmetic has shown a good appreciation of our students for this method. In fact, we have carried out a comparative statistical study of the scores obtained by the students before ( ) and after ( ) the application of this method, more specifically we have carried out a comparison over the same number of students, following the same study level and with the same teachers and the same content. We have noticed a significant progress in scores regarding this chapter ( ). We have also noticed an increase in motivation for the courses of the students having participated in the game of the serious games in comparison with those having followed a classical-based active pedagogy course. This could be explained by the will to interact with the game, it is this attractive side of the game which appears to enhance students' motivation.

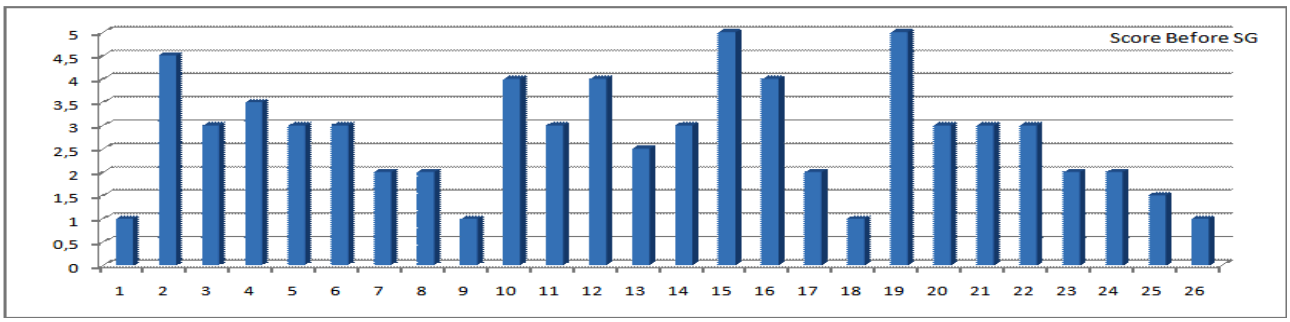


Figure 2. Scores before serious games method.

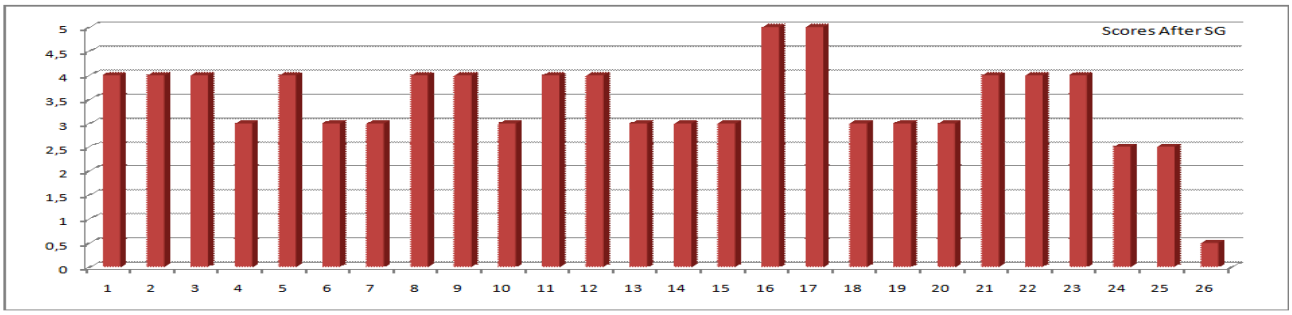


Figure 3. Scores after serious games method.

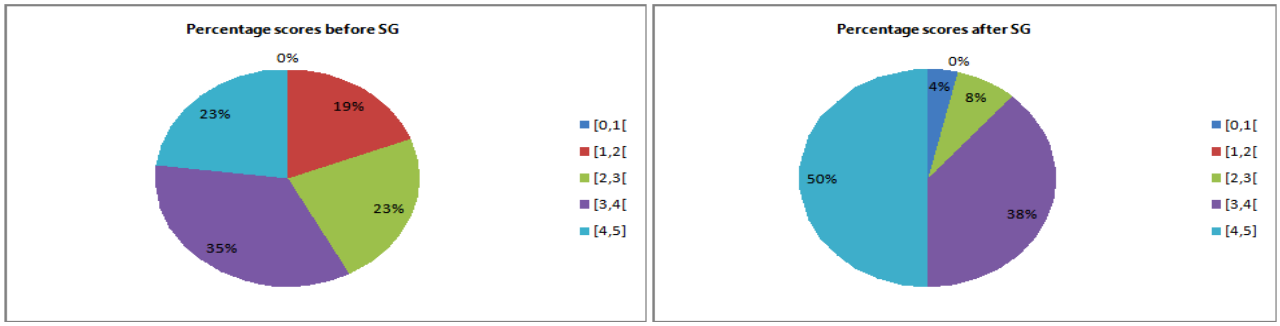


Figure 4. Percentage scores before and after serious games method.

We have also carried out students testimonies, by asking them to provide us with their impressions regarding this method, and the results showed that the majority of the students have stated that the serious games improve:

- The development of abilities of cooperation, communication and human relationship, and this by enhancing the capacity to enter into relationship, to negotiate, to discuss, to collaborate, to share ideas and to develop the team spirit.
- The development of abilities to solve problems, by enhancing their capacities to understand the problem, to state assumptions and to solve a studied problem. Hence, by enabling the learners to develop the required process logic to solve a problem.
- The structuration of the knowledge, by encouraging the consolidation of specific knowledge
- The integration of the information by developing the capacity to create bonds, transposing the knowledge acquired in contexts other than purely theoretical contexts.

We have also asked the students to assess the role of the teacher in the serious games, the majority reported that:

- The serious games dramatically changes the classical relation teacher/student
- The teacher plays the role of mediator between the theoretical knowledge and the practice of the serious game.
- The serious games enable to create bonds between the teacher and the student.
- The teacher becomes a resource person, by encouraging the students to develop and conduct their own research.

The serious games may also bring quite a few constraints for the teacher. The time of the happening of the game has to be well calculated to stick to the schedule. The two serious games in groups that we have applied have led to a certain excitement and tension in class, since it includes competition or a challenge. Therefore, it is necessary to set the rules of conduct from the beginning. The anticipation and the preparation of the material required for the game may be quite simple or may require a real investment in time and in imagination.

5 Conclusion

The use of the serious games, in the course of arithmetic for Engineering students, provides an innovative method of entertaining to boost the interest regarding the topic, by improving the understanding, the transfer of knowledge and the alternative learning activities. The teachers will be able to introduce a numerous concepts in a significant way and to assess the understanding and the assimilation of these different concepts by means other than traditional tests. The use of these examples of serious games, offers an instruction means which removes the fear or reluctance factor traditionally considered in the teaching of the chapter of arithmetic. This enables the teacher to meet several objectives namely: motivate the learning, giving examples of complex concepts in a significant way, consolidation of the transfer and assimilation of knowledge by providing alternative evaluation methods.

6 References

Gros, B., (2003). The impact of digital games in education, First Monday 8(7).

Engström, Y. (1993). Developmental studies of work as test bench of activity theory: The case of primary care medical practice, in Understanding Practice: Perspectives on Activity and Context. *Cambridge University Press, Cambridge, pp. 64-103.*

Louati, K. Bettaib, L. & Derbel, L. (2014). Team Based Learning in mathematics courses. *SEFI, Bermingham, UK*.

Louati, K., Ben Amara, F., & Ayari, W. (2015). Active Learning of Useful Mathematics in Engineering Education. *IJCLEE, San Sebastian , Donostia, Spain.*

Wouters, P., Van Nimwegen, C., Van Oostendorp, H., & Van der Spek, E. (2013). A Meta- Analysis of the Cognitive and Motivational Effects of Serious Games. *Journal of Educational Psychology, Vol. 105, No. 2, 249 – 265.*

Gloeckner, G., Love, C., & Mallette, D. (1995). Alternative teaching startegies for 1990s, *Denver, CO.*

Sauvé, Louise, Renaud, Lise, Gauvin, & Matthieu (2007). Une analyse des écrits sur les impacts du jeu sur l'apprentissage, *Revue des Sciences de l'Éducation, V.33, n°1, pp. 89-107.*

Sustainability in Three-Cycle Engineering Education Based on CDIO Syllabus

Natalia V. Daneikina[1], Yury V. Daneykin[1], Alexander I. Chuchalin[1]

[1] Tomsk Polytechnic University, Tomsk, Russia

Email: mischenko@tpu.ru, daneykin@tpu.ru, chai@tpu.ru

Abstract

The idea of sustainable development was defined in 1987 by the World Commission on Environment and Development (Brundtland Commission 1987) as: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". Since then the idea of sustainable development has grown both in its popularity and in topicality. The main problem the world community faces is who will take care of sustainable development. It becomes obvious that specialists should be trained first to solve the task of such development. That is why many leading universities took their first attempts to design special educational programs for preparing specialists in the area. The modern direction of educational programs "Education for Sustainable Development" is a synergy of disciplines that focus on research and solution of the planetary scale tasks in the area of resource efficiency, satisfaction of human needs while saving environment so that these needs can be met by both contemporary and future generations. As the initiative is relatively new, it is difficult to evaluate how effective the programs are, but it is reasonable to think of an approach that can help to systemize the knowledge and competences necessary for a specialist in sustainable development. Many universities around the world use CDIO approach (Conceive, Design, Implement, Operate) to update training programs for bachelors to prepare them to complex engineering activities at all stages of life cycle of technical objects, processes and systems. This approach is widely used, as it is consistent with the requirements of international standards IAE Graduate Attributes and Professional Competences to the learning outcomes in high school and competences of professional engineers. CDIO approach can also be applied to designing Master's and PhD programs. The paper will present the analysis of applicability of CDIO Syllabus v2 to the training of specialists in sustainable development at all three levels of higher education.

Keywords: Sustainable Development, CDIO Approach, CDIO Syllabus, Educational Programs.

1 Introduction

One of the newest trends in engineering education is the concept of sustainable development. The idea of sustainable development originates from numerous environmental movements in earlier decades and was defined in 1987 by the World Commission on Environment and Development (Brundtland Commission 1987) as: "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs". To support the concept and implement it into life it is necessary to train specialists able to promote sustainable development that inevitably leads to the necessity to develop educational programs embracing newest approaches considering up-to-date conditions and requirements (http://www.globalissues.org/article/408/sustainable-development-introduction).

2 Authors' Artwork

The issue of developing educational programs is also of great importance to the Russian Federation. Being the largest country in the world, having almost all the climatic zones on its territory and being rich in natural resources Russia cannot but take an active part in preserving the Earth for the future generations and doing all possible kind of research that can be able to help the mission. Therefore, the necessity for specialists in sustainable development is obviously urgent.

The solution of the Commission under the President of the Russian Federation on modernization and technological development of Russia's economy of 18 June 2009 also became an important initiative for

innovative development. Five priority areas for further development were declared: energy efficiency and energy conservation including development of new kinds of fuel and deep recycling of raw materials, nuclear technologies, space technologies, medical technologies and strategic information technologies. Realization of listed above priorities is not possible without the serious approach to students' training (http://www.ifsusu.ru/sites/default/files/BK_22_24_1.pdf).

First, it is necessary to understand what can be the content of educational programs for sustainable development. The experience of the leading Universities shows that generally existing programs and courses mostly embrace the following areas:

- interdisciplinary approach to understanding complex ecological, economic, social, scientific, political, and philosophic problems. Educational programs can embrace business strategies for sustainable development
- "smart" architecture and design of sustainable spaces
- climate change, human health, clean water, energy, biodiversity, ecosystems, poverty, human resources, safety, globalization and economy
- strategic forums for top leaders for the study of innovative and pragmatic approaches for sustainable development
- issues concerned with poverty, social inequality. Programs can suggest a possibility of cooperation with a wide circle of organizations and subjects including national and local authorities, non-governmental organizations and local communities
- programs targeted at local needs, for example sustainable development of local rivers or lakes, communities or environments

Programs listed above embrace virtually every field that can be associated with sustainable development, but few Universities develop programs, which include all the spheres. Mostly, Universities have their own specialization. In addition, it is not a usual situation to offer educational programs in sustainable development in all three levels: Bachelor's, Master's and Postgraduate's degrees. So it necessary to find approach that can be used for developing complex engineering educational programs (Daneykin, Yu. & Daneikina, N. (2015)).

A number of works are devoted to the problem of curriculum design in the view of sustainable development education (SDE) including (but surely not limited by) the following examples (for the sake of space the authors just give a couple examples). For example, Colombo, Moreiro and Alves (2015) suggest and discuss the results of using the elements of sustainability within Project-Based Learning (PBL) Approach (Ciliana Regina Colombo, Francisco Moreira & Anabela C. Alves (2015)). Neto et al. describe their experience in implementing PBL in engineering school and provide profound research in faculty perceptions of the PBL Approach. This approach is also widely used in Russian universities, though not always being the part of the curriculum. In addition, the task of the Higher Education Institutions is to integrate the best practices for curriculum design including those for sustainable development. We suggest considering CDIO Approach for educational programs' upgrade and design. Our purpose is to provide a sound background for the Use of a definite approach with the aim to develop a competitive and state-of-art educational program for Sustainable Development. The development of a program is a multi-element process. It can include an approach, methodology, teaching staff, authorities, employers, students and procedures. In this case, we narrowed our paper to a brief history of approach we are going to use and a case study including students' perception of the Approach. This is intended for better understanding of how ready they are for the change in the traditional curriculum, how fully they understand what Approach can require from them and what expectations they may have of the educational program for sustainable development using CDIO approach as the basis.

3 Brief Background

Many universities around the world use the CDIO approach (Conceive, Design, Implement, Operate) to update their Bachelor's (BEng) programs to prepare graduates to more complex engineering activities at all stages of the life cycle of technical objects, processes and systems (Chuchalin, A. (2015)). This approach is widely used, as it is consistent with the requirements of international standards (IAE Graduate Attributes and Professional

Competences) to the engineering HEI's graduate learning outcomes and competences of professional engineers (www.ieagreements.org/IEA-Grad-Attr-Prof-Competencies.pdf). The CDIO approach allows the design and implementation of BEng programs as a basic engineering education in accordance with the criteria for accreditation of engineering programs in the countries - signatories of the Washington Accord, including the accreditation criteria of the Association for Engineering Education of Russia (AEER) (Chuchalin, A., Tayurskaya & M., Malmqvist, J. (2015)).

Tomsk Polytechnic University (TPU) joined CDIO Initiative in 2011. One of the goals was to update educational programs to international standards. TPU is one of the oldest technical universities of Russia and has a long history of best practices in the sphere of engineering education. Now TPU takes its deserved place in the so-called Top-10 Universities of Russia. The leading positions are also the result and achievement of educators and graduates demanded on the domestic and international labour market. One of the nearest targets of the University is to enter leading positions in the world rankings. TPU developed a road map to achieve the goal and one of the priority areas that University supports is resource efficiency and sustainable development. These priorities condition the necessity to elaborate the challenge and prepare a profound program for training the specialist in the field of sustainable development.

4 Study of Students' Perception and Expectations

Multiple approaches can be used to work out the issue. One of them is to look on the problem form inside, i.e. to see how students understand the education for sustainable development based on CDIO Approach and Syllabus. This is what we decided to focus on in this paper with the aim to develop the topic further based on the result of our initial research.

A group of students (more than 50 participants) of the Institute of Physics and Technology, Tomsk Polytechnic University, took part in the questionnaire. The students already have the elements of sustainability study and research embedded in their educational programs and their awareness of the importance of sustainable development is rather high due to many factors. These include the content of the subjects, motivation due to knowledge they receive, involvement into the process of achieving a higher position in the world rankings by the University etc. In addition, they study one of the areas prioritized by the government. They were asked to underline the most important aspects of CDIO Standards from the point of view of educational program for sustainable development as the project work within the framework of the Conference week that is held once a semester in TPU in the form of an open discussion. The results of the discussion are summarized for each Standard below.

STANDARD 1: The Context. Students underline that the most important aspects where the stages Conceive, Design, Implement and Operate should be embedded are resource efficiency, development of nuclear energy and eradication of poverty and social equality, affordability of healthy food and clean water to all the population. Decomposing such aspect as nuclear energy for sustainable development in all the four stages they emphasized the following:

- Conceive: considering more modern, safer and secure technologies for producing nuclear fuel as well as making plants safer and secure.
- Design: developing schemes of high technology power plants.
- Implement: building modern power plants.
- Operate: first – providing the customer with safe and cheap energy, second- developing technologies for facilitating burnt-out nuclear fuel.

STANDARD 2: Learning Outcomes. Students note that it is very important for them to know the expectations of the employers to their learning outcomes and find the initiative of Tomsk Polytechnic University to organize fairs helpful where students can meet their potential managers and discuss what exactly they want to see in their future workers. Increasingly students are interested in developing their personal (Section 2 of CDIO Syllabus) and interpersonal skills (Section 3 of CDIO Syllabus). They find introducing the activities developing critical thinking, skills of teamwork and leadership, creative thinking and communication skills in every subject useful and able to help them in their future career in the industry.

STANDARD 3: Integrated Curriculum. Students highlight the importance of integrated curriculum. They suppose they firstly would like to see the interconnection between the disciplines they study admitting that sometimes they do not feel they see the whole picture of the future result.

STANDARD 4: Introduction to Engineering. After discussion students agreed that introduction is more a part of a curriculum for the first year students. If talking about Master's students and Postgraduate students the Introduction is not relevant. More attention should be paid to the development of skills and deepening the knowledge. Master's and PhD educational programs students' should be more reliable for the component of sustainability in nuclear industry involving awareness of consequences of nuclear energy use for the future generations, keeping environment and wellbeing of the population.

STANDARD 5: Design-Implement Experiences. Students mostly understand this aspect as the opportunity to put their hands on the real process. This means being acquainted with laboratory equipment and excursions to real production sites. They also think that this kind of activities are also differently implemented on different levels. The difficulty of such activities can increase gradually from simple acquaintance and simple operations on the first stages and increasingly complex activities further more. Also, multi-level admittance to the facilities reflect the multi-level system of education including the programs for sustainable development.

STANDARD 6: Engineering Workspaces. Standard implies a wide spectrum of study places that are not purely engineering such as lecture halls. TPU can boast of comfortable classrooms and modern equipment. Students mostly think of workspaces for engineering activities. Again, they underline they have the access to laboratory equipment but sometimes need more autonomy to practice outside the laboratory time or having more time to keep to their own pace that sometimes can be a bit slower than other students'. In addition, it is clear that students of Master's and PhD programs expect to have access to a more complex equipment and their degree of autonomy is primarily higher.

STANDARD 7: Integrated Learning Experiences. Students mainly associate integrated learning experiences with integrated curriculum. After some discussion they expand this meaning to learning experience outside the classroom but feel they are not completely sure about the inside of the Standard, so the task may be here to adopt existing educational programs so that students can have better understanding of the concept.

STANDARD 8: Active Learning. First that comes to the students' mind is active learning as opposed to just passive participation in knowledge and skills acquisition. However, there is quite a number of cases now when student feel they take part in active learning and describe their experience. This part also needs more elaboration within educational programs.

STANDARD 11: Learning Assessment. This question is a bit tricky for students at times. However, students feel their responsibility for the knowledge and skills and they feel it is necessary to be monitored, although they would like to have a wide range of assessment tasks within different disciplines, which can be a topic of a separate paper.

We decided not to ask for students' analysis of STANDARD 9 (Enhancement of Faculty Competence), STANDARD 10 (Enhancement of Faculty Teaching Competence) and STANDARD 12 (Program Evaluation) as we think it mostly refers to Teachers' competence.

However based on the questionnaire we analysed the level of students' satisfaction with their educational process according to listed above Standards. We have the following graph according to a group of students of TPU studying at all three levels of education.

As the second part of our joint analysis of developing a sample three-level educational process for sustainable development we asked the students to evaluate what parts of CDIO Syllabus are of more urgent relevance on each stage of education: Bachelor's, Master's and PhD and give their short comments. The Fourth Chapter of the Syllabus was given for analysis as it fully reflects necessary skills and knowledge with a view for sustainable development. Results are given in Table 1.

Table 1. Analysis of CDIO Syllabus (4. CONCEIVING, DESIGNING, IMPLEMENTING AND OPERATING SYSTEMS IN THE ENTERPRISE, SOCIETAL AND ENVIRONMENTAL CONTEXT – THE INNOVATION PROCESS).

4.1. EXTERNAL, SOCIETAL AND ENVIRONMENTAL CONTEXT	BEng	MSc	PhD
4.1.1. Roles and Responsibility of Engineers. The goals and roles of the engineering profession The responsibilities of engineers to society and a sustainable future	Mostly should be aware of goals and roles of the engineering profession. Graduates of Bachelor's programs are mainly performers.	Masters are more responsible for society as obtain more scientific knowledge	Graduate students should be able to foresee the consequences of the use of nuclear energy.
4.1.2. The Impact of Engineering on Society and the Environment. The impact of engineering on the environmental, social, knowledge and economic systems in modern culture	Bachelors should know the impact of their activity on environment, e.g. know the nuclear fuel cycle. Be aware of the advantages of the choice of nuclear energy being responsible for the possible accidents though setting the target to prevent them.	Masters should be more concerned not with the operation of power plants but with providing save technologies.	PhD students should develop waste-free technologies and think of completely new approaches in the development of nuclear energy.
4.1.3. Society's Regulation of Engineering. The role of society and its agents to regulate engineering. The way in which legal and political systems regulate and influence engineering. How professional societies license and set standards. How intellectual property is created, utilized and defended.	Relevant	Relevant with more emphasis on documental side (licenses, standards).	Relevant
4.1.4. The Historical and Cultural Context. The diverse nature and history of human societies as well as their literary, philosophical and artistic traditions The discourse and analysis appropriate to the discussion of language, thought and values	Relevant	Relevant	Relevant
4.1.5. Contemporary Issues and Values. The important contemporary political, social, legal and environmental issues and values. The processes by which contemporary values are set, and one's role in these processes. The mechanisms for expansion and diffusion of knowledge.	Nuclear energy is one of the more disputable issues in the world. Continuous discussions of the issue as a blessing or curse still hot and have counterparts on each side. Specialists in this field should be professionals having strong commitment to safety and security to the humanity. The same refers to Master's and PhD students. Master's and PhD students should be more responsible for expansion and diffusion of knowledge participating in relevant forums and scientific events.		
4.1.6. Developing a Global Perspective. The internationalization of human activity. The similarities and differences in the political, social, economic, business and technical norms of various cultures. International and intergovernmental agreements and alliances.	The results are mostly the same as for the previous section. Students of all levels should be able to realize the role of their activity from the point of view of political, social, economic, business and technical norms.	Master students are more active in internationalization of human activity. They can discuss such issues on higher level of knowledge especially taking part in academic exchange programs and international events.	PhD students can make scientific contributions into the development, improving and expanding international and intergovernmental agreements and alliances having scientific background in the area.
4.1.7. Sustainability and the Need for Sustainable Development. Definition of sustainability. Goals and importance of sustainability. Principles of sustainability. Need to apply sustainability principles in engineering endeavors.	All the aspects are relevant for Bachelor students.	Master students should look deeper inside the principles of sustainability in the sphere of nuclear energy. Application of sustainability principles in engineering endeavours should also take place here, as Master students are more aware of the needs of industry in the perspective.	In addition to all the mentioned PhD students are responsible for the development of new technologies to be applied in the industries.

As we can see from the table students have some valuable ideas about the educational process for sustainable development. While they consider some aspects of the Syllabus relevant in all three stages of educational process, they also can differentiate some aspects of knowledge between three levels of education.

5 Conclusion

The idea of sustainable development for the future generations is not a trend but objective necessity for the future wellbeing, which is globally recognized.

To develop having the concept of sustainability in mind it is necessary to have specialists able to support sustainable development that inevitably leads to the necessity to develop educational programs in all three levels of higher education: BEng, MSc and PhD to prepare highly qualified staff.

Though many Universities round the world implemented educational programs for sustainable development, there is a lack of profound educational programs offered in all three levels of higher education, which leads to the necessity to develop such programs.

To develop and update the curriculum it is necessary to consider many elements involved in the process, including teaching staff, authority, learning outcomes, procedures and students. In addition, it is of interest to have a fresh view from the people interested in receiving a high-quality education and to see the level of their readiness and awareness of the formation of sustainability education in all three levels of higher education.

To ensure the high quality of the educational program it is necessary to adopt it to existing international Standards. CDIO Approach is the concept able to become a foundation for the development of a comprehensive educational program for sustainable development.

Students of the Institute of Physics and Technology (Tomsk Polytechnic University) underline that their major "Nuclear Physics" is an essential part of sustainable development of the world and note that CDIO Standards and Syllabus can be beneficial for the development of the educational programs for sustainable development in all three levels of higher education: BEng, MSc and PhD.

6 References

Daneykin, Yu., & Daneikina, N. (2015) Sustainable development programs as the guarantee for the higher rating of Russian universities in the world rankings in the perspective of the sixth technological order. *Privolzhsky Scientific Bulletine*, *3*(2)-43, 41-46.

Chuchalin, A., (2012). RAEE Accreditation Criteria and CDIO Syllabus: Comparative Analysis. - Proc. 8th Intern. CDIO Conf., Queensland University of Technology, Brisbane.

Chuchalin, A., Tayurskaya, M. & Malmqvist, J. (2015). Professional Development of Russian HEIs' management and faculty in CDIO standards application. *European Journal of Engineering Education*, 40(6),

Crawley E. F., Lucas W. A., Malmqvist J., Brodeur D. R. (2011) The CDIOsyllabus v2.0. - Proc. 7th Int. CDIOConf. Tech. Univ. of Denmark, Copenhagen, June 20–23, 2011. – [Copenhagen, 2011]. – 13 p. – URL: http://www.cdio.org/files/project/file/cdio_syllabus_v2.pdf, free. – Tit. from the screen (usage date: 18.12.2013).

Colombo, C.R., Moreira, F., & Alves, A.C., (2015) Sustainability education in PBL education: the case study of IEM-UMINHO. Proc. 7th Intern. Symp. On Project Appr. In Engin. Education., Aalborg University, Denmark.

Neto, O.M., Lima, R.M., & Mesquita, D., (2015). Project-Based Learning approach for engineering curriculum design: faculty perceptions of an engineering school. Proc. 7th Intern. Symp. On Project Appr. In Engin. Education., Aalborg University, Denmark.

Entrepreneurship: A Practical Approach with Project-Based Learning

Marina Pazeti[1], Marco Antonio Carvalho Pereira[1]

[1] School of Engineering of Lorena, University of Sao Paulo, Lorena, Brazil

Email: marina.p@alunos.eel.usp.br, marcopereira@usp.br

Abstract

An Entrepreneurship course is being taught in at the School of Engineering of Lorena since the second semester of 2014. From the beginning, the choice was to set a practical approach, with the use of PBL, in which students received the minimum content on theoretical Business Plan, Business Model and Lean Startup. Students were challenged with the use of PBL, to enterprise in practice as they should deliver concrete results by the end of the semester. A case study was conducted in the first two classes: the second semester of 2014 and the first semester of 2015. Both classes responded at the end of each semester to the same questionnaire, using a Likert scale, on regards to 4 issues regarding Skills transversal. Furthermore, in the second group, all students were interviewed about the use of Project Based Learning as a learning method. Questionnaire data were quantitatively analyzed, while the data obtained from the interviews were treated qualitatively through content analysis. A triangulation with the collected data was used to determine the points of convergence or existing divergence. It was concluded that the use of Project Based Learning proved to be an efficient way to work the concepts and practice of entrepreneurship. In addition, the results obtained and the analysis performed allowed numerous improvements, which have been proposed for the next classes of this entrepreneurship course.

Keywords: Entrepreneurship; Project-Based Learning; Transversal competences.

1 Introduction

The technological advances of the last decades have led entrepreneurship to be one of the largest and most used forms of differentiation among companies. As a result, universities have begun to incorporate in their curricula courses focusing on understanding and on the first contact of students with entrepreneurship (Kuratko, 2005).

Entrepreneurship is often directly associated with the creation of new businesses. In Brazil, for example, every year there are more micro and small enterprises. These end up enhancing the economy, increasing the hand number of contract workers and, consequently, generating greater tax revenue.

This study aimed to analyze the use of active learning methodologies, especially Project-Based Learning, to an entrepreneurship course in the School of Engineering of Lorena at the University of São Paulo (USP). From our analysis, we also suggested improvements to the discipline aiming to improve student learning.

2 Entrepreneurship

To understand the basic meaning of the term entrepreneurship, one can look at the etimology of the word entrepreneur. It originated from the word "entrepreneur" in French, which is literally translated to "one who is among or between" (Hisrich, 1986, p. 96).

For Schumpeter (1934 apud Shane, 2000), the project is the "creative destruction" that moves the economy, with the emergence of innovations as responses to previously identified needs, culminating in new processes, products and new markets.

As for Drucker (1986), to be an entrepreneur consists on a behavior. This should be a practice that bases demand of knowledge that can be acquired, not being just psychological traits or entrepreneurial intuition. Such entrepreneurial behavior enables economic and social changes and is seen as opportunities to do something new that disturbs and desorganize pre-existing paradoxes.

For Kuratko and Hodgetts (2004), entrepreneurship is a dynamic process related to vision, change and creation application that requires not only technical knowledge but also energy and passion throughout the creation and implementation of a project.

Three instruments are relevant to the topic of entrepreneurship: Business Plan, Business Model and Lean Startup.

A business plan can be explained simply as a tool for the description of a business. It is the project in its current state, but can - and should - be used to make projections of the company's development within a horizon of time. It is a logical description of a venture, following a clear line of reasoning that allows whoever to read the document a clear understanding of the business (Blackwell, 2011).

A business model can be characterized as a tool that allows the integration of a system of activities to create a product or service that will be offered and delivered to the customer. They can also be defined as logical arrangements that organize clearly the core business and their interactions with each part of the system that composes it. Furthermore, how it works to deliver the desired customer value (Spencer, 2013). A tool proposed by Fritscher and Pigneur (2010), used in the creation of a business model is the business model canvas (BMC). BMC is composed of nine separate blocks with the key areas of a business. The key point of the use of the blocks is that they enable a global view of the project, showing the link among the various areas of a business and allowing each block to be arranged strategically.

Lean Startup is a methodology created by Eric Ries, and is based on Lean Manufacturing. It is geared towards startups, i.e. companies that are starting in very uncertain markets and therefore do not adapt well to solid planning strategies used by companies already consolidated (Ries, 2011). The concept of a lean startup seeks to provide entrepreneurs tools to enable the development of the project in the shortest time possible with a directed customer. Ries (2011) deals with important concepts related to its methodology. Among them is the concept of Minimum Viable Product, consisting of a primary version of the final product of the startup, which "allows to aggregate maximum validated learning with the least effort."

3 Project-Based Learning (PBL)

Over the years, the traditional teaching in universities no longer present the same credibility as before. It has not been considered more efficient for the preparation of students upon graduation to step into the labor market (Prince and Felder, 2006; Jollands and Molyneaux, 2012).

PBL is a methodology that consists of active learning, where the focus of the classes becomes the students. It has as its starting point a real problem to be solved (ECHAVARRIA, 2010). For Mills and Treagust (2003), PBL is basically the process in which students have to identify problems in a given situation and propose appropriate solutions through acquired knowledge. Suh process does not only in the classroom, but mostly through other sources of knowledge. The main focus of PBL is the application of knowledge to solve a problem that can vary in complexity depending on the situation in which it is used. Previous experiences of students on regards to the subject or the project runtime will always be directly related to the discipline that serves as the basis for the project. (Lu, 2007)

According to Lehmann (2008), PBL can be used as an approximation of reality to contextualize the knowledge acquired in the subjects of support and develop in students a range of skills through the union between the university and society.

4 Methods

4.1 Research method

Given the importance of a consistent methodology to the analyzed case, the case study method was chosen because it best fits within the object of study. According to Voss (2002), a case study allows to deepen the study of a unique situation. It also allows an analysis of questions, such as what the motivation before this

situation were and which are the factors that influenced the current framework of such. It, thus, allows the understanding of the correlations among the factors studied.

According to Yin (2005), the choice of the case study is recommended for situations in which the categories of questions raised on the study table is a "why" or "how". These must be made when the researcher has little or no control over the object of study and/or studied phenomenon is embedded in real life. The case study is well suited for situations where there is no control over the chosen object of study and the outcome of understanding of the scenario in which the studied phenomenon is desired. (Meredith, 1998; Stuart et al, 2002)

4.2 Object of study

The object of study was the first two classes in Entrepreneurship offered at the School of Engineering of Lorena: the first in the second semester of 2014 and the second in the first semester of 2015. Both classes were conducted by the same instructor.

The first class in 2014 consisted of 29 students of biochemical, chemical and materials engineering. The students were divided into teams, through which they should create businesses. They would behave as the creators of a startup with the main goal to be drawn as a business plan to be presented at the end of the semester. The class of 2014 has created 8 different startups, the number of members ranging from 1 to 6. The second class in 2015 consisted of 12 students in Chemical and Materials Engineering, as well as Engineering Physics. As in the previous semester, students were divided into startups. However, during the semester, they should create and propose a Business Model, based on the Business Model Canvas (BMC) to be submitted for assessment at the end of the semester. The class 2015 created 5 startups, the number of members ranging from a 1 to 3 people. In both applications, the students were evaluated by material produced in writing and also according to their presentations during the semester where external evaluators - people who do not attended the course and that somehow had knowledge of the concepts of entrepreneurship - were invited to attend the presentations and submit feedbacks to the companies.

4.3 Data collection

For a case study, data collection should be done through various forms, in order to converge the information. It is as if the various data sources provide different measures of the same phenomenon. It is common to conduct interviews, questionnaires and observation of the study object as tools for further analysis of convergence or divergence of the data. This technique is known as triangulation data (YIN, 2014).

In the present study, data were collected from three sources: closed questionnaires answered by the two groups, information gathered during lessons and presentations of both groups, and interviews with the students of the second class.

The questionnaire used was the same for both groups and was answered in the last class of each semester.

Since the interviews were conducted with 12 students enrolled in the second class in 2015. The interviews were recorded and later transcribed. These occurred in the last three weeks of the semester, when the startups already had some degree of development.

4.4 Data analysis

Since the source of data from this study was different in both semesters, each was treated differently according to their origin. Therefore, in principle, the data were separated by type of collection, date on which - 2014 or 2015 - and respondents.

Analysis of the questionnaires was made from the use of tools of basic statistics, in order to verify changes that could have occurred from the first to the second group, since some key changes occurred in the structure of the course from one semester to another.

The interviews, on the other hand, were analyzed using content analysis method, which is described as "a technique that aims an objective, systematic and quantitative description on the communication manifest from its content" (Silva et al., 2005).

From the data obtained from different sources, triangulation technique was used to identify points of convergence or divergence, causing an increase in accuracy of analysis and conclusions drawn.

5 Results and discussion

In this chapter, we first show the results regarding the questionnaires for the two groups. Second, the interviews with the second group are analyzed. Finally, the results obtainedf from the questionnaires and the content of the interviews are analyzed using triangulation.

5.1 Questionnaire

The questionnaire used for both groups contained 4 issues Soft Skills to be answered on a scale that ranged from "Strongly Disagree" with value assigned to a "Strongly Agree" with assigned value of five. Table 1 shows only the simple arithmetic mean of all respondents from the classes of 2014 and 2015 to the four questions. It was decided to calculate only the simple arithmetic average due to small sample size in both cases studied (29 students in 2014 and 12 students in 2015)

Table 1 - Average of questions about Soft Skills.

	Question	2014 class	2015 class
1	My capacity of oral and written communication has been enhanced in this project	4.14	4.00
2	My partners managed well their time and fulfilled the proposed timeline	4.00	4.17
3	My partners and I sought information in different sources to build our startup	4.66	4.92
4	I see that I have a more accurate critical sense that helps me to evaluate different work proposals	4.59	4.79
	General score	**4.35**	**4.47**

The arithmetic mean of the four issues Soft Skills ranged from 4.35 (class of 2014) to 4.47 (class of 2015). This small difference shows that the results of both groups were similar, but the analysis of each question revealed that in general, there are small differences in perception between one class and another, depending on the issue.

Question 1 is related to "Communication". This question had to evaluate the students' perception regarding the development of the ability to communicate, either orally or in writing. The results show that when comparing the perception of the first and second class, students in 2014 showed that the development of their communication skills, both oral and written, was slightly higher than in 2015. In both classes, the number of oral presentations during the semester was the same, but the first group had a greater degree of demand in relation to written communication in relation to the second class. The small difference between the two groups may be related to the fact that the first class produced during the semester a Business Plan, which clearly demands greater dedication to written communication than the creation of a business model. Thus, the constant contact with the preparation of a robust written document may have contributed to the students in 2014 to have an apparent better resourcefulness regarding their written communication skills.

Question 2 is related to "Time management". The question sought to assess the ability of students to manage the time available for their operating hours to devote to the project and to meet its deadlines. The results show that there was a slight improvement in the perception of the second group when compared to the first. This suggests that students of the second group knew better how to tailor the available time of the members of each group and to optimize their meetings, so that each task was completed on time. Regarding Time Management, it is important to highlight that all students who attended the course in two groups found

themselves in the last two years of their courses and because of this, most of them were interns at a company and had limited time for dedication to a startup developed in the discipline.

Question 3 relates to "Initiative" in the pursuit of knowledge, i.e., how proactive students with the content not provided within the classroom. It is related to the sought the knowledge to create their business elsewhere. The results obtained in the first group were good, but in the second group were much better once the full agreement of the second group was almost unanimous. These results suggest that the pursuit of knowledge for the development of startups was made from the most different sources for almost all students enrolled in the course, and particularly at a higher intensity in the second group analyzed. Was this because of the reduced size of the second class? Is there a negative correlation between class size and proactivity? Only further study can better evaluate this point.

Question 4 is related to "Self Knowledge". This question aimed to analyze the perception of students and the ability to better evaluate proposals and possible ways and weigh their decisions according to the objective to be attained. The results show that students in both years had the perception that this happened, but the students of the 2015 class had a higher average for the 2014 class. This result suggests that the use of the critical sense of the 2015 class seems to be more careful. Likewise from the previous point, only further study can better evaluate this question.

5.2 Interview with the 2015 class

The interview consisted of 10 questions. The first two questions referred to the major of the interviewee, as well as their year of entry. The other questions were divided into three different dimensions: (i) Entrepreneurship, which aimed to understand what the opinion of students on the theme were, relating the prospects they had before enrolling in the course and how this view had changed over the semester; (ii) Company, which aimed to identify the essential objective of each company as well as the major difficulties identified in each society; (Iii) PBL, which aimed to identify the students' opinions on the methodology and how such lessons format impacted learning. The results presented here refer only to the use of PBL in the discipline.

Initially, students were asked: What do you understand by PBL? And what is your opinion about this methodology? The responses show that students were able to distinguish clearly the goal of the methodology.

> "Something innovative, as the course itself. (...) He (teacher) leaves this relationship that the teacher is the bureaucrat who is there in front, only writing, only explaining content; and the student has to be quiet, watching, copying. Such style by some teachers that unfortunately we still have here, but he leaves this area, it is much closer to the student. "(Student B)

> "I understand it's a methodology that will teach you something by doing. You have a base and someone helping you but you have to find your way alone. I thought it was interesting, I liked it. "(Student E)

The answers show that the students understood well what was the proposal of the methodology used, with special attention to the importance given to the fact that the student is the center of their own learning and the teacher acting as a facilitator of the learning process.

Another question sought to assess, in the opinion of the students, the noticeable differences between this discipline and other disciplines of their curricula. The responses revealed that students had clear perception of the difference of using PBL in relation to traditional teaching methods.

> "I wanted to come to class. I'm at the end of the course, I have no patience to come to a class, sit in a chair and be listening to the teacher talk for two hours. And I come to class entrepreneurship because it's cool, it's fun, it's good." (D Student)

> "The main difference I see is this relationship of what we learn in the classroom to what we see in the industry. Because as much as we take a number of key disciplines to our course, with regard to a more technical issue, this vision we had in

entrepreneurship is what we use most, in my view. Not that technique is less important, but it (entrepreneurship) is what we experience the most. "(Student F)

"It is able to participate and to express their opinion. (...) The freedom to say what you think and get quick feedback. (...) So I think that's it, more freedom. "(Student G)

The answer to this question introduced a variation according to the perception of each student about what one experienced the most in the course. But it is apparent that the use of PBL was very positive and it was perceived by the students, as they were able to deal with real problems and with the freedom to express their opinions and get quick feedback as every step was completed.

5.3 The utilization of learning based on projects

Over the two semesters of application of PBL it was possible to calculate the positive impact that this class format had on student learning, either by quantitative answers from the questionnaire or qualitative responses in interviews. The analysis of the four transversal skills showed that the students had a clear perception of its development during the semester because all the means of the four questions answers were between 4.0 (agree) to 5.0 (totally agree).

The importance of using PBL has become even more evident with the interviews made with the 2015 class. It has been reported by 8 of the 12 students that they did not "expected much of the course" since they were much more used to lectures than to classes aimed at implementing practical projects. In addition, students who had had previous experience in other disciplines with PBL, were not convinced of its effectiveness due to the fact that had not been properly applied. In this Entrepreneurship course, by the end of the semester, students found themselves satisfied and some even surprised with the quality of content and methodology, since both gave students an experience close to reality to start a business in real life.

5.4 Lessons learned and proposals for the upcoming classes

From the results obtained and the observations made *in loco*, some proposals are aimed at the continuous improvement of the entrepreneurship course.

External evaluators - It is recommended that their presence not only occur in the final presentation, but during the development of the semester. People who are directly linked to entrepreneurship in real life or have different worldviews have much to contribute with proposals for startups. The startup creators receive feedback from experienced entrepreneurs and/or potential future customers.

Errors: Dealing openly about mistakes. It is very important that all students and their startups have the perception that some decisions taken by the team did not lead to the expected results, learning from these events. It is important to show that the problem is not to make mistakes, but not to take valuable lessons from these mistakes. Thus, it is crucial to stress that the inevitability of making mistakes and the need to learn from them, so that there is a constant improvement. This can directly be related to the product that is being created or the company being formed or even the student himself/partner as a person.

Prototyping: Also related to mistakes and learning, one should be encouraged to prototype a minimum viable product. Monitoring of presentations identified that several of the startups presented no primary versions of their products by not considering them to be ready. As once said Reid Hoffman, co-founder of LinkedIn social network: "If you do not feel embarrassed by the first version of your product, you launched too late" (Hoffman and Casnocha, 2012). It is important that students in this course develop the habit of prototyping their products, even if they are not physical products. This idea is linked with design thinking, methodology used in solving problems centered on humans and their interactions (Brown, 2010).

Standpoint shifting: Provide students at an early stage of creating their startups the contact with people questioning nature and who have ease to review their paradigms; people who, for some reason, have a design and quite different world view of the world view that a student of a public university has. These meetings should provide talks to students through which they could question situations that before could be foreseen by their point of view. The analysis of such reality in which they live by another standpoint can get them to

observe problems beforehand. It also aids them to perceive the existence of a solution and ways to work on it. From this meeting, students should not come out with answers, but with questions during the semester.

A new view on Entrepreneurship: the interviews showed that many of the students still associated primarily entrepreneurship to start a business or a new product. It is important, however, to expose students with tangible examples that entrepreneurship is characterized as a new way of thinking and acting. It can be applied within large companies - intrapreneurship - or even within the academic area where entrepreneurship comes as a way to innovate what is being taught or the way in which issues are being addressed. There is also social entrepreneurship, working on social issues using classic entrepreneurial concepts, supporting a financially independent, self-sufficient and sustainable entity (Abu-Saifan, 2012).

6 Conclusion

Upon all data and analyzes presented, we conclude that since its first application, the entrepreneurship course proved to be efficient for the presentation of concepts related to entrepreneurship through the use of PBL. Such course put students in direct contact with the reality of creating a new business from the moment of idealizing a conception.

The results showed that, in general, changes made to the application of the course in 2015, as the business plan for migration business model had good impact on the final result of the presented startups.

In addition, the data collected, especially those from the interviews with the second group, led to the creation of proposals that aims to further improve the application of such course in future semesters. These improvements include bringing external evaluators to academia for feedback sessions to startups, inviting previous students who took the course to assist with feedback and advice, encouraging students to share and what they learned their mistakes, demystifying the belief that to make a mistake is synonymous with failure, encouraging students to use prototypes to try out their business ideas, to see to what extent their ideas are useful to customers, putting students in touch with people from different realities and different backgrounds, providing students with questions about problems and consequently the opportunities that exist and that often go unnoticed for several reasons. Finally, we aimed at clearly showing students that entreprising goes well beyond founding a company or create a new product, being the point in which one realize a problem and find a way to solve it.

7 References

Abu-Saifan, S. (2012). Social Entrepreneurship: Definition and Bounderies. Disponível em <http://timreview.ca/article/523>. Acessado em 6 de dezembro de 2015.

Blackwell, E. (2011). How to Prepare a Business Plan: Create Your Strategy; Forecast Your Finances; Produce That Persuasive Plan. *Kogan Page*. eISBN: 9780749462536

Brown, T. (2010) Design Thinking. Rio de Janeiro: Campus-Elsevier, 249 p.

Drucker, P. F. (1986) Inovação e Espírito Empreendedor: Prática e Princípios. *São Paulo: Cengage Learning*.

Echavarria, M. V. (2010). Problem-Based Learning Application in Engineering. Rev.EIA.Esc.Ing.Antioq [online],14, pp. 85-95. ISSN 1794-1237.

Fritscher, B., Pigneur, Y. (2010). Supporting Business Model Modelling: A Compromise between Creativity and Constraints. *Task Models and Diagrams for User Interface Design*, 5963(1), 28-43.

Hisrich, R. D. (1986) Entrepreneurship, p.96.

Hoffman, R., Casnocha, B. (2012) Comece por você. Adapte-se ao futuro, invista em você e transforme sua carreira. Campus-Elsevier. 272p.

Jollands, M.; Molyneaux, T. (2012). Project-based learning as a contributing factor to graduates work readiness. *European Journal of Engineering Education.* 37(2), pp. 143-154.

Kuratko, D. (2005), The Emergence of Entrepreneurship Education: Development, Trends and Challenges. *Entrepreneurship Theory and Practice*, 577-597.

Kuratko, D., Hodgetts, R.M. (2004). Entrepreneurship : Theory, Process. Practice. *South-Western Publishers, Mason OH.*

Kuratko, D., Hoskinson, S. (2014). Innovative Pathways for University Entrepreneurship in the 21st Century. *Advances in the Study of Entrepreneurship, Innovation & Economic Growth*, 24.

Lu, S C-Y. (2007) A scientific foundation on collaborative engineering. *Techinical report, International Academy for Production Engineering*.

Masson, T.J.; Miranda, L. F.; Munhoz, A. H.; Castanheira, A. M. P. (2012) Metodologia de ensino aprendizagem baseada em projetos (ABPJ). *COBENGE 2012*, Belém, Pará, 3 a 6/09/2012.

Meredith, J. (1998). Building operations management theory through case and field research. *Journal of Operations Management*, 16(4), pp. 441-454

Mills, J. E., Treagust, D. F. (2003). Engineering Education – is problem-based or project-based learning the answer?, *Australian Journal of Engineering Education*. Obtido em 21 de janeiro de 2015, de http://www.aaee.com.au/journal/2003/mills_treagust03.pdf

Prince, M. J; Felder, R. M. (2006) Inductive teaching and learning methods: definitions, comparisons, and research bases. *Journal of Engineering Education*. 95(2), pp. 123-138.

Ries, E. (2011) Lean Startup. *Crown Publishing Group*. ISBN: 978-0-307-88789-4.

Shane, S. (2000). Prior Knowledge and the Discovery of Entrepreneurial Opportunities. *Organization Science. Catonsville*, p. 448-469. Disponível em: <http://pubsonline.informs.org/doi/abs/10.1287/orsc.11.4.448.14602>. Acesso em: 19 ago. 2014.

Silva, C. R., Gobbi, B. C., Simão, A. A. (2005) O uso da análise de conteúdo como uma ferramenta para a pesquisa qualitativa: descrição e aplicação do método, *Organ. Rurais Agroind.,* Lavras, 7(1), pp.70-81

Spencer, B. (2013). Business Model Design and Learning: A Strategic Guide. *Business Expert, New York: Business Express Press, LLC*.

Stuart, I., McCutcheon, D., Handfield, R., McLachlin, R. Samson, D. (2002) Effective case research in operations management: a process perspective, *Journal of Operations Management*, 20(5), pp. 419-33

Voss, C., Tsikriktsi, N., Frohlich, M. (2002). Case research in operations management. *International Journal of Operations & Production Management*, 22(2), 195-219.

Yin, R. K. (2014) Case Study Research: Design and Methods. SAGE Publications, California

PBL in School of Engineering of Lorena at the University of São Paulo: Lessons Learned and Challenges

Marco Antonio Carvalho Pereira[1], Maria Auxiliadora Mota Barreto[2]

[1] Department of Chemical Engineering, School of Engineering of Lorena, University of São Paulo, Lorena, Brazil
[2] Department of Basics and Environmental Sciences, School of Engineering of Lorena, University of São Paulo, Lorena, Brazil

Email: marcopereira@usp.br, maribarreto@usp.br

Abstract

The course of Industrial Engineering at the School of Engineering of Lorena, at the University of São Paulo has been using, since 2013, the Project-Based Learning (PBL) methodology in the "Integrated Project I in Industrial Engineering" course, taught at the first term of the academic year. In this way, PBL has been used as an integrator of three other courses: "Calculus I", "Chemistry I" and "Reading and Interpretation of Portuguese Language". In 2013, the coordination team was set up by a teacher and two senior undergraduate students. The freshmen were divided into teams with 6 to 7 student, each one having a professor as a tutor. A peer evaluation was made at the end of the semester by the students. Different background learnings occurred and the main shift from 2013 to 2014 was the final product of the project: a theoretical report to a prototype. In 2014, the coordination was done by a professor and two other undergraduate students. From this experiment, new main changes were adopted for 2015, which were: (i) - Coordination team expansion: the professor coordinator, a psychology professor, one undergraduate and one graduate student, and (ii) - the two monitor students followed the conversations teams through social media as passive participants. At the end of the semester, an evaluation of the use of PBL was made with the students. In 2013, the overall grade obtained was 4.41 points (on a maximum scale of 5.0 points). In 2014, 4.61 points, and in 2015, 4.84 points. Three major challenges are still present to the coordination staff: (i) - interaction with the discipline of Calculus I, since the students' perception reveals that they do not see this interaction; (ii) - the peer evaluation needs to be enhanced, since there are some students who are little involved with the project, but which are still approved in the course and (iii) - the expansion of the project coordination team.

Keywords: Active Learning; Engineering Education; Project-Based Learning.

1 Introduction

The speed in which changes occur is increasingly rapidly. Cultural, social, and especially technological changes are moving on an incredible pace. Similarly, labor market requirements are also changing, and at a similar speed. These changes directly affect the training of engineers, which is yet very focused, in most schools, in traditional models of teaching, where the teacher "teaches" and the student "learns"; where, in the classroom, the teacher is the active agent of knowledge, and the student the passive agent. In current times, where knowledge is widely disseminated in various information technology platforms, students increasingly feel less attracted to this traditional model of the classroom. Due to them feeling less attracted to it, the degree of learning is lower because most of the time, they are limited to study to "pass a test" and not to assimilate the factual knowledge.

We need to rethink education as a whole, and this includes engineering education. For Felder (2006), it is critical that future engineers know how to work in a group and face the inner reality of a company that is increasing its dynamism.

UNESCO (2010) presented a solid and consistent study on the engineering, in which it shows several challenges for the current years, such as "to transform engineering education, curricula and teaching methods to emphasize the relevance and approach to problem solving to engineering". This same report highlights the importance of engineering curricula to be based on relevant activities for students, among which are highlighted educational activities based on projects and problems, among others.

For UNESCO (2010), the world's future is in the hands of young engineers and the university needs to provide them with the best possible guidance to be prepared to face the challenges of the future. These challenges,

which over the past few years, have been leading universities to use a series of active learning methodologies, among which is included in UNESCO report (2010), Project-Based Learning (PBL), which proposes that the learning to be focused on the student solving real world problems in an Academic setting.

PBL inclusion in engineering curricula is considered one of the most efficient ways to add value to the student learning, and it has been recognized as an effective way to prepare students for professional careers (Helle et al., 2006; Jollands & Molyneaux, 2012; Litzinger et al., 2011; Prince & Felder, 2006). According to Lu (2007), students who participate in activities focused on PBL are more active, communicate better, know how to work in groups, and stand as top professionals, since they apply the acquired knowledge to solve a professional problem.

PBL has been implemented in the course of Industrial Engineering at the School of Engineering of Lorena, University of São Paulo, Brazil similar to the experiences at the University of Minho (Mesquita et al ,. 2009) and the University of Brasilia (Lima et al, 2012). This work chronicles the first three years of implementation, the learning occurred year after year, and the lessons learned in this period and the challenges that remain to further enhance student learning and their inclusion to their course.

2 Project-Based Learning

PBL is an active teaching method which aims to engage students in acquiring knowledge and skills through a real-world and well planned activities.

One of the first definitions for PBL was given by Adderley et al. (1975). For them, PBL:

> (1) involves the solution of a problem, often, though not necessarily, proposed by the students; (2) involves the initiative of the student (or group of students), and it requires a variety of educational activities; (3) usually results in a final product, such as a thesis, a report of a project or a computer program, among others; (4) involves projects, which in most cases are long and take a considerable period of time to be completed, and (5) leads teachers to engage in a consultant role, rather than an authoritative position, at all stages of a project (initiation, conduct and conclusion).

Thomas (2000) seeking to answer the question: "What must a project have in order to be considered an example of PBL?" presents five core criteria for a successful approach:

> (1) Centralization: Projects are an integral part of the curriculum. They are not peripheral. They are part of the basic education strategy, since students will learn the core concepts of the discipline through them; (2) - Question triggering: Projects must be focused on questions or problems that lead students to find (and even, to face) the central foundations of a given discipline; (3) - Constructive Research: The core project activities should involve the transformation and construction of knowledge by students; (4) - Autonomy: The development project is the students responsibility, without the typical supervision of traditional teaching and (5) - Realism: Projects should be realistic, dealing with concrete, tangible problems. It should not be a mere academic activity. They should have characteristics that allow the student the feeling of authenticity.

According to Powell & Weenk (2003), PBL involves students working in teams in order to solve concrete problems by using the theory in practice. Furthermore, they must also learn to relate what they are learning to their future profession. Moreover, for them, PBL should place the student as the main actor of the teaching-learning process and relate content from various disciplines on a project.

Helle et al. (2006) sought to define and distinguish PBL pedagogical or psychological reasons in this kind of pedagogical approach. For them, the most important feature of PBL is the fact of having direct oriented problems, which serve to conduct learning activities. Furthermore, they have proposed a number of additional reasons in order to justify the use of PBL:

> 1) the construction of a concrete artifact forces the student (or group of students) to develop a series of learning activities during the stages of the construction process; 2) the control of the student in the learning process, since it is the student's role to make decisions about the pace of work and its sequence; 3) the contextualization of learning is evident in projects carried

out by students; 4) the potential for the use and creation of various forms of representation, since as in professional life most activities require the use of interdisciplinary knowledge and 5) the existence of motivating features for students

For Duch et al. (2001), PBL should lead students in search of open problem solving, as well as the acquisition of skills, such as problem-solving ability, oral communication, written communication and teamwork, among others.

To Lehtovuori et al. (2007), the labor market is demanding extraordinary professional skills and just knowledge is not enough. Thus, teaching through PBL provides many benefits for students, and improves their academic development. These authors emphasize, among others, the following benefits for students: they do not only gain knowledge, but they learn to do a project; they practice their skills and acquire others; they know how to behave in a group; they gain as practical activity, as it approaches those of their profession. In addition, the authors propose that: projects, whenever possible, should involve the university and the communities in surroundings; should evaluate students based on the reality that they will find in the labor market; should increase communication and unity within the classrooms.

3 PBL in the Industrial Engineering Course

The Industrial Engineering course aims to capacitate a professional with solid scientific expertise who is able to design, model, implement, operate, maintain and improve integrated production systems of goods and services, involving human, financial, and material resources, technology, information and energy. In addition, it is expected that this professional know also how to specify, predict and evaluate the results obtained from these systems benefitting both the society and the environment, using specialized knowledge of mathematics, physics, humanities and social sciences together with the principles and methods of analysis and engineering design.

In line with the objective of the course, the student profile of this course should be a generalist with solid scientific and professional training to enable this person to identify, formulate and solve problems linked to the design, operation and management of work and systems production of goods and/or services, considering the human, economic, social and environmental aspects, ethics and humanistic vision in meeting the demands of society. In addition, these professionals must be creative and flexible, have a critical spirit, initiative, judgment and decision making, be able to lead and work in multidisciplinary teams, have skills in oral and written communication and know how to value continuing education.

The course was first implemented in 2012 with 40 students. Since then, every year, the course receives 40 new students. The first class, 2012, did not apply PBL in their first year of course. PBL was introduced in the course in the second class in 2013, from visits conducted in 2012 by the Course Coordination at the Massachusetts Institute of Technology and Harvard University in the United States, the University of Minho in Portugal and the University of Brasilia in Brazil.

During the years of 2013 and 2014, PBL was applied in the course of "Introduction to Industrial Engineering", in which students were divided into teams, under the guidance of a tutor. From the successful experience of these two years, the course now has three specific subjects project since 2015: Integrated Project I in Industrial Engineering (first semester), Integrated Project II in Industrial Engineering (fourth semester) and Integrated Project III in Industrial Engineering (seventh semester). This paper describes the experience of using PBL only with freshmen in the years 2013-2015.

In all these years, a design guide, based on the model used by the University of Minho, was delivered to all students enrolled in the design discipline in the first class of the semester. The guide is a tool that introduces students to the concept of PBL and explains the main objectives to be pursued, throughout the semester, from the use of this methodology. The design guide defines the responsibilities of students and tutors. The guide explains that the technical skills to be acquired by students during the course of the interdisciplinary project are the specific skills to be acquired in direct support of the project disciplines: Calculus I, Chemistry I and Reading and Portuguese interpretation. In addition to technical skills, the Project Guide provides transversal

skills that are expected to develop in students throughout the semester: teamwork, personal development, communication, and project management.

3.1 First class: 2013

This year, PBL was applied in the discipline of "Introduction to Industrial Engineering" with 46 students enrolled, 40 of them being freshman in Industrial Engineering. The other six were upper-level students, three of which had changed their major and three were attending the course as an optional course to their major.

The coordinating team of the discipline was made by an instructor and two senior undergraduate students with no previous experience in projects.

The theme proposed for the project was "Sustainability of a university campus."

Six teams were assembled, each consisting of 6 or 7 first-year students. Each of the teams had, in addition to freshmen, a teacher in the role of tutor and a senior student in the advisory role. In addition, each of the teams had to choose among its members, a leader and a secretary.

The tutor, a professor at EEL, had some technical knowledge of the problem and had the responsibility to guide the group. It was not up to tutor to interfere with the actions taken by the group but to question whether these would be the best for each situation. Six EEL professors in total were engaged in this project, having one directed to each group.

The consultant, a senior student, had responsibility to support and motivate new students, from previous personal experiences. Consultants should not, under any circumstances, be the leaders or secretaries of the groups.

The leader, chosen among the freshmen, had the responsibility to arrange and conduct meetings, assign tasks and collect their outcomes, among others that were delegated by their teams.

The secretary, chosen among the freshmen, had a responsibility to record the progress of discussions and work routine under the form of a meeting minute.

Each group used three supporting tools: a blog, which should be disclosed the progress of work on the web; minutes of meetings, in which the records of the meetings were made; and a communication protocol through which made the internal communication of the group.

A peer evaluation was made at the end of the semester by the students.

Several positive points that stood out this first application were: (i) - the fact that the students do four oral presentations during the semester; (Ii) - to conduct a lecture on teamwork in the third week of class .; (Iii) - the use of an Evaluation Questionnaire use of PBL twice during the semester (in the middle and at the end) and (iv) –enhanced motivation of students in the last class of the semester, to do the oral presentation of the Final Project. These four positive points have been held every year since then. Only the Assessment Questionnaire was enhanced from 2013 to 2014.

The main lesson drawn from this first class was that it lacked a prototype as a final product of the project, because the students just delivered a conceptual design proposal for improving campus sustainability. It turned out also that the advisory role for the senior students did not work properly, because several times their opinions conflicted with the role of the tutor, played by a professor.

Difficulties were also encountered in integrating the disciplines of General Chemistry I and Calculus I with the project.

3.2 Second class: 2014

In the year of 2014, PBL was also applied in the course of "Introduction to Industrial Engineering" with 43 students enrolled, 37 of them being freshman in Industrial Engineering. The other six were sophomores or upper-level students, which were freshmen in previous years, three of which had changed major via internal transfer and three of them were attending the course as non-required credits to their major.

The coordinating team of the discipline was made by a teacher and two students who were part of the project in the previous year.

The design theme for this class was: "Biofuel Production", in which the ultimate goal was the same as the previous year, in addition to the delivery of a prototype in the laboratory bench scale that produce biofuel.

Students were divided into 8 teams of 5 or 6 students. Two significant changes have occurred in the composition of the groups in relation to 2013: all six non-freshman students made up a group and each group received a godfather, who was a non-freshman student of Industrial Engineering. The "Project Guide" had minor changes from the experience of the previous year and was delivered to each of the students. The schedule of this group was similar to the 2013 class, with only one significant change: in the last class of the semester the students made a demonstration of the prototype in the lab for three instructors.

The roles of the tutor, leader and secretary were kept within the same scope of the previous year. As support tools, the blog was no longer used; but only the meeting minutes. The main internal communication protocol was made using Whatsapp.

A peer evaluation was made at the end of the semester by the students.

Positive points that stood out this year, besides the four already highlighted in the previous year were: (i) - the construction of the prototype during the semester increased contact between students; (ii) - the presentation of a prototype in the last class of the course.

The difficulties encountered in the integration of General Chemistry I discipline in the previous year were overcame. This is due to the design to be linked with chemistry and the construction of the prototype to have been run in a chemistry laboratory. However, the difficulties in integration with Calculus I continued.

Several learning opportunities occurred for the coordination team and the main change for 2015 was the creation of the Integrated Project discipline of Industrial Engineering for the project to be fully performed in this discipline. The discipline of "Introduction to Industrial Engineering" was held in the grid and returned to its main goal, which is to give a general view of industrial engineering for students entering the course.

3.3 Third Class: 2015

This year, PBL was applied in the discipline of "Integrated Project I in Industrial Engineering" for 40 students starting Industrial Engineering. This is a required course offered only for Industrial Engineering students. They began to consider students "veteran" those that, although they are entering this course of Industrial Engineering, they had already taken partially or entirely another undergraduate degree.

The coordinating team of the discipline was expanded to a coordinator instructor, a professor of psychology, a student that participated in the project in previous years, and a graduate student.

The theme of this semester was "Safe Drinking Water Production from unconventional sources," in which the ultimate goal was the same as the previous year: the delivery of a prototype in the laboratory scale and a written report at the end the semester.

The students were divided into six teams of 5 or 6 students. A significant change occurred in the composition of the groups in relation to 2014: six students considered "veterans", which have already had previous experiences in other college-level courses, made up a group. All groups received a godfather who was a veteran student of Industrial Engineering. The "Project Guide" as well as the schedule of this group was similar to the class last year.

The roles of the tutor, leader and secretary were kept with the same powers as the previous year. As support tools, the meeting minutes remained. The main internal communication protocol group was using Whatsapp, which was monitored throughout the semester by both monitor students who only followed the discussions of the teams as passive participants.

A peer evaluation was made at the end of the semester by the students.

Positive points that stood out this year, beyond those already highlighted in previous years were: (i) - the psychology professor's entry into the coordination team and (ii) -the monitoring of Whatsapp throughout the semester by both monitors.

Again the difficulties encountered in the integration with General Chemistry I discipline have been overcome. On the other hand, difficulties with integration with Calculus I continued and even worsened this year, a fact that resulted in even greater failure of students in Calculus I in the three classes in which the project was implemented.

A fact that drew much attention in 2015 was that the teams were looking for more than their tutors to seek guidance on the project. One of the facts that may have contributed to this, this higher ratio of 2015 tutors in relation to the 2014 class, is that all the 2015 class godfathers were students who had already done the project in previous years, which did not occur with the 2014 class. As a result, in the 2016 class, tutors will continue to be students who have done the project in the past.

4 Lessons Learned

Table 1 presents issues concerning the use of PBL as a teaching and learning method, answered by the students in the middle and at the end of the semester, in three years. The questionnaire used had a scale of 1 to 5, where the answer to "Strongly Disagree" was awarded grade one in the scale adopted and the answer "Strongly Agree" was awarded grade five. The results presented refer to the arithmetic mean of respondents in each group.

Table 1 – Analysis of PBL application.

Question	2013 Half semester	2013 End of semester	2014 Half semester	2014 End of semester	2015 Half semester	2015 End of semester
The utilization of PBL in the first semester is a great course differential	4.51	4.71	4.87	4.88	4.89	4.93
I understand that the concepts of PBL should be used with more frequency in more courses	4.15	4.18	4.21	4.37	4.61	4.73
The utilization of this methodology makes the learning process more involving	4.31	4.07	4.53	4.44	4.87	4.83
The PBL methodology enhances the development of personal relationships	4.73	4.68	4.79	4.76	4.71	4.88

The analysis of the four questions in table 1 shows that during the three years, the students showed a high degree of evaluation of the use and importance of PBL in the first semester of their engineering course. They recognize that the use of PBL in the first semester is a course differential, and recognize it in a very relevant way, as in the years 2014 and 2015, almost all the students, both in the middle of the semester and at the end answered "strongly agree" to this question. Another important fact to highlight on these answers is that the best evaluation of PBL occurred with the third group, the 2015 one, which may reflect factors such as the greater experience of teachers in their application, the collaboration of a psychology professor during the semester and greater interaction among groups with their godparents, who were students who had already done the project in previous semesters. It should be noted that in addition to being one of the course differentials, other responses clearly show that the accomplishment of a real project in the first semester, through the PBL methodology, in the opinion of the students, should be used in other disciplines of the course. Adding to that, PBL makes learning more motivating and enhances the development of interpersonal relationships.

A fact that confirms the objective fact of the responses of the students is that teachers who work in this project will also teach classes to students from other school engineering courses. The difference among the students of Industrial Engineering and the other undergraduate students is noticeable, especially on the following points: (i) – they are more participatory and (ii) - the quality of their presentations. This, in the opinion of these teachers, although subjective, is due to the focus that the project has in the development of soft skills such as

teamwork and communication. This focus does not exist at the same extent with the other students in the first semester of other engineering courses at the School of Engineering of Lorena.

PBL as an effective method of learning has been stimulated by the Course Coordination to be used in other disciplines of the Industrial engineering course. Beginning in 2015, two other courses were created in the course: Integrated Project II in Industrial Engineering (fourth semester) and Integrated Project III in Industrial Engineering (seventh semester). In addition, four other courses have adopted PBL as the main teaching-learning method in full: Administration and Organization (second semester), Automation and Control (seventh semester), Project Factory (ninth semester) and Product Design and Process (ninth semester).

The acceptability of the use of PBL was great in these three years that it became visible to the whole school community. Because of this, from 2015, three other courses have adopted PBL in some subjects of their courses. It is noteworthy that the course of Chemical Engineering has created a discipline of design, along the lines of what has been implemented in Industrial engineering from the second semester of 2015.

5 Challenges

The positive results already achieved and the high acceptability obtained by the use of PBL in the first semester of the course point out that this chosen path has proved to be very positive. However, there are some challenges that have been clear throughout the process.

The biggest challenge of all is the integration of the project with the discipline of Calculus I, as the perception of students as shown in Table 2 reveals that they disagree more than agree that there is such integration.

Table 2 – Integration between Calculus I and PBL.

Question	2013 Half semester	2013 End of semester	2014 Half semester	2014 End of semester	2015 Half semester	2015 End of semester
I can notice a direct relationship between Calculus I and what I have been working on the project.	2.13	3.00	2.11	2.59	2.00	1.95

The results show that integration does not exist in the opinion of the students, and that this scenario has worsened over the years, having obtained the worst result in 2015, the year including the higher failure rate of freshmen in industrial engineering in this Calculus I along the analyzed years. A concrete fact is that Calculus I is the discipline with higher failure rate of the first semester of all engineering courses at the School of Engineering of Lorena. This fact is similar in most engineering schools in Brazil. There are several possible causes for this: the deficiency of teaching math in high school, the large volume of the course content, the traditional teaching methods with which the discipline is taught and evaluation mechanisms of discipline, among others. The point is that regardless of the cause, it is essential to seek greater integration between Calculus I and the project, even as a motivating factor for the students interested and obtain greater scores in Calculus I. There are three actions planned for the class of 2016: (i) - regular meetings with the course instructor; (ii) - participation of such instructor in a Integrated Project I in Industrial Engineering class time, in which students must show, in a concrete way, real examples of application of Calculus I knowledge in their project design, and (iii) – the delivery of an appendix to the final report on the interface between the Project course and Calculus I. Only at the end of the semester it will be possible to determine, based on the questionnaire, and the final report, if this goal (the integration of Calculus I and the project) is reached.

The project coordination team has varied over the three years of implementation, having remained constant only the main coordinator instructor. In the first two years (2013 and 2014) the instructor worked with the direct support of monitor students, which changed from year to year. In the year 2015, two new monitor students and a psychology professor were added to the team. Their contribution provided a differentiated valuable feedback opinion on regards to the development of transversal competences. A challenge that can bring greater outcomes for the course will be the contribution of a few more instructors to the course, that can add value sharing their experience in other areas. An economy professor has been invited, so then he can contribute in improving the analysis of financial economic viability of the projects developed by the students.

In the three years of the project, in the last class of the semester, an evaluation among peers has been made. Students have participated with maturity and the results have revealed that in some teams, there are some students with low participation in the final result of the project. The only concrete result of the peer evaluation has been an impact on the final grade of the student in the course. Concrete fact that peer review is to be enhanced, since the three years up to now been carried out in the same manner.

6 Conclusion

PBL was first implemented in the course of Industrial Engineering at School of Engineering of Lorena in 2013. The results have been very positive, among which stand: (i) - the four oral presentations made by the students during the semester; (ii) - the use of an Evaluation Questionnaire on the use of PBL in half and end of the semester; (Iii) -a motivation of students in the last class of the semester both in the presentation of the prototype and in oral presentation and (iv) - the presence of a professor of psychology at the coordination team.

Furthermore, challenges remain to enhance the subject. Three stand out: (i) - interaction with the discipline of Calculus I; (ii) – a more effective peer assessment and (iii) - the expansion of the project coordination team.

7 References

Adderley, K. et al. (1975). *Project Methods in Higher Education*. SRHE working party on teaching methods: Techniques group. Guildford, Surrey: Society for research into higher education..

Felder, R. M., (2006), Teaching engineering in the 21th century with a 12th century teaching model: How bright is that?, *Chemical Engineering Education*, 1(4), 110-113

Duch, B. J.; Groh, S. E.; Allen, D. E. (2001). *Why problem-based learning? A case study of institutional change in undergraduate education*. In: Duch, B. J., Groh, S. E. & Allen, D. E. The power of problem-based learning. Virginia: Stylus.

Helle, L., Tynjala, P. e Olkinuora, E. (2006). Project-based learning in post-secondary education – theory, practice and rubber sling shots. *Higher Education*, 51(2), 287–314.

Jollands, M., Jolly, L.; Molyneaux, T. (2012). Project-based learning as a contributing factor to graduates' work readiness. *European Journal of Engineering Education*, 37(2), 143-154..

Lehtovuori, A.; Costa, L.R.; Gonkala, M. (2007).The problem-based learning approach to teach elementar circuit analysis. *IEEE Transactions on Education*, 50, 40-51.

Lima, R. M.; Silva, J. M.; Janssen, N.; Monteiro, S. B. S.; Souza, J. C. F. (2012) Project-based learning course design: a service design approach. *Int. Journal of Services and Operations Management*, 11(3), 293-313.

Litzinger, T., Lattuca, L., Hadgraft, R.; Newstetter, W. (2011). Engineering Education and the Development of Expertise. *Journal of Engineering Education,* 100(1), 123–150.

Lu, S. C-Y. (2007). *A scientific foundation on collaborative engineering.* Technical report. International Academy for Production Engineering.

Mesquita, D.; Alves, A.; Fernandes, S.; Moreira, F.; Lima, R. M., (2009) A first year and first semester Project-Led engineering education approach. *Anais: Ibero–American Symposium on Project Approaches in Engineering Education - PAEE2009*, Guimarães, Portugal, 2009, pp 181-189.

Prince, M.; Felder, R. (2006). Inductive Teaching and Learning Methods: Definitions, Comparisons, and Research Bases. *Journal of Engineering Education*, 95(2), 123-138.

Powell, Peter C.; Weenk, Wim. (2003). *Project-led engineering education*. Utrecht: Lemma Publishers.

Thomas, J. W. (2000). *A review of research on Project-Based Learning*. Available in: http://www.bie.org/images/uploads/general/9d06758fd346969cb63653d00dca55c0.pdf Acessed in 12 February 2016

UNESCO (2010). *Engineering: Issues, Challenges and Opportunities for development*. Paris. France, 2010, Available at: http://unesdoc.unesco.org/images/0018/001897/189753e.pdf Acessed 10 january 2016.

Framework for Implementing a Sustainability Curriculum in an Engineering Technology Program

Dan Centea[1], Greg Zilberbrant[1 2], Allan MacKenzie[1]

[1] School of Engineering Practice and Technology, Faculty of Engineering, McMaster University, Hamilton, Ontario, Canada
[2] Principal, JBI Environmental Consulting Inc.

Email: centeadn@mcmaster.ca, zilberg@mcmaster.ca, mackenza@mcmaster.ca

Abstract

Many programs offered in engineering have substantial technical components and a selection of non-technical mandatory or optional electives. Although sustainability was often considered an optional course in many engineering programs, several faculty-wide, national and international initiatives seek to encourage the faculty members to include sustainability concepts in several courses. Although many agree that creating a sustainable future starts with education in sustainability, the process of implementing key sustainability concepts within technical courses is neither straightforward nor widely accepted by educators. The objective of this paper is to present a proposed framework in implementing a sustainability curriculum in engineering. The paper describes the development of a proposed framework to be used to implement sustainability concepts in several courses throughout an automotive engineering technology program and describes the implementation approaches and the challenges that may occur in introducing sustainability concepts.

Keywords: Curriculum; Framework; Sustainability; Sustainability Curriculum.

1 Introduction

The curriculum of the automotive engineering technology program offered at McMaster University in Hamilton, Ontario, Canada during the 2014/2015 academic year included 33 technical courses and 13 business and management courses. Within the current curriculum, there is one management course focused on sustainability, along with sustainability concepts integrated into two engineering design capstone projects. The paper describes the need to scaffold, sustainability principles throughout the four-year Bachelor of Technology program as well as the possible challenges associated with introducing sustainability-related materials in already developed courses. Scaffolding, means dividing topics into smaller pieces, delivered to students continuously throughout their degree. Pieces are integrated in required courses, so students learn to consider sustainability in all their decisions. Each piece of curricula seeks to build on, and reinforce, the last (Scaffold Learning, n.d.).

Participants in the 2002 Johannesburg Earth Summit endorsed the proposal that sustainable development needs to be an integral component of all levels of education (Reid and Petocz, 2006). A large collection of articles related to the implementation of sustainability concepts from kindergarten to high school is analysed by Skamp (2009), who presents a critical review of best practice and research evidence regarding the implementation of education for sustainability in Australia. Looking at a broader spectrum of learners, the Canadian government developed the-Framework for Environmental Learning and Sustainability in Canada in 2002. The objectives of the Canadian framework are to (1) promote greater awareness, capacity, engagement and action on the part of all Canadians, at the personal, family, community or corporate levels; (2) validate, support and encourage existing efforts made by many in environmental learning and sustainability; (3) expand and increase the support for initiatives and extend the dialogue to new participants in all sectors of society; (4) build a coherent culture of environmental learning and sustainability that touches Canadians of all ages, ethnicities, geographic settings and socioeconomic backgrounds; (5) facilitate the making of connections and broader sharing of knowledge and ideas; (6) offer principles and strategies that provide direction to strengthen learning about the environment and sustainability. The document encourages educators to find ways to present environmental and sustainability concepts that will allow learners to draw their own conclusions about important environmental and societal issues.

Implementation of a curriculum network in an existing university program is not an easy task. The proclamation of the United Nations Decade of Education for Sustainable Development observed that there is no universal model of education for sustainable development (UNESCO, 2005). The document states that education for sustainable development means including key sustainable development issues into teaching and learning and requires participatory teaching and learning methods that motivate and empower learners to change their behaviour and take action for sustainable development. The document suggests that by implementing far-reaching changes in the way education is often practised today, the education for sustainable development promotes competencies like critical thinking, imagining future scenarios and making decisions in a collaborative way.

The introduction of a sustainability curriculum through an entire engineering education often encounters various barriers and challenges. Frisk and Larson (2011) state that the transition towards sustainability will require action and change that is guided by an understanding of the complexities that arise within an interconnected system, as well as the ability to collaborate with people from diverse backgrounds, while keeping an eye to the future. In formulating an approach for educating for sustainability, both behavior change research and sustainability competencies, such as; triple bottom line, stakeholders, metrics, ethics and responsibilities, and complexity need to be integrated for transformative actions among students (Irons, Cotton & Smith, 2012).

Reid and Petocz (2006) investigated the ways that academics understand sustainability within their own disciplines. They describe how academics view sustainability in the context of their teaching and suggest a range of ways in which sustainability could be integrated into their teaching. Meanwhile, they observed that "while many teachers are aware that sustainability has some role to play in their teaching, some of them view that role in quite limiting ways." The results of their research indicate that sustainability topics need to span over a range of subjects and extend to the development of appropriate curriculum. They state that "real change in thinking about sustainability requires creative pedagogy which acknowledges the different ways that people think about sustainability and provides spaces in which their ideas can be developed."

When students are motivated and willing to understand the topics discussed in a lecture, they become engaged and pay attention to the meaning of the concepts covered in these topics. This process leads to a high level of holistic learning that results in deep learning. Warburton (2003) noticed that "deep learning is particularly relevant in the context of education for sustainability." He also noticed that "deep learning can be inhibited if the existing interests or backgrounds of students have a strong disciplinary focus." He reviewed the factors that influence deep learning and discussed some ways in which environmental educators can encourage students to use deep learning strategies. The question that arises is how to encourage deep learning. Kolb (2015) considers the practice of experiential learning – learning by experience – to be an effective way to encourage deep learning. Experiential learning approaches include problem-based learning, project based learning, group projects, hands-on labs, and several other forms of active learning strategies. From the list of experiential learning approaches, Belhkir (2015) presents an approach to embed sustainability in engineering education through team based projects. The framework presented in this paper will need to identify and selectively integrate the experiential learning strategies, such as team based projects, that are appropriate for the courses offered in the Bachelor of Technology program at McMaster University.

Sustainability concepts can be introduced and discussed in education at different levels. The high levels use frameworks that suggest integrated approaches throughout several years of education. However, a framework can change over time as a result of major international declarations and institutional policies related to sustainability in university education. Wright (2002) presents several of these declarations, identifies emerging themes and priorities that result from these declarations, and discusses how different universities perceive their commitment to sustainability. The commitment of the university should be transferred to the faculty who are expected to include sustainability concepts in their courses. Obermiller and Atwood (2014) remarked that, although most of the sustainability literacy focuses on teaching students, professional development and training programs aimed at faculty have to be put in place to ensure successful implementation.

2 Scope

The vision of the McMaster University Faculty of Engineering, as stated in the 2009 Strategic Plan (Engineering a Sustainable Society) is to be known internationally as a leader in research and education supporting the development of sustainable engineering practices. The Bachelor of Technology program (B.Tech.) currently emphasizes sustainable practices in a specific course, Technology Ethics and Sustainability delivered in the final term of the program. Wright, Cain & Monsour (2015) noted this type of curricular offering is common, because it is easiest to isolate the variable as a subset of the whole curriculum rather than integrate sustainability across the undergraduate curriculum. The approach in B.Tech. is to move towards more of a holistic model, threading sustainability across both the technical and management courses within the curriculum in order to better prepare our students to understand and meet 21st century engineering technology sustainability issues. It also clearly sends the message that sustainability touches everything and therefore should be embedded in and across every technical discipline (Wright, Cain & Monsour, 2015).

2.1 Sustainability Framework

The current framework allows for the introduction of sustainability principles throughout the B.Tech. program by individual instructors. This introduction, however, does not scaffold the knowledge from one year to another nor does it ensure that all elements of sustainability are well covered by the time students graduate. The framework, as it currently functions, will allow for delivery of sustainability concepts independently throughout courses but not as an integral component to the technical work of engineers. As shown Pappas et al (2013), the introduction of sustainability principles in lower-level courses that are built on throughout the undergraduate education can lead to students' ability to analyze problems from a sustainability context even when such questions are not posed to the student. Pappas et al. (2013) also highlighted that "students have carried the mindset and holistic appreciation of sustainability on to the other course projects. The most notable has been the students' capstone projects."

Our framework incorporates this transformative approach thereby turning(shying) away from the 'Modern Engineer' model, where students learn how to solve technical problems, toward what we're referring to in this paper as the 'Timeless Engineer' model where graduates will be able to understand the context of a problem and apply sustainable engineering solutions (see more infomation below).

2.2 Current Model

The current model functions well to train the 'Modern Engineer' with coverage of core engineering principles, stream-specific knowledge and applied management principles including a course strictly focused on sustainability. This model is presented in Figure 1. The core engineering principles (blue/solid boxes), management courses (green/diagonal hashed boxes), and the stand-alone sustainability course (orange/vertically hashed box). Modern concepts are introduced by instructors in many courses that will include sustainability but this is not a systematic approach that allows for scaffolding or integration of the concepts into thought processes of students. Specifically, the student can apply sustainability principles when called upon but may not consider these as a common practice in technical or business application.

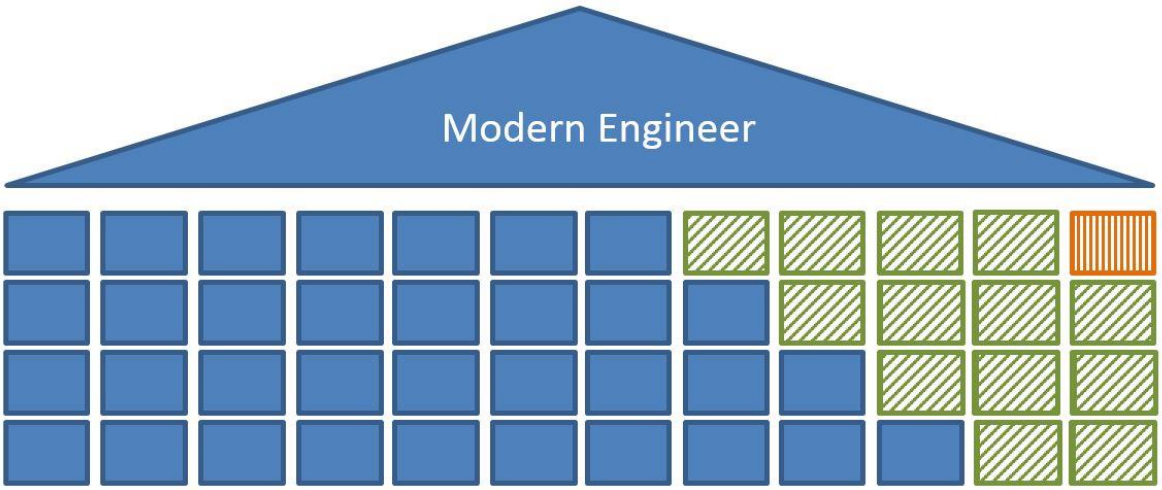


Figure 1: Modern Engineer Framework (existing).

2.3 Proposed Model

The proposed model moves the current program from graduating 'modern engineers' to 'timeless engineers'. The definition of a 'timeless engineer' is someone who is able to adjust to the needs of the world's dynamic challenges in order to create solutions that are consistent with the needs of current and future generations. Such an engineer must understand not only the current challenges but also be educated to integrate sustainability into his/her solutions.

This model is proposed in a way that would frame the stream-specific and management courses within the context of sustainability. In this approach, students are taught to internalize sustainability concepts in such as matter that sustainability becomes foundational thinking in all problem-solving. The current framework has evolved in such as way in the Bachelor of Technology program as to facilitate this transition.

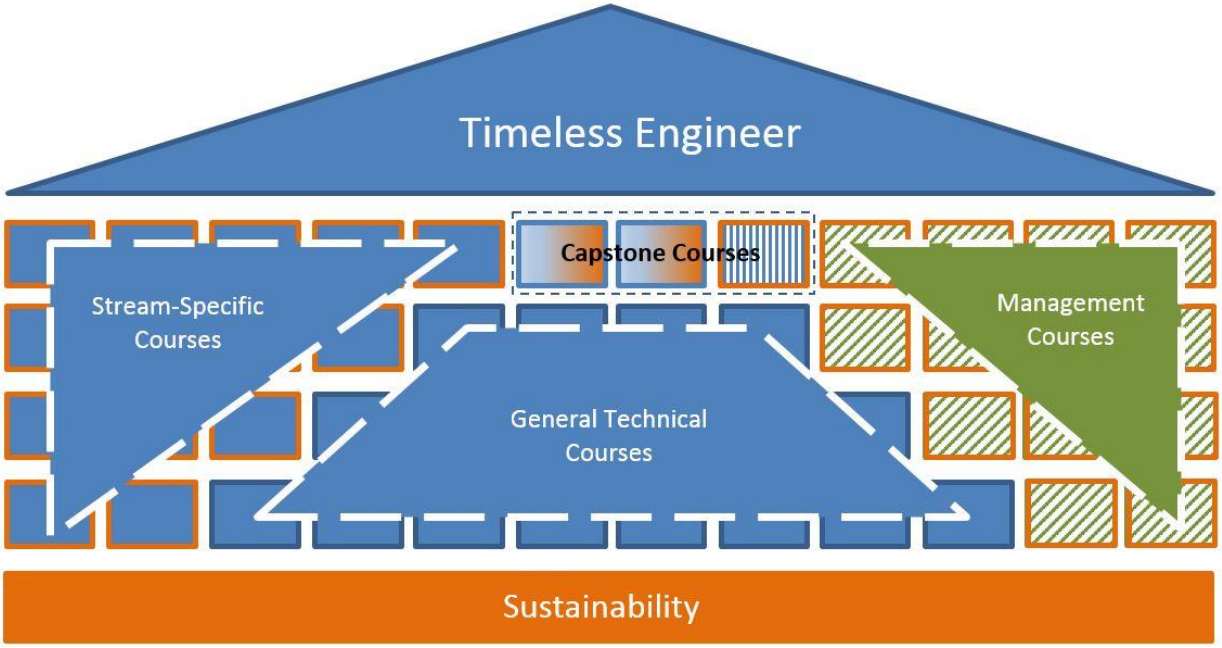


Figure 2: Timeless Engineer Framework (proposed).

The proposed model (Figure 2) presents the general structure of the framework. This framework consists of four components: (1) General Technical Courses; (2) Stream-Specific Courses; (3) Management Courses; and (4) Capstone Courses as shown.

(1) General Technical Courses are courses in math, physics, chemistry, etc., that are fundamental within an engineering education. It is not expected that sustainability concepts would be introduced in these courses. The objectives of these courses are to build the foundational knowledge for further technical education in upper years. This would remain unchanged.

(2) Stream-Specific Courses are courses that are specific to the program of study. The Automotive and Vehicle Technology program has 20 such courses. Opportunity exists within these courses to integrate sustainability thinking into course content. This introduction would be in the form of principles that are specific to the course content so that students can appreciate the application of sustainability in different aspects of the automotive industry. The level of integration would vary depending on course content, but scaffolded from year to year.

(3) Management Courses focus on business and management principles and are delivered to all the B.Tech. program streams. The role of the management courses in the new model is to frame business practices, policies, and decision-making in a sustainability context. As with stream-specific courses, sustainability principles would be scaffolded from year to year.

(4) Capstone Courses represent the final year technical capstone design (two courses) and the sustainability capstone that was offered for the first time in the fall of 2015. These courses represent the final stage of the students' undergraduate degree education. Under the new model, sustainability is an integral focus of the final year technical project. The sustainability principles learned and applied up to the commencement of this capstone will frame not only the final design evaluation but the choices of projects. The focus of the sustainability capstone, completed in the final term of the program, works to reinforce the concepts of complex sustainability challenges that must be addressed by a dynamic thought process and, unlike the technical capstone, allows the students to study a relevant current topic outside their technical field.

3 Implementation Methodology

Research has been mixed regarding the best approach to embed sustainability education into the curricula. Some advocate a "top-down" approach with an initial push from senior administration, which is in charge of "defining" the policy, to drive the shift (Thomas, 2004). However, other research suggests that a "bottom-up" approach could be more realistic, as evidenced by the relatively minor progress made in establishing sustainability across disciplines (Thomas, 2004). The Bachelor of Technology program methodology will encompass an amalgamation of both approaches to assist the transformation process at the program level and facilitate successful change and buy-in from faculty members at the course level.

Table 1: Implementation Elements.

Approach	Elements	Purpose
Top-Down	B.Tech. Director and Program Chairs Faculty of Engineering 2009 Strategic Plan - Engineering a Sustainable Society	Support and drive the strategy to embed sustainability education across the B.Tech. curricula
Bottom-Up	AVT Faculty (pilot group) Faculty Sustainability Curriculum Mapping and Innovation Committee	To work together to lead and oversee the sustainability curriculum development and change initiative.

3.1 Curriculum Change Steps

The Bachelor of Technology program will incorporate de la Harpe's (2009) successful curriculum change initiative steps outlined below:

- A core group of faculty will be identified and work together to lead and oversee the sustainability curriculum initiative;
- They will work to ensure sustainability curriculum mapping and framework is completed collaboratively for department buy-in;
- Resources (time and funds) for curriculum development will be identified and set aside;
- Faculty professional development needs tailored to the curriculum initiative will be identified and planned for;
- A clear implementation strategy will be developed and resources will be specifically allocated to support implementation activities;
- A monitoring program to assess periodic developments and the degree to which the desired change has occurred. As well small successes will be communicated often and rewarded along the way.

Ultimately, the success or failure of embedding sustainability into the B.Tech. curriculum will be the willingness and ability of the professors to integrate this new material into their current course topics and materials, along with a willingness to enhance their sustainability knowledge. This is easier said than done: a report on professional development done for Australian and New Zealand Universities by Wyborn and Bekessy (2008) noted that academia is a culture that "perpetuates the image of academics as people who 'know' and therefore do not need to 'learn.'" The report concluded that a lack of professional development and training was the primary cause of the discrepancy between the interest in embedding sustainability and its actual implementation (Wyborn & Bekessy, 2008).

4 Conclusions

The focus of this article is to present the opportunity that exists within an established program to integrate the concepts of sustainability. The proposed framework presents a modification to the existing structure that would embed sustainability into the technical and management courses of the Bachelor of Technology program and, in doing so, could create integrated critical-thinking practices considering sustainability issues within existing courses. Such embeddedness is not without clearly identified challenges, however, the need exists to adopt frameworks that better prepare technical graduates to integrate sustainability into their decision-making processes rather than consider sustainability as a separate subject or department in the professional environment.

A number of limitations should be understood in considering such a framework. Firstly, the Bachelor of Technology program is in a position, based on the succession of course offerings, to consider its next evolutionary step in sustainability education. This may not be the same approach for other existing programs. Secondly, this is a proposed framework that has not yet been implemented. The authors of this paper will monitor the progress of the implementation and any required adjustments to achieve a successful outcome. And lastly, sustainability is a subject that should be applied within the context of the jurisdiction and the educational institution. The specific application within the courses that may resonate with students in Canada may not be the same as those being taught in other parts of the world. There are fundamental learnings that should be considered in a global context but the connection to specific subject matter may change by jurisdiction as much as it does by program.

5 References

Barth, M. and Rieckmann, M. (2012). Academic staff development as a catalyst for curriculum change towards education for sustainable development: an output perspective. *Journal of Cleaner Production*, *26*(1), 28-36.

Belkhir, L. (2015). Embedding sustainability in education through experiential learning using innovation and entrepreneurship. *Higher Education Studies*, 5(1), 73-80.

de la Harpe, B. and Thomas, I. (2009) Curriculum Change in Universities: Conditions that Facilitate Education for Sustainable Development. *Journal of Education for Sustainable Development*, 3, 75-86.

Faculty of Engineering, McMaster University. (2009) Strategic Plan 2009-2014: Engineering a sustainable society. Retrieved from www.eng.mcmaster.ca/sustainability/documents/EngineeringSustainableSociety.pdf

Frisk, E. and Larson, K. (March, 2011). Educating for sustainability: competencies & practices for transformative action *Journal of Sustainability Education* 2.

Government of Canada (2002). A framework for environmental learning and sustainability in Canada. Available at http://www.emsb.qc.ca/en/Greenplan/pages/resources/pdf/govDocs/EnvironCda_Framework.pdf [Retrieved March 9, 2016]

Irons, G., Cotton, J. & Smith, S. (April, 2012). *Descriptions of sustainability competencies.* Task Force on Sustainability in Engineering Education. Retrieved from www.eng.mcmaster.ca/sustainbility/documents/SustainabilityCompetencyDescriptions.pdf

Kolb, D.A. (2015) Experiential Learning: Experience as the Source of learning and Development. Upper Saddle River, New Jersey: Pearson Education

Obermiller, C. and Atwood, A. (December, 2014). Comparing faculty and student sustainability literacy: are we fit to lead? *Journal of Sustainability Education* 7

Pappas, E., Pierrakos. O. & Nagel, R. (2013). Using Bloom's Taxonomy to teach sustainability in multiple contexts. *Journal of Cleaner Production*, 48, 54-64.

Reid, A. and Petocz, P (2006), University lecturers' understanding of sustainability. *Higher Education*, *51*(1), 105-123

Skamp, K. (2009). Critical review of current practice and research of Environmental Education and Education for Sustainability for Kindergarten to Year 12 from 1990. Retrieved from http://www.curriculumsupport.education.nsw.gov.au/env_ed/assets/pdf/review_skamp2.pdf

Scaffold Learning: A Blueprint for building sustainable managers (n.d.) Network for Business Sustainability. Retrieved March 20, 2016 from http://nbs.net/sustainability-centres/scaffold-learning-a-blueprint-for-building-sustainable-managers-2/

Thomas, I. (2004). Sustainability in Tertiary Curricula: What is Stopping It Happening? *International Journal of Sustainability in Higher Education,* 5.1, 33-47.

UNESCO (2005). Education for sustainable development (ESD). Available at http://www.unesco.org/new/en/education/themes/leading-the-international-agenda/education-for-sustainable-development/ [Retrieved March 9, 2016]

Warburton, K. (2003). Deep learning and education for sustainability. *International Journal of Sustainability in Higher Education*, *4*(1), 44-56.

Wright, M.F., Cain, K.D., & Monsour, F.A. (September, 2015). Beyond sustainability: A context for transformative curriculum development. *Transformative Dialogues: Teaching & Learning Journal*., *(8)*2. 1-19.

Wright, T. (2002). Definitions and frameworks for environmental sustainability in higher education. *International Journal of Sustainability in Higher Education, 3*(3), 203-220.

Wyborn, C. and Bekessy, S. (2008). Professional Development for Education for Sustainability. *International Journal of Sustainability in Higher Education*, 9.2, 131-146.

Implementing a Vehicle Dynamics Curriculum with Significant Active Learning Components

Dan Centea[1], Timber K.M. Yuen[1], Moein Mehrtash[1]

[1] School of Engineering Practice and Technology, Faculty of Engineering, McMaster University, Hamilton, Ontario, Canada

Email: centeadn@mcmaster.ca, timber@mcmaster.ca, mehrtam@mcmaster.ca

Abstract

A primary concern in the study of the effectiveness of active learning strategies in automotive engineering is to deliver students with skills based on the emerging needs of automotive industries in research-and-development and production. The key aspects of the required expertise can be listed in vibration analysis and control, modeling and simulation of dynamic systems, assessment of ride and safety of a road vehicle, and vehicle performance analysis. A much more systematic approach in curriculum development would identify how modern active learning strategies can deliver a new generation of automotive engineers with the esteemed competence. This paper provides a new insight into the vehicle dynamics curriculum that can be discussed under three headings which are: courses contents, context sequences, and active learning implementation. Moreover, the extensive discussion on the learning outcomes provides a framework for vehicle dynamic curriculum that will serve as a base for future studies and developments.

Keywords: Vehicle Dynamics; Curriculum; Active Learning; Automotive Engineering; Learning Outcomes;

1 Introduction

Due to the challenges created by global competition in the automotive market, the automotive industry currently uses modern tools for designing, prototyping, testing, and manufacturing in order to significantly reduce the lead time to introduce a new vehicle into the market. Preparing graduates for such a fast evolving industry and providing them the skills required for employment is a difficult task if a purely academic curriculum and a traditional lecture-intensive approach are used. Miller (1998) highlighted the problem of lack of real-world preparation of new engineering graduates going into industry. He observed that curricula have traditionally been slow to respond to industry needs, and have not kept pace instructionally with technological advances. In a detailed survey prepared by Zargari (1999) manufacturing engineering graduates in the USA believed that there is a lack of competency because of the distance between education and real world applications. Alternative approaches that address these issues include industrial involvement that complement the automotive engineering education, and student-centered course delivery approaches that increase student involvement, encourage deep learning and provide better learning outcomes.

1.1 Industrial involvement in engineering education

Guerra-Zubiaga et al. (2008) highlight the importance of collaborative learning methods that integrate education with industrial or practical influences to improve automotive engineering education. Mears *et al* (2011) present an automotive engineering graduate curriculum complemented by various forms of industrial involvement. This involvement includes input in course development, guest lectures, sponsored factory tours, and in-kind equipment and software donations, and real-life case studies related to the current challenges within the automotive industry. The industrial involvement in curriculum development is also discussed by Sudsomboon (2007), who presents an automotive engineering curriculum built around competencies. Using a similar approach, the Automotive and Vehicle Technology program offered by McMaster University that is described in this paper was designed with input from the industry. The industrial involvement includes advice in curriculum development, industry nights, factory tours, equipment donations, industry judging events, mentorships for engineering competitions, and workplace placements. This approach allows students to be constantly aware of the progress in the automotive industry and provide them with more confidence during job interviews and employment.

1.2 Student-centered course delivery approaches

Classroom instruction approaches have evolved considerably in the last 40 years through the development of several teaching and learning methods that include experiential learning approaches. Experiential learning is a powerful approach that allows learners to develop skills and knowledge by personal experience and involvement. Experience plays a central role in the learning process (Kolb, 1984). Although early work on experiential learning was introduced in early 1900's by John Dewey, Kurt Lewin, Jean Piaget, William James, Carl Jung, Paulo Freire, Carl Rogers and others (Barrows et al., 1980; Kolb, 2015), the experiential learning theory and model developed in the early 1970s by David Kolb (Kolb et al., 2011) gave guidelines for designing and developing practical curriculum.

Engineering as a profession requires both conceptual knowledge and hands-on experience; therefore, experiential learning can be used for teaching and learning of engineering topics (Lynch & Russell, 2009). Engineering programs have been proven to be successfully implemented through experiential learning activities (Biggs, 2003). These student-centered experiential learning activities include role-based learning, project based learning, problem based learning, collaborative learning, and active learning. Considering that learning through a medium that combines course materials with game characteristics can be a powerful tool for engineering education, Siddique (2013) shows that students using the game module, when compared with lecture-based instruction, had significant improvements when addressing questions that involved higher-order cognition. Montequin et al. (2013) assess engineering teams in project based learning, a methodology that emphasizes instruction by assigning projects. Adams et al. (2005) examine the application of experiential learning principles to six areas of team functioning – purpose, membership, roles, context, process, and action taking – and describe how team effectiveness can be improved. Centea at al. (2015) describe the teaching and learning methods used in several courses offered in the automotive engineering technology program described in this paper and provide details about different experiential learning implementations that include active learning approaches. These approaches provide students the kinds of skills that help them succeed in the current manufacturing and automotive-related industry.

1.3 Active learning

Throughout the 1980s, leaders in higher education advised faculty members to actively engage students in the process of learning. Despite the urgency of these calls, research consistently has shown that traditional lecture methods, in which professors talk and students listen, dominate college and university classrooms (Bonwell, 1991). Bonwell's study identifies the common obstacles and barriers that give rise to faculty members' resistance to active learning instructional techniques. The barriers include: (1) the powerful influence of educational tradition; (2) faculty self-perceptions and self-definition of roles; (3) the discomfort and anxiety that change creates; and, (4) the limited incentives for faculty to change. The specific obstacles associated with the use of active learning include: (1) the difficulty in adequately covering the assigned course content; (2) the limited class time available; (3) a possible increase in the amount of preparation time; (4) the difficulty of using active learning in large classes; and, (5) a lack of needed materials, equipment, or resources (Bonwell, 1991).

Although the term active learning is not precisely defined in the teaching and learning literature, the characteristics commonly associated with the use of strategies promoting active learning in the classroom include: (1) students being involved in activities that promote more than listening; (2) less emphasis being placed on transmitting information and more on the developing students' skills; (3) students being involved in higher-order thinking (analysis, synthesis, evaluation); (4) students being engaged in activities (e.g., reading, discussing, writing); and, (5) greater emphasis being placed on students' exploration of their own attitudes and values (Bonwell, 1991).

Grabinger and Dunlap (1995) describe and organize the shared elements of Rich Environments for Active Learning (REAL). REALs include collaboration, personal autonomy, generativity, reflectivity, active engagement, personal relevance and pluralism, and provide learning activities that, "instead of transferring knowledge to students, engage students in a continuous collaborative process of building and reshaping understanding as a natural consequence of their experiences and authentic interactions with the world".

Kuh (2008) presents an overview of (active?) teaching and learning practices that have been widely tested and have been shown to be beneficial for university students of many backgrounds. He describes high-impact practices that increase rates of student retention and student engagement including first-year seminars and experiences, common intellectual experiences, learning communities, writing-intensive courses, collaborative assignments and projects, undergraduate research, diversity/global learning, service learning, community based learning, internships, as well as capstone courses and projects.

Michael (2006) shows that there is evidence that active learning, student-centered approaches to teaching physiology work, and that they work better than more passive approaches. Therefore, "we should all begin to reform our teaching, employing those particular approaches to fostering active learning that match the needs of our students, our particular courses, and our own teaching styles and personalities. There are plenty of options from which we can choose, so there is no reason not to start. This will mean that we too become learners in the classroom".

Sokoloff and Thornton (1997) present a strategy for making the learning environment more effective by increasing student involvement. In their experiment students are actively engaged by the use of a learning cycle that includes a written prediction of the results of an actual physical experiment, small group discussion with their nearest neighbors, observation of the physical event in real time, and comparison of observations with predictions. The results of their experiment indicate that there is strong evidence for significantly improved learning and retention of fundamental concepts by students who participate in interactive lecture demonstrations as compared to those taught in traditional lectures.

Not all active learning strategies have a similar impact on a student. Acknowledging that creating student-centered learning situations is an ongoing challenge for engineering education, Hulme et al. (2009) presents a methodology that incorporates driving simulations, motion simulations and gaming-inspired simulations for implementing a modern approach of a vehicle dynamics curriculum. Their approach allows students to promote active participation in engineering experience that enhance learning about vehicle dynamics in two upper-level courses.

2 Methodology

Vehicle dynamics is a common topic taught in automotive engineering programs. This topic plays a significant role in providing students the knowledge and skill required to solve engineering problems related to machine isolation and control. The purpose of machine isolation is to separate the driver from the disturbances occurring as a result of the vehicle operation. These disturbances include the disturbances generated by the vehicle itself, like engine vibration and noise, and the disturbances imposed by the outside word, like road undulations and aerodynamic interaction of the vehicle with its surroundings. On the other hand, control is concerned with the behaviour of the vehicle in response to driver demands. Control includes path curvature that can be adjusted by a combination of steering wheel and vehicle velocity inputs, and speed variation that is governed by the mass of the vehicle and the available tractive or braking power. The analysis of these engineering problems required a large amount of knowledge that cannot be taught in a single course. Section 3 of this paper presents the development of a vehicle dynamics curriculum that spans over three courses and presents the learning outcomes for each of these courses.

The knowledge associated the vehicle dynamics curriculum includes various elements, from simple to complex, that are challenging to comprehend if taught using only the conventional lecture-centered education. The vehicle dynamics curriculum implementation presented in this paper incorporates practical experience accomplished through a range of student-centered learning strategies. These learning strategies include class demonstrations, project based learning with individual and group projects, computer modelling, computer simulations, guided laboratory experiments with different level of complexity, and vehicles tests, and are used together with lectures to enhance learning. Section 4 of this paper presents a correlation between the teaching approaches and the active learning strategies that proved to be efficient for each learning outcome.

3 Curriculum development

Many engineering programs provide a strong theoretical knowledge that allows students to understand and analyse engineering problems. However, the graduates are often under-prepared in solving practical engineering applications. Many engineering curricula do not spend enough time assuring that students graduate with sufficient experiential and hands-on knowledge. The Automotive and Vehicle Technology program offered at McMaster University excels in experiential learning by combining theoretical knowledge with a significant amount of applied experiences, which are delivered during lectures and through hands-on labs.

The vehicle dynamics curriculum starts with the analysis of isolation by analysing the internal and external disturbance that affect a driver. This analysis is accomplished through vibration analysis – a fundamental knowledge for vehicle dynamics that is covered in the first of the three vehicle dynamics courses. Being a fundamental knowledge course, it includes one- and two-dimensional analytical analyses that model vehicle components as simple mass, spring and damper systems. The purpose of these analyses is to predict the response of mechanical systems to external forces, and to determine the practical solutions that allow an efficient control of these vibrations to improve the ride.

In the second vehicle dynamics course the complexity of the analyses is significantly increased. At the beginning of the course the students analyse the dynamic behaviour of simple three-dimensional systems using analytical approaches. However, the complexity of the analytical approaches increases significantly when the number of bodies included in the system also increases. This issue is addressed by modelling the mechanical systems using multibody dynamics software. The Adams software package is used to model, simulate, and obtain the response of engines, steering systems, and quarter-vehicles to various stimuli. The Adams/Car software package is used to model, simulate and predict the response of a full-vehicle model when passing over a bump or when performing lane change operations. The CarSim software package is also used to model full-body car dynamic with considering the dynamic of the driver and environment and to predict vehicle performance due to driver and environments inputs.

The third course in vehicle dynamics covers topics related to the control of the vehicle and vehicle performances by analysing the response of the vehicle to the driver's commands. The major topics covered in this course include tire mechanics, acceleration performance, braking performance, roll over, handling performance, and aerodynamic analysis. The sub-topics associated with each of these major topics are presented in Appendix 1.

The vehicle dynamic curriculum presented above has been developed in consultation with industry partners. The industry involvement included advice on the topics covered in the three courses that would provide graduates with the practical skills valued in the automotive and manufacturing industry and research, as well as suggestions for the type of hands-on laboratory experiments that would reinforce the theoretical knowledge provided to students in each of these courses.

The initial curriculum development process for vehicle dynamics included the following steps:

- Defining the basic and advanced vehicle dynamics knowledge that will be include in the curricula
- Defining a framework for implementing curricula
- Defined learning outcomes for all three courses
- Defining the laboratory experiments that complement the theoretical knowledge

The learning outcomes associated with the three vehicle dynamic courses presented in this paper are

- Course #1 – Mechanical Vibrations
  - L1–1: Relate real world components to vehicle dynamic system model parameters
  - L1–2: Evaluate the effects of changing the mass, damping and/or stiffness elements on the free and forced vibration behavior
  - L1–3: Predict the performance of a vehicle, based on the mass, damping and stiffness, under the effects of various excitation inputs
  - L1–4: Design vibration control methods, including vibration absorbers, to achieve the required vibration reduction criteria

- Course #2 – Kinematic and Dynamic Modelling and Simulations
  - L2–1: Analyse kinematics and dynamics of rigid bodies using an analytical approach
  - L2–2: Investigate mechanical systems using multibody system analysis
  - L2–3: Develop models of automotive subsystem using multibody system simulation software
  - L2–4: Simulate the dynamic behavior of mechanical automotive subsystems
  - L2–5: Evaluate the dynamic response of full-vehicle models on various road surfaces
- Course #2 – Road Vehicle Dynamics
  - L3–1: Identify the road loads (aerodynamic, tractive and rolling resistance) experienced by a vehicle
  - L3–2: Interpret the design considerations of a road vehicle performance in acceleration, braking, cornering, handling, and roll over
  - L3–3: Analyse the fundamentals of ride excitation and comfort
  - L3–4: Design, perform, simulate, and interpret standard vehicle road test

The learning outcomes presented above are defined in a sequence that ensures that: (1) each course provides the fundamental knowledge for the topics covered in the course; (2) each course prepares the students for the knowledge that will be taught in the subsequent course; (3) there are no gaps in knowledge between courses: and, (4) there is no overlapping material between courses.

4 Active learning strategies

The literature review indicates that student-centered teaching that includes active learning strategies encourages students' involvement in the courses and provides better learning outcomes. The three vehicle dynamics courses described in this paper employ a combination of lectures, problem solving activities, and hands-on activities. Students learn the theory and governing dynamic equations of the vehicle in the traditional lectures, and then apply that knowledge and the results of mathematical modeling and simulations in hands-on experiments. In addition, lectures and laboratory experiments are taught and supervised by the same instructors; this allows reinforcement in the labs of the theory taught in the lecture and allows presenting in lectures examples that will be experienced hands-on by students.

Before teaching each of the vehicle dynamics courses, the course instructor: (1) selected the activities that support the learning outcomes; (2) selected a sequence of activities that enhances students learning; (3) implemented active learning strategies in lectures immediately followed by laboratory experiments; and, (4) identified means to assessed the effectiveness of the active learning strategies. Furthermore, after each course delivery, the course instructors: (1) redesigned the strategies based on feedback from peers, students and technical support personnel; and, (2) redesigned some of the existing experiments, and designed a new set of experiments.

The active learning activities used in the three vehicle dynamics courses presented in this paper have been designed to address the learning outcomes of each course. Their level of difficulty correlates with the students' expected knowledge and maturity in thinking.

The first course uses in-class demos that (1) allow the course instructors to explain concepts that would have been very difficult to grasp using sketches or equations alone; (2) take away the fear often associated with complicated mathematical models; (3) link theories with real world applications right away; and, (4) make abstract concept easier to remember. The in-class demonstrations are followed by active learning labs. Figures 1, 2, and 3 present three such examples of topics that include both class demos and hands-on active-learning laboratory experiments for three of the course learning outcomes. The figures also indicate the hands-on activities performed by students. Figure 4 shows an analytical model discussed in the lecture and the associated active learning activity that consists of a simulation performed on a computer.

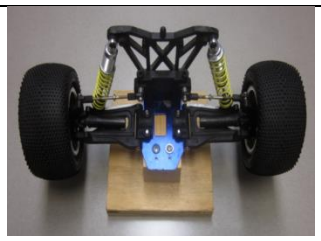
Topic	Lecture	Active Learning In-Class Demos	Active Learning Labs
Effects of changing mass, damper and/or stiffness on vehicle vibrations	Present theoretical model on effects of M, C and K terms on system natural frequency and damping factor.	 Effects of spring pre-load on vibrations	 **Experiment 1:** Use of accelerometer to collect vibration data as M, C & K terms are changed – To support learning outcome L1–2.
Design of Experiment 1: • System mass to be adjusted by changing the number of C-clamps. • System stiffness to be adjusted by changing the number of springs. • System damping to be adjusted by attaching a damper. • Measure system response with accelerometer. • Excitation to be applied by hand as an impulse input.			

Figure 1: Active learning strategies to support the learning outcome L1–2.

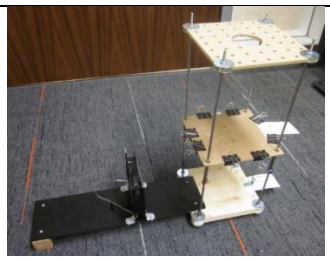
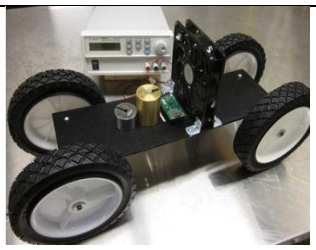
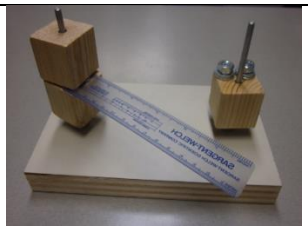
Topic	Lecture	Active Learning In-Class Demos	Active Learning Labs
Rotating unbalance (cabin noise due to unbalanced engine and fans)	Present theoretical treatment of the rotating unbalance problem	 Effects of rotating unbalance, and the concept of frequency ratio.	 **Experiment 2:** Predict the effects of changing the system mass on vibration due to rotating unbalance - learning outcome L1-3
Design of Experiment 2: • Each group is provided with a model vehicle with a certain system mass. • System stiffness and damping to be fixed. • Excitation to be applied by turning on the unbalanced motor as harmonic input. • Measure system response (frequency and amplitude) with accelerometer. • Redesign the system to reduce the steady state oscillation amplitude by 50%. • Calculate the new system mass required to achieve the vibration reduction. • Adjust system mass by changing the brass weight on the model vehicle • Measure system response with accelerometer. • Repeat until the objective is achieved.			

Figure 2: Active learning strategies to support the learning outcome L1–3.

Topic	Lecture	Active Learning In-Class Demos	Active Learning Labs
Vibration Control	Present design principles and equations for vibration absorbers	 Vibration absorber demo	 **Experiment 3:** Design of vibration absorber based on system model and input frequency measured by an accelerometer - To support Learning Outcome L1–4.

Design of Experiment 3:

- System mass, stiffness and damping to be fixed.
- Excitation to be applied by turning on the unbalanced motor as harmonic input.
- Measure system response (frequency and amplitude) with accelerometer.
- Design a vibration absorber for the system to reduce the steady state oscillation amplitude by 70%.
- Calculate the absorber mass and stiffness required to achieve the vibration reduction.
- Install absorber.
- Measure system response with accelerometer.
- Repeat until the objective is achieved.

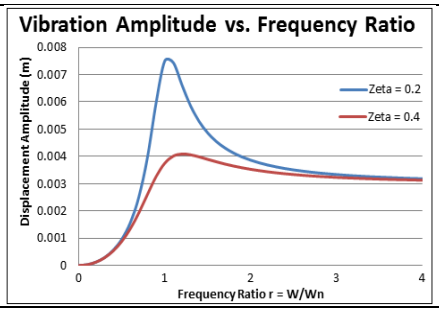
Figure 3: Active learning strategies to support the learning outcome L1 – 4.

TABLE 4.1-1 Sine Response of an Underdamped Model

Model: $m\ddot{x} + c\dot{x} + kx = F_o \sin \omega t$

Roots: $s = r \pm qi \qquad r = -\frac{c}{2m} \qquad q = \frac{\sqrt{4mk - c^2}}{2m}$

$$x(t) = \frac{F_o}{(k - m\omega^2)^2 + (c\omega)^2}\left[-\frac{\omega}{q}\left(rc + k - m\omega^2\right)e^{rt}\sin qt + c\omega e^{rt}\cos qt\right] + \frac{F_o}{(k - m\omega^2)^2 + (c\omega)^2}\left[\left(k - m\omega^2\right)\sin \omega t - c\omega \cos \omega t\right]$$



Students learned the theories during the lecture	Active Learning Activity Example: Excel Simulation Assignment

Figure 4: Active learning simulation based on the knowledge taught during the lecture.

The second course in vehicle dynamics includes significant hands-on computer-based components. The associated active learning strategies include prescribed and open-ended modelling and simulation activities. This course includes the modeling of multi-body systems as vehicle subsystems and a full vehicle. Figure 5 shows a model of a quarter-car obtained using Adams. Figure 6 shows the full engine model as a subsystem of vehicle.

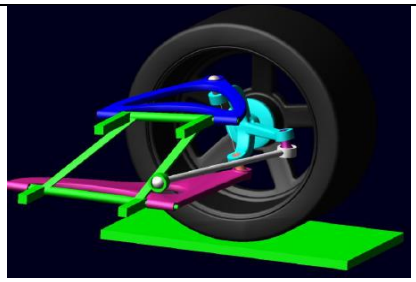


Fig. 5. Quarter-car model: suspension response to bump using Adams/Aview.

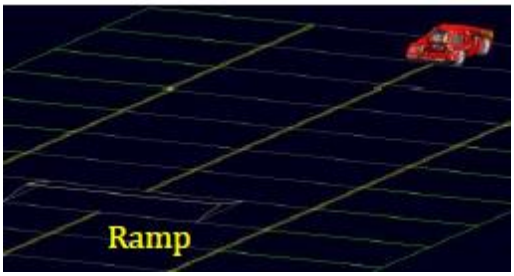


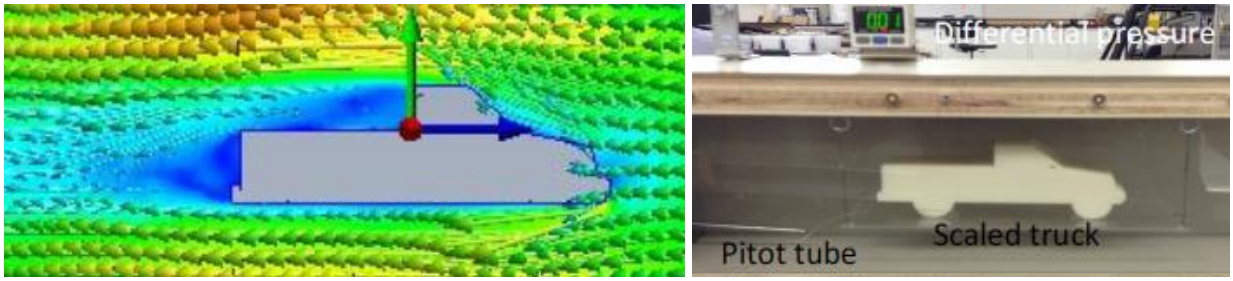
Fig 6. Vehicle performance passing over ramp using Adam\Car.

The road vehicle dynamic curriculum included in the third course has been developed based on theoretical and analytical aspects of real-world phenomena during lecture time and experiential learning with laboratory activities. The field of vehicle dynamics has the advantage that every student has either driven or been a passenger in an automobile. Thus, vehicle motions are inherently familiar to the student. However, concrete knowledge of vehicle dynamics requires abstract conceptualization, active experimentation, and reflective observation from concrete experiments (Kolb 1984, Silberman 2007). The learning outcomes L3–1 to L3–4 presented in the previous section of this paper emphasize the need for students to practice the application of their knowledge in an active manner. Thus, active experimentation was introduced through the extensive use of "hands-on" laboratories to demonstrate the theory taught in the lectures. Table 1 demonstrates the learning outcome, course concept, and active experimentation in the curriculum of the vehicle dynamics.

Table 1. Road vehicle dynamic active learning curriculum design.

Learning Outcome	**Concept**	**Active experimentation**
L3–1	Vehicle aerodynamic	Wind tunnel test and CFD simulation to determine aerodynamic drag
L3–1, L3–4	Tire Forces	Use simulation software CarSim to evaluate generate longitudinal force in tire contact patch
L3–2, L3–4	Vehicle handling	Perform standard road test and post process the result to determine the understeer gradient of the vehicle
L3–2, L3–4	Brake performance	Use simulation software CarSim to evaluate and asses the brake performance based on FMVSS 105 safety standard
L3–3	Ride and comfort	Use a half-car experimentation to determine the "bounce" and "pitch" performance
L3–2, L3–4	Roll over propensity	Use simulation software CarSim to evaluate and asses the vehicle performance in standard fishhook test

The laboratories support the theory that is provided in class. Laboratory experiments are developed for practical experience using various engineering approaches. In vehicle aerodynamic lab session, students use the/a wind tunnel to investigate the effect of the vehicle after-body geometry on the aerodynamic drag, as shown in Fig. 7. From this activity, the student gains concrete knowledge of aerodynamic forces while observing the change of drag force on the scaled-model vehicles. In addition, students compare their wind tunnel findings with the computational fluid dynamic (CFD) simulation software. In addition, the vehicle aerodynamic laboratory session allows the students to attain numerous experiences in sensors and instrumentation, data capturing and filtering, and CFD simulation validation.



a. Flow around a truck using CFD tool b. Scaled model truck in the wind tunnel

Fig 7. Vehicle Aerodynamic Laboratory.

Fig 8. Fishhook test: visualization of lift-off.

A professional vehicle dynamic simulation software CarSim has been adopted for the road vehicle dynamic course to investigate the aggressive maneuvers motion such as aggressive braking, j-turn, and fishhook. Fig. 8 demonstrates the axle lift-off during the fishhook test using CarSim. The simulation-based analysis provides active student participation in authentic engineering experiences for learning about vehicle dynamics. The experience of using simulation tools allows students to observe the importance of the dynamic simulation in the design process and performance predictions of vehicles.

In vehicle handling lab session, the students are expected to perform standard road test. Electric off-road buggies are equipped with accelerometer sensors, speedometer, steering wheel angle sensor, and data recording systems. Students are required to do this test in a group of three because this test requires one driver, one data recorder, and one student to measure test track information. After preforming the test, students post-process the measured data. This test allows the students to observe lateral acceleration generated due to steering and then compare it with captured and theoretical lateral acceleration.

Students enrolled in this course reported in the course evaluations that it was more work and more demanding than other typical courses, since all the labs were very similar to real-world practices and needed more in-depth multidisciplinary knowledge for reflective observation. Students have also reported that having lectures immediately followed by labs helped them understand the theory, be well prepared for the lab experiments, and allowed them to accomplish significant work in the labs. Students were also clearly more satisfied with the course work, citing the large hands-on component of the lab sessions.

5 Conclusion

The paper presents the implementation of a vehicle dynamics curriculum that is delivered through three courses offered at McMaster University. The steps used in developing and improving the curriculum and the learning outcomes of each course were presented in detail. Each course includes theoretical components complemented by several active learning strategies. The combination of lectures with in-class demonstrations and hands-on modelling, simulation and vehicle ride experiments allow students to apply in practice the theoretical knowledge immediately after the lecture.

The authors of this paper intend to ask the students enrolled in the vehicle dynamics courses to complete a detailed survey and provide feedback comparing the learning process that they experienced in the courses reported in this paper with other courses in which lectures and labs are not synchronised.

6 References

Adams, A.B., Kayes, D.C. and Kolb, D.A. (2005). Experiential Learning in Teams. *Simulation and Gaming*, *36*(3), 330-354.

Barrows, H.S. and Tamblyn, R.M. (1980). *Problem-based learning: An approach to medical education*. Springer Series on Medical Education

Biggs, J. *Teaching for Quality Learning at University*. Open University Press, 2003.

Bloom, B.S. et al. (1956). *Taxonomy of Educational Objectives Handbook: Cognitive Domain*. London: Longman Group.

Bonwell, C.C., and James, A.E. (1991). Active Learning: Creating Excitement in the Classroom. *ASHE-ERIC Higher Education Report No. 1*. Washington, D.C.: The George Washington University

Centea, D, Singh, I. and Yuen, T.K.M. (2015). A framework of the Bachelor of Technology Concept and its Significant Experiential Learning Component. *Proceedings of the Canadian Engineering Education Association Conference* (CEEA 2015), Hamilton, May 31 – June 3, 2015

Grabinger, R.S. and Dunlap J.C. (1995). Rich Environments for active learning: a definition, *Research in Learning Technology*, *3*(2), 5-34

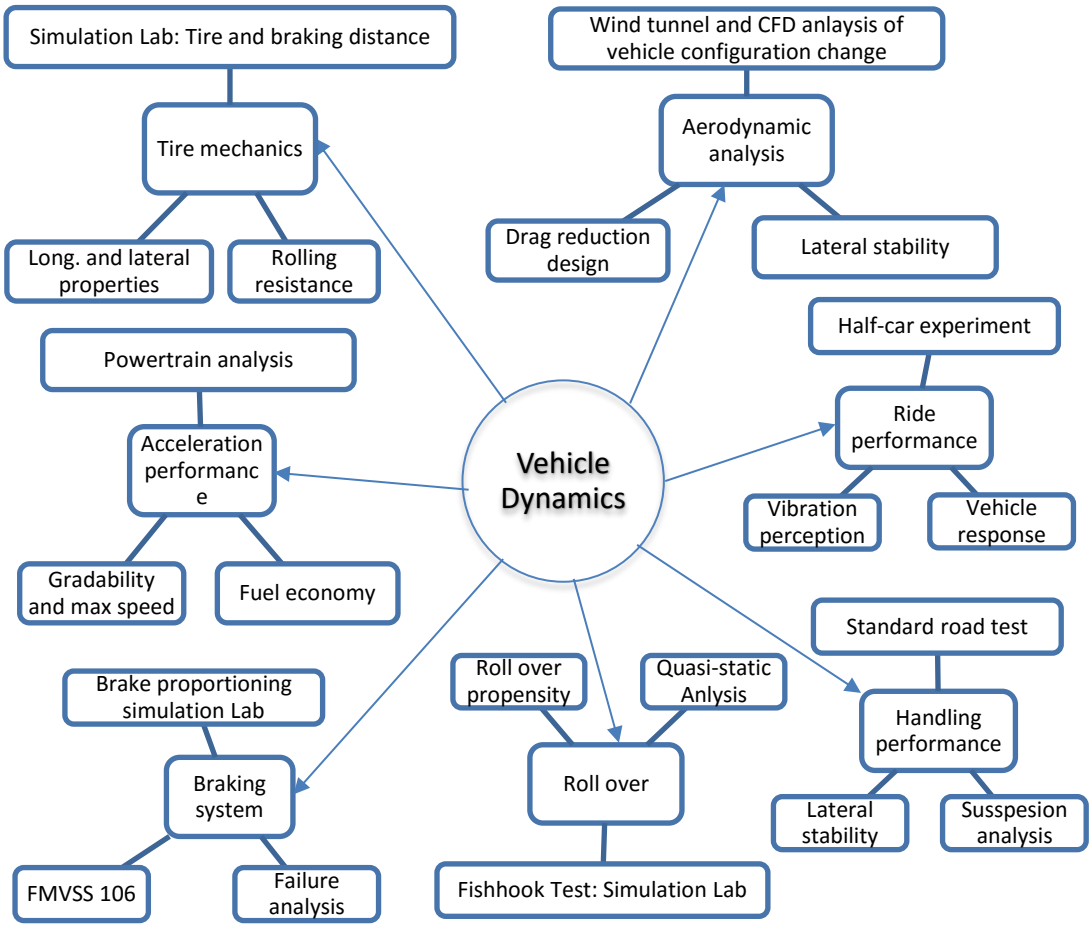
Guerra-Zubiaga, D., and Elizalde, H. (2008). Product lifecycle management tools and collaborative tools applied to an automotive case study. *International Journal of Engineering Education, 24*(2), 266–273

Hulme, K., Kasprzak, E., English, K., Moore-Russo, D. and Lewis, K. (2009). Experiential learning in vehicle dynamics education via motion simulation and interactive gaming. *International Journal of Computer Games Technology*, January 2009, article No. 2, Hindawi Publishing Corp, New York, NY, USA

Kolb, D.A. (1984). *Experiential Learning: Experience as the Source of Learning and Development.* Upper Saddle River, NJ: Prentice Hall

Kolb, D.A., Boyatzis, R.E. and Mainemelis, C. (2011). Experiential Learning Theory: Previous Research and New Directions. *In: Perspectives on Thinking, Learning, and Cognitive Styles, Routledge,* Taylor and Francis Group.
Kuh, G.D. (2008). High-impact educational practices: What they are, who has access to them, and why they matter. *AAC&U*, http://accreditation.ncsu.edu/sites/accreditation.ncsu.edu/files/ Kuh_HighImpactActivities.pdf
Lynch, D.R. and Russell, J.S. (2009) Experiential Learning in Eng. Practice *J. Prof. Issues Eng. Educ. Pract*, *135*(1), 31-39.
Mears, L., Omar, M., and Kurfess, T.R. (2011). Automotive engineering curriculum development: case study for Clemson University. *Journal of Intelligent Manufacturing, 22*, 693-708.
Michael, J. (2006). Where's the evidence that active learning works? *Advances in Physiology Education* 30: 159–167
Miller, M. H. (1998). Industry internships as a tool for curriculum development. Seattle, WA: ASEE (Washington, DC).
Montequin, V.R., Fernandez, J.M., Balsera, J. and Nieto, A. G. (2013), Using MBTI for the success assessment of engineering teams in project-based learning. *Int. Journal of Tech. and Design Education, 23*(4), 1127-1146
Siddique, Z., Ling, C., Roberson, P., Xu, Y.J., and Geng, X.J. (2013). Facilitating Higher-Order Learning through Computer Games. *Journal of Mechanical Design*, 135(12).
Silberman, M. (2007). *The Handbook of Experiential Learning*. San Francisco: Pfeiffer
Sokoloff, D.R. and Thornton, R.K. (1997). Using interactive lecture demonstrations to create an active learning environment, *AIP Conf. Proc*. 399, 1061-1074
Sudsomboon, W. (2007). Construction of a competency-based curriculum content framework for mechanical technology education program on automotive technology subjects. *Proceeding of the International Council of Associations for Science Education (ICASE) Asian Symposium*, *Pattaya*, *Thailand*, 6-9 November 2007
Zargari, A., Hayes, R., et al. (1999). *Curriculum development in manufacturing technology: A survey of Society of Manufacturing Engineers (SME) college fellows*. Charlotte, NC: American Society for Engineering Education.

7 Appendix 1: Vehicle dynamics topics covered in the course Road Vehicle Dynamics



The Perceptions of Engineering Teachers on a "Practice What You Preach" PLE Training Program

Samuel Ribeiro Tavares[1], Lea Paz da Silva[2], Luiz Carlos de Campos[3]

[1] Universidade Nove de Julho – UNINOVE – Rua Vergueiro, 235 – 01504-000 – São Paulo – SP – Brasil
[2] Universidade Nove de Julho – UNINOVE – Rua Vergueiro, 235 – 01504-000 – São Paulo – SP – Brasil
[3]Pontifícia Universidade Católica de São Paulo – PUC-SP – Rua Marquês de Paranaguá, 111 – 01303-050 – São Paulo – SP – Brasil

Email: samueltavares@yahoo.com; leapazsilva@gmail.com, lccampos@pucsp.br

Abstract

This study is meant as contribution to the theoretical foundations and practical applications of the PLE (Project-Led Education) methodology, which is still very incipient, and requires much discussion about how and with what results it has been being used in engineering programs throughout the world. The purpose of this paper is to present a conceptual model of engineering teachers' necessary competencies in PLE developed by eight teachers from one of those three universities studied by Tavares & Campos (3), who decided to prepare themselves for the PLE methodology new teaching roles, through a training program designed on the basis of PLE methodology itself, which would allow them to experience the PLE methodology from their students' perspective. A synthesis on the teachers' perceptions about the training program, obtained through a Likert scale questionnaire, and confirmed through observation and unstructured interviews, indicated that a teachers' training based on the PLE methodology can be an effective way for universities to help them understand students' and teachers' roles in this new educational methodology.

Keywords: Engineering teaching and learning; problem-based learning; project-led education.

1 Introduction

In recent years, the expansion of higher education and the growing pressure from the productive sectors for qualified people have increased the demand for a university that facilitates social and economic progress through knowledge generation and dissemination.

On the one hand, a growing number of students from ever more diverse social classes come to the university seeking to identify and develop skills that enable them to fulfil themselves and to improve the quality of their lives and of the groups they belong to.

On the other hand, as economies demand the improvement of products and services, their societies expect higher education to champion technical and scientific development, and to ensure its harmonious integration to the political and cultural fabric.

Thus, the issue of the unitary school, which seeks to join professional education (the preparation of skilled labor to the market) with humanistic education (the formation of critical and conscious citizens), finally knocks at the gates of the university, which now needs to face the challenge of meeting a technological demand – to advance culture in order to fuel economic development – and an ethical requirement – to make sure that knowledge becomes an instrument against social injustices.

As a consequence of this, slowly but steadily gaining awareness that modern human action is less and less related to doings (memorization and reproduction) and more and more connected to interventions (prediction and facing of the unknown), the university has been reviewing its relationship with knowledge.

Specifically in engineering, which now requires innovation through the creative adaption of old knowledge to new contexts, it is becoming clear that the mere recollection of solved problems and the direct transfer of previously implemented procedures and solutions are not enough to cope with the ever challenging world.

Modern engineering professionals are faced with ever more uncertainty, with partial information and competing demands from companies' stakeholders, forcing them to acquire and develop not only technical skills but human relations competence as well.

So, abandoning the unidirectional and linear transmission of fragmented content, the PBL (Problem-Based Learning) and the PLE (Project-Led Education) methodologies are engineering programs' attempts to enable students to look for solutions to daily problems by means of a contextualized, dynamic and critical connection between theory and practice.

The PBL methodology has been used to help learners adapt underlying theories to their individual cognitive structures through contextualized questions carefully designed to stimulate the students' critical and committed participation in finding explanations to authentic situations of the real world (Barrett; Moore, 2010). In this methodology (Figure 1), inductive (from practice to theory) non-linear (simultaneous access to multiple knowledge) teaching and active (doing more than just seeing and repeating) learning have reportedly allowed students to tap into interdisciplinary knowledge (Amador et al., 2006).

aspects	pbl - problem-based learning
expected deliverables	students are expected to provide explanations or suggestions to authentic situations of the real world
educational approach	built as a research model, with emphasis on diagnosis which helps contextualize interdisciplinary knowledge
educational curriculum	educational curriculum is organized around a question, with educational focus being on the process
educational design	after question is presented, large groups of more than 10 students look for an answer for 1 or 2 weeks
theory-pratice integration	students look for missing information to share a hypothesis or solution in class, when theory is finally elaborated
teachers' role	act as facilitators of students' quests and as specialists in classes
students' role	analyse, discuss and generate questions/learning tasks from the open case

Figure 1. PBL main aspects – Tavares and Campos (2013).

Going beyond the case problems, with small tasks and known answers to known difficulties, that characterize the PBL methodology, the PLE methodology focuses on creating products, with big tasks and multiple innovative solutions to challenging unknown questions (Weenk, W.; van der Blij, 2011), and adopts (Figure 2) an even more hands-on educational approach, whereby students, while creating materials, artifacts, processes and systems closely related to their future professional situations, identify, analyze and apply the most suitable theories to develop and manage their projects (Powell; Weenk, 2003).

aspects	ple - project-led education
expected deliverables	students are expected to develop new materials, artifacts, processes and systems to the changing world
educational approach	built as a production model, with emphasis on practice which mimics the real world professional environment
educational curriculum	educational curriculum is organized around a solution, with educational focus being on the product
educational design	after theme is presented, small groups of up to 8 students plan and develop their projects for 10 or more weeks
theory-pratice integration	while elaborating on theories in classes, students develop a project, looking for information and managing resources
teachers' role	act as supervisors of students' projects and as specialists in classes
students' role	analyse, discuss and generate questions/learning tasks from the open theme and manage product development

Figure 2: PLE main aspects – Tavares and Campos (2013).

However, although very promising, the theoretical foundations and practical applications of both methodologies are still very incipient and require much discussion about how and with what results they have been being used in engineering programs throughout the world.

Tavares and Campos (2013) investigated how the PBL and the PLE methodologies have been being implemented in the engineering programs of three Brazilian universities whose advertisements mention an investment in modern educational methodologies, aiming to contribute to the consolidation of a scientific basis. They found out that while teachers believed their actions were in right path to adequately implementing their universities' attempts to revamp their educational methodologies by means of the PBL and the PLE, their students hardly perceived their universities' intended proposals.

Informal talks with many of the teachers who took part in the research indicated that they (almost secretly) felt unable to adequately implement the PBL and PLE methodologies' theory and practice in their classes, and, among the possible reasons for this, it stood out their perception that it was because they had been taught in the traditional way.

Exploring this point a little further, it was common ground that, as students, they had not been stimulated to comprehensively acquire Knowledge; that they had always worked alone or in ill-formed groups; and that they lacked the experience of critical thinking and problem solving, together with sharing common objectives and results (as it is required in the PBL and PLE methodologies), and so, as teachers, the concept of tutoring (supporting students' cognitive and social skills development) was almost alien to them.

This led the authors to the idea of creating an opportunity where some of those teachers could practice what they were preaching in their classrooms, and to experience the PBL/PLE proposal as students, so that they could become aware of the opportunities and difficulties of intense team work, strict timelines, real life problems and interdisciplinary knowledge.

As the PLE methodology, with its concept of project management and product delivery, is more akin to the engineering profession and academics than the PBL methodology (Mills; Treagust, 2003), which itself is part of the PLE methodology (Tavares; Campos, 2013) (Figure 3), a practical PLE methodology training program was devised.

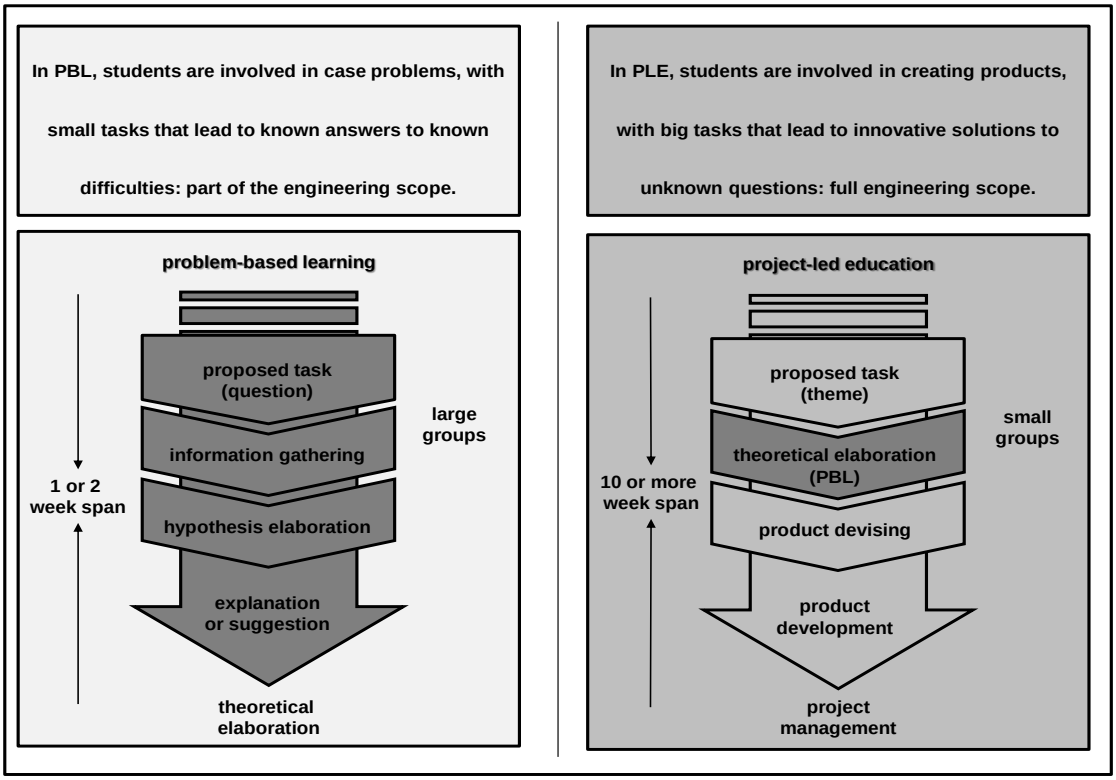


Figure 3: PBL and PLE in engineering courses – Tavares and Campos (2013).

The purpose of this paper is to report the experience of preparing eight teachers from one of the three universities studied by Tavares and Campos (2013) to take on their new roles in the PLE methodology, through

a training program designed on the basis of the PLE methodology itself, in order to provide them with the experience of practicing what they preach.

The main research question was "Can a teachers' training program based on the PLE methodology be an effective way for universities to help them understand students' and teachers' roles in this new educational methodology?"

2 Methods

As method of approach (the more abstract and broader methodological behavior for investigating events) (Marconi; Lakatos, 2006), this study was developed under the inductive method, which constructs or evaluates general propositions that are derived from specific examples (Fachin, 2005).

As method of procedure (the methodological behavior adopted in the more concrete phases of a study) (Marconi; Lakatos, 2004), this investigation embraced the monographic method, which is an in-depth study of certain individuals, professions, policies, institutions, groups and communities, in order to obtain generalizations (Fachin, 2005).

As method of investigation – the methodological behavior regarding the way the researcher intervenes in reality (Vergara, 2005) – this research adopted the case study, which constitutes an account of an activity, event or problem that contains a real or hypothetical situation, used to help you see how the complexities of real life influence decisions (Fachin, 2005).

From among the different techniques for data collection, this study relied on observation, unstructured interviews and a Likert scale closed-question questionnaire (Marconi; Lakatos, 1990); and, with regard to the techniques for data analysis, mainly the quantitative (the objective numerically expressed analysis of observed phenomena) (Gil, 2006) treatment was applied.

Once this study endeavored to stimulate the development of educational models that bring less domination and exclusion, and because it rejected unilateral views and oppressive actions, perceived as useless in today's world, it adopted a critical orientation to teaching and learning (Baptisa-dos-Santos et al., 2010).

For the organization of the training program Weenk and friends' principles (Weenk et al., 2004) were followed, since they provide engineering teachers with the opportunity of experiencing PLE learning from their students' viewpoint: in a five session course participants underwent teamwork project development and management, whose final deliverable was the presentation of a conceptual model of engineering teachers' necessary competencies in PLE.

3 Results

This section presents the organization of the training program, the conceptual model produced by the participants and their perception on the task they performed.

3.1 Organization of the training program

Based on Weenk and friends' principles (Weenk et al., 2004), Tavares acted as the tutor of 8 engineering teachers who took part in Tavares and Campos's investigation (2013) on how the PBL and the PLE methodologies were being implemented in the engineering programs of three Brazilian universities.

The training program was carried out in five two-hour sessions from June 17 to June 21, 2013.

In the first session, participants received from their tutor the project they had to complete working as a team – the development of a conceptual model of engineering teachers' necessary competencies in PLE – and started to share ideas and concepts for the development of the task due at the end of the week.

In the second, third and fourth sessions, participants worked in a pattern similar to what they require from their students in their classrooms, feeling the pressure to make decisions within a limited time frame, without the opportunity to discuss different points of view for extensive periods of time.

In the fifth session, participants, after presenting the most important features of their conceptual model and discussing their proposal both in theoretical and practical terms, talked freely about their experience as PLE students, and answered a Likert scale closed questionnaire handed out by their tutor.

3.2 Conceptual model produced by the participants

Following the PLE methodology – characterized by mutual cognitive and social interaction – participants, after collecting and analyzing data and information that could lead to the development of a conceptual model of engineering teachers' necessary competencies in PLE, arrived to the idea expressed in Figure 4.

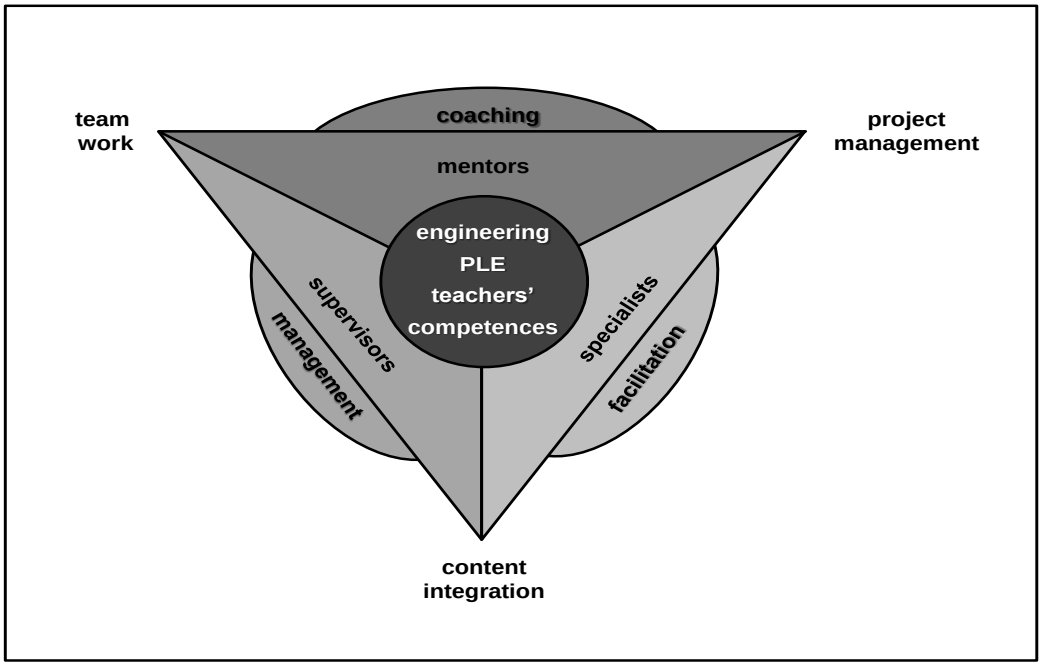


Figure 4: Engineering teachers' necessary competencies in PLE.

The conceptual model starts with the three basic tasks PLE engineering students are expected to perform:

- content integration, in which students, instead of being told exactly what they should learn and in what sequence, are helped to determine such things independently, finding out, learning and integrating whatever knowledge is necessary to complete their projects (Campos et al. 2012);

- project management, in which students are exposed to engineering projects planning, organization, direction and control, and guided on how to engage in and oversee their own works, in order to ensure they meet their goals, time lines and budget expectations (Fernandes et al. 2012);

- teamwork, in which students are encouraged to work cooperatively, and supported in the development and improvement of their interpersonal skills, while monitoring and adjusting their own, their peers' and their group's learning processes and performance (Van Hattun-Janssen; Vasconcelos, 2008).

From those, it defines the three basic tasks engineering teachers are expected to perform in PLE, based on which their necessary competences are identified:

- specialists, the competence of providing support to students' content integration and project management tasks, based on their academic and professional technical experience, in such a way that they act as facilitators of students' learning;

- supervisors, the competence of evaluating students' content integration and teamwork tasks, based on their academic and professional administrative experience, in such a way that they act as a managers of students' performance;

- mentors, the competence of guiding students' teamwork and project management tasks, based on their academic and professional interpersonal experience, in such a way that they act as coaches for students' cooperation.

3.3 Participants' perception on the training program

While discussing and negotiating roles and approaches concerning the development of a conceptual model of engineering teachers' necessary competencies in PLE, participants collected and analyzed data and information on the subject in a process which demanded cooperation and collaboration for the gradual construction of knowledge.

In order to better understand how this research's participants perceived this training experience, they were asked to answer a Likert scale closed-question questionnaire (Figure 5), which was complemented by observation and unstructured interviews by the authors of this paper.

	1 = I totally disagree / 2 = I partially disagree / 3 = I partially agree / 4 = I totally agree	1	2	3	4
content integraton	**Q01** In this training program, we had to search for, apply and integrate knowledge into our end product.				
	Q02 In this training program, we felt the need to take more responsibility for our learning.				
	Q03 In this training program, we were engaged in active learning, primarily self-directed.				
project management	**Q04** In this training program, we had to plan, organize, direct and control our project.				
	Q05 In this training program, we felt the pressure to meet goals, time lines and budget expectations.				
	Q06 In this training program, we had to deal with interpersonal communication and conflict management.				
teamwok	**Q07** In this training program, we had to exercise the communications skills of listening and speaking.				
	Q08 In this training program, we had to work cooperatively and exercise collaborative skills.				
	Q09 In this training program, we had to manage our own as well as our peers' performance.				
tutoring competences	**Q10** In this training program, coaching competencies had to be exercised by the tutor.				
	Q11 In this training program, facilitation competencies had to be exercised by the tutor.				
	Q12 In this training program, management competencies had to be exercised by the tutor.				
training program effectiveness	**Q13** In this training program, we had the opportunity to experience engineering students' reality in PLE.				
	Q14 In this training program, we had the opportunity to visualize engineering teachers' challenges in PLE.				
	Q15 This training program increased our level of confidence to effectively implement the PLE methodology.				

Figure 5: Structure of the closed-question questionnaire.

The questionnaire was structured in three parts in order to evaluate participants' perceptions on 1) the adequacy of the training course to the PLE methodology (which seeks to ensure content integration by means of project management carried out in teamwork) (questions 01 to 09); 2) the tutor's need to apply the competencies participants devised in their conceptual model of engineering teachers' necessary competencies in PLE (questions 10 to 12) ; and 3) the effectiveness of a training course based on the PLE methodology in helping teachers understand students' and teachers' roles in this new educational methodology (questions 13 to 15).

In order to stimulate participants to talk freely about their experience as PLE students, 3 questions (Table 1) were proposed as general guiding lines:

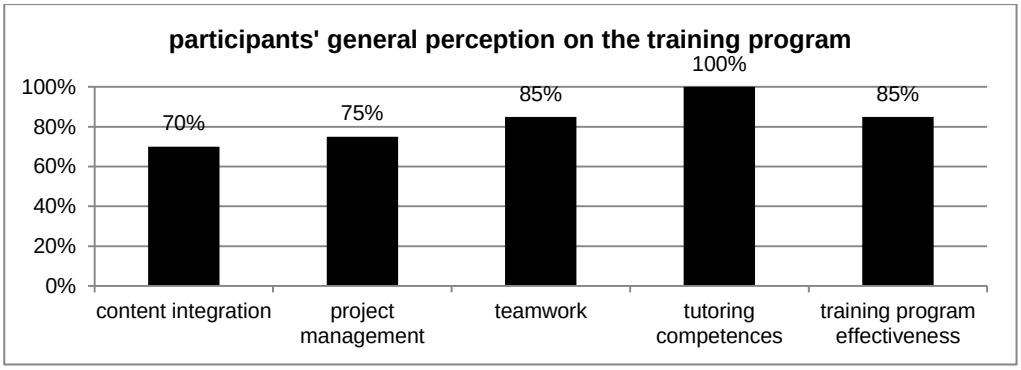
Table 1: Unstructured interviews general guidelines.

1	The most positive aspect(s) of the educational approach adopted by the training course to the PLE methodology is(are):
2	The least positive aspect(s) of the educational approach adopted by y the training course to the PLE methodology is(are):
3	My suggestion(s) for improving the educational approach adopted by the training course to the PLE methodology is(are):

4 Analysis

Results of the answers provided by the participants in the Likert scale closed-question questionnaire (Figure 5) are showed in Table 2:

Table 2: Participants' perception on the task they performed.



Analysis of the answers provided by the participants in Table 2 revealed that:

- 70% of the participants totally agreed that the training program was designed to ensure content integration (questions 1, 2, 3);

- 75% of the participants totally agreed that the training program was guided by the project management methodology (questions 4, 5, 6);

- 85% of the participants totally agreed that teamwork was an essential part of the training program (questions 7, 8, 9);

- 100% of the participants totally agreed that the tutor had to exercise the competences of coaching, facilitation and management in the training program (questions 10, 11, 12);

- 85% of the participants totally agreed that the training program was an effective way to understand learning and teaching in the PLE methodology (questions 13, 14, 15).

Participants' main ideas collected in the unstructured interviews general guidelines are synthesized in Table 3:

Table 3: Participants' Participants' main ideas on the training course to the PLE methodology.

1	The most positive aspect(s) of the educational approach adopted by the training course to the PLE methodology is(are): ***Class time devoted to application of concepts by the participants.*** ***More time for one-on-one teacher-participant interaction.***
2	The least positive aspect(s) of the educational approach adopted by y the training course to the PLE methodology is(are): L***imited time frame for the scale of the task.***
3	My suggestion(s) for improving the educational approach adopted y the training course to the PLE methodology is(are): ***Adjust time frame to the scale of the task.***

5 Conclusion

This paper reported the experience of preparing eight engineering teachers to take on their new roles in the PLE methodology, through a training program designed on the basis of this same methodology, in order to provide them with the experience of practicing what they preach.

In face of the collected data, it is possible to infer that the answer to this research's main question is yes, a teachers' training based on the PLE methodology can be an effective way for universities to help them understand students' and teachers' roles in this new educational methodology.

As expected, adjusting time frame to the complexity of the task is a main concern, which has to be taken into careful consideration when implementing the PLE Methodology.

This is an exploratory case study, and so, additional studies are needed in order to better understand – and, eventually, disseminate – this throughout the engineering teaching and learning community.

6 References

Amador, J. A.; Miles, L & Peters, C. B. The practice of problem-based learning: a guide to implementing PBL in college classrooms. New York: John Wiley Professional, 2006.

Barrett, T. & Moore, S. An introduction to problem-based learning. In: Barrett, T.; Moore, S. New approaches to problem-based learning: revitalising your practice in higher education. London: Routledge, 2010.

Campos, L. C.; Dirani, E. A. T. & Manrique, A. L. Challenges of the implementation of an engineering course in problem based learning. In: Campos, L. C.; Dirani, E. A. T.; Manrique, A. L.; Van Hattun-Jansen, N. (Eds) Project approaches to learning in engineering education: the practice of teamwork. Rotterdan: Sense Publishers, 2012.

Fachin, O. Fundamentos de metodologia. São Paulo: Saraiva, 2005.

Fernandes, S.; Flores, M.A. & Lima, R. M. Students' views of assessment in project-led engineering education: findings from a case study in Portugal. Assessment & Evaluation in Higher Education, 2012, 37:2, 163-178. Available at: http://dx.doi.org/10.1080/02602938.2010.515015.

Gil, A. C. Didática do ensino superior. São Paulo: Atlas, 2006.

Marconi, M. A. & Lakatos, E. M. Técnicas de pesquisa. São Paulo: Atlas, 1990.

Marconi, M. A. & Lakatos, E. M. Metodologia científica. São Paulo: Atlas, 2004.

Marconi, M. A. & Lakatos, E. M. Metodologia do trabalho científico. São Paulo: Atlas, 2006

Mills, J. E. & Treagust, D. F. Engineering education: is problem-based or project-based learning the answer? Australasian Journal of Engineering Education, online publication 2003-04. Available at: http://www.aaee.com.au/journal/2003/mills_treagust03.pdf

Powell, P. C. & Weenk, G. W. H. Project-led engineering education. Utrecht: Lema Publishers, 2003.

Tavares, S. R. & Campos, L. C. A survey on the synergy between teaching and learning approaches in Brazilian Engineering Schools. In: 5th International Symposium on Project Approaches in Engineering Education: Closing the Gap between University and Industry. Eindhoven: PAEE, 2013.

Thiollent, M. Metodologia da Pesquisa-Ação. São Paulo: Cortez, 1988.

Van Hattun-Janssen, N. & Vasconcelos, R. M. The tutor in project-led education: evaluation of tutor performance. In: Proceedings of the SEFI 2008 36th Annual Conference. Denmark: Aalborg, 2008. Available at: http://www.sefi.be/wp-content/abstracts/1095.pdf.

Vergara, S. C. Projetos e relatórios de pesquisa em Administração. São Paulo: Atlas, 1998.

Vergara, S. C. Métodos de pesquisa em Administração. São Paulo: Atlas, 2005.

Vergara, S. C. and Branco, P. D. Empresa humanizada. Revista de Administração de Empresas,

Weenk, W. Govers, E. & Glas, H. Training in project-based education: practice as you preach. European Journal of Engineering Education, v. 29, n. 4, pp. 465-475.

Weenk, W. & Van Der Blij, M. Tutors and teachers in project-led engineering education: a plea for PLEE tutor training. In: 3rd International Symposium on Project Approaches in Engineering Education: aligning engineering education with engineering challenges. Lisbon: PAEE, 2011.

The Design of a Master Programme in Innovative Textile Development: Designing Relevant Projects

Natascha van Hattum-Janssen[1], Sacha N. Tournier-Pelle[1]

[1] School of Creative Technology, Saxion University of Applied Sciences, Enschede, the Netherlands

Email: n.vanhattum@saxion.nl, s.n.tournier@saxion.nl

Abstract

As the textile and fashion industry is changing rapidly due to international economic and technological developments, the need for a new master's degree in this area became apparent in the Netherlands and more specifically at Saxion University of Applied Science that already offers a bachelor degree in Fashion and Textile Technologies. This degree programme fits within the institutional strategies aimed at Living Technology and the involvement of undergraduate and graduate students in applied research. Students of the new programme need to be prepared for the development and implementation of innovative textile products, processes and/or materials. The use of interdisciplinary projects as foundation for the curriculum was one of the first decisions made in the design process. As a theoretical model, the conceptual framework for Apparel Design by Lamb and Kallal (1992) was used, as this model combines consumer needs with design criteria, including functional, aesthetic and expressive aspects in a textile context. Furthermore, the involvement of companies providing project assignments is crucial to the curriculum. Companies do not only provide assignments, but also participate in the role of expert/consultant and the assessment of student groups. Company representatives are members of so-called expert teams that consist of a project teacher/lecturer a textile teacher,/lecturer a coach and a company representative. The former two are responsible for the final grade, the latter two have an advising role during the whole process. The article will analyse the curriculum design process and the influence of and co-operation with the professional field in the creation of relevant projects that represent the nature of the professional master in Innovative Textile Development. The design model and the horizontal and vertical developmental lines in which the projects are embedded are discussed, as well as the strategies used to guarantee the commitment of all stakeholders to the creation of relevant projects. As the master will start later this year, this as a work-in-progress paper.

Keywords: Curriculum development, co-creation, co-operation with industry.

1 Introduction

1.1 The context of the degree programme

Saxion is a University of Applied Sciences in the eastern part of the Netherlands. The bachelor degree in Fashion and Textile Technologies has a history of over 150 years, due to the textile industry that used to be of large economic importance in the 19th and a large part of the 20th century. Saxion decided to develop a master's degree in textiles, called Innovative Textile Development, based on a number of demands. In order to be an accredited and financed degree programme, it is necessary to show the legitimacy of the programme. A study had to be carried out to demonstrate that the programme has a clear place in the Dutch educational landscape. The outcomes of the preliminary study provided a profound foundation for the development of the degree programme.

Firstly, there is the demand in the textile industry. The labour market in the textile industry is moving fast. Products, processes and materials are developing rapidly and changes in one of these elements mean changes in the other two as well. The transition to more sustainability in the industry, see e.g. Maia, Alves and Leão (2013), offers chances for innovative product developers. The shift towards more sustainable products and processes in the traditional textile industry on the one hand and the application of fundamental knowledge for valorisation in new products in the technical textile industry on the other hand were also motives for the creation of a professional master's degree in textiles at Saxion. Furthermore, the region of Twente, were Saxion is located, also plays a role in attracting professionals in the textile industry to the region. Potential markets for the future graduates are threefold. The primary market is the national textile industry. Apart from that there

are companies that are part of the supply chain like machine makers, suppliers of raw materials and washing companies. A third potential market for graduates of the degree consists of companies that apply functional textiles, like the defence industry, healthcare, smart fashion and naval industry.

The degree also related fits in regional and national strategies for the developments of the materials industry and connects with European Horizon2020 initiatives.

1.2 The design framework

The degree programme as developed emphasises the systematic approach to design in textiles product development that is supposed to be stimulated in the students. This approach is based on the design framework of Lamb and Kallal (1992). The starting point of the framework is the assumption that it could be applied "(...) to design of any type of apparel, including garments intended for people whose needs are not routinely met in the marketplace and therefor have been considered special" and "(...) a framework that could be adapted as students face new design challenges throughout their careers" (Lamb & Kallal, 1992, p. 42). By incorporating the design approach of Lamb and Kallal (1992) in each one of the projects, students are trained to integrate the approach in their thinking about product development. At the centre of the model is the intended user of the innovation and his or her needs. Based on this intended user, the student is supposed to make functional, aesthetic and expressive considerations. The functional considerations are about the utility of the product. Expressive considerations say something about communicative and symbolic aspects of the final product, whereas aesthetic considerations refer to the desire for beauty. According to Lamb and Kallal (1992) these considerations are interrelated and ask for reflection when put on a continuum together. The authors incorporate the functional, expressive and functional concerns in a design process strategy that starts with problem identification and the generation of preliminary ideas. The third step is the design refinement in which the generated ideas are scrutinised. After that, a prototype will be developed and ideas that seem viable are tried. Testing is also included in this phase. In the evaluation stage, prototypes are held against criteria of the problem identification stage. In case of any conflicts with the functional, aesthetic and expressive considerations, the design process goes back to the problem identification stage. The model is originally intended for apparel design, but is now used in the context of textile product development that goes beyond apparel and can extend to products, processes and services in the textile industry. Although the functional considerations are highly important and in specific cases the main consideration, expressive and aesthetic considerations also need to be integrated in the design thinking process of the students and become an integral part of their reflections on usability. The added value of the framework is the add-on of the customer needs that consist of three dimensions. These three dimensions are specifically helpful in the Textile context of this master. In other frameworks, functional, aesthetic and expressive considerations are joined together as customer needs. This model distinguishes between the three dimensions and requires the students to make all of them explicit.

The model as delineated is the basis for the projects that are carried out in the first four quarters of the degree programme. Each project requires the development of an innovative product, service or process for a company. At the same time, students have Textile courses that are not directly based on the model, but provide just-in-time input or context for the project. Simultaneous courses that are closely linked to the learning needs of the students are based on the assumptions as also argued by Alves et al. (2012) that students need an environment that integrates courses to a high degree, instead of offering separate modules in a fragmentised way.

1.3 Industry involvement in course development

A characteristic of the master degree in Innovative Textile Development is the strong involvement of the textile industry, especially in the projects, but also in guest lectures and the master thesis projects. Several authors emphasise the importance of involvement of companies in projects thus providing a real-life context by enabling project assignments based on company questions. Learning through projects has a positive effect on student content knowledge and the development of skills such as collaboration, entrepreneurship, communication, critical thinking, and problem solving which increases their motivation and engagement. It is a challenging task for academic staff to implement a project-based approach and integrate technology into projects in meaningful ways. Chandrasekaran, Stojcevski, Littlefair and Joorden (2012) comment that learning

through projects is considered as a way of interactive learning. It benefits all the stakeholders such as students, industry, community, and of course the university. It provides a framework for embedding experiential and rich learning activities, integrated with a discipline-based curriculum that improves employment and career outcomes. The benefits of learning through projects include enhanced students' participation in the learning process (active learning and self-learning), enhanced communication skills, addressing of a wider set of learning styles, and promotion of critical and proactive thinking skills.

The industry is also involved in the assessment of the groups of students. The representative of the industry has an advisory role. Halfway the project the students present the status quo of the project in order to show the progress of the project and get feedback. This is a summative assessment. At the end of the project (in week 10) the group presents their result to a team of experts, which consists of: Module responsible teacher, Textile responsible teacher, coach (advisory role) and the representative of the industry (advisory role). This is formative assessment. The students present the results as a group and are individually questioned. Each student is also pear evaluating each group member. The companies are involved in the assessment, but are not responsible for the final grades, as the institution is always held accountability for the final attribution of credits.

This results in a final grade that is based on 40% report, 20% group presentation, 20% verbal individual assessment and 20% peer evaluation.

1.4 View on education

In this master's degree programme, learning is regarded a multi-disciplinary process in which the student constructs his or her own knowledge through meaningful experiences. Project-based learning was therefore adopted as an appropriate approach to learning, as PBL is based on real-life open-ended problems (van Hattum-Janssen, 2012) that are by nature multi-disciplinary. This social constructivist way of learning means that, according to Marra, Jonassen, Palmer and Luft (2014) basics first can go out of the window and students learn through a meaningful, but ill-structured problem solving activity. The authors describe five theoretical principles of constructivism in PBL. Firstly that knowledge is constructed in interaction with the environment. New ideas and phenomena are related to exiting beliefs and knowledge representations. The second principle is that reality is in the mind of the knower, as also referred to by Hendry, Frommer and Walker (1999). It is an internal process that can be shared with others. Making sense happens in the mind of the learner. Further more, the authors argue that the process of meaning making is influenced by the community in which this happens. Values and beliefs of this community shape the meaning as given by the individual. Another relevant principle is that knowledge is anchored in and indexed by relevant contexts (Marra, Jonassen, Palmer, & Luft, 2014). Skills and knowledge that are acquired are closely related to the context in which they were acquired. The context is used to make sense of what the leaner has learned. A last and very important tenet is that knowledge construction is stimulated by a question, need or desire to know. Student experience a lack between what is known and what is observed in the environment and develop ownership of a learning need. Working in projects helps them to develop meta-cognitive skills, as also argued by Downing, Kwong, Chan, Lam, and Downing (2009) who state that

> The highest 'meta-level' of cognition is usually not implicated when we receive an outside task and when the task solution is known. The meta-level tends to be consulted only when things go wrong or when a new problem is confronted. In other words, the challenging new social and academic context of working in the different culture of a problem-based learning environment increases the use of metacognition because the student cannot call upon routinised or 'automatic' cognition. (Downing, Kwong, Chan, Lam, & Downing, 2009, p. 619)

The projects do not only provide experiences for the development of content knowledge, but also enable the development of organising and professional competencies, like communication, problem solving, working in projects, commercial skills and learning and reflection and responsibility (Powell & Weenk, 2003; Alves, et al., 2012). Through project management activities, assessment of different individual and groups communication and reflection on individual and group contributions, students are actively working on these competencies.

2 Course outline

The Master's programme lasts 1,5 years (90 ECTS). It is a fulltime professional master in English. During the first year the program is set up with 3 lines: Project-, Textiles- and Paper line. The year is divided into 4 quarters of 10 weeks each. Each quarter, students learn in an industry-led Project, a literature based Paper course and theory/practice based Textiles course. The students work in groups of four in a project and individually in the Textiles and Paper line. In the Curriculum the projects account for 9 ECTS, the Textile courses for 3 ECTS and the Papers for 3 ECTS. During the last 6 months each student conducts a master thesis project individually. The master thesis accounts for 30 ECTS and is the master proof.

The master program aims to develop 12 competencies/skills, as shown in Table 1. The competencies are derived from the bachelor programme in Fashion & Textile Technologies at Saxion University of Applied Sciences. :

Table 1. Competencies Master ITD.

Type		Competencies
I Technological competencies	1.	Technical knowledge and analysis
	2.	Design, Prototype
	3.	Test and implement
II Design competencies	4.	Research and analysis
	5.	Concept
	6.	Design
III Organising competencies	7.	Entrepreneurial skills
	8.	Commercial skills
	9.	Project management
	10.	Communication
IV Professional competencies	11.	Ability to learn and reflect
	12.	Responsibility

These competencies are assessed throughout the curriculum.

Table 2. Competencies Matrix Master ITD.

		Competencies											
Quarter	Type	1	2	3	4	5	6	7	8	9	10	11	12
1	Project				x			x	x		x	x	
	Textiles	x											
	Paper	x			x		x						
2	Project		x	x		x				x		x	
	Textiles	x											
	Paper				x	x		x					
3	Project					x	x			x		x	
	Textiles	x											
	Paper				x		x						x
4	Project	x	x	x									x
	Textiles	x											
	Paper				x	x			x				
5 + 6	Thesis				x						x	x	x

Each project has its own set of competencies that are assessed (see Table 2). Each project is co-created with 3-4 companies. So preferably each project has 4 projects that 4 groups of 4 students will work on. The set of competencies determine the focus on one or two steps of the Lamb and Kallal **Invalid source specified.** framework. During the co-creating day, the co-creation team discovered that each company could in fact participate in more than one project as each project has its own set of competencies. The company determines the context of the project and the competencies determine the scope of the project.

Some of the theory from the Textiles line should also be included in the Projects. It gives input to the following Textiles courses in order to provide input for crossovers, which are very important in this master's program. Within each Paper theme, the student is free to choose his/her own subject. This gives students the opportunity to steer their own master's program. The student will also learn from each other as they will share their papers and give feedback in the form of peer evaluations.

This master's program complements Saxion's vision of education with pivots, such as creating innovative practice based knowledge co-created with industry, where the student is the centre and is able to outperform himself but also the stimulation of personal leadership and professional skills, and the regional, national and international orientation. The focus of each project is to answer real industry research questions and also to provide theoretical deepening knowledge on the subject of the project. Interdisciplinary collaboration is an important factor. The focus of each Paper is to be able to write a paper ready for publication in a relevant professional journal, based on proper research.

The focus of each Textiles course is either deepening or broadening the theoretical knowledge of the student as a basis for crossovers from textile to other disciplines that can create new innovative materials, product, processes or business concepts.

The Master in Innovative Textile Development is defined by Project and Paper based education and cooperative learning.

3 Conclusions and further research

The model of Lamb and Kallal **Invalid source specified.** as used for the development of the projects proved to be useful during the co-creation sessions with the industry. Using their design process for apparel as a starting point appeared to be transferable to the development of innovative textile products. The companies did not only provide suggestions for real-life problems for student groups that could contribute to solutions for industry problems, but also engaged in meaningful discussions on how to provide useful learning experiences that enable students to become familiar with the wide range of textile companies and processes that represent the professional field. Although the authors recognise that other product design models could fit the same purpose, the integration of general design principles as outlined in the model, combined with specific apparel and textile features was experienced positively. Evaluation of the model in practice is a next step to determine whether or not the projects in co-operation with industry accomplish the development of all competencies. Apart from this evaluation, further research is needed on the development of the professional and organising competencies. Are these competencies sufficiently developed and assessed during the projects and other courses and how can their development be stimulated?

Long-term company involvement is another issue for further research. How to provide students with relevant industry experiences and how to guarantee input of companies that are at the frontline of innovations? As the developments in the textile industry are advancing rapidly, curricular innovations need to be an integral part of the programme.

4 References

Alves, A., Moreira, F., Lima, R., Rui, S., Dinis-Carvalho, J., Mesquita, D., et al. (2012). Project Based Learning in first year, first semester of Industrial Engineering and Management: soome results. *ASME 2012 International Mechanical Engineering Congress & Exposition.* Houston (TX): ASME.

Chandrasekaran, S., Stojcevski, A., Littlefair, G., & Joordens, M. (2012). Learning through Projects in Engineering Education. *SEFI 40th Annual Conference.* Brussels: SEFI.

Downing, K., Kwong, T., Chan, S., Lam, T., & Downing, W. (2009). Problem-based learning and the development of metacognition. *Higher Education , 57*, 609-621.

Hendry, G. D., Frommer, M., & Walker, R. (1999). Constructivism and Problem-based Learning. *Journal of Further and Higher Education , 23* (3), 359-371.

Jollands, M., Jolly, L., & Molyneaux, T. (2012). Project-based learning as a contributing factor to graduates' work readiness. *European Journal of Engineering Education , 37* (2), 143-154.

Lamb, J. M., & Kallal, M. J. (1992). A conceptual framework for apparel design. *Clothing and Textiles Research Journal , 10* (2), 42-47.

Maia, L. A. (2013). Sustainable work environment with lean production in textile and clothing industry. *International Journal of Industrial Engineering and Management , 4* (3), 183-190.

Marra, R. M., Jonassen, D. H., Palmer, B., & Luft, S. (2014). Why Problem-Based Learning works: theoretical foundations. *Journal on Excellence in College Teaching , 25* (3&4), 221-238.

Powell, P., & Weenk, W. (2003). *Project-Led Engineering Education.* Utrecht: Lemma.

van Hattum-Janssen, N. (2012). The role of teachers in projects. In L. C. Campos, E. Dirani, A. Manrique, & N. van Hattum-Janssen (Eds.), *Project Approaches to Learning in Engineering Education: The Practice of Teamwork* (pp. 161-176). Rotterdam: Sense Publishers.

Opening the Black Box of Collaborative Writing: Experiences from a Teamwork Based Course in Industrial Management

Lars Uppvall[1], Pär Blomkvist[1], William Bergqvist[1]

[1] Department of Industrial Economics and Management, Royal Institute of Technology, Stockholm, Sweden

Email: par.blomkvist@indek.kth.se, lars.uppvall@indek.kth.se, wber@kth.se

Abstract

In this paper we discuss the introduction of Collaborative Writing (CW) tools in a course in the Industrial Management master program at the Royal Institute of Technology (KTH), Stockholm. The course, and the whole program, is designed using learning activities based on Problem Based Learning (PBL), Authentic Case Methodology and Teamwork.

Our students have the general knowledge how to lead, plan and execute a teamwork based project. But what about writing? What happens if a large part of a project is actually to write a collective report?

We argue that CW is a vital, but poorly understood, part of teamwork, that CW is a black-boxed activity. Nearly every teamwork project includes CW. But no one really pays much attention to what we actually do, when we produce a text in a team setting. Our ambition is to open the black box of CW and discuss how CW-concepts can enrich teamwork activities.

The paper builds on our students' reflections on challenges linked to CW in a teamwork setting. As part of the course examination the students were asked to evaluate the usability of CW-tools in performing the teamwork project. In total the data consisted of 77 individual reflection papers with a length of min 2 and max 3 pages, which were analyzed using constructs from prior literature on CW.

Our results show our students actively used CW tools and strategies and that CW had a large impact, and in fact enhanced teamwork management. The CW-tools also helped in creating sustainable teamwork in the sense that they enhanced the three criterions of team performance: *productivity*, *cohesion*, and *learning*.

Keywords: Active learning; Engineering education; Collaborative writing; Teamwork.

1 Active Learning in the IM-master program

In this paper we discuss the introduction of CW-tools in a course in the Industrial Management master program at the Royal Institute of Technology (KTH), Stockholm. By CW-tools we mean concepts and methods that highlights the collective writing process (see chapter 3). The course, where CW was introduced, and the whole program, is designed using learning activities from what we call our *active learning package*. This package consists of three elements: Problem Based Learning (PBL), Authentic Case Methodology and Teamwork.

PBL is our pedagogical foundation, Authentic Case Methodology is our way of implementing PBL, and Teamwork is naturally an integrated part in both PBL and case methodology, and, for obvious reasons, a central part in management education. Teamwork knowledge is usually framed by concepts from the fields of Project management and Team leadership. Our students have the general knowledge how to lead, plan and execute a teamwork based project. But what about writing? What happens if a large part of a project is actually to write a collective report?

We argue that CW is a vital, but poorly understood, part of Teamwork, that CW is a black-boxed activity. Nearly every teamwork project includes CW. But no one really pays much attention to what we actually do, when we produce a text in a team setting.

In this article we present the results of an investigation on the implementation of CW-tools as an extension of our *active learning package*. We want to open the black box of CW and discuss how CW-concepts can enrich teamwork activities. We argue that CW in fact facilitates and enhances the quality of Teamwork, by making a large portion of the work explicit and possible to reflect on.

The Industrial management two-year master program (launched in 2010) admits 70-100 engineering Bachelor degree students per year (e.g. Mechanical Engineering, Computer Science, Material Design). Students come from BSc programs at KTH and through an international admission. In this paper we focus on one specific course where Active Learning is especially prominent. The course is called *Change Project in Industrial Management* (CPIM). We discuss the introduction of CW-tools in the CPIM course and how these tools have influenced Teamwork in the case assignment given to our students.

Subject vise the program could be described as covering most of the primary and supporting activities of Porter's well-known value chain model [Porter, 1980], including leadership, functional, strategic and the industrial dynamic perspectives. Our students' has the ability to handle large workloads, they are analytically skilled and trained in problem *solving*. At the same time industrial managers do not primarily solve problems, they *formulate* problems. Our goal is to enhance the students' transition from problem solving to problem formulation. To foster this transition, we have as mentioned, introduced an ***active learning package*** including **PBL, Authentic Case Methodology and Teamwork** and before we explain the role of CW-tools in the CPIM course we will briefly present these central learning activities:

PBL is a well-known concept (Cheong 2008, Spence 2012, Barrows and Tamblyn 1980). Learning comes from the students struggle to absorb, understand, reformulate and solve a complex real world problem setting. In PBL the focus is put on vaguely defined problem scenarios and students are expected to engage in the complex situation presented and decide on their own problem formulation (Cheong, 2008; Spence 2012). The bottom line in our version of PBL is aligned with our goal of turning *problem solvers* into *problem formulators*. We insist on presenting the students with vaguely structured problems and open ended questions – Why? Because ill structured problems prepare you for a managerial position.

Our second active learning activity is **Authentic Case Methodology**. By using authentic cases we contend that there is a need for a progression beyond pre-developed cases. Traditional case methodology is not enough to reach our learning objectives. We argue that authentic cases are a necessity when trying to turn problem solvers into problem formulators and that learning activities must encompass elements that bring a high degree of *ambiguity* to the problem setting.

The Authentic Case Methodology is introduced early in the program and executed fully in CPIM, where we engage four industrial companies as partners. All companies represent large industrial companies (Net sales >2 700 €), all are global or Pan-Nordic, and all have a strong demand of Industrial management competence.

The practical setup is quite complex. We label the four companies A, B, C and D and each company is assigned three student teams (6-8 students each). Thus we have a total number of 12 groups (A1-3, B1-B3, etc.) investigating change processes in four industrial areas. Each team gets the same general assignment from course management: "*You are to act as a consultancy team. Based on the assignment you get from your company: Define a problem that is not trivial. Suggest a plausible solution to this problem in an academic report.*"

Each team presents the whole scope of the project for the company representatives three times (problem formulation; mid-project reporting; final product). During the project students visit the company several times. Planning, setting up meetings, interviews and other types of data collection are important parts of the skills training.

Our third active learning activity is **Teamwork**. As touched upon earlier, our students have quite a lot of knowledge from courses in for example Project Management. In the CPIM they are challenged with an assignment where the final product is a large academic report (approx. 60 pages) written collaboratively. Building on their general teamwork experience, we explicitly add writing into the repertoire of teamwork skills.

Our approach to writing has, since we launched the master program, been connected to the notion of "tangible communication". We argue that in an Industrial master program, you are supposed to actually build a product. And in this case the written report is the product.

Inspired by Design Thinking at Stanford University (Leifer 2010; Carleton et. al. 2013) we have launched the concepts of *prototyping* and *protostorming*. At prototyping seminars, the students present their drafts and get feedback from teachers, industrial clients and peers. The seminars are aimed at strengthening the incentive for

peer-peer learning by focusing on tangible communication (show and talk). By prototyping and protostorming, and with a focus on unfinished presentations of ideas and prototypes, we believe that we have created an atmosphere where both teamwork processes and the writing process are in focus.

By implementing PBL, Authentic Cases Methodology, and Teamwork, we have set the stage and created structures for Active Learning in a project bases course, where the students formulate and solve a real world change project. In the CPIM course we have already put the written report at center stage of the teamwork process (prototyping a product). In the following we concentrate on the addition of CW-tools into this teamwork setting and how these tools have enhanced the Teamwork. For further details on program design and authentic cases of our master program see Blomkvist and Uppvall (2012 a,b).

2 Purpose, Research Questions and Method

Our purpose is to investigate the effects of CW on the teamwork in a project based course where collective text production is a central part. Our research questions are:

1. Did the students use the CW-tools and how did they use them?
2. How did CW influence teamwork activities (including management of teamwork)?
3. Did the introduction of CW-tools help to create sustainable teamwork?

The paper builds on the CPIM-students' own reflections on challenges linked to CW in a teamwork setting. As a part of the course examination we asked the students to write an individual paper evaluating the usability of CW-tools in performing the group project. We gave them the following assignment:

Provide a short individual report covering insights and challenges related to the process of Collaborative Writing (CW). Can concepts of from the field of CW help in creating sustainability on an individual/group level when working in these types of projects (similar to the CPIM course)?

As a foundation and to create a common nomenclature we gave a lecture on CW-tools and distributed the following two articles explaining and discussing CW:

- Building a Taxonomy and Nomenclature of Collaborative Writing to Improve Interdisciplinary Research and Practice, by Lowry et al. (2004).
- Collaborative writing in engineering: Perspectives from research and implications for undergraduate education, by Gimenez and Thondhlana (2012).

In total the data material consisted of 77 individual reflection papers with a length of min 2 and max 3 pages. The material was analyzed in **two stages** according to students' own use of CW tools in their projects. First, the material was coded using constructs from prior literature on CW. Themes and codes for CW strategies and Document control was based on the constructs presented by Lowry et al. (2004). The analysis of CW writing activities used themes from the work of Gimenez and Thondhlana (2012). In the second stage we adopted a more open approach using both the complete material and the reduced, coded, material interpreting the students accounts on the relation between use of CW tools and teamwork management as well as teamwork dynamics.

3 The students' use of CW-tools

In this part we will present and shortly discuss our results regarding our first research question: Did the students use CW-tools and how where these tools used? These results will mainly be presented in a quantitative format, following taxonomy by Lowry et al. (2004).

Starting with the use of CW strategies, the summarized results are presented in Table 1, below.

Strategy (Lowry et al. 2004)					
Strategy	**Singel author writing**		**Parallel writing**		**Reactive writing**
	Group single author	**Sequential**	**Horizontal division**	**Stratified division**	
Sum (tot no = 77)	**15**	**15**	**63**	**33**	**35**
%	**19%**	**19%**	**82%**	**43%**	**45%**

The most frequently applied CW strategy is Parallel writing/Horizontal division writing, described as applied by 82% of the students. This means that this CW strategy is almost twice as frequently applied as the two next frequently used CW strategies: Reactive writing (45%) and Parallel writing/Stratified division writing (43%). Single author writing CW strategy were in total applied by 38%, with an even distribution between Group single author writing (19%) and Sequential writing (19%).

These results confirm that the students used CW-tools actively and to a high degree in order to manage their writing activities in the course. All students, except from 4, were able to identify and clearly describe how different types of CW strategies were used in relation to their group's collaborative writing process.

When it comes to which of the CW strategies that the students used throughout the projects, the high proportion of Parallel writing/Horizontal division writing could be expected. This particular strategy is described as effective for high volume and fast input (Lowry et al., 2004). Hence, given that large student groups, heavy workload, and an expected high volume output characterize the course in focus, the Parallel writing/Horizontal division writing strategy could be argued to be the most logical choice. All groups used a parallel strategy in at least some stage of their writing process in order to cope with the size of the given assignment.

Furthermore, these results also confirm the results by Gimenez and Thondhlana (2012) regarding the dynamic aspects of CW applied in students group work. However, our analysis seems to show a more emphasized process logic. That is, while the results of Gimenez and Thondhlana (2012) mainly connects CW strategies to the writing of different parts of a report, our results seem to reflect more managerial aspects of handling a process. More specifically, going from problem formulation (creative) toward the handling of different authors contribution and assuring the logic of the report's reasoning and quality aspects when meeting a deadline (complexity).

4 The role of CW in Teamwork

In this part of the paper we turn to the second research question: How did CW influence teamwork activities (including management of teamwork).

As we showed above, CW was used actively and issues how to manage the CW-tools were prominent in the student´s reflections. In the following we move to a qualitative analysis focusing on these managerial aspects. We use well known concepts from management and teamwork literature (*in italics*), when analyzing our student´s reflections (the same concepts are present in the course literature from earlier courses in Project management and Team leadership: e.g. Thompson, 2011; Maylor, 2010).

In all teamwork, as our students are well aware, *planning* is a key component. In our source material we can see **s**trong agreement on importance of planning and planning and re-planning. There is a clear link between shifts in project structure and shifts in CW strategies.

As expected a large part of the planning activities were about *setting objectives* for the project. Since the written report is the outcome of these projects (as typical for most management consultant work) many of the project objectives were set in the context of writing. A large part of the groups "internal objectives" was focused on the text in itself, text structure and text quality. Students used their knowledge on effective teams and transformed them into CW strategies.

In early parts of a project students typically struggle with *breaking down* the overall project objectives in to sub-tasks. This aspect had a huge impact on CW activates in the course. How students simultaneously worked with defining the industrial problem, learned from theory related to the problem, and wrote texts to share new knowledge is described in our data as a highly complex managerial challenge. Examples of such situations are individual student's different ability to accept uncertainty, different ability among sub-groups to develop strong group dynamics, and issues of acceptance regarding the fact that some of the work done will not be useful as a mean for the projects' outcomes, and had to be scraped, are all interesting and complex aspects of both Teamwork and CW.

Deciding on different *roles* in the teams, including appointing a *leader*, represents central aspects in team-leadership literature, but is also frequently highlighted in resent CW research. Students often referred to these aspects as critical when discussing difficulties or as a part of overcoming obstacles related to coordination and complexity in their projects.

In addition, several groups also deliberately changed their leadership according what challenged different phases of the project put on the team, either by replacing the person holding the leader position or by adopting a different leadership style. Students referred to different writing activities (such as drafting, producing literature overviews and final editing) and how they related to a perceived need of leadership. Most clear were the abilities to socially engage all members during problem formulation and drafting (including objectives), the need for interpersonal relations and motivation from the leader with overview and individual students when complexity of the text grew.

Project organization and structure was also influenced by the CW-tools. Students used CW strategies in order to meet critical aspects within their projects. The results also show that most students had actually worked in similar patterns as described in CW literature (Lowry et al. 2004) in earlier projects of this type in order to meet aspects, such as of high volume of text output and limited ability to physically write together. However, having a common nomenclature on CW seems to increase the teamwork management activity. Having a toolbox of structures directly aiming for the type of work students actually do in most assignments – namely to wright collaboratively – enhance students' abilities to actively use knowledge and skills obtained in e.g. prior project management courses, as reflected upon in the quote below:

"CW is something that has been commonly used throughout my academic education, however, this is actually the first time I have reflected over it. I believe that it is very important to reflect and analyse your working methods, both what can be improved and what have been performed perfectly, in order to improve your abilities. Therefore, I believe that this exercise is important and it is also quite strange that I never got it before."

IT-tools are an integral part in all teamwork management. It is obvious that software and IT-tools is of great importance in collaborative writing practices. In the literature the focus is mainly set on advances and positive outcomes from (e.g. Zhou et. al., 2012). When our students reflect on theses aspects from a team management perspective, the outcome of IT-tools is less clear. Some examples were given students struggle to find IT-tools that offered sufficient richness in communication. This often led to less use of IT tools since the one of its main benefits (to work asynchronous) did not work in practice.

However, there are also many positive examples from teams that actively used IT-tools in their collaborative writing. It seems as the most common benefit was the use of IT-tools for final editing and adjustments for cohesion. Interestingly, this was sometimes described as a face-to-face approach where each author had its own computer. By this, teams could overcome both challenges associated with authorize a single author to make the final adjustments and restrictions in communication using these IT-tools when physically separated.

Lastly we would like to touch upon an issue that every team has to manage: *quality assurance*.

We want to highlight that a high proportion of students emphasized the use of CW-tools for reaching expected quality of their final texts. Our results indicate, that the simple fact that students got access to models and nomenclature regarding CW is reported to enhance both the process and outcome of their texts. These CW-tools, in a basic manner, seemed to help students to plan, keeping track of, and evaluating links between how they managed the team and the progression of the quality in their reports. In the quote below these aspects are discussed:

"Besides realizing the challenges and difficulties that can occur when six people are trying to write a report together there were also hidden benefits. What we realized in the CPIM course was that when writing together we could identify gaps and flaws in our solution. This helped us elaborate more on our analysis and as a result we were able to refine our initial solutions. Furthermore the collaborative writing helped us truly understand the analysis and the solution, something that is validated by the literature as well (Gimenez and Thondhlana, 2012)."

5 Sustainable Teamwork

So far we have established that our students actively used CW tools and strategies and that CW had a large impact, and in fact enhanced teamwork management. In this section we turn to the inner workings of the team – teamwork dynamics – and discuss its relation to CW. We address the third research question of this paper: Did the introduction of CW-tools help to create sustainable teamwork?

In line with prior CW literature, high-performing groups conducting CW must be able to simultaneously organize the CW-work effectively and develop the group's dynamic processes. The overall aim is to reach sustainable teamwork. That is, teamwork that leads to sustainable performance of the group during and after the project.

Sustainability in team performance could be evaluated based on three aspects according to Thompson (2011). These are *productivity*, *cohesion*, and *learning*.

In order to achieve high *productivity* it is argued that teams must be able to adapt, change, and adjust project goals. One of the fundamental characteristics of the CPIM-course is the ambiguity inherent in the assignments given to the students. This means that no team will be able to reach a high level of performance without actively managing change and adoption. Therefore teams also need to develop capabilities of handling change and adopt in order to meet the objectives of the project and to reach sustainable performance.

For most teams using the CW-tools and knowledge seemed important in order to facilitate change, as illustrated in the quote below:

"Our project benefitted from adjusting CW strategy based on how much joint decision and convergence was needed based on what section was written and in what phase we were in. Shifting control mode and roles brought issues such as lack of consensus, differences in style and lack of familiarity to information up to the surface, stimulating an iterative process of CW activities where drafting and reviewing in led to brainstorming and convergence on brainstorming, that in turn led to revising and editing."

Change in complex projects is also dependent on *cohesion* among its members in the team. Most teams articulated a strong need for face-to-face meetings in order to facilitate communication. Successful work was often reported as a result of frequent and long meetings with the whole group gathered. But we can also find reflections where some members at the time questioned the usefulness of these meetings, only to realizes its value later in the project. This need for a common view (*cohesion*) of the project by all team members is illustrated in the quote below:

"The group needed to come to a consensus on how to delimit the study to make it feasible to conduct in the short period of time available. This was in fact one of the main issues throughout the project, i.e. to ensure that all group members had the same idea of the tasks that needed to be done and that they were done in a coherent manner"

However, when communication fail and cohesion gets weak, there is only a matter of time before mistakes are made, such as overlapping work when group members are unaware of what other are doing. In these situation the articulated knowledge of different CW strategies – the acquired nomenclature – is reported to be important. Teams use this knowledge in order to agree on structural changed to overcome these types of issues and to achieve higher effectiveness in their work.

Turning to *learning*, the third aspect of team performance, we can conclude that our students' use of CW knowledge lead to good performance through an ability to *learn from work and develop* their working mode. Firstly, a strong focus on communication was present in most teams. The urge to reach higher level of richness

in communication was also a common aspect leading teams to experiment and develop hybrid CW strategies. Typical examples were teams that managed writing in peers, or trios, when using overall parallel strategy. Secondly, using CW-tools is described as making members more involved in all parts of the projects and is perceived as positive for team member´s commitment to the project – thus creating trust. Since trust is built on the perceived fulfillment of expectations from another person, this aspect of CW in the teams was highly valuable. The aspect of trustful relationships is also often described as proof of team performance and strength of teams. Especially, since division of tasks seldom results in an even distribution of workload all the time, members need trust in order to manage a "give and take" balance over time.

However, it should also be mentioned that teams not always succeeded in terms of workload distribution. From a CW perspective editing work in the final stages often lead to situations where members with high capacity in this area were experiencing putting in more effort than others.

Finally, there were also some concrete examples of increased transparency coming from the use of CW-tools that helped teams manage typical aspects of student teamwork. One such aspect was related to social loafing or free-riders, as shown in the quote below:

"I would argue that the CW method used was the major factor influencing our team work, so that we could avoid social loafing. The CW method we used ensured that everybody had a specific task to accomplish, and no one could free ride on this project."

6 Conclusion: CW as a Tool for Active Learning

As discussed above, students in the CPIM course used CW tools extensively. The introduction of CW opened up the black box of writing activities in students' projects. For example, it facilitated students' ability to express writing related issues and helped students to identify need and directions of change in their collaborative writing setups. As such, CW contributed positively to our active learning package by making a large part of the teamwork explicit and possible to reflect on.

The CW-tools also helped in creating sustainable teamwork in the sense that they enhanced the three criterions of team performance: *productivity*, *cohesion*, and *learning*.

Finally, we would like to touch upon another meaning of the term sustainable teamwork. That is, teamwork skills and methods that are explicit and possible to reproduce. Sustainable in this sense would mean that the CW-tools also can influence future teamwork and the acquired CW knowledge can be transferred to other settings.

Of obvious reasons we don´t have any data on how CW will influence our student´s future teamwork assignments. But a strong indication that CW in fact has influenced student views on teamwork is given by frequent witnesses on the eye opening quality of CW. Before getting the CW-knowledge they struggled with low team performance due to non-existent structure related to CW. Many student´s express frustration on why they had not been introduced to CW earlier in their education. Based on these testimonies we argue that the introduction of CW-tools most probably will increase team performance in the long-term.

We hope, that by introducing CW-tools we have given our students a deeper knowledge regarding teamwork. That is, by making CW explicit as a teamwork activity and possible to reproduce, we believe that we have enhanced their abilities to continuously learn and perform in future educational and professional writing centered teamwork (Lowry et al., 2004; Gimenez and Thondhlana, 2012; Biggs and Tang, 2007).

7 References

Barrows, H. S., & Tamblyn, R. H. (1980). Problem-based learning: An approach to medical education. New York, NY: Springer Publishing.

Biggs, J.B. & Tang, C. (2007). *Teaching for Quality Learning at University*, Third Edition. Berkshire: McGraw-Hill

Blomkvist and Uppvall (2012 a) Blomkvist, Pär and Lars Uppvall: "A Chain is only as Strong as its Weakest Link: Managing Change in the Curriculum of Industrial Management Education" in *International Journal of Industrial Engineering and Management* (IJIEM), Vol. 3 No 2, 2012, pp. 53-65

Blomkvist and Uppvall (2012 b) Blomkvist, Pär and Lars Uppvall: "LEARNING TO LOVE AMBIGUITY: AUTHENTIC LIVE CASE METHODOLOGY IN INDUSTRIAL MANAGEMENT EDUCATION" in *International Journal of Case Method Research & Application* 2012, XXIV, 4

Carleton, T., Cockayne, W. & Tavahainen, A. (2013). *Playbook for strategic foresight & innovation.* Available at: http://foresight.stanford.edu:16080/playbook/.

Cheong, France. (2008), "Using a Problem-Based Learning Approach to Teach an Intelligent Systems Course" in *Journal of Information Technology Education* Volume 7, Editor: Linda Knight.

Gimenez, J., & Thondhlana, J. (2012). Collaborative writing in engineering: Perspectives from research and implications for undergraduate education. *European Journal of Engineering Education*, *37*(5), 471-487.

Larry Leifer at the PIEp Workshop: *Changing Mindset, Improving Creativity and Innovation in Engineering Education*, Stanford University, 2010

Lowry, P. B., Curtis, A., & Lowry, M. R. (2004). Building a taxonomy and nomenclature of collaborative writing to improve interdisciplinary research and practice. *Journal of Business Communication*, *41*(1), 66-99.

Maylor, H. (2010). Project Management 4:ed. Essex: Pearson Education.

Spence, Larry D. "Problem Based Learning: Lead to Learn, Learn to Lead." (Director, Undergraduate Learning Initiatives, School of Information Sciences and Technology, Penn State University, USA. http://www.studygs.net/pblhandbook.pdf (accessed 2012-02-24).

Thompson, L (2002) *Making the Team. A Guide for Managers*. International Edition. Pearson.

The perceptions of faculty engaged in a curricular change to Project Based Learning in an Engineering School at Brazil

Octavio Mattasoglio Neto[1], Rui M. Lima[2], Diana Mesquita[2], Mylla Moreno Ciciliano[1], Geysa Losovoi[1]

[1] Mauá Engineering School, Mauá Institute of Technology, São Caetano do Sul, 09580-900, Brazil
[2] Department of Production and Systems, School of Engineering, University of Minho, Campus of Azurém, 4800-058 Guimarães, Portugal

Email: omattasoglio@maua.br; rml@dps.uminho.pt; diana@dps.uminho.pt; myllamc@hotmail.com; geysalosovoi@yahoo.com.br

Abstract

The curricular change of an engineering school had as guideline the partial replacement of traditional school activities by Projects and Workshops, which put students as the main protagonists in the learning process, working actively. In this context, faculty were encouraged to propose activities that fulfil this request. Teachers from various specialties and even those who work in more advanced disciplines have submitted their proposals, which were offered to freshman students of an engineering course. The opening of the new curriculum began in 2015 when those activities were introduced in the course. The aim of this study is to know, analyze and evaluate the perception from teachers engaged in create these Projects and Workshops to this new curriculum. The survey was conducted from two focus groups, one with teachers' proponents of Projects and other with teachers' proponents of Workshops. The results show that the teachers attribute different meanings to the goals, strategies, evaluation and their own role in the process, though all the activities aim to ensure a common basis on engineering knowledge, which reflects the inductive character chosen in the curricular change.

Keywords: Curricular change, Project Based Learning, Faculty perceptions.

1 Introduction

The curriculum change has a life cycle that begins in a formal proposal named "ideal curriculum" chosen and adopted by the school organization. Afterwards, this initial step is translated into manuals and textbooks and became the "formal curriculum" that, in turn, will be translated again on "operational curriculum", which take shape from whom will implement it in the classroom (Goodlad, 1979).

Project Based Learning – PBL, is an alternative to traditional curriculum to promote the training of new engineers, by introducing technological tools and classroom strategies in an interdisciplinary frame, which may develop skills required in the labor market (Mesquita et al, 2013). There are many teachers that start to use these strategies in classroom (Kolmos, 1996; Lima et al, 2012), trying to involve their students, stimulating motivation for learning and assuring the development of new skills (Kolmos and De Graaff, 2007). To support the change to PBL, Powell and Weenk (2003) listed three conditions: Infrastructure - Facilities, training the teaching staff and communication that can ensure a common basis on the perception and need to change; Authority - To ensure the planning, lead and progressive institutionalized implementation, and; Consensus – Among all direct stakeholders involved on innovation process. All of these are important to ensure a good change.

The aim of this work is to analyze the motivation and expectations of teachers involved in the transformation of an "ideal curriculum" into a "formal curriculum". They are responsible for proposing Projects, Workshops and Engineering Practices to compose a list of activities offered to students of the first period of an engineering school in which are promoting a curricular change toward to a PBL curriculum. More precisely, the objective is to identify their perception on process - the evaluation tools, the main characteristics of the projects and workshops offered to students, the relationship of this activities with the disciplines of curriculum; the role of process agents - students and teachers; and the contribution of Projects, Workshops and Engineering Practices of curricular change, the product of this change.

Fernandes et al. (2008) suggest the model Context, Input, Process and Product - CIPP as a tool that links the curriculum to the decision-making process. The authors used these results to interpret the PBL application in the course of Industrial Management, University of Minho. In this model, the context evaluates the needs,

problems and opportunities based on the objectives and significance of the products. The Input evaluates alternative approaches to project planning and resource allocation. The Process evaluates the implementation of plans to guide the activities and later to explain the Product, which in turn, are interpreted as the result of curricular aims.

This work is the third part of a major project of research, which analyzes the full curricular change in the first period of an engineering school. The first work studied the perceptions of teachers on PBL before the announcement of the curricular change (Mattasoglio Neto et al, 2015a). The second analyses the motivation to curricular change, from the head of the managers of school, which started this process (Mattasoglio Neto et al, 2015b). Now, it is time to know the perceptions of teachers involved in delivering proposals of Projects and Workshops, which will be offered in the course.

2 Methodology

The main aim of this work is to identify the point of view of teachers who are the proponents of activities, on the process - the evaluation tools, the main characteristics of the projects and workshops offered to students; the process agents, students and teachers' roles; and the product, contribution of Projects, Workshops and Engineering Practices of curricular change. Therefore, methodological approach has bases on two focus groups, one with four teachers' proponents of Workshops (FG1) and another, with four teachers' proponents of Projects or Engineering Practices (FG2).

2.1 Context of the study

The Mauá Engineering School - EEM is an engineering school that offers nine engineering courses, with classes from February to December, in an annual calendar. A curricular change is taking place since February 2015, with the main guideline focused on increasing the use of Workshops, Projects and Engineering Practices undertaken by the students at the school, under the supervision of a teacher.

For the first period some Projects, Engineering Practices and Workshops were created by a group of teachers, which asked the management group of School, responsible by the "ideal curriculum". The guidelines for these activities were: should be carried out by students in the school environment; without necessarily having ties to the disciplines of the 1st year of the course; without the need for an evaluation with grading and be carried out with the active participation of students. A call for proposals was opened and teachers of various periods proposed almost 100 works. To this total, 38 were accepted and offered to students who freely chosen those who would hold. Table 1 shows activities offered to students.

Table 1 - Projects, Engineering Practices and Workshops offers to students

Projects - Period of 8 months	Workshops – Period of 4 months	Engineering Practices – Per. 4 months
PRO 101 – Jam Manufacturing	PRO 401 – Mathematical bases	PRO 701 – Fuel injection
PRO 102 – Autonomous robot	PRO 402 – Graphics	PRO 702 – Spaghetti Bridge
PRO 103 – Flying over the campus	PRO 403 – Competitive Brazil	PRO 703 – Aerodynamics of buildings
PRO 104 – Water treatment	PRO 404 – Entering by cone	PRO 704 – Lean production
PRO 105 – Industrial shed	PRO 405 – The Logic of games	PRO 705 – Sustainable City
PRO 106 – Electronic games	PRO 406 – Knowing LINUX	PRO 706 – Chips Fruits
PRO 107 – Soap manufacturing	PRO 407 – The art of solving problems	PRO 707 – "Houston, we have …
PRO 108 – Weather station	PRO 409 – Modern physics	PRO 708 – Mobile applications
PRO 109 – Waterway	PRO 410 – Creating problems	PRO 709 – Rocket Science
PRO 110 – Skateboards factory	PRO 411 – Negotiation	PRO 711 – Master user
PRO 111 – Combustion engine	PRO 412 – Excel-VBA	PRO 712 – Engineer Stirling
	PRO 413 – Python	PRO 713 – Corrosion
	PRO 415 – Newton in equilibrium	PRO 714 – Tensile/Compression
		PRO 715 – Arduino

Activities were offered in different times, in periods of 2 hours per week, usually after school hours to the 1st period. One student ought to perform in year, at least: A Project, a Workshop, a Practical Engineering and another Workshop or Engineering Practice, that is, on average, the student should meet a minimum total of 5 hours per week of these activities (4 at first half and 6 in other).

2.2 Data collection and analysis

This research is an exploratory study, which aims to get prior knowledge from teachers about the Projects, Engineering Practices and Workshops, introduced on new curriculum. This study have as basis two focus groups conducted, both with four participants, one of them with proponents of Projects and Practices of Engineering and other with proponents of Workshops. They were chosen without specific criteria, among about 30 teachers proponents of Projects, Engineering Practices and Workshops. The focus groups had a previous script, characterizing then as a semi-structured interview (Lüdke and André, 1986). Some dimensions addressed in focus group to know the point of view of teachers about Projects, Engineering Practices and Workshops were: Importance in training students; Strategies used to carry out these activities; Learning assessment of students; Role of participants; Difficulties in its implementing. Were held during April 2015, recorded in audio with the consent of the interviewees and transcribed, to allow a precise analysis of its contents (Bardin, 2009). In that analysis respondents were nominated from [FG1Px] or [FG2Py] with x and y from 1 to 4, without a relevant criterion for this numeration. These numbers appear in the analysis and discussion of the results, near of excerpt transcript of the speech to illustrate the results obtained.

3 Findings

From the data analysis, emerged four relevant dimensions used to discuss the perception of teachers about the new configuration of curriculum: Learning environment, the role of process agents, the process, assessment and strategies; product. Some of them can be found in works related with evaluation process of Project-Based Learning (Lima et al, 2007; van Hattum-Janssen & Mesquita, 2011; Fernandes et al., 2012).

3.1 Learning Environment

3.1.1 Characteristics of Projects, Engineering Practices and Workshops

For the respondents the definition given to activities in Projects, Engineering Practices and Workshops was not adequate, with classification criteria that overlapped raising doubts. For one of the interviewees the initial classification indicated that an "Engineering Practice would be a smaller project, lasting up to six months" [FG1P2] and Workshops were related to other activities not directly relevant to engineering knowledge. In the focus group, a consensus was reached on the concept of Projects, Engineering Practices and Workshops.

Projects – From an enough common perception, are identified by: having long-term, with periods of up to eight months; be divided into stages; and related to an open and multidisciplinary problem. Open problems are understood as those that allow a variety of ways to solution, or a variety of tools [FG2P4; FG2P3]. They are also associated with the need for a multidisciplinary knowledge, which often are not dominated by students yet.

> *In my case, I leave open. The software that the student wants to use. 'You want to use this software. Use it. If you want to use another ... If you want to make an application on the cellphone, do it' "[FG2P1].*

> *"... is something bigger, so I need more resources, several knowledge of specific engineering areas, in the case of mine which is control automation ... have to do research, I have to see how it works (the software, the mechanism) ..." [FG2P4].*

The Projects follow a work strategy in stages, which emphasize: organization of work teams; definition of roles of the participants; proposition of the problem; presentation of content by the teacher, which will support the work of the teams; some prior researches on the topic of the problem; search for a solution to the problem; development and testing of prototypes; presentation, oral or written, of results of the work.

Engineering Practices - There is no convergence on the characterization of this category. For some, unlike the projects, the Engineering Practices do not have an initial stage of research and development, but a stage in which the teacher presents the content and the problem in a direct way. Related to solution of a problem, but in a **more targeted manner**. For others, the Engineering Practices are identified as **open mini-projects**, only because they have a shorter period for development "with a 'slight' initial research in technical articles" [FG2P3].

"The student will make the practical implementation of a proposal that is already half set by the teacher. The specific objective is set by the teacher" [FG2P1].

"... the student can give his solution, but it's very controlled, that is, with restrictions placed by the teacher and with a specific goal also set by the teacher" [FG2P2].

It is possible affirm that the Engineering Practices are focused on implementing a process or building a product [FG2P1] in a directed way, without possibility of the student fully utilize their creativity. The goal is to develop engineering skills.

Workshops - The aim is essentially lead the student to develop skills in a structure that has a stage of: theoretical presentation by the teacher, of some content; and proposition of a oriented work, to be done. Ends in a single class [FG2P1, FG2P4, FG2P2]; may have a playful character [FG2P2], with the handling of parts, equipment or instruments, to promote skill, in using, installing or building a prototype or, yet, development skills in pencil and paper activities. An example is the workshop 'Mathematics bases', which aims to develop mathematical skills in which the students have difficulty.

"I think a workshop has ... content to be addressed without ... the intention of creating a product as a project, but generate knowledge of some content" [FG1P2].

It is possible to conclude that Engineering Practices are associated with the application of an engineering tool without handling many variables, without giving the student the ability to create, as widely as in projects. The Projects are associated with open and multidisciplinary problems, with unknown solution, developed in stages. Workshops, in the other hand, are associated with the development of specific skills, to support the engineering formation and to broaden the horizons of knowledge in technological or scientific aspects.

3.1.2 The activities in the context of the 1st year

Some Projects, Engineering Practices and Workshops have a direct link to the subjects of the 1st period, due to the perception that the activities will support the content learned in the subjects. There is also a link with disciplines and contents of higher periods, anticipating the use of them, in the 1st period.

"In the design of skateboards, at various times ... we deal with materials, and the teacher of materials (following series) helps us. We talk about Physics, Calculus, Materials' Resistance ... We try to show them... because, when the student study this content ... he will do with another perspective, because they realize the actual application" [FG2P2].

Some Workshops have no link with disciplines. Such is the case of "Negotiation Techniques" which aims are to develop transversal skills, important in the formation of the Engineer.

3.2 The process agents

3.2.1 Teacher role

According to the participants, the teacher has different roles: advisor, tutor, model, content provider and team coach. One of their functions is to promote the student autonomy, identified as a problem of students arriving to higher education

"... we need to develop the autonomy of the students, ... every year it is getting more difficult, students have less and less autonomy and, facing the first difficulty, they stop" [FG2P4].

For each Project a teacher is assigned to act as a team coach, who helps the students in their different roles in the tasks and how they relate, aiming better performance at work. In Engineering Practices, their paper is to be a model, translates into an example of professional skills, to be followed by students. In both the idea is to ensure autonomy to the student.

"In the project, I think the main role is to assume a position as team advisor. In Engineering Practice is to become a model, as it is very controlled ... you have to show how to do, for him to do the same. In the Project should bring information, help teamwork, and bring all design features, help them to make the schedule ... you have to give them a helping hand, but they have to do (the work themselves)" [FG2P2].

The teacher's role, as content provider, is to bring the most advanced content necessary for the development of projects, practices and workshops that are not common to the students.

> *"I cannot start from premise that they all know how to work with Arduino. So, I give them a basic training in Arduino, focused on programming" [FG2P4].*

In the Workshops the role of teacher is directly associated with a tutor, who conducts a directed study work, respecting the different ripening stages of students.

> *"We act as a tutor in the following sense ... There are students who are more autonomous. When he cannot understand something, he asks us. However, there are other students ... who are more passive. They expect you to bring referrals to proceed. What we have done is to give a challenge to the student, in form of a questionnaire, etc., which has a logical evolution ... and, he will answer on..." [FG1P1].*

3.2.2 Student role

The teachers have some expectation of students' role as to make choices, decide, conduct practices, research, give solution to problems, all of it associated with having a proactive attitude. The proactivity is an important feature of an engineer's performance, both to identify problems as seek solution. There is a complaint that students arrive to higher education without this profile and should be encouraged to develop it.

> *"...I teach: 'Look, that's the way you start the engine.' So he knows that he has to do the little robot walk forward. He starts the engine ... I said: 'Did you know that you could get that engine and another one, connect the two together for the robot go forward? 'The student says,' Oh yeah? ' You always have to give that little push,' goes a little bit, goes a little goes a bit '. He fails, as was taught by teacher, to join ideas and to do something. We have to develop that autonomy in students ..." [FG2P4].*

About decisions, the argument is that the student does not reach at engineering school prepared for this. Does not realize that a decision, before it is right or wrong, will lead to some consequence: "*This is the role they have to play to become an engineer*" [FG2P1]. Making researches is another assignment of students, whether in Projects or Engineering Practices, research is an element that makes up the process of developing a product or service. Conducting a practical implementation is another assignment of the student, both a proposal from the teacher, such as Workshops or Engineering Practices, and those decided by the student, as in Projects.

3.3 The process of assessment

The evaluation of students in Projects, Engineering Practices and Workshops happens in different way. In some Projects and in Engineering Practices students were evaluated for compliance with a set of targets, considering milestones.

> *"... They have deadlines. So, at the end of two months, the sensing module have to work properly ... after six months, the communication wireless module has to be working properly and, in the end eight months, to finish, all the artifact and the interface have to be done and working properly" [FG2P1].*

The Table 2 summarizes how the interviewed teachers assess Projects.

Table 2 - Assessment components

Interviewed	Assessment components			
[FG2P1]	Control class attendance	Goal: sensing Programming	Goal: Communication Module	Goal: Prototype Report on the work done
[FG2P2]	Goal: Provide product knowledge - Movies, shows, open.	Project Management Goal: Team Training and role assignments	Specific targets to be met	Target: Report and defence facing "stakeholders"
[FG2P4]	Mechanical design, electronics and software. Reports over the activity.		Goal: Prototype performance in robots Racing	Final report and robot design: electronics, part of the software, mechanics.

Some Engineering Practices and Workshops use the presence in the meetings as a criterion for assessment. As reported by the teacher [FG2P4], who conducts an Engineering Practice, his evaluation just classifies as "*fulfilled or not fulfilled (the activities) ... if the student makes a video, or a sequence of photos, if he makes notes of something ... that's how I'm evaluating*" [FG2P4]. Similarly, for another workshop, the respondent [FG1P1]

reports: "*Formally have no evaluation. The students have a work, they will fulfill and we will discuss, we correct on the errors ...*" [FG1P1].

3.4 Contribution of Projects, Engineering Practices and Workshops - Product

The data analysis showed some main contributions of Projects and Engineering Practices. Materializes the role of the engineer already in the first series; It stimulates responsibility for the acquired knowledge; valorizes the course subjects, both the basic cycle, as the most advanced series; stimulates mature attitudes to assume the attributions of the engineer's work; motivates the student; creates a scenario of freedom allowing to choose their way.

> *"Materializes the role of the engineer, already from the first year. ... You do (the student) feel the responsibility and the need for certain knowledge that will be acquired in the first year. Something that when I did (the engineering course), I felt very discouraged because I found engineering in the third, fourth year. Then you already bring in the first trial, the discussion ..." [FG2P2]*

The ripeness of attitudes is translated by involvement with problems: seek solution, seek knowledge, conduct research, make choices, and carry out critical analysis of the situations it faces.

> *"He (student) gets out of that context, when he is in high school, in which is always passive and only receives knowledge. Not now. He needs to take a different attitude ... The teacher will not come to him (saying) 'look you will use this tool. Do that way, this, this and this.' You will be directing, but he has freedom to make choices" [FG2P1].*

Explicitly the student's motivation is pointed as the main contribution of Projects, Engineering Practices and Workshops.

> *"The engineering course is an extremely dull course in the first two years. You must first motivate. The person has to have a very focused idea ... to endure the first two years of a common course of engineering. In calculus class, the teacher does not always specifies what and when and he will use what he is taught" [FG2P4].*

It is interesting to note that teamwork, although it is considered as differential in work by projects, is indicated just in an isolated speech on the testimony of the respondents, nothing significant.

Workshops are strongly associated with promoting the teaching content and skills, either as subjects of transversal knowledge. They are also associated with the "rescue of high school content that fail on student's knowledge" [FG1P4].

> *"In the specific case of the Workshop "mathematical bases", it has a prompt use already in calculus, because we are reviewing a bit before the use in calculus. We are seeing exponential function, logarithmic function, things used in calculus. So there is a direct link" [FG1P4].*

In general, the new curriculum is associated with a scenario of freedom, in which the student can choose the activities they will participate and practice engineering.

> *"I think the students saw it the curriculum as being stuck in cast. They had the opportunity to work in that specific area, or something that would give more pleasure to them, only from the third grade on. So now, at first series he already has this possibility to integrate disciplines, (put) really hands-on, and develop complementary topics to what is being seen in theory" [FG1P3].*

3.5 Benefits and difficulties

There is a positive outlook on the implementation of Workshops and Projects, but also doubts, sometimes justified by this moment of beginning of changes. The commitment of people is identified as a risk factor, for which just time can promote a better engagement. The speech of the respondent [FG2P1] summarizes some ideas about curriculum reform, shared by other participants:

> *"The reform have a lot of positive things. I think it was a big step, and leave a square model ... audacious, for any institution. It is logical, I think we will reap a lot of good, but I think this model will only get good in about five years, at least, when people are already more involved. ... Has a great deal of people involved. Some of them share the ideas proposed, but others do not. I believe that those who do not share the proposal, with time they will getting into rhythm and realizing what is improving. Then, you need to have a great effort to work the team, to have group as a whole, supporting ... 'A gain?' I believe so, because I think the goal of all*

that is being done is to change the form of teaching engineering. ... Needs to be taught differently, we already have other schools with this view, and engineering [education] needs to get a little more practical, a little less theoretical ... The course has to gain a lot if it can offer the student in a different way [FG2P1].

The courage in carrying out the reform is shared by other participants in the focus group [FG2P3; FG2P4]. The time for adaptation is another highlight, linked to membership and involvement of teachers to the reform. At the same time there is the indication of the need of group effort, of all teachers to support and sustain the curricular reform, which can be translated into the need for authority and consensus (Powell and Weenk, 2003), to share ideas and reach a working team, to discuss and know results and requirements of new curriculum.

As for infrastructure, respondents showed concern about the adequacy of environments at this beginning. Some activities had a great demand, but a small number of places in classes, hindering meet the demand. This generated the discomfort of having to deny student access to certain activities [FG2P4]. The suggestion is that you create classes and schedules to meet students.

"My original classroom was U03 and you cannot make a workshop in this classroom. So this is a problem that we will have to think, which the workshops that really need labs are, and what times they must be offered, in such a way as not to overlap classes." [FG1P1]

The process of choice of activities by students, called "tasting", which is the stage in which students can experience the Workshops, Engineering Practices and Projects, is a disapproving point, because the vast majority of students did not effectively participated and, consequently did not make the choice fully aware of the importance to their training. Participants identify that the choice of students is set by timetable of tasting, title or suggestion from peers and not by the theme or content. Another criticism comes from that the "tasting", happens in just one week, which is a short period, being difficult to students effectively experience all of it and know its value in their training. The high number of activities that the student has to perform throughout the year justifies the option of pursuing the activities in better times, so they can perform all activities.

"Even the way these workshops and projects were offered; I think we have to change. I do not know if the tasting was a good way, I think we have to check everything" [FG1P4].

"The appeal of schedule is much higher than any kind of tasting" [FG1P2].

"...I think this problem is also because he is obliged to do many activities. .... Is that it has to do so much ... that will try to set the time, more so than choose.... then need to analyze, think at the end of this year. It was really important to have it done many activities?" [FG2P3].

Finally, a point raised is the need for evaluation of the work done, so that we can optimize the process, with an eye to the necessary adjustments.

"Well, at first, it is working. From what we are seeing. Of course I think declare success, or not, will still depend a little bit. We need to reach the end of the year. I think we need to see what will be the condition that these students will reach the second year. Evaluate, compare students we had, the profile of the student we had with the student who will come to us next year. I think all this will require a good evaluation, honest, to maybe even make an assessment to verify 'let's back up a little'. We will need to fix a little here and there" [FG1P1].

4 Final Remarks

The aim of this work is to analyze the motivation and expectations of teachers involved in the transformation of an "ideal curriculum" into a "formal curriculum". They are responsible for Projects, Workshops and Engineering Practices offered to students of the first period of an engineering school, which is promoting a curricular change to PBL. Many benefits in student's learning were reported such as responsibility by acquired knowledge, appreciation of course subjects, mature attitudes and a scenario of freedom allowing students to choose their way in the course. Similarly, teachers assume their role differently, confirming the readiness to work with these strategies. There is a non-convergent view on various aspects of the Projects, Engineering Practices and Workshops, generating doubts and uncertainties about the strategies used in these activities and in the evaluation process. These differences may be a factor that implies a lower efficiency to ensure maturation of the teaching staff and ripening of these activities. That is, the time to reach an optimum level with the curriculum reform can be extended, and thus generate a climate of dissatisfaction and even discouragement

of participants. In this sense, the attention of the management team is crucial to support work development, as revealed by the participants of the focus groups.

In general, there is a perception that the work is being done but there is much to be improved. It is possible to notice the commitment of teachers who put their creativity and talent making changes, seeking the success of the proposal, although there has been a critical skepticism, prompting careful evaluation to be know if the results are actually positive. Sharing knowledge about the PBL characteristics is something that deserves attention, which is evident from the fact that interdisciplinary has not been used in the activities, as noted in previous interviews reported by Mattasoglio, Lima and Mesquita (2015), which could enhance the performance of work, aligning it with the definition of Problem Project (Kolmos, 1996). It is possible to realize that the context has some conditions that need alignment to guarantee a better performance of curricular change. As an example, there is the need to improve the suitability of classrooms and timetables, to attend the students. Further, the process of assessment and a better organization of strategies claim for change too.

5 Acknowledgments

The authors thank the teachers that kindly participated in the focus groups.
This work has been partially supported by projects COMPETE-POCI-01-0145-FEDER-007043 and FCT-UID-CEC-00319-2013, from Portugal.

6 References

Bardin, L. Análise de Conteúdo. Edições 70: Brasil. 2009.

Fernandes, S., Flores, M. A., & Lima, R. M. (2012, 26-27 July 2012). A Aprendizagem baseada em Projetos Interdisciplinares no Ensino Superior: implicações ao nível do trabalho docente. 4th Symposium on Project Approaches in Engineering Education (PAEE'2012): Organizing and Managing Project Based Learning Challenges, São Paulo - Brasil, 227-236.

Fernandes, S., Flores, M. A., & Lima, R. M. (2008). Using the CIPP Model to Evaluate the Impact of Project-Led Education. A case study of Engineering Education in Portugal. In: Research on Diversity of PBL Practice in Engineering Education, Chapter: 5, Publisher: SENSE, Editors: Kolmos, Anette and Graaff, Erik de and Du, Xiangyun, pp.45-55.

Goodlad, J. (1979). *Curriculum inquiry: The study of curriculum practice*. New York: McGraw–Hill.

Kolmos, A. (1996). Reflections on Project Work and Problem-based. Learning. In: European Journal of Engineering education, vol. 21, no. 2, 1996. P. 141-148.

Kolmos, A. and De Graaff, E. (2007) Processing of changing to PBL. In: Kolmos, A., De Graaff, E. (2007) *Management of change: Implementation of problem-based and project-based learning in engineering*. 2007. p. 31-43. Rotterdan: Sense Publisers.

Lima, R. M., Carvalho, D., Flores, M. A., & van Hattum-Janssen, N. (2007). A case study on project led education in engineering: students' and teachers' perceptions. *European Journal of Engineering Education, 32*(3), 337 - 347.

Lima, R. M., Carvalho, D., Souza, R. M. A. da S. e, Alves, A., Moreira, F., Mesquita, D., Fernandes, S. (2012) A Project management framework for planning and executing interdisciplinary learning projects in engineering education. In: *Project approaches to learning in engineering education*. (2012) Campos, L. C. de, Dirani, E. A. T., Manrique, A. L. and Hattun-Janssen, N. van. Rotterdan: Sense Publisers.

Lüdke, M., André, M. E. D. A. (1986) Pesquisa em Educação: Abordagens Qualitativas. São Paulo: EPU, 1986.

Mattasoglio Neto, O; Lima, R; Mesquita, D. (2015a) *Project-Based Learning approach for engineering curriculum design: the faculty perceptions of an engineering school*. Proceedings, 8th International Symposium on Project Approaches in Engineering Education. San Sebastian. Spain.

Mattasoglio Neto, O; Lima, R; Mesquita, D. (2015b) *A Construção de um currículo de Project-Based Learning: O currículo ideal e o currículo formal*. Anais, Congresso Brasileiro de Educação em Engenharia. São Bernando do Campo, Brasil.

Pacheco, J. A. (2005). *Escritos curriculares*. São Paulo: Cortez. 176 p.

Powell, P. C., & Weenk, W. (2003). *Project-led engineering education*. Utrecht: Lemma.

van Hattum-Janssen, N., & Mesquita, D. (2011). Teacher perception of professional skills in a project-led engineering semester. *European Journal of Engineering Education, 36*(5), 461-472.

Mesquita, D., Lima, R. M., & Flores, M. A. (2013) *Developing professional competencies through projects in interaction with companies: A study in Industrial Engineering and Management Master Degree*. 5th International Symposium on Project Approaches in Engineering Education, PAEE'2013. Eindhoven, The Netherlands.

Mapping of a mechanical engineering course curriculum focusing on the implementation of learning strategies - Project Based Learning

Mylla Moreno Ciciliano[1], Octavio Mattasoglio Neto[1]

[1]Escola de Engenharia Mauá, Centro Universitário do Instituto Mauá de Tecnologia, São Caetano do Sul, 09580-900, Brasil

Email: myllamc@hotmail.com; omattasoglio@maua.br

Abstract

The purpose of this paper is to present the mapping of the mechanical engineering course curriculum of the Escola de Engenharia Mauá - EEM, in the years before 2016, seeking to verify the teaching strategies used and how much these strategies are approaching the use of projects as a guideline for student's work. In addition, a survey of the changes to be introduced in the curriculum based on new guidelines for the course, which implies on the introduction of Elective Complementary Activities, conducted by projects. This research is justified because EEM is going through a curricular reform process and the results will be used for comparison and identification of changes in learning and hence the pedagogical project. In the specific case of this study, the goal is to assist those responsible for the course of mechanical engineering to evaluate the proposal implemented. For this study, two elements have been used to date as a source of research data: The first were the teaching plans from before and after the curricular reform, this analysis sought elements to check for any previously disciplinary or interdisciplinary projects. The second source of data was the proposals of the Complementary Activities in the form of Project Based Learning which will be introduced in the second year of the course and will have features aimed on projects in the mechanical engineering area, conducted in order to place students in activities aimed at solutions to realistic problems related to the area or participation in competitive activities such as mini-baja, aero-design and SAE formula. This curricular reform was introduced in 2015 in the first year of the course and now it is being modeled for the second year and will be implemented in 2016, in other words, the curriculum being analyzed exists, yet, as a project without having been translated into practice, so the analysis being held so far is of an idealized curriculum.

Keywords: Curricular Change; Project Based Learning; Mechanical Engineering.

1 Introduction

Throughout the years, the expectations for engineers have been changing, increasingly requiring different skills and attitudes that come from the professionals. New forms of education are being implemented in schools around the world in order to develop these skills and attitudes during the course of Engineering. The purpose of this work is the teaching strategy called Project Based Learning, a methodology that has been used more intensively lately and that allows the development of transversal skills through the elaboration of projects, and the implementation of that methodology in an engineering school.

The school, which has been the focus of analysis, is going through a curricular change process to adapt their teaching methods so their students will be able to develop skills and attitudes that fit the new demands of the employment market. Thus, the curriculum, which was previously based on traditional teaching strategies making use of lectures in which the student is passive and the teacher is the holder of knowledge, will incorporate active teaching methods in subjects of the curriculum and, complementarily, encourage the use of projects and workshops to assist in desired education.

The aim of this study is to analyze the curriculum change in the second year of a Mechanical Engineering course, based on the analysis of teaching plans from the years of 2015 and 2016, years before and after the implementation of the curricular reform. In addition, the proposals of workshops and projects that will be offered to students in 2016 were analyzed. This is a descriptive study, based on qualitative data and does not currently intend to further discuss the results of the changes made in the curriculum.

This research is justified for making a survey about the changes happening in an engineering school due to the curricular reform, focused on the implementation of PBL in their curriculum. It may become the basis for future reviews of the effectiveness of used teaching methods and adaptation of students with the new class schedule and as support for institutions that want to tread the same path.

2 Background

The theoretical supports of this work are the ideas related to curriculum changes and Project Based Learning.

2.1 Curricular change

The curriculum change of a school goes through several steps before it is ready to be implemented. First, the curriculum has to be designed and formally presented to the various schools' entities. This first form of curriculum is called "ideal curriculum" in which ideas are initially presented and wrought so that, following an agreement between the rectory and teachers, a new curriculum can be developed (Goodlad 1979). After being formed the "ideal curriculum", the new program is formalized in the syllabus, in which subjects specify the timetable of content to be developed throughout the year. The curriculum presented in the form of lesson plans is called "formal curriculum".

The curriculum development has three stages: preparation, implementation and evaluation. The process involves people who structure its organization. It is something beyond a rational process, since there is the subjectivity of interpretation of those who build, which gives it an open feature (Pacheco, 2005), other than a mechanical design.

2.2 Project Based Learning - PBL

PBL is a type of active teaching method that has been studied recently. This methodology is an alternative method that enables soft skills to be developed (Silveira, 2008). PBL encourages learning through open project proposals and issues to students (Lima et al, 2012), seeking to develop the student transversal skills beyond specific content (Mesquita et al, 2013). Thus, learning becomes part of the student's responsibility, who must play an active role as the teacher assumes a posture tutor, facilitator, with the function of motivating and encouraging students (Silveira, 2008).

The purpose of this methodology is to encourage students to create new products/processes that can be used in real life, with an educational approach to real production models (Sesoko & Mattasoglio Neto, 2014).

For Silveira (2008), some advantages can be achieved with PBL:

- Student engagement with issues and conflicts that are rich, real and relevant;
- Improves communication, organization, presentation, management, research, questioning, self-assessment, reflection, relationship skills, and group leadership skills;
- Working in group to achieve a common goal;
- Aims at deeper conceptual understanding, leading the student to effectively link the existing knowledge of the new information.

Sesoko and Mattasoglio Neto (2014), make a synthesis from other authors on the structure of PBL, and identify that this strategy is characterized by:

- Curriculum based on the proposition of tasks, product focused;
- Completion time: two months to one year;
- Integration between theory and practice: ideas → research → tests → results → theories and hypotheses;
- Student Role: have ideas, assign tasks, schedule and deploy the work, analyze results.

Based on Kolmos' classification (1996), there are different types of PBL: Assignment based project - project based on a part of a discipline; Subject Project - Design based on a complete discipline; Problem Project - Determined by open problem and characterized by a development process that goes beyond disciplinary boundaries.

3 Methodology

Surveys were conducted on two different sources of information: works on the Mechanical Engineering department, published in the editions from 2011 to 2015 of the Brazilian Congress on Education in Engineering - COBENGE, and also data obtained from the syllabi of the courses of the second year of a Mechanical Engineering course.

3.1 Bibliographic survey

A survey was conducted to form a theoretical basis for the research. For this, articles from the years 2011 to 2015 of the Brazilian Congress on Education in Engineering – COBENGE were selected. The articles were chosen based on the analyzed content. The initial choice was based on their name, and the criteria for selection was PBL approach in teaching various courses of engineering, although it has been given preference to items related to Mechanical Engineering.

After this initial screening, the selected articles' abstracts were studied. Based on the content in the summaries, another selection took place, sorting out the papers that contained issues more aligned to the interest of this work. From this search, some articles were chosen as a basis for the research. In total, were selected and analyzed eight papers from different years and authors. Table 1 shows the articles analyzed for this research.

Table 1 - PBL related papers from COBENGE analyzed, from 2011 to 2015.

Year	Analyzed
2011	1
2012	1
2013	2
2014	2
2015	2
Total	8

3.2 Syllabi's analysis

Once the bibliographic survey was done, the research with syllabi had a start. The syllabi from the years 2015, year prior to reform, and 2016, year of implementation of the curricular reform were gathered in addition to the data given by the school on the workshops and projects offered to students of the second year of the Mechanical Engineering course in the year 2016.

First there was the reading and comparison of previous and post-reform syllabi, seeking common ground and divergent points of them. After this comparison was made, the lesson plans were reread, focusing more accurately on the topics: Teaching and Evaluation Methodology in search of forms of active teaching, not necessarily in the form of PBL.

After analyzing the teaching plans, there was the analysis of the material provided by the school on workshops and projects. This stage is characterized by being a documentary analysis of the proposed workshops and projects that will be offered to students in 2016.

4 Findings

Based on the reading of articles, analyzes of teaching plans, and proposals for workshops and projects, it was possible to identify two topics: the first was the existing curriculum that was modified to fit the new implanted teaching standards in school; the other were the workshops and projects developed and implemented in the year of curricular reform.

4.1 Curriculum change

The curriculum change covers the curriculum of the second year of a Mechanical Engineering course. Thanks to the reform, existing disciplines have undergone some changes to adapt to the new curriculum standard. The two most significant changes were the transposition of hours of classes held in the traditional classroom for projects and workshops, and school incentive for active teaching methods approach within the classroom.

The disciplines suffered reduction in the number of weekly hours, for such hours to be used by projects and workshops. Thus, the subjects have changed their schedules so that the content before approached, were preserved throughout the course of Mechanical Engineering. In addition to the transposition of hours to the new discipline, there was an incentive from the school to the approach of active methodologies in the classroom, making previously expository classes make use of different teaching strategies, preferably active learning. Table 2 shows the changes highlighted in the syllabus for each subject.

Table 2 – Changes in the existing disciplines.

Disciplines		**Changes Related to Active Learning**
2015	2016	
EFB103 - Differential and Integral Calculus II	EFB107 - Differential and Integral Calculus II	Exercises and motivating discussions with active student participation
EFB202 - Physics II	EFB206 - Physics II	Laboratory classes with effective participation of students Participatory exercises in class **
EFB104 - Numerical Methods	EFB108 - Computational Mathematics	
ETM201 - Mechanical Construction Materials	ETM202 - Mechanical Construction Materials I	*
ETM301 - Introduction to Manufacturing and Design	ETM302 - Introduction to Manufacturing and Design	Applications of lesson content in projects *
EFB204 - Mechanics	EFB204 - Mechanics	Classes with active participation of students - "inverted classroom"
ETM101 - Strength of Materials	ETM101 - Strength of Materials	
ETM401- **Electricity**	ETM401- Electricity	Development of projects in laboratory classes *

* Disciplines applying Integrated Project, a project that goes beyond the boundaries of disciplines, using specific knowledge for the development of the project, with the purpose of using theoretical concepts in real applications. The Integrated Project is evaluated by all disciplines involved, however, it is not evidenced the form of evaluation in the syllabus of any discipline that applies it.

** The course of Physics II applies, in their laboratory classes, the Semester Project. It is a project that uses the active learning methodology called Problem Based Learning. The implementation of this project in the discipline was established in 2013 in order to address the concepts and physics content usually covered in theoretical form in real engineering applications (Cutri, R.; Baracat, D.E.; Marim, L.R.; Witkowski, F.M., 2014). The project appraisal is through seminars held at the end of the semester.

4.2 Workshops and Projects

The workshops and projects involve a new concept of lessons in the curriculum of the school. The proposal involves a transposition of 16% of the workload of the old curriculum to projects and workshops. The discipline

that combines such activities receives the name of PAE - Projetos e Atividades Especiais (Special projects and activities).

The PAE are several half-yearly activities in different areas of mechanical engineering with an active educational approach based on PBL. Each activity of the PAE discipline offers a number of hours of work and, at the end of the second year, all hours fulfilled by each student must add up to 160 or more.

Thus, students enrolled in this course have the freedom to choose projects and workshops that interest them most, as they are offered by different teachers and cover various themes. In Table 3 are the activities related to Mechanical Engineering area offered to students in the year 2016.

Table 3 - Workshops and Projects related to Mechanical engineering offered in 2016.

Workshops and Projects 2016		Total Hours
MC2001 - Manufacture and Assembly of Truck *Cara Chata*		35
MC2003 – Super Structures - Composite	Learn basic information about polymers, resins, fillers, fibers and combinations thereof for the production of composites;	35
MC2004 - Application of programmable electronic Devices in Mechanical and Automotive Systems	Knowledge and expertise in control systems, with application in the automotive area, directly in a commercial car or special line, using simplified programmable devices.	35
MC2005 - ECO Mauá	Development of high efficiency vehicle for national competition.	35
MC2006 - Aerodesign	Airplane model development for national competition.	35
MC2007 - Mauá Racing (SAE Formula)	Development of vehicle for national competition of speed.	35
MC2008 - Mini - Baja	Development of off-road vehicle for national competition.	35
Minimum Annual Workload of PAE second grade = 160 Hours		

4.2.1 The use of active strategies in the disciplines of course-PBL

It is observed that some subjects already use active learning strategies. It seems that they are individual initiatives that were born before the school performed the option for the curriculum change. However, these strategies already put into practice, converge to the proposal of using active learning in the classroom.

The discipline of physics II is an example in which a project in the form of challenge is performed by all students, and presented at the end of each semester, in the form of a students' seminar. Such a project can be classified as Subject Project in Kolmos' classification (1996).

Another example is the Integrated Project, which links different disciplines: Mechanical Construction Materials, Introduction to Manufacturing and Design, and Electricity; and which aims to encourage students to assimilate the information provided in classroom for the development of a project to the area of operation of a mechanical engineer in the labor market. This project can be included in the ranks of Problem Project for Kolmos (1996).

4.2.2 The role of the agents in the process – Teachers and students

It does not appear in the project proposals and workshops the role of the student and also the role of teachers in the description of the projects. As well as in the teaching plans of the disciplines is not made explicit the

expectation of change of posture of the students and teachers with the deployment of active teaching methods.

This is another element that deserves better research, from an interview with those responsible for projects.

4.2.3 Goals and evaluation of Workshops and Projects – Work product

In the documents, the objectives of the subjects show no indication of soft skills that should be attained by students. What appears is the indication of a product related directly to the workshop, for example, the airplane of Aerodesign or the vehicle of ECO Mauá, or the indication of a specific knowledge, without being connected directly to a product.

In addition, it is not indicated any procedure of evaluation of students' learning, whether relating to content, whether relating to transversal skills in project and workshops proposals.

5 Final considerations

Although the PBL can promote learning and development of transversal skills, it does not appear explicitly in the proposals of the projects and workshops offered in the course of mechanical engineering. The perception is that this should be investigated, in the form of interviews with proponents of these projects and workshops, but that was not purpose of this work.

Even if there isn't a better detailing of some elements of the curriculum, such as the roles of teachers and students and learning evaluation process, it is noted that there is already a reform movement, since the Projects and Workshops were created and are being offered to students and that the disciplines already incorporate active learning strategies.

This is the initial stage of evaluation of the implementation of PBL in a Mechanical Engineering course and will continue with the search for information from interviews and observation of the implementation of the proposal.

Acknowledgements: To CNPq, for the financial support of this research through PIBIC-CNPq.

6 References

Cutri, R.; Baracat, D. E.; Marim, L. R.; Witkowski, F. M. Avaliação do uso da metodologia PBL para disciplina de física (eletromagnetismo e ondas) num curso de engenharia. Anais: XLI - Congresso Brasileiro de Educação em Engenharia. Juiz de Fora: ABENGE, 2014.

Goodlad, J. Curriculum inquiry: The study of curriculum practice. New York: McGraw–Hill. 1979.

Kolmos, A. Reflections on Project Work and Problem-based Learning. In: European Journal of Engineering education, vol. 21, no. 2, 1996. P. 141-148. 1996.

Lima Mendes, J. U.; Silvério Freire Júnior, R. C.; Formiga Barbosa, C. R.; Oliveira Fontes, F. A.; Pinheiro de Paiva, P. D.; Oliveira Campos, V. B. Os programas minibaja e aerodesign como projetos pedagógicos na engenharia mecânica da UFRN. Anais: XL - Congresso Brasileiro de Educação em Engenharia. Belém: ABENGE, 2012.

Lima, R. M., Carvalho, D., Souza, R. M. A. da S. e, Alves, A., Moreira, F., Mesquita, D., Fernandes, S. A Project management framework for planning and executing interdisciplinary learning projects in engineering education. In: Project approaches to learning in engineering education. (2012) CAMPOS, L. C. de, Dirani, E. A. T., Manrique, A. L. and Hattun-Janssen, N. van. Rotterdan: Sense Publisers. (2012)

Mattasoglio Neto, O.; Lima, R. M.; Mesquita, D. Project-Based Learning approach for engineering curriculum design: the faculty perceptions of an engineering school. InActa: Workshop in Project Approaches in Engineering Education. San Sebastian-Donóstia. 2015.

Mesquita, D., Lima, R. M., & Flores, M. A. Developing professional competencies through projects in interaction with companies: A study in Industrial Engineering and Management Master Degree. Paper presented at the Fifth International Symposium on Project Approaches in Engineering Education, PAEE'2013. Eindhoven, The Netherlands. 2013

Monteiro, S. B. S.; Quirino, M. G.; Zindel, M. L.; Costa Oliveira, E.; Rodrigues, E. C. C. Uma nova abordagem de ensino de engenharia: aprendizagem baseada em projetos (PjBL) na disciplina PSP1 do curso de engenharia de produção da UnB. Anais: XXXIX - Congresso Brasileiro de Educação em Engenharia. Blumenau: ABENGE, 2011.

Musse, B. F.; Fonseca, A. B.; Melo, G. M.; Frizoni, L. H.; Gomes, F. G. Utilização de uma estratégia PjBL para desenvolvimento das competências transversais do perfil profissional do engenheiro. Anais: XLI - Congresso Brasileiro de Educação em Engenharia. Gramado: ABENGE, 2013.

Nunes Torres, R.; Mendonça de Alencar, R.; N'Guessan, A. J. B. R. K.; Magalhães Viana, D.; Kalume Maranhão, A. C.; Favaro Garrossini, D. Projetos integradores: uma reflexão sobre a aplicação de experiências com base na aprendizagem orientado por projetos. Anais: XXXIX - Congresso Brasileiro de Educação em Engenharia. Blumenau: ABENGE, 2011.

Parucker, M. L. Aprendizagem baseada no desenvolvimento de projetos integradores no ciclo básico do curso de engenharia mecânica. Anais:XLI - Congresso Brasileiro de Educação em Engenharia. Gramado: ABENGE, 2013.

Sesoko, V. M.; Mattasoglio Neto, O. Análise de experiências de Problem e Project Based Learning em cursos de engenharia civil. Anais: XLII - Congresso Brasileiro de Educação em Engenharia. Juiz de Fora: ABENGE, 2014.

Silveira, M. A. *et al*. Projeto LAPIN: um caminho para a implementação do aprendizado baseado em projetos. Anais: XXXVI – Congresso Brasileiro de Educação em Engenharia. São Paulo: ABENGE, 2008.

Pedagogical evolution based on implementation of case teaching method in masters engineering courses

Krzysztof Pikoń[1], Magdalena Bogacka[1]

[1] Department Of Technologies And Installations For Waste Management, Faculty Of Power And Environmental Engineering Silesian University of Technology, Gliwice, Poland

Email: krzysztof.pikon@polsl.pl, magdalena.bogacka@polsl.pl

Abstract

The pedagogical evolution following social changes is the challenge for present day education. The case teaching method is considered to be the effective method of teaching in many types of courses. It is proven that it develops practical skills and allows to look at the different situations, from cultural and economic perspective. It shows different possibilities of solving problems based on real-life situations. In engineering courses case teaching could give excellent opportunity to introduce business related context. It seems to be especially important from the project based learning perspective which gives the student knowledge and skills of practical character. Due to significant pedagogical benefits of case teaching method it seems to be the right tool in implementation of challenge driven education model.

Although the case teaching method is definitely regarded as modern, developing critical thinking and boasting the high knowledge retention rate it suffers from some implementation problems. The universities in Europe are organized in fairly similar way for many years and the structures seems to be rather conservative. This results in some formal based problems in introduction of this tool in everyday practice. Case teaching method is more time consuming which reflects the range of knowledge mastered by the student while attending the courses. This results in learning outcomes range associated with courses. Case teaching method is more requiring for teachers as well. They should be trained in a different way and master different teaching skills, some part very distant from classic ones. Problems with their proper understanding and willingness to adopt new pedagogical tools are observed as well.

The problems and opportunities related to implementation of case teaching method especially in engineering master courses are discussed in the manuscript. Methods of reshaping the courses in order to make them effective and fulfilling the modern criteria of pedagogical evolution together with proper approach to building engineering cases are discussed as well.

Keywords: active learning; case teaching method; engineering courses.

1 Introduction

The KIC Innoenergy master school tries to ensure the best quality of teaching using the models and techniques that proven its feasibility and best possible performance in engineering courses. The key notions is "active learning" as well as "learning by doing" and "project based learning" (Bonwell 1991, Sivan 2000).

The further step is implementation of challenge driven education. This means that the master programs should be based on learning experience through identification, analysis and design of a solution to sociotechnical problems. The learning experience is typically multidisciplinary, takes place in an international context and aims to find a collaboratively developed solution which is environmentally, socially and economically sustainable.

The challenges are supplied by external stake-holders (mainly industrial partners), and solved by interdisciplinary teams of students. Each student participates in one new challenge per semester, in different teams, for the first three semesters. The challenges can be linked and have a progression built in. Challenge driven education in some way redefines the students priorities: diploma is not the goal – the goal is to find a solution to the challenge.

One of the most important elements which include the modern pedagogical approaches is implementation of case teaching method. The case method is an established form of learning in many academic and professional learning contexts. However, its use varied dramatically with a strong focus on law, medicine and business (Yadav 2007). The use of case teaching method in engineering courses is not usual practice.

Pedagogical goals to be gained from implementing case teaching in the pedagogical process could be indicated in following fields: critical thinking, learning and participation.

The Critical Thinking improvement is connected with better student's ability to view an issue from multiple perspective and with deeper understanding of concepts as well as to improve ability to make connections across multiple content areas. Equally important is to increase student's ability to discuss different issues.

The learning benefits related to implementation of case teaching are focused on improvement of student's ability to better grasp of the practical application of core course concepts as well as strengthening communication skills and understanding of ambiguity.

The CTM makes students to take a more active part in the learning process and be more engaged in class. Additionally it could develop positive peer - to - peer relationships, increase attendance and strengthen ability to work in small groups.

Finally CTM causes that students evaluate teaching process more positively. It could be the hard befit for institution applying the method.

It is now documented that students can learn more effectively when actively involved in the learning process (Bonwell 1991, Sivan 2000, KIC 2015). Besides long list of advantages the case teaching method seems to have some disadvantages. It is more time consuming for teachers and students with comparison with traditional teaching methods. As a result some problems with covering all scope for each semester could appear. First, the special preparation of teachers towards techniques to stimulate discussion is needed. As a fairly new technique which is not commonly used especially in engineering courses its implementation requires time to adjust to case study learning by students as well as by teachers. It could also require modifications of pedagogical framework and some formal structures of universities.

The case method is a form of storytelling. The teaching process should be designed in a form of a scenario which would be interesting and somehow connected with emotions. The real life examples are therefore generally good starting point for building the cases. In engineering sciences the emotional side is usually problematic and should be introduced with special attention in order to keep the course in a technical university style, but definitely it should built on the real examples basis. The value of problem should be as high as possible and should be well understood by students.

2 Case teaching in engineering courses

The EIT (European Institute for Innovation and Technology) is a body of the European Union, which was established in March 2008. The EIT has selected KIC InnoEnergy as the leading engine for innovation and entrepreneurship in sustainable energy in Europe. KIC InnoEnergy implements a concept of the knowledge triangle. The triangle symbolizes how the three components (higher education, research and industry) interact and how the resulting innovation-entrepreneurship-business model fosters market-oriented innovation.

For achieving this goal KIC InnoEnergy operates as SE company, incorporated in the Netherlands, with 29 European shareholders, all of them key players in the energy field, with top rank industries, research centers and universities. Those 29 entities are geographically attached to one of 6 Co-Location Centers (Sweden, Poland, Germany, Benelux, France and Iberia). This activity is supported by 200 European research and industrial partners.

KIC InnoEnergy Master School offers master programs which are directed at a completely new type of education in the energy field, by mobilizing the innovative and entrepreneurial spirit of the students. Seven Master programs, accredited by top technical universities in Europe offer a combination of engineering and entrepreneurship courses.

The KIC Innoenergy Masterschool started the project of defining the framework for the case teaching in engineering cases which is significant novelty. The case teaching method is usually used in the business courses and was developed for this purpose. Taking into consideration unbeatable pedagogical benefits form

implementation of this method the attempt to adopt it in hard sciences especially engineering courses seems to be extremely attractive but challenging.

Introduction of case teaching gives the technical university some advantages comparing to the universities that keep strongly to the formal "chalk-and-talk" way of teaching. For example, as case teaching gives more opportunities for soft-skills development, enhancing collaboration abilities and tools and even enabling dynamic negotiation exercising, graduating students will be better prepared for future job requirements. This in turn will be reflected in more favourable statistics concerning graduate employment levels, therefore more and more students will perceive the university as a promising career starter.

Case teaching classes, due to their specific construction can also contribute to improve the working atmosphere and all students are involved in the learning process. Also, the class attendance increase should be expected as well as more engagement during the classes and more active participation (Gudmundsson 2014).

On the other hand, a dedicated students' progress evaluation methodology should be developed and clearly presented to the students in the beginning of the course. Evaluation of students' performance during case teaching classes shouldn't be based on direct methods (exams, papers) but rather on teachers (but also other students) perceptions of how well certain students have achieved an objective during the case analysis. In other words, the assessment should be more qualitative than quantitative.

Additionally, the assessment of student performance by defined measures should be accompanied by monitoring of case teaching program strengths and weaknesses and overall institutional effectiveness should be assessed at the end of the academic year.

Pedagogical goals to be gained from implementing cases in teaching progress could be indicated in following fields: critical thinking, learning, participation and other. It is now documented that students can learn more effectively when actively involved in the learning process (for instance: Bonwell 1991, Sivan 2000).

The National Center for Case Study Teaching in Science has trained thousands of science teachers in the case study method over the past 20 years and counting. In 2006, we conducted a survey to assess the effectiveness of trainings.

Students' critical thinking increased and their understanding deepened when learning via case - based instruction. The faculty reported that the students in the classes using case studies demonstrated stronger critical thinking skills (88.8%), were able to make connections across multiple content areas (82.6%), and developed a deeper understanding of concepts (90.1%). Most of the faculty also agreed that when they used case study teaching the students were better able to view an issue from multiple perspectives (91.3%). Faculty reported that students had a better grasp of the practical applications of core course concepts when learning via case - based instruction (91.3%). When asked whether more content was covered in their classroom when using case studies, only 18.8% of the faculty agreed, while 33.8% were neutral and 47.6% disagreed. The majority (93.8%) of faculty using case study teaching also agreed that students were more engaged in the class when using cases (Yadev 2007).

KIC Innoenergy Master School pilot case building was launched. In Clean Fossil and Alternative Fuels Energy Masters program, conducted in Silesian University of Technology, Gliwice, Poland, AGH (Kraków, Poland) and IST (Lisbon, Portugal). The first case has been developed and prepared to implemented in course of Environmental Impact Assessment and Thermoeconomic cost evaluation.

3 Case structure and framework

Convincing students to buy into your viewpoint is critical to successful teaching process. It is essential to present a perspective that is relevant to the person or group you are addressing the teaching. The logical structure is very important. In order to do it well and in

What is the potential value in this situation?

A strong case begins with a logical financial and strategic foundation which show the value of the issue. The essential question which should be answered by case creator is: What is the potential value in situation shown in the case? Identification of all stakeholders is the next step. Is reflects the first one by shaping the arguments used in the case in order to paint the whole picture in proper way. It's important to understand what drives a stakeholder's behaviour and focus. In engineering case additionally technological content should be added and "sold" to students in an attractive way. The added value would be the presentation of interactions and interdependence between technological and economic issues. The steps of cases creation and implementation are (adopted from Leenders 1989):

- Step 1: Case Origin - Identify the needs - formulating the main message and main question to be answered
- Step 2: Establishing the needs - the search for specific issues, ideas, and individuals or organizations that might supply the case information
- Step 3: Initial Contact - the establishment of access to material on the case subject
- Step 4: Shaping the case - creation of concept of case content and its division into parts and identifying the main messages for all parts and questions to be answered as well as forming group of content deliverers - industrial partners, university professors.
- Step 5: Data Collection - the gathering of the relevant information for the case.
- Step 6: The Writing Process - the organization and the presentation of the data and information.
- Step 7: Release
- Step 8: Feedback - the gathering information about effect in students skills shaping and their satisfaction.

The data collection stage could be based on the written material or interviews. Essential is obtaining of permission from the appropriate individuals to use the case for educational purposes. This could be important if the content deliverer are form the industry. The date about economic and technological performance could be fragile for the industrial partners. The date must be reviewed from this point of view. We must remember that implantation of cases in teaching process could be treated as a form of publication.

4 Application sample

Struggle for CO2 abatement which main goal was to show different pathways leading to CO2 abatement in energy generation processes

Main messages for students was that there are many different methods to reduce the CO2 emission. The renewable energy sources could be used but this solution has its own limitations. Significant reduction could be obtained by investing in new technologies in fossil fuels power industry. Finally that the economic efficiency of CO2 emission reduction could be higher while introducing new technologies in fossil fuels power industry than implementing renewable energy sources

Different scenarios of actions to limit or avoid CO2 emission will be presented, basing on real life case studies. They were chosen in a way to illustrate the most representative stories for the last few years ending up either with success or with failure. Analysis of the individual case studies will give students the idea about the complexity of taking-up technological investment decisions and what is the role of policy-making, technological development, legal environment and R&D in this field.

The package shows different perspective for reduction of CO2 emission issue, together presenting the complete picture.

The whole case is divided in 4 parts (fig.1). Each part represents the different perspective on the same phenomenon. The results could be treated as an alternative solution to the same problem. Finally students are receiving the complete product and complex answer which could be based on different approaches. The

general description of case was developed as a main case, pre-reading materials for students together with teaching notes which help to conduct teaching process into the right direction.

For each part of the case the main massages was defined together with questions which should be answered during classes in order to reach all teaching goals. Students were free to answer questions as well as asking additional ones. It was organized as moderate discussion with large margin of freedom.

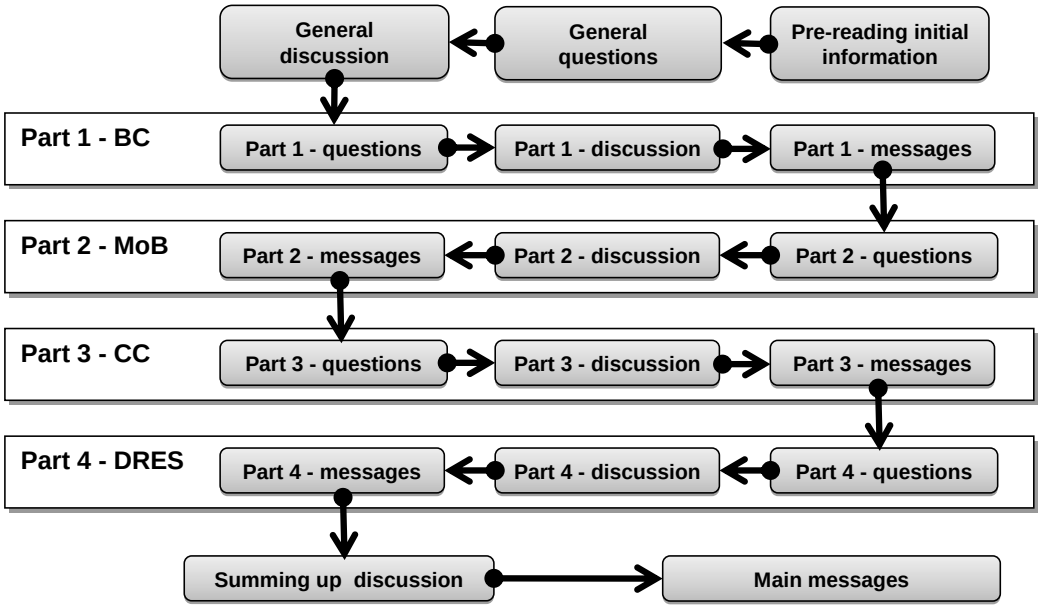


Figure 1. CO2 abatement case structure

4.1 Part 1 of the case - biomass combustion

The general goal was to present the stepwise approach leading to full scale implementation of biomass combustion in biggest biomass CFB boiler in the world. Overcoming legal, logistic and technological barriers would be the base for the case study build-up as well as the business models evaluation will be presented. Early stakeholders identification will be presented as a crucial element of building up a successful business case.

The main messages defined for this part of the case was as follows:

- Biomass will remain an important and most stable fuel for RES electricity and heat in the nearest future.
- Fuel flexibility must be maintained therefore coal will still play a role, however it will be different than at present.
- To build up a successful business case it is important to identify all the stakeholders first.
- Although technological barriers are often dangerous, they should be regarded more like opportunities than like threats.

Questions defined to be answered by students were as follows:

- What is the economy of the production of electricity from biomass; what is the impact of biomass combustion on operation and life span of the boiler elements; what comparisons of coal fired installations with co-combustion and 100% biomass combustion boilers can be done?
- Is it necessary to make any adaptations of the boiler for biomass combustion looking from the perspective of the technology and from the perspective of law?
- What are the advantages and disadvantages of the use of biomass as fuel?
- Does biomass really contribute to CO_2 emission abatement?
- Should the incentive system differ the biomass in terms of its geographical origin?
- What were the success factors in case of implementation of biomass combustion?
- Were all the bottlenecks successfully eliminated?

4.2 Part 2 of the case - modernization of boilers

The General goal of this part of case is to show how modernization of boilers could contribute fulfilling energy needs and in reduction of CO2 emission.

The main messages defined for this part of the case was as follows:

- The efficiency of is highly dependent on Biomass could be important source of energy but to limited scale!
- To provide a sufficient amount of electricity new boilers should be constructed or existing boilers should be modernized.
- The modernization of boilers could increase efficiency what means reduction of emission!

Questions to be answered:

- Is boiler modernization important?
- What kind of modernization is the most environmentally and economically efficient?
- What scenario (modernization or building new) is more optimal in economic and environmental terms?
- What is the scale of emission reduction possible to be reached by implementing new technologies in existing fossil fuels boilers?

4.3 Part 3 - CO_2 capture

The general goal of this part is to show highlights and shadows of implementation of carbon capture technology in Europe's biggest existing lignite firing power plant.

The main messages defined for this part of the case was as follows:

- CCS is a potential technology for reduction the emission of carbon dioxide from an existing power plant
- CCS is the only possibility to turn an existing power plant into a zero-emission one
- CAPEX and OPEX of CCS system are very serious barriers of the implementation
- Technology development of other (than CCS) technologies of CO_2 emission reduction are expected by the utilities.
- Underground geological storage of CO2 requires overcoming of the societal aspects of CCS which can turn out to be a are very strong non-technological barrier of the implementation.

Questions to be answered:

- What is the influence of CCS on power plant operation (energy, economy,...)
- What is the necessary degree of the integration of CCS plant with the existing utility?
- CCS or CCS-ready?
- What must be the legal/market environment to boost CCS in utilities/energy generation?
- If not CCS than what technological solutions for utilities can be proposed?
- How to plan and run a successful CCS campaign to achieve the stakeholders consent? Who should be involved and to what extent? Local administration, central administration, industry, NGOs?

4.4 Part 4 - Distributed Renewable Energy System

The general goal of this part is to underline value of small scale solutions which multiplied could significantly contribute CO2 reduction efforts and make power systems more flexible and reliable.

The main messages defined for this part of the case was as follows:

- Distributed systems could be used as an alternative to classic solutions
- Distributed systems could be effective and not requiring as the investment costs are concerned
- Distributed systems based on biomass could reduce CO2 emission significantly when used extensively.

Questions to be answered:

- What does it mean for power system that it is "distributed"?
- What are technical advantages of distributed systems?

- What could be environmental footprint of distributed systems based on biofuels?
- Do we need large scale investments – and what could be investment structure in distributed energy systems

The special survey after implementation of Case teaching Technique in the described course has been launched. The general results showed high students satisfaction. 75% of students assessed this method as very effective and affective. Only the small fraction was not satisfied with the method (5%). As the main reason students claimed that "they are more accustomed to traditional methods". However the overwhelming majority would like to have the method to be implemented in wider extent in engineering courses.

Hence satisfying for students and effective from pedagogical point of view some problems could be indicated. The method is time consuming. It requires long preparation time for teachers and additional effort. It is rather far from usual approach which means that if the method is implemented teachers should gain new skills. The method requires additional time for preparations for students. They should be well prepared while attending classes. The CTM is based on discussion therefore the good preparation before classes is essential. The pre reading material with basic information and the general story and additional sources listed should be prepared. This could cause some problems with proper understanding of technical details which are usually explained by teachers during classes. Therefore some issues should be discussed and if not properly understood by student, corrected during classes. As an effect the ratio of information delivered to the time is lower than in classic methods. On the other hand the retention rate is much higher.

5 Conclusion

KIC Innoenergy Master school is focused on creating professional leaders and decision makers. The programs are focused on delivering high level expert knowledge together with hard and soft and behavioral skills. Special pressure is put on pedagogical tool. Therefore many projects dedicated to pedagogical evolution are carried out. The ambition is implement challenge driven education at a large scale. One of promising tools to reach this goal is Case Teaching Method. Business and entrepreneurial skills should be delivered to engineering courses and this could be done busing case teaching method. It makes students to think independently, form and talk about their own visions as well as give additional motivation to be creative, shaping at the same time behavioral skills.

The CTM implemented in Clean Fossil and Alternative Fuels program of KIC Innoenergy Masterschool showed that this method answers to the question how to change the teaching process in order to get better results.

The presented messages and questions in the manuscript could be the treated as sample of modification made in classic approach - mostly designed for business cases - towards using case teaching in engineering courses. The added value would be defined as the presentation of interactions and interdependence between technological and economic issues.

Case Teaching implemented in engineering courses is a requiring tool but delivering good results.

Acknowledgement

This paper has been developed as a part of KIC Innoenergy activity in Clean Fossil and Alternative Fuels Energy Msc program.

6 References

Bonwell, C. and Eison, J., Active Learning: Creating Excitement in the Classroom AEHE-ERIC Higher Education Report No. 1, Washington, D.C., Jossey-Bass, ISBN 1-878380-08-7, 1991.

Sivan A, Wong Leung R, Woon C. and Kember D., An Implementation of Active Learning and its Effect on the Quality of Students, Learning Innovations in Education and Training International, Vol. 37, No 4, pp. 381-389, 2000.

Yadav, A., Lundeberg, M., DeSchryver, M., Dirkin, K., Schiller, N.A., Maier, K., and Herreid, C.F., Teaching science with case studies: A national survey of faculty perceptions of the benefits and challenges of using case studies. Journal of College Science Teaching 37(1), 34, 2007.

KIC InnoEnergy EDU Teaching in the Knowledge Triangle with Challenges – internal communication by Henrik Svensson, KIC IE, 2015.

Gudmundsson B.I.: Decision-Forcing Cases. April, 2014

Bonwell, C.; Eison, J. (1991). Active Learning: Creating Excitement in the Classroom AEHE-ERIC Higher Education Report No. 1. Washington, D.C.: Jossey-Bass. ISBN 1-878380-08-7

Leenders, M., & Erskin, J. A. (1989). Case research: The case writing process. Ontario: the School of Business Administration, University of Western Ontario.

Results Analysis from Peer Assessment for Entrepreneurship's PBL class in a Business Management Undergraduate Course

Andre F. Uebe Mansur[1,2], Brian Joyce[3], Maria Cristina V. Biazus[4], Elizabeth L. G. Siqueira[2]

[1] Instituto Federal de Educação, Ciência e Tecnologia Fluminense, Campos dos Goytacazes, Brazil
[2] Institutos Superiores de Ensino do CENSA, Campos dos Goytacazes, Brazil
[3] HAMK University of Applied Science, Hämeenlinna, Finland
[4] Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil

Email: andreuebe@gmail.com, brian.joyce@hamk.fi, cbiazus@ufrgs.br, bethlandim99@gmail.com

Abstract

The innovative assessment method for an entrepreneurship class under Project-based Learning (PBL) approach has been functioning since 2015's second semester at a Business Administration undergraduate course of a private university in the municipality of Campos dos Goytacazes in Rio de Janeiro state, Brazil.

This PBL methodology was implemented in the Brazilian college as an experimental adaptation of a learning model usually adopted in Finland. The process required substantial changes in the teaching/learning methods and methodologies and had a significant impact on students´ learning and motivation.

In this first edition of an entrepreneurial class under the PBL methodology as an innovative experience, it was aimed to verify the results about the student's PBL experience. The final student's assessment method from this learning experience was made in two ways: firstly, in the traditional way using a business plan quality analysis and secondly, through an peer assessment learning perception.

The paper presents the overview concepts of PBL applied to entrepreneurship in managerial undergraduate classes. In addition, the adopted assessment methodology is presented. Finally, the merits of the new assessment method learned in Finland are discussed from surveys results and workshops organised as part of class assessment.

The results indicated that the PBL approach applied to college entrepreneurship classes were profitable, as well as the effectiveness of the peer assessment method.

Keywords: Assessment Method; PBL; Business Management Learning; Learning Model.

1 Introduction

The recent growing interest about formative assessment approach indicates the changes that began at the end of the 20th century. Traditional approaches focussing on summative assessment did not necessarily promote learning. In the best cases, summative assessment is used as a unique approach for student feedback for teachers, educational institutions and students themselves concentrating on how much information students have memorised from subject package as a whole.

From a 2014 entrepreneurship class on business management private college in Brazil, students had the opportunity to experience how to develop a business plan under a Project Based Learning (PBL) approach. PBL is a learning approach where students can develop new personal and professional skills from a real-life situation.

The PBL approach adopted in the entrepreneurship classroom at the college has been unusual since traditionally a brick-and-mortar/expositive classroom has been adopted. Traditionally the students had memorised the business plan's parts and had been assessed in a summative approach only. A great motivation to change the learning approach was to blend an unedited learning approach to entrepreneurship subject while maintaining the same traditional assessment approach. From this, an adoption of this peer assessment approach was considered. The challenge of changing the learning process and assessment in an entrepreneurship classroom has required the development of a specific methodology described in this paper.

The structure of this paper is as follows. First, we discuss Project Based Learning (PBL) concepts followed by discussions about assessments approach. Next the methodological development and implementation of Peer Assessment (PA) in the PBL classroom are explained. Finally, the results and its analysis as well as conclusions are laid out.

2 Project Based Learning (PBL)

The Project Based Learning (PBL) approach comes from the idea that learning is most effective when students have the opportunity to experience the theory into practice. PBL can be identified as a student-centred approach that promotes engagement among students in an investigative, collaborative and experiential learning way. (Morgan, 1983; Krajcik et al., 1999).

Learning in PBL becomes more significant since the internal learning ambiance of academia connects with the external ambiance of social, political and environmental processes by a "real-world" and motivating learning tasks (Harmer and Stokes, 2014; Bell, 2010).

These concepts come from the Constructivism proposed by John Dewey focused on a learning-by-doing approach, since teaching is not a knowledge transfer from teacher to students but students' self-knowledge construction guided by the teacher (Biggs and Tang, 2007, Hickman et al., 2009).

From these concepts, collaboration and group work are the core of PBL students' learning activities (Harmer and Stokes, 2014; Von Kotze and Cooper, 2000), so teamwork is the most challenging element of a student's project work (Stauffacher et al., 2006; Frank and Barzilai, 2004).

Additionally, PBL's advantage to students' learning are deep learning, using the application of theoretical concepts and principles to solve real-problems, developing critical and proactive thinking since students need to formulate plans and assess solutions (Blumenfeld et al., 1991). Further advantages are improvement of socialisation, communication, collaborative skills among students (Hadim and Esche, 2002) and active learning promotion among students since they need to create realistic products or presentations from prior knowledge has retained (Felder et al., 2000, Jones et al., 1997; Thomas et al., 1999).

Thomas (2000) has identified a set of five criteria to capture the uniqueness of Project-Based Learning. The criteria are: (a) Centrality - This criterion has two corollaries. The first one is the idea that PBL is not a part of student curricula but it is the curricula as the central teaching strategy. Second is the idea that projects where students acquire knowledge outside their curricula cannot be considered as PBL. (b) Driving question - That means PBL has been thought around thematic units or the intersection of topics / disciplines, but also aims at driven questions that make the student's learning process from PBL really useful for an intellectual purpose; (c) Constructive investigations - Despite the goal-directed process involving inquiring (decision-making, problem finding) PBL must promote new understandings and skill in students. In other words if PBL activities represent no difficulty to students or there is no development of new skills it is not PBL but only tasks to be accomplished; (d) Autonomy - PBL is not a teacher-centred learning approach or a packaged learning process. In the context of Learning Complex Environment (Uebe Mansur, 2013), PBL has some complex aspects like retroactivity and recursivity that are important elements to promote of student's autonomy. (e) Realism - PBL promotes real-life challenges in comparison other learning approaches that are more close of academic-scenario or scenario-challenges and because it PBL increase the student's feeling of authenticity (Thomas, 2000)

3 Assessment Approaches

According to Boud (1995) in education assessment methods there are more bad practices and ignorance than significant issues. The effects of these bad practices are one of most potential aspects of learning process since they increase the students' problems for those who want to graduate and cannot avoid bad assessments effects as they avoid bad teaching effects. Some bad effects on students are loss of confidence and self-esteem when they dislike a subject.

Michael Scriven's (1967) has proposed a distinctive concept between formative assessment and summative assessment. For him the first one is feedback support for students' learning endeavours such as teacher teaching, and the second is a summative judgment for accreditation or certification. In a different way from Scriven's dichotomic point of view, Boud (1995) reinforces that both assessment concepts are inseparable.

Assessment is a feedback message about students that should be about learning. Consequently, students will adopt different approaches in different studying circumstances. So good assessment is not only an issue of finding an "appropriate" method but it is about the tutor and students engagement in a relational process as learning in its whole (Boud, 1995; Ramdsen, 1987)

Usually assessment methods are focused on the scope of how much content a student can memorise as if it would be the most important issue in the learning process. According to Boud (1995, p2) "The perceptions and interactions of a student are more important to learning than what staff take for granted as the 'reality' of the assessment. These perceptions cannot be assumed: they are only available from the students themselves."

Aslo, Andrade and Du (2007, p.160) state that self-assessment is a "(...) process of formative assessment during which students reflect on and evaluate the quality of their work and their learning, judge the degree to which they reflect explicitly stated goals or criteria, identify strengths and weaknesses in their work, and revise accordingly". Self-assessment differs from peer assessment once the first one does not mandatorily require students to provide either feedback to their pairs.

Meanwhile Falchikov (2007, p.132) writes, "Peer assessment requires students to provide either feedback or grades (or both) to their peers on a product or a performance, based on the criteria of excellence for that product or event which students may have been involved in determining"

Spiller (2012, p.2) reports that the growing interest in peer assessment "(...) is partly driven by changing concepts of teaching and learning". The author considers that these changing concepts come from needs to drive the education process towards a more constructivist approach using dialogical, collaborative and co-construction student behaviour. In this way, designing student-centred assessment opportunities is as important as designing classroom learning opportunities despite design and implementation of assessment tasks are usually neglected. This negligence promotes a teacher-centred approach in assessment design resulting in nonsense tending of teacher's ownership assessment despite a student-centred classroom learning design (Spiller, 2012).

4 Applying PA in PBL

In 2014´s second half, the author has taken learning and teaching expertise from an immersive training in Finland´s universities of applied science. The Brazilian CNPq has sponsored this training to Brazilian teachers. In 2015, from this Finland´s training the author developed some pedagogical experiments in his entrepreneurship classrooms seeking alternative paths to traditional brick-and-mortar approach.

In the traditional learning approach, the students passively listen and memorise about how to make a business plan. Further, the assessment method is focused in a summative and content-centred approach. Self-conduction of his/her own knowledge construction as soon as peer or self-assessment is usually almost unthinkable.

In a trying of changing this pedagogical scenario, the experiment took place among 27 students from different ages in 2015´s second semester in an entrepreneurship classroom. Students from different undergraduate courses have been involved in the experiment: Business Administration and Production Engineering.

Project Based Learning (PBL) has been chosen as the student-centred learning approach. As initial step, the students were invited to freely self-organise in seven teams without a predetermined number of members. The number of seven teams was mandatory since it is the same numbers of parts of a business plan.

After this initial step, the students had the opportunity to decide among themselves about strategies for the business plan development. The team members decided that each team would be responsible for a different part of the business plan and its oral presentation. As the students were free to decide about assessment steps,

they also decided that a peer and self-assessment would happen only after delivering the business plan document and after oral presentation. Since the formative assessment occurred by peer and self-assessment approach, the summative assessment occurred by a content analysis from the business plan.

The developing of a questionnaire to formative assessment was not an easy task since it was not possible to find a model that well fit to demands of the research. Because this challenge the final model presented below comes from expertise gathered from different universities. Contributions from a pilot experiment made by Fernando Santana Pacheco researcher from Instituto Federal de Santa Catarina (Brazil), as theoretical knowledges shared by Brian Joyce and Essi Ryymin, researchers from HAMK University of Applied Science in Finland were essential to the final model questionnaire.

Table 1 - Peer Assessment Model Questionnaire

This assessment shall be made together team members. The assessment's goal is to acquire the qualitative perception of your learning according theorectical concepts as your developed personal and professional abilities.

Criteria	General Score (0 a 10)	Self Engagement (0 a 100%)	Learning Details
Planning			
Organisation of tasks and activities			
Management			
Steps control			
Whole view of business plan			
Seizure of Marketing knowledge			
Seizure of Accountability knowledge			
Seizure of Operational knowledge			
Teamwork effort for written report			
Teamwork effort for lecture			
Participation at activities development			
Participation in the meetings			

My Global self score: _____

Related to questionnaire, the first column refers to the criteria related to the students´ tasks. In the second column, the team as whole would assess how its involvement on the tasks in a scale happens, from zero to 10. This score would be the same for all team members despite students having their own questionnaire. In third column each team member would self-assess in accordance his/her involvement. To this column, the percentage could differ among team members. In the fourth column, each student should highlight meaningful aspects in him/her learning in accordance with the first column's item. From these description in column fourth the students could self-reflecting about the learning process at same time that could avoid a random self-evaluation in column third.

The peer assessment process in column second deal with psychological aspects since the teams should made a self-assessment of each activity presented in the first column of questionnaire. This step had deal not only with group ethics but also with morality, since the team presented his part of a business plan to cohorts, in oral presentation. Since in column third where the student had to self-assess, the same ethical and moral aspects were deal by student but now in an individual point of view.

From peer and self-assessment the result analysis has present some important feedback. The analysis process had two corollaries: a quantitative approach where the numerical results had been percentage analysed as well as a qualitative analysis where the results were analysed in convergence of peer assessment aspects.

5 Results

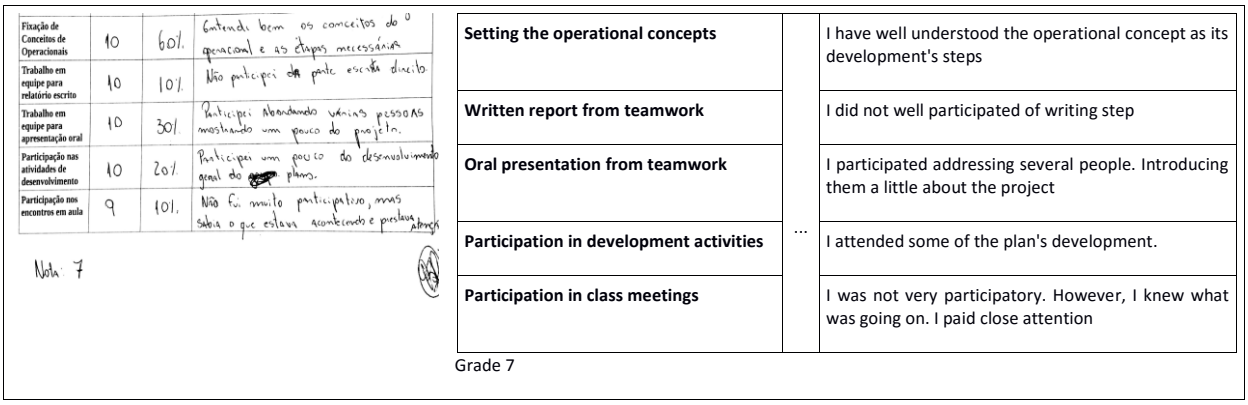
For peer-assessment step the students was grouped in each team of business plan. Although dialogue and exchanging ideas was encouraged, the questionnaire was filled individually. From students that had participated on assessment, nine of them were from Marketing team, two students were from Strategic Planning team, five of them were from Finances & Accountability and ten students were from Operations team. One student who was responsible for executive summary did not participate in the peer assessment. From a range from 0 to 10, students assessed themselves. The score "6.0" is the minimum break point:

Table 2 - Student self-assessment

Team	Score						Total Students
	10	9.5	9.0	8.5	8.0	7.0	
Marketing	0	0	1	4	1	3	9
Strategic Planning	1	1	0	0	0	0	2
Finance & Accountability	0	0	2	3	0	0	5
Operations	1	1	0	1	3	1	9

In the Operations team, only nine students have been scored although there were 10 students. It had happened since one of them had not assessed herself/himself in the global score. It is possible to notice that even though students were free to assess themselves, the score concentration has occurred between 8.0 and 8.5. Team members like Marketing and Finance & Accountability even came to assign values 9.5 or 10.

In the figure below, it is possible to analyse some aspects that highlight the student commitment for the peer assessment. Despite the satisfactory team performance indicated in the second column, the student self-assessed on a poor engagement in items from first column. In the second item "Teamwork for final report", the student has given a 10% engagement in this task even though the team as a whole had self-assessed at the maximum score. The student has declared in the fourth column "I was not well participated from this teamwork task". Concerning the third item about public presentation the student has informed a 30% engagement declaring in fourth column "I had participated addressing several people showing a little about the project". In the fourth item, self-attributing 20% of engagement the student has declared: "I have participated a little in the general development of business plan". Finally, the student self-assessed as 7.0 in the global score and 10% of engagement in 5th item, declaring "I was not very participatory, but I knew what was going on and watching".



Fixação de Conceitos de Operacionais	10	60%	Entendi bem os conceitos do operacional e as etapas necessárias
Trabalho em equipe para relatório escrito	10	10%	Não participei da parte escrita do relatório
Trabalho em equipe para apresentação oral	10	30%	Participei abordando várias pessoas mostrando um pouco do projeto.
Participação nas atividades de desenvolvimento	10	20%	Participei um pouco do desenvolvimento geral do plano.
Participação nos encontros em aula	9	10%	Não fui muito participativo, mas sabia o que estava acontecendo e prestava atenção

Nota: 7

Setting the operational concepts		I have well understood the operational concept as its development's steps
Written report from teamwork		I did not well participated of writing step
Oral presentation from teamwork		I participated addressing several people. Introducing them a little about the project
Participation in development activities	...	I attended some of the plan's development.
Participation in class meetings		I was not very participatory. However, I knew what was going on. I paid close attention

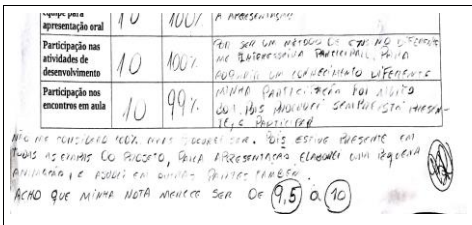
Grade 7

Figure 1 - Evidence of students commitment for peer assessment

In the last sentence where student has declared that "However, I knew what was going on. I paid close attention" the adoption of "however" conjunction highlight that student got conscious by self-assessment together with her/his team about her/his lack of behaviour/engagement. Somehow, she/he needed to confront the conclusions of this reflection that caused her/him discomfort feelings since the justification.

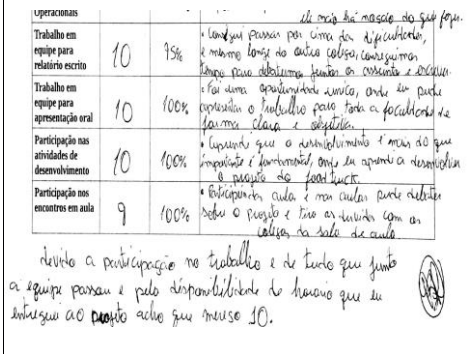
Continuing analysis, is possible to identify that some students has concluded that her/his engagement could point to high scores. The main arguments from students to asking for high scores were engagement in the

tasks and time dedicated to the project. In accordance to the first argument, one student has declared: "I do not consider myself 100%, but I had tried. Since I made myself present in all project steps. For oral presentation I have developed a short animation and I have cooperated in other parts too". The other one has declared: "From my engagement in the project and all teamwork as time available addressed to the project I believe that I deserve 10".



Participation in development activities	...	How it seems to be a odd learning method I got interested in participate in trying to acquire a special knowledge.
Participation in class meetings		My participation was quite good. Since I have tried to be always present and participative.

I do not consider myself 100% but I have tried to be. I have been present in all process steps. For (oral) presentation, I have prepared a short animation. Moreover, I have aided in other steps too. I believe my grade deserves to be from 9.5 to 10.

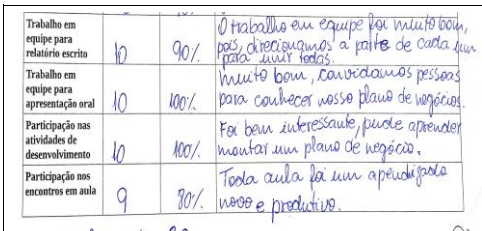


Written report from teamwork	...	I managed to overcome the challenges and even (physically) away from another colleague, we got time to discuss and write together.
Oral presentation from teamwork		It was a unique opportunity when I have introduced the project to whole university in a clearly way and objective.
Participation in development activities		I have learned that the development is more than important. It is fundamental. I have learned to develop the food truck project.
Participation in class meetings		From my participating on classes I could discuss about the project and clear up doubts about it together class mates.

Since my participation and everything have lived by the team as well as my time dedicated to the project I believe I deserve (a grade) 10.

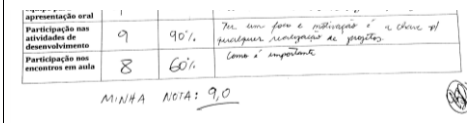
Figure 2 - Students asking for high scores in self-assessment

The global score requested by the students were not decreased at any time. However, in two different cases the global scores were increased once the student commitment was perceptibly higher than requested by her/him in her/his global score.



Written report from teamwork	...	The teamwork were well done. Because we steered the project's parts made by each one joining them together at the end.
Oral presentation from teamwork		Very good. We invited people to know more about our business plan.
Participation in development activities		It was very interesting. I could to learn how to develop a business plan.
Participation in class meetings		The whole class was a new learning and productive.

My grade: 8.0



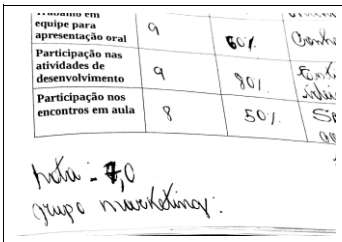
Participation in development activities	...	Having focus and motivation is the key to any project developing.
Participation in class meetings		How it is important.

My grade: 9.0

Figure 3 - Students self-assessed less than their real engagement

The reasons for global scores' shifting came from the perception that since students were knowing that global score was going to be his/her final score from formative assessment it was clear that students was committed with self-assessment step, not wanting to take advantage.

About the global score is interesting to highlight that in a first moment some students had self-assessed in a global score that was changed by her / himself later. Examples comes from a member of marketing team that had self-assessed in an upper score of 8.5 decreased later. Other example comes from another student that increased her/his global score from 6.0 to 7.0.



Oral presentation from teamwork	...
Participation in development activities	
Participation in class meetings	

Grade: 7.0 (adjusted from 6.0)

group: Marketing

Figure 4 - Student's reflection evidence on self-assessment

6 Conclusions

Despites some studies as reported by Kaufman and Schunn (2010) where negative perceptions from students to peer assessment were evident; we could not primarily identify any issue related with this negative aspects since the students had comfortably declared comfort feelings from peer assessment experiment.

We could identify as was shown in figure 1 (and its analysis), that students had self-recognised their commitment with the project and in some way maybe ashamed to attribute themselves a score far from the engagement perceived by their team. The results indicate that the PBL approach applied to college entrepreneurship classes were profitable, as well as the effectiveness of the peer assessment method.

Some improvements are demanded in PBL and assessment processes, once despite good results from formative assessment, a methodology is still demanded. Since formative assessment has a subjective approach and a quantitative final score is demanded as student score, this procedure of change a qualitative assessment to a quantitative score need to be incremented.

We can conclude that this first peer assessment experiment applied to an entrepreneurship class at a business management private undergraduate course was satisfactory and motivating to other experiments like the questionnaire improvements and procedures as applied to other classes from business management and other courses.

7 References

Andrade, H. & Du, Y. (2007). Student responses to criteria-referenced self-Assessment. Assessment and Evaluation in Higher Education, 32 (2), p. 159-181

Bell, S. (2010) Project-Based Learning for the 21st Century: Skills for the Future in The Clearing House: A Journal of Educational Strategies, Issues and Ideas, 83 (2). p 39-43.

Biggs, J. and Tang, C. (2007), Teaching for quality learning at university: what the student does, 3rd ed, Society for Research into Higher Education & Open University Press, Maidenhead. Blumenfeld, P.C., Soloway, E., Marx, R.W., Krajcik, J.S., Guzdial, M. and Palincsar, A. (1991), Motivating project-based learning: sustaining the doing, supporting the learning., Educational Psychologist, vol. 26, no. 3 & 4, p. 369-398.

Blumenfeld, P. C., Soloway, E., Marx, R. W., Krajcik, J. S., Guzdial, M. & Palincsar, A. (1991) 'Motivating project-based learning: Sustaining the doing, supporting the learning'. Educational psychologist, 26 (3-4). pp 369-398.

Boud, D. (1995) Assessment and learning: contradictory or complementary? in Assessment for Learning in Higher Education. 35-48. London: Kogan

Falchikov, N. (2007). The place of peers in learning and assessment. In D. Boud & N. Falchikov (Eds.), Rethinking assessment in higher education: Learning for the longer term. London: Routledge. p. 128-143

Frank, M.; Barzilai, A. (2004) Integrating alternative assessment in a project-based learning course for pre-service science and technology teachers. Assessment & Evaluation in Higher Education, 29 (1). p 41-61.

Felder, R.M., Woods, D.R., Stice, J.E. and Rugarcia, A. (2000), The future of engineering education II: teaching methods that work, Chem. Engr. Education, vol. 34, no. 1, p. 26-39.

Hadim, H.A., Esche, S.K. (2002),'Enhancing the engineering curriculum through project-based learning in Proceedings of the 32nd ASEE/IEEE Frontiers in Education Conference, Boston.

Hickman, L. A.; Neubert, S.; Reich, K. (2009) John Dewey between pragmatism and construtivism. New York: Fordham University Press.

Jones, B. F., Rasmussen, C. M., and Moffitt, M. C. (1997). Real-life problem solving: A collaborative approach to interdisciplinary learning. Washington, DC: American Psychological Association.

Kaufman, J.H., Schunn, C.D. (2010) Students' perceptions about peer assessment for writing: their origin and impact on revision work. Pittsburg: University of Pittysburg. http://www.lrdc.pitt.edu/schunn/research/papers/KaufmanSchunn-StudentPerceptions-.pdf

Krajcik, J.S., Czerniak, C.M. and Berger, C.F. (1999), Teaching science: a project-based approach, New York: McGraw-Hill College.

Harmer, N., Stokes, A. (2014) The benefits and challenges of project-based learning: A review of the literature. Plymouth: PedRIO

Morgan, A. (1983) Theoretical Aspects of Project-Based Learning in Higher Education. British Journal of Educational Technology, 14 (1). p 66-78.

Ramsden, P. (1987). Improving teaching and learning in higher education: the case for a relational perspective. Studies in Higher Education, 12, p. 275-286.

Scriven, M. (1967). The methodology of evaluation. R.W. Tyler, R M. Gagne, M. Scriven (eds.), Perspectives of curriculum evaluation, pp.39-83. Chicago, IL: Rand McNally.

Spiller, D. (2012). Assessment Matters: Self-Assessment and Peer Assessment. New Zealand: University of Waikato. Retrieved: http://www.waikato.ac.nz/tdu/pdf/booklets/9_SelfPeerAssessment.pdf

Stauffacher, M., Walter, A.I. Lang, D.J., Wiek A. and Scholz, R.W. (2006). Learning to research environmental problems from a functional socio-cultural constructivism perspective: the transdisciplinary case study approach. International Journal of Sustainability in Higher Education 7(3): p. 252-275.

Thomas, J. W. (2000) A review of research on project-based-learning. California: Autodesk Foundation. http://www.bobpearlman.org/BestPractices/PBL_Research.pdf

Thomas, J. W., Mergendoller, J. R., and Michaelson, A. (1999). Project-based learning: A handbook for middle and high school teachers. Novato, CA: The Buck Institute for Education.

Uebe Mansur, A.F. (2013) Use of Social Networks and Complexity for Enhancement of Academic Learning in Supervised Internships: An Internalization by Doing. Nuevas Ideas en Informática Educativa.

Von Kotze, A. & Cooper, L. (2000) Exploring the transformative potential of project-based learning in university adult education. Studies in the Education of Adults, 32 (2). p 212-228

Developing and assessing the learning pathway 'Problem-Solving and Design'

Marjolijn Burman[1,2], Elsje Londers[1,2], Inge Van Hemelrijck[1,2], Yolande Berbers[1]

[1] Faculty of Engineering Science, KU Leuven, Leuven, Belgium
[2] Leuven Engineering and Science Education Centre, KU Leuven, Leuven, Belgium

Email: marjolijn.burman@eng.kuleuven.be, elsje.londers@eng.kuleuven.be, inge.vanhemelrijck@eng.kuleuven.be, yolande.berbers@eng.kuleuven.be

Abstract

The Faculty of Engineering Science at KU Leuven has over ten years of experience in letting students develop problem-solving and design competences. Within the learning pathway 'Problem-Solving and Design' (PS&D) students collaborate in small groups to solve real-life engineering problems. This pathway consists of four courses that are spread over the three years of the Bachelor's programme and is based on three Design Pyramids. The central one shows the different aspects of the design process and rests on two smaller pyramids: communication and teamwork on the one hand and project management on the other (Berbers, Londers, Froyen, Ceusters, De Jong, & Van Hemelrijck, 2015).

However, a lack of feedback on the design competences was stated by the students and indicated in quality review reports (de Jong, Londers, Van Hemelrijck, & Froyen, 2014). For this purpose, two steps were taken to make the competences that students develop during PS&D more transparent and develop a tool to assess them. A first step was making the content of each part of the design process explicit, resulting in a table of objectives. Subsequently, rubrics were formulated according to the different components of the Design Pyramids. In this way, students will receive more information than merely a numeric score.

The following paper gives an overview of the objectives and reports on the rubrics that were developed. Future plans are also discussed, such as training the coaches of PS&D to guarantee a similar assessment and stimulating the students to use these rubrics during self- and peer-evaluation.

Keywords: Learning Pathway; Problem-Solving and Design; Engineering Education; Rubrics.

1 Introduction

The Faculty of Engineering Science at KU Leuven has over ten years of experience in letting students develop problem-solving and design competences. Within the learning pathway 'Problem-Solving and Design' (PS&D) students collaborate in small groups to solve real-life engineering problems. This pathway consists of four courses that are spread over the three years of the Bachelor's programme (Heylen, Smet, Buelens, & Vander Sloten, 2007). PS&D1, the first course of the pathway, takes place in the first semester, PS&D2 in the second and PS&D3 in the third semester of the Bachelor. In the third year, the fourth course is given (Berbers et al., 2015).

The learning pathway PS&D is characterised by an increasing complexity on the one hand and a decreasing guidance on the other. During PS&D1 for instance, the students receive a problem definition and guidelines that make clear what they should do each session they come together. In PS&D2, the assignment is formulated in a more open way and planning and timing become more the responsibility of the students themselves.

The pathway is based on three Design Pyramids (Figure 1). The central one shows the different steps of the design process and rests on two smaller pyramids: communication and teamwork on the one hand and project management on the other (Berbers et al., 2015). The arrows in the main pyramid stress that designing is not a linear process but rather an iterative learning process.

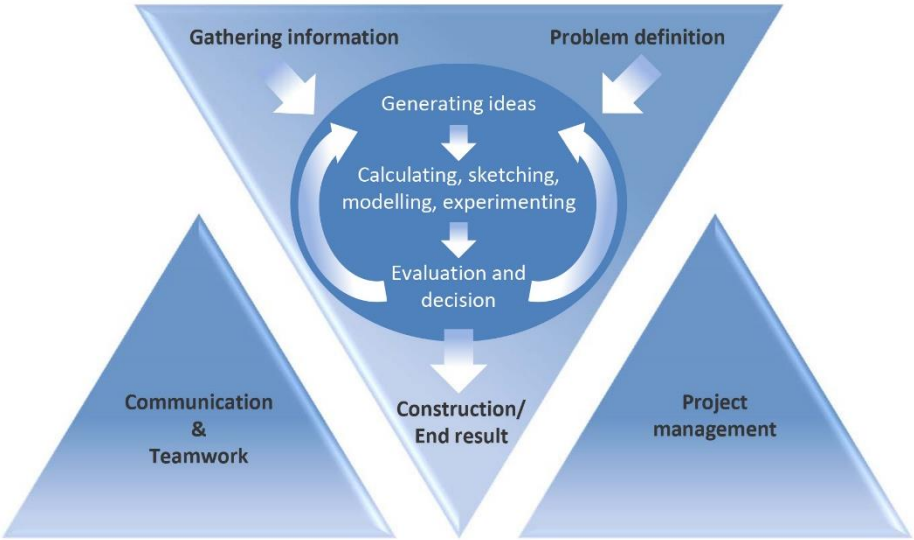


Figure 1. Design Pyramids.

However, providing the teams and individual students with feedback on their learning outcomes needed further improvement (Heylen, Smet, Buelens, & Vander Sloten, 2007). This lack of feedback on the design competences was stated by the students and indicated in quality review reports (de Jong, Londers, Van Hemelrijck, & Froyen, 2014). In addition, the coaches of PS&D did not have an explicit shared vision regarding the different steps of the competences within the learning pathway. The goal of this paper is to make the competences that students develop during PS&D more transparent and create a tool to assess them. To this end, two steps were taken.

2 Step 1: objectives

The visualisation of the design process in Figure 1 has the advantage that it presents all the different aspects that define PS&D in one clear image. Since this representation does not show how the problem-solving and design competences evolve exactly within the learning pathway, the content of each step of the design process was made explicit. This resulted in an overview of objectives that determines the competences that students will develop gradually within PS&D. Table 1 focuses on the competence 'problem definition' that is located at the top right of the central pyramid in Figure 1. It illustrates how this element was translated into objectives for the first three PS&D courses of the learning pathway. Subsequently, objectives were formulated according to all the components of the Design Pyramids.

Table 1. Objectives according to the competence 'problem definition'.

Aspects of Design Pyramids	PS&D1	PS&D2	PS&D3
1. Problem definition • Translate the core of the task/question/problem into a problem definition	Understand the core of the design task. Distinguish the important from the more trivial aspects.	Understand the core of the design task. Identify the core of the task from a technically defined problem definition.	Identify a problem definition from an open, but rather structured question from the perspective of the customer.
• Clarify design specifications, including relevant constraints	Clarify design specifications based on a given problem definition and an example.	Translate a given technically formulated problem definition into design specifications.	Translate a problem definition into design specifications, taking relevant constraints into account.

The overview of objectives can help coaches and students to know the minimal expected outcomes during each project. Furthermore, it can facilitate both the creation and the evaluation of new projects to what extent project proposals fit into PS&D. It is possible that one project seems to fit in several PS&D courses. Then, the table with objectives should clarify the different aspects: how much guidance can be offered, what are the expectations regarding the final results, and so forth.

3 Step 2: rubrics

In order to make the competences that students develop during PS&D more transparent, rubrics were formulated according to the different elements of the Design Pyramids. A rubric has three essential features: evaluation criteria, quality definitions and a scoring strategy (Popham, 1997, in Reddy & Andrade, 2010). The first feature, the evaluation criteria, consists of the aspects of the Design Pyramids that students should acquire during the learning pathway PS&D. Regarding the quality definitions, four degrees are used: excellent, good, fair and poor. For the third feature, the scoring strategy, the four quality degrees refer to the levels of achievement of respectively greatest distinction (≥17/20), distinction (≥14/20), tolerable (≥8/20) and failed (≤7/20). However, the rubrics are not developed to assess students and give them numeric scores but rather to provide feedback and use the rubrics as a guideline during formative evaluation. If students receive a 'fair' or 'poor' grade on a certain competence, this should be an indication to learn which aspects still need some improvement, to formulate learning goals and to be a stimulation to take actions.

The left column of Table 2 shows all the elements of the Design Pyramids. The other columns refer to the four quality degrees. These rubrics are applicable to the course PS&D3.

Table 2. Rubrics.

Aspects of Design Pyramids	Excellent	Good	Fair	Poor
1. Problem definition • Translate the core of the task/question/problem into a problem definition • Clarify design specifications, including relevant constraints	The task is translated into a clear problem definition. Relevant (sub)goals are clearly formulated. Clear design specifications are present, with relevant prioritising. All relevant criteria and limitations are included, with attention for constraints.	The problem definition points out most important goals of the problem. The most important specifications, criteria and constraints are included.	The core of the problem is not completely clear from the problem definition. Specifications and criteria are not clear or some important aspects lack/are incorrect.	The problem definition includes few relevant goals and/or does not include the core of the task.
2. Gathering information • Search and efficiently use relevant scientific and technical information • Refer correctly	During each phase of designing, relevant information from several relevant sources is used. The reliability of the sources is examined and all references are correct.	Sufficient relevant information is found and used in the design process. Students are provable critical regarding the reliability of sources. References are mostly correct.	Information is based on limited sources and/or the link between the found information and the implications for the design is not always clear. More information is needed for the reliability of sources and/or references.	The found information is too limited and/or not relevant enough for the design task. Not enough attention is paid for the reliability and references.

Aspects of Design Pyramids	Excellent	Good	Fair	Poor
3. Generating ideas • Be creative and innovative, develop several alternatives and analyse them • Assess the alternatives, taking into account design specifications and constraints	Several (creative) ideas are considered and analysed. During the assessment of alternatives, customer requirements, constraints and limitations are structurally taken into account.	Several alternatives are considered. The most important customer requirements and constraints are taken into account to analyse the alternatives.	Several ideas are generated, but only existing solutions are considered/the alternatives show little creativity. The relation with the design specifications is not taken sufficiently into account.	Insufficient attention is paid to systematically generating ideas and assessing alternatives (e.g. the focus is only on one solution or the conclusions and arguments for a design are unclear).
4. Calculating, sketching, modelling, experimenting • Translate the design proposal and components into relevant sketches	Sketches show the core and important details of the design. They clarify an oral explanation.	Clear and readable sketches that show the design and/or most important details.	Sketches are not always clear or important parts are lacking.	No or insufficient sketches are present.
• Use the techniques right to model a (detail of a) design	Make relevant models and/or schemes independently and use the most appropriate techniques.	Make relevant models and/or schemes and use the most appropriate techniques (under guidance).	Sometimes, the wrong techniques are used to model a (detail of a) design.	The wrong techniques are often used to model a design.
• Design and perform relevant experiments/measurements to optimise the design	Starting from the problem definition, relevant measurements and/or experiments are designed and performed efficiently.	Mostly correct measurements and/or experiments are used for essential aspects/theories of the design.	There is no clear plan or no clear relation between the experiments/ measurements and the design; measurements are too scarce.	Experiments or measurements are done inaccurately: the goals are not clear enough.
• Pay attention to safety and material	Measurements/ experiments are done according to the safety prescriptions. The work with material, equipment and instruments is done carefully.	Measurements/ experiments are done according to the safety prescriptions. The work with material, equipment and instruments is done well.	More attention needs to be paid to safety and/or working with material, equipment and instruments.	There is a lack of attention for safety and/or working with material, equipment and instruments.

Aspects of Design Pyramids	Excellent	Good	Fair	Poor
5. Evaluation and decision • Adapt the design based on the results of the measurements and experiments	Excellent conclusions and translation of test results to a final design (the adaptations and recommendations).	Test results and conclusions are mostly taken into account for adaptations to or recommendations for the end result.	Some conclusions are taken into account for adaptations to or recommendations for the final design.	Conclusions are lacking and/or are not clearly related to the design or the problem definition.
• Motivate and critically evaluate results, process and choices made	Excellent motivated choices and insight into (dis)advantages of each decision. Critical, constantly looking for improvement.	Can motivate most decisions. Critical, mistakes are searched for and improved, on request.	Some choices made can be motivated on request, but few insight into (dis)advantages. Often not critical, not clearly focused on improvement.	No clear arguments for the choices made. Not critical, mistakes/ problems are not seen or improved.
6. Construction/End result • Construct a final product that fits the demands of a design	The final product fits certainly the demanded criteria and has extra functionalities.	The prototype is well-constructed and has a good functionality.	The prototype is present, but the functionality is unstable and/or too limited.	The design is clearly not yet finished or not enough attention is paid to the design (e.g. the prototype does not work).
• Be aware of the possibilities and limitations of the final result	Clear analysis of the final product, including necessary next steps for possible implementation in practice.	Possibilities and limitations of the final product are explained correctly.	Analysis of the final product is limited/not critical enough.	Final results are analysed incorrectly or unclearly. Mistakes are not noticed or improved.
• Be aware of the design process • Reflect on one's own learning process	Have insight into the Design Pyramid and be aware of different design theories. Can reflect spontaneously on the development of design competences and set learning goals, related to the Design Pyramid.	Have insight into the Design Pyramid. Can reflect independently on the development of design competences and set learning goals, related to the Design Pyramid.	Have only limited insight into the Design Pyramid. Can reflect on the development of design competences or set learning goals on request, but these are not related to the Design Pyramid and/or in depth.	Have no insight into the Design Pyramid. Cannot reflect on the development of design competences or set learning goals, related to the Design Pyramid.
7. Teamwork • Be aware of own role and responsibilities within the team	Students can handle their own strong and weak aspects and those of other team members independently.	Students can usually handle their own strong and weak aspects and those of other team members.	Students have difficulties pointing out their own strong and weak aspects and those of other team members, and/or handling them.	Students cannot point out their own strong and weak aspects and those of other team members.

Aspects of Design Pyramids	Excellent	Good	Fair	Poor
• Work constructively in group	Students work constructively in team (respect agreements, work effectively, etc.).	Students mostly work constructively in team (respect agreements, work effectively, etc.).	Students have difficulties respecting agreements, work effectively, etc.	Students do not work constructively in team (e.g. do not respect agreements).
8. Communication • Write a report about the process and results	The final report of the design is technical scientific, correct and clear.	The final report of the project is technical scientific, but has some mistakes or can be more clear.	The final report is clear, but not technical scientific and/or complete.	The final report is not technical scientific, clear and/or complete.
• Give an oral presentation for peers, the coach and costumer/others	The presentation is clear and interesting for peers, coaches and third parties.	The presentation is clear for peers, coaches and others.	The presentation is uncomplete and/or unclear for peers, coaches and others.	The presentation is uncomplete and unclear for peers, coaches and others.
9. Project management • Plan the project (time and human resources) and adjust it	The project is planned independently and realistically. The progress of the project is monitored critically and work methods are adapted where necessary.	The project is mostly planned independently and realistically. The progress of the project is monitored critically and work methods are adapted where necessary (on request).	The project is not completely realistic and needs correction of the coach. The progress of the project is not monitored independently.	The project is not realistic and needs correction of the coach. The progress of the project is not monitored independently.
• Have financial insight	The arguments regarding finance (e.g. cost of materials) are motivated.	The arguments regarding finance, material, etc. are mostly motivated.	The choices regarding finance, material, etc. are only partly motivated.	The financial choices regarding e.g. material cannot be motivated.

Generally, the level of quality was used to conceptualise the different rubrics. When will the students receive an excellent score for a presentation, what is missing if they receive a fair, etc.? Additionally, the different rubrics were phrased according to the number of times a certain behaviour was demonstrated (was it always present, often, sometimes or completely lacking?) or the amount of guidance that was needed (was the task done independently or on request?). Although it may seem that the rubrics are only useful at the end of a PS&D course, they can also be introduced as a preliminary or intermediate assignment. In this way, the students become aware of which problem-solving and design competences they should acquire during the learning pathway.

While developing the rubrics, attention was paid to an important aspect that was still missing in the Design Pyramids, namely 'Be aware of the design process' and 'Reflect on one's own learning process'. Since both aspects are important during the whole process and for the result of PS&D, it was categorised as a part of construction/end result in the middle pyramid. However, arguments can be given to see it as the basis for the three pyramids, since reflection is also important for team work and project management (the left and right pyramid).

4 Discussion and future plans

The Faculty of Engineering Science aims at making its students aware of the competences they are acquiring during the learning pathway PS&D. Hence, the rubrics can stimulate the students to use the rubrics for self- and peer assessments (de Jong, Londers, Van Hemelrijck, & Froyen, 2014). In this way, the rubrics can be part of a student-centred approach to assessment and "have the potential to help students understand the targets for their learning and the standards of quality for a particular assignment, as well as make dependable judgments about their own work that can inform revision and improvement" (Reddy & Andrade, 2010, p. 437).

Furthermore, as Reddy and Andrade (2010) state in a review about the use of rubrics in higher education, the rubrics' quality should be examined, by verifying its reliability and validity. To guarantee that the coaches of PS&D assess the students in the same way, they will be trained to use these rubrics. This training can be integrated in the already existing educational programme for PhD students with an additional teaching assignment, which focuses among others specifically on the course PS&D (Burman, Van Hemelrijck, Londers, & Berbers, 2015). Since reliability or a common interpretation of student performance is a necessary but not sufficient condition of validity, the rubrics' appropriateness of the language and content need to be discussed in depth with representatives of PS&D as well. During the formulation of the different objectives and rubrics, several coordinators and coaches of the first three courses of PS&D were asked to give input on the various aspects of the Design Pyramids. Although they did not always share the same vision regarding the design process and they often rephrased the objectives, their feedback and revision of each other's input was valuable.

In conclusion, the rubrics will be used both by the coaches of PS&D and the students. The coaches can use the rubrics to give students feedback, both on an individual and a group level, instead of using the rubrics only for a summative evaluation. Besides receiving more information than merely a numeric score, the students can assess themselves and their peers in order to learn about and improve their problem-solving and design competences. In the future, a portfolio will be introduced to let them reflect on these competences.

5 References

Berbers, Y., Londers, E., Froyen, L., Ceusters, J., De Jong, M., & Van Hemelrijck, I. (2015). Learning Pathway "Problem Solving and Design" at the Faculty of Engineering Science of the KU Leuven. In N. van Hattum-Janssen, R. M. Lima, D. Carvalho, S. Fernandes, R. M. Sousa, F. Moreira, ..., & D. Mesquita (Eds.), *Proceedings of Seventh International Symposium on Project Approaches in Engineering Education* (pp. 64-70). Aalborg Universitetsforlag.

Burman, M., Van Hemelrijck, I., Londers, E., & Berbers, Y. (2015). *How to coach engineering project-based learning?* Proceedings of the 43rd SEFI 2015 Annual Conference, Orléans.

de Jong, M., Londers, E., Van Hemelrijck, I., Froyen, L. (2014). Towar*ds an aligned design approach for the engineering curriculum*. Proceedings of the 42nd SEFI Annual Conference 2014, Birmingham.

Heylen, C., Smet, M., Buelens, H., & Vander Sloten, J. (2007). Problem solving and engineering design, introducing bachelor students to engineering practice at K. U. Leuven. *European Journal of Engineering Education, 32*(4), 375-386. doi: 10.1080/03043790701337114

Reddy, Y. M., & Andrade, H. (2010). A review of rubric use in higher education. *Assessment & Evaluation in Higher Education*, *35*(4), 435-448. doi: 10.1080/02602930902862859

Colibri: An International Blended Learning Experience based on Real-World Problems

Jens M. Pedersen[1], M. Şükrü Kuran[2], Jan Frick[3], Lea Mank[4]

[1] Department of Electronic Systems, Aalborg University, Aalborg, Denmark
[2] Abdullah Gul University, Kayseri, Turkey
[3] University of Stavanger, Stavanger, Norway
[4] Atene KOM, Berlin, Germany

Email: jens@es.aau.dk, sukru.kuran@agu.edu.tr, jan.frick@uis.no, l.mank@atenekom.eu

Abstract

Colibri is a European project funded by Erasmus+, where seven universities, a governmental organisation and two enterprises work together and explore new and innovative approaches to teaching. As part of the project we offer a joint course during the spring semester which was followed by 30 students in 2015. It contains both course and project activities. In this paper we describe our experiences from the project work, from the initial formulation of the project problems by the companies, over the organisation of the seminars and virtual collaboration phase to the final exams.

The whole course was organised as follows: First there was a virtual kick-off meeting for all students and teachers. This was followed by a phase where students studied different modules online. Each student chooses an individual combination of modules that fits his/her background while also supporting the later project work. After the online modules, the students and teachers all meet physically for a week in Istanbul to finalize the modules and begin working on the real life projects provided by the enterprises. Then there was a period of virtual collaboration in the groups followed by the final seminar in Riga where everyone (students, teachers, and company representatives) met to finalize the projects, prepare for presentations/exams, and conduct examinations.

Overall, the project was successful and received positive evaluations from the students, particularly regarding the international and interdisciplinary dimensions. On the other hand, we also learned how important it is to facilitate the collaboration, group work, and project planning during the first physical seminar. We found that it is both challenging and important to be very explicit about what exactly is expected from the students, as both students and supervisors have differing understandings of what a project is. Discussing the learning objectives with the students to obtain a common understanding can be a useful tool.

Keywords: Project work; Problem Based Learning; Blended Learning.

1 Introduction

The Colibri project (Colibri, 2016), (Lopez et.al, 2015) is Strategic Partnership funded by Erasmus+, which aims at tackling some of the main challenges the European educational system is facing (European Commission, 2011) including:

- The need for enhancing the quality and relevance of the learning offer in education by developing new and innovative approaches, and by supporting the dissemination of best practices.
- Increase labour market relevance of learning provision and qualifications.
- Promote the take-up of innovative practices in education by supporting personalised learning approaches and collaborative learning, by making use of ICT and Open Educational Resources, and by exploring the use of blended and virtual mobility.

As part of the project, a joint course based on blended learning has been developed between all the participating organisations: 7 universities from different countries, 1 governmental organisation, and 2 private companies. There is a Colibri course during the spring semester in three consecutive years and each year it is adjusted according to comments from the previous year in order to improve and try out new methodologies. The course is entitled "Future Internet Opportunities", and focus on exploring business, technical and social aspects of Future Internet Opportunities. The course consists of both course modules, where each student

follows his individual track/combination, and project work where students with different profiles work together on solving a real-life problem proposed by the involved companies.

The course is being followed by students from all 7 universities, and consist of the following phases:

- A development phase (October - February), where the content of the course is developed in collaboration between staff from all organisations. This includes a one-week teacher training seminar with focus on development of teaching methods and exchange of knowledge on best-practices.
- A virtual kick-off meeting in February, where the students are introduced to the course and each other.
- A First virtual phase, running from February through April, where the students follow a number of modules based on blended learning. We offer 10 different modules, where each can be taken at introductory, basic or advanced levels. All students follow all modules at introductory level, and then chooses a set of modules to be taken at basic and advanced levels. The topics include more technical topics such as wireless networks and future Internet architecture, more usability focused topics such as Information systems and Services and applications, and more business oriented topics such as Enterprise architecture and Entrepreneurship. The modules are mainly based on online learning materials, but some also make use of virtual peer learning.
- A midway seminar in April, where the modules are finalised and the students introduced to the groups and project work. The seminar is physical, so all students and teachers/supervisors are gathered for five days. The first days focus on finishing the modules, along with training in group work, whereas the last days focus more on the problem based project work in groups.
- A second virtual phase, running from April through July, where the students work on the projects virtually.
- A project seminar in July (5 days), where all students, supervisors and company representatives would meet to finalise the projects and conduct the exams.
- The period from August to September is reserved for evaluation, documentation and dissemination.

The course counts as a 5 ECTS course, and thus the workload for the students is expected to be 140 hours, including preparation, self-study activities, seminars, project work and examination. In order to help align expectations with the students, we provided a suggestion of how the workload would be distributed with 4 hours for the virtual kick-off seminar, 41 hours for the modules, 35 hours for the midway seminar, 25 hours for the virtual project work, and 35 hours for the project seminar.

Colibri runs for three years, and so the cycle is repeated three times. Every year new tools and methods are used, and the course is adjusted according to the previous experiences. Both development of course material and blended learning activities is funded by Erasmus+ (Strategic Partnership framework). There is funding for a total of 4 students per country per year, so 28 students in total, but the first year two additional students participated from other funding sources.

In this paper, we will focus on describing the approaches with the projects, our learning points from the first year, and our ideas for adjustment in the second year. The paper is organised as follows: After the general introduction to Colibri in Section 1, we introduce the project approach in Section 2. Section 3 summarizes the feedback from students, teachers and companies, and Section 4 describes our learning points and suggestions for adjustments. Section 5 concludes the paper and summarizes our contributions.

2 The project approach

The basic idea has been to let students work together on real-world problems posed by real-world companies in groups with students of different nationalities and with different cultural and scientific backgrounds. The approach is inspired by how Problem Based Learning is carried out in Aalborg University (Kolmos et al., 2004) as well as the CDIO initiative (Crawley et al., 2007) implemented in UPC and experiences from RTU with self-organized student groups working on real-life problems (Kapenieks et al., 2002). Problem Based Learning in online settings is described and discussed in e.g. (Lajoie et al., 2014) and (Savin-Baden and Wilkie, 2006).

In Problem Based Learning, the problem formulation is the "driver" of the project, and based on this the students are responsible for choosing appropriate methods and tools in order to solve it. This requires the students to work rather independently. In Colibri this, including the process of understanding and narrowing down the problem formulation, is done in close collaboration with the academic and company supervisors each group is assigned. While the purpose of the project is to facilitate the learning of the students, it is important that the problems are highly relevant for the involved companies as this ensures a higher commitment, and the fact that the companies can get useful inputs/ideas/solution proposals is a key motivational factor for their participation in this kind of learning processes.

Compared to existing work, our main contribution lies in the international and blended approach where students work together across universities and disciplines through a combination of physical and virtual collaboration. In the following, the process from formulation of project proposals to exam and feedback received at the end of the course, is described.

2.1 Developing the project proposals

Within the project consortium there are two companies (Talaia Networks and Atene KOM) as well as a Greek governmental organisation (The National Hellenic Research Foundation, NHRF). Well ahead of the midway seminar, these organisations come up with 2-4 proposals each based on their own real problems/challenges/opportunities while at the same time respecting the learning objectives of the project. In this regard, NHRF acts as a collaboration partner with different smaller companies, and formulates problems together with these - in this way we were able to obtain problems from also smaller companies and start-ups. The project proposals were then reviewed, revised if needed, and finally accepted by the project coordinator together with the local organiser of the midway seminar. While the formal reason for this was to align the proposals with learning objectives and student backgrounds, it also allowed for a good dialogue and thus improved project proposals. One of the challenges we were facing in the process was to find the best trade-off between "real" problems and at the same time ensuring that all students would be able to contribute with their specific knowledge.

The problems to work on should not only be "real-life", but also fit into the learning objectives of the course, and thus the students would need to take into account technical, business and social aspects of Future Internet. In order to succeed, the students would need to work together and all contribute with their backgrounds including the modules they selected during the first virtual phase as well as the competences they had before starting with Colibri. Given the time frame of the project, it is not possible for the students to implement or build a solution, so at the end they are expected to develop and qualify concepts/ideas rather than final solutions. One example of a problem is from Talaia Networks, who is making network monitoring and visualisation solutions. They would like to design a strategy for extending their market from academic institutions to the private market, including e.g. identifying potential costumers, understanding their needs and which new features/functionality is needed, and develop a business model canvas.

2.2 Project selection process

Since the first part of the course (kick-off meeting and completing the modules) was entirely virtual, the students would meet each other for the first time at the midway seminar. We therefore chose to use the midway seminar to start off the project period including presentation of projects, forming of groups, and assignment of supervisors. In this way we could also properly introduce the students to problem based project work in groups, including project management, time planning, conflict resolution etc.

Presenting the projects in a physical meeting also made it possible to better clarify the requirements and expectations from the students. Doing so was actually more challenging than initially expected, since both students and supervisors from different traditions have different ideas of what a project is and what the students are expected to deliver; in particular, some universities are quite focused on problem analysis and the problem solution process, whereas others are more focused on task solving and implementation. In our experience, neither students nor staff are used to be explicit about these expectations, but build upon either an implicit understanding of what a good project is or by looking at previous project examples. We used the learning objectives to explain and discuss our expectations with the students.

There is an important process in forming groups and distributing or selecting the projects. In Aalborg University most often the students are responsible for forming groups and for selecting a project they would like to work on (there can be practical constraints and limitations). However, in this setting we need to keep in mind that the students don't know each other very well, that the students have different levels of experience with problem based project organised learning (some have formed groups before, some have not) and that the students only have limited time together to sort out disagreements and conflicts. Regarding the group formation, we also wanted each group to consist of students with different backgrounds and nationalities. Therefore, it was decided to create the groups administratively, and to announce the groups at an early stage of the midway seminar. This made it possible to also base some of the initial team-building exercises on the groups.

Regarding the group formation, a total of 8 groups were made, thus with 3-4 students per group. Each group would consist of people of all different nationalities, and with a diversity in technical and cultural backgrounds.

Regarding the project selection, we chose to do this randomly through a public draw. While this made the selection fair and transparent, it did not make it possible to assign projects based on interest or special knowledge/background available in the groups. But it did ensure that the students could start working on their projects straight away instead of first going through a project selection process, which could potentially lead to disagreements and conflicts, and where it might not be possible to assign all groups their favourite choice. The supervisor distribution was agreed upon between the supervisors just after the project distributed, based on supervisor knowledge/interest, and in a way so that supervisors would only supervise students not from their own university (i.e. a supervisor from UPC would supervise a group with only non-UPC students).

2.3 The project work in groups

The groups were announced on the second day of the midway seminar. In this way, the groups were working together during the second teambuilding exercise, and thus started to get to know each other. The third day included several elements related to the project work: The students had a workshop with introduction to group work including project management, time planning, group collaboration, intercultural communication and conflict resolution. While this was introduced through a short lecture, the main focus was on students reflecting and discussing together, role plays, and personality tests followed by discussions in the groups. It was an intense workshop, but very important since the students would have only little time together before starting the virtual collaboration. On the last two days of the seminar, the students were working on the project in groups with the main focus on problem analysis and on planning the virtual collaboration phase. At the end of each day, each group would make a pitch presentation of their progress (based on a list of requirements provided by the supervisors). During this time, the supervisors would be around to support the students. The time was also used for having supervisor seminars to discuss topics related to good supervision practices. We encouraged the students to also make use of other supervisors than their own, in order to benefit from the expertise knowledge available.

From previous Intensive programmes, e.g. (Pedersen et al., 2015) it was our experience that the exam form with presentations in front of all other students would be challenging for some of the students: For some it would be their first project based exam, their first presentation in front of an audience, and their first presentation in English. Therefore, we organised already in the midway seminar workshops with training of presentation techniques including video recordings and individual feedback. This was very well received by the students.

After the midway seminar, the students were expected to spend approximately 25 hours each on the virtual group work. While we could have chosen to let the process of finalising the project be completely student driven, we found it was important to help the students get at least a common view on what should be the outcome of the virtual phase. We therefore asked each group to prepare and upload a 20-minute presentation (PowerPoint or similar) at least one week before the project seminar. This presentation should be self-explanatory and contain:

- An analysis of the problem at hand
- The expected outcome
- A preliminary suggestion for design of a solution
- A plan for what work to carry out during the project seminar

- At least three critical questions that the students would like to receive feedback on

Apart from this, the students were organising their own work, and they could ask their supervisors for support as needed. Each group had the opportunity to hold at least three virtual meetings with their supervisor. Both groups and supervisors approached the tasks differently; In some groups the process was well organised from the beginning and went very smooth. For others it was a more difficult process, and it turned out challenging to agree on tasks and meeting times. However, all groups managed to prepare the required presentations before the project seminar.

The project seminar was started by providing feedback to the groups from supervisors, company representatives, and other students. The groups were divided into pairs, and then each group would present their project (based on the uploaded presentation) and receive feedback both from students, supervisors and company representatives. In the next days, the students were working on the projects with support from supervisors and company representatives. They were again encouraged to benefit from the presence of experts in different fields, and they did so more than in the midway seminar. They also provided feedback on each others work, e.g. through daily progress presentations.

The training of presentation techniques from the midway seminar continued, now with more focus on the final presentation. We had cameras and tripods that the students could borrow for practicing their presentations. We experienced that the students appreciated this, and that they became both much better and much more confident with their presentations. It was also one of the aspects that received consistently positive comments in the evaluations.

2.4 Project documentation, examination and feedback

The requirements for the project were defined from the very beginning of the course to help everyone get a common understanding of the requirements. Basically, the students were asked to for each group:

- Upload what corresponds to a 30-minute presentation in PowerPoint or similar (one presentation per group). This format was chosen in order to let the students focus on the problem solving part which requires collaboration and discussions, rather than spending time on preparing and writing a nice looking report.
- Prepare a 2-page document describing the learning process of the project. This document could contain (but was not limited to) aspects such as: Group work organization, remote interaction and experience, main challenges, valuable learnings and outcome of the course. The idea behind this reflection report was among other things to ensure that the students would reflect on what they have learned during the course.

We also used the learning objectives to discuss these requirements with the students. It was done in different ways, but in the most elaborate case the students had to specify exactly how they would meet each of the learning objectives.

The examination was done one group at a time, and contained the following elements:

- A 30-minute presentation, where all students in the group should actively contribute.
- A session with questions from supervisors, where all students should actively participate in discussions. The questions would take the starting point in the project, but cover all modules the students had participated in.
- An individual assessment of each student by examiner and censor (pass/fail)

The students also received feedback and questions from the involved companies, either directly or through video link. The seminar was co-located with a project meeting on the first two days, which made it possible for all to receive feedback on their initial presentations, and most also received additional feedback afterwards e.g. through email.

One challenge when conducting a joint course is to ensure rules and procedures for every possible case (i.e. students failing, students being ill or exam complaints). In order to be able to handle such cases in unified and unambiguous ways, it was chosen to follow the rules by Aalborg University in all such cases.

3 Evaluations from students, teachers and companies

In this section, we will present a summary of both quantitative and qualitative feedback received from students, teachers and company representatives. It is based partly on evaluation forms and partly on the reflection reports the students had to hand in together with the project presentations. Moreover, both company representatives and supervisors have delivered written, qualitative feedback as well.

3.1 Feedback from students

Figures 1-5 show the qualitative feedback from the students, specifically related to the projects. The evaluations are collected from the students on the final day of the project seminar.

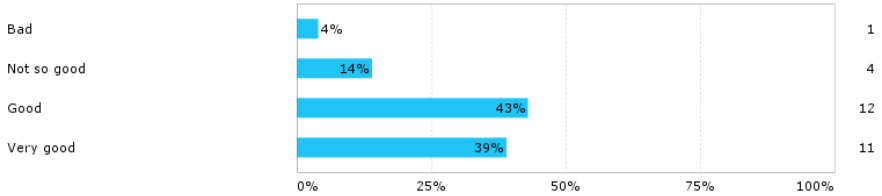


Figure 1. Please rate your overall satisfaction with the project.

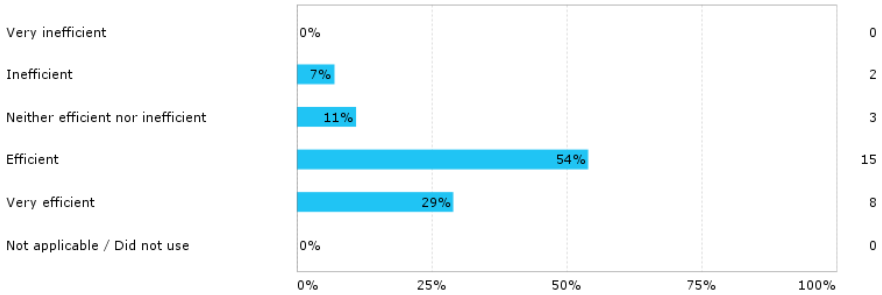


Figure 2. Please rate how efficient the following parts of the project have been for you with respect to learning: The project overall.

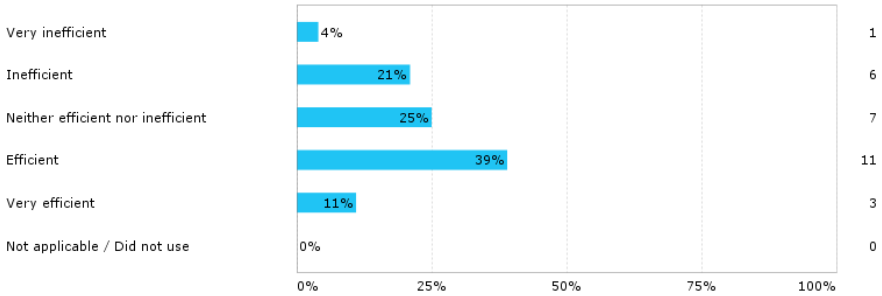


Figure 3. Please rate how efficient the following parts of the project have been for you with respect to learning: The virtual collaboration in the group between midway and project seminars

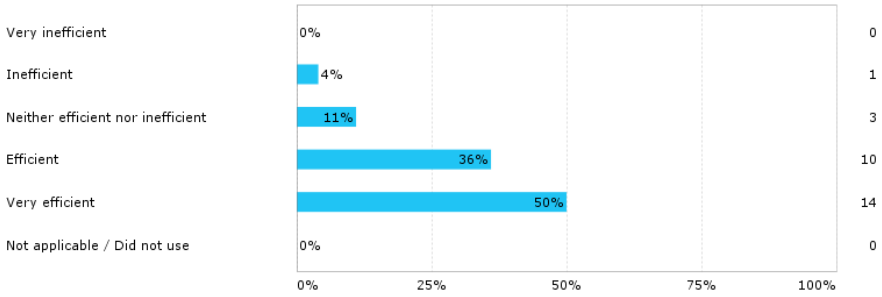


Figure 4. Please rate how efficient the following parts of the project have been for you with respect to learning: The physical collaboration in the group (midway and project seminars).

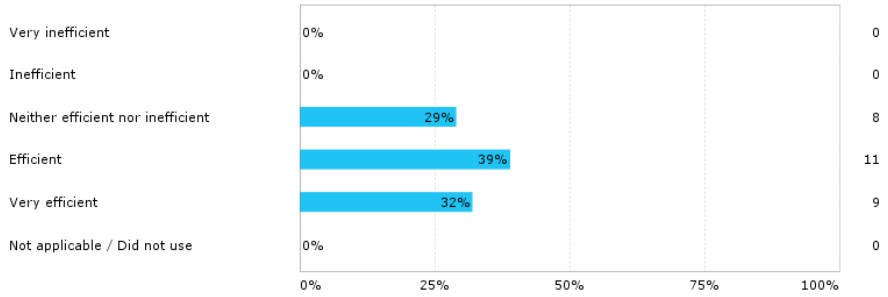


Figure 5. Please rate how efficient the following parts of the project have been for you with respect to learning: The use of blended learning overall (mix of virtual and physical mobility)

We see in Figures 1-2 that the students are generally happy with the project. However, there are also students who are less happy about the project. Among the most satisfied students, many point towards the following:

- The international dimension
- Working together with students with other cultural and academic backgrounds
- The mix of academic, cultural and personal development
- Getting to work with real problems from real companies.
- Technical students were happy to learn more about the business context of the work, and business-oriented students were happy to learn more about the technical context of their work.

Among the less satisfied students, the most common points were:

- It was unclear what was expected from the project
- It was not clear how the projects were related to the modules
- Project descriptions were vague
- The groups were formed late in the midway seminar, so not enough time to get to know each other.

Studying figures 3-5 it is clear that the physical part of the blended learning overall received better ratings than the virtual collaboration. Especially from the reflection reports it can be seen that there is a big variation between the groups in how well the virtual collaboration worked out. It is difficult though to point out exactly what makes it work in some groups but not in others, but it seems that the groups who were successful in project management and planning generally were happier about the virtual aspects.

Some students found the project descriptions to be broad, vague or imprecise. We believe this is not only related to the formulation of the projects, but also because it is important to formulate clearly the goals and expectations when working problem oriented rather than task oriented.

In addition to the specific evaluation of the project, the students were also asked to evaluate the Colibri project overall (including e.g. the modules). On a general level, the students found that the teaching methods in Colibri increase the quality of the learning offer (average 3.7 on a scale 1-5), that the teaching methods increase the relevance of the learning offer (average 3.7 on a scale 1-5), and that the teaching methods used in Colibri increase the labour market relevance of learning provisions and qualifications (average 4.0 on a scale 1-5).

On a personal level, the students found that the teaching methods to a high extend will make them better prepared for the national (average 3.9 on a scale 1-5) as well as international (average 4.3 on a scale 1-5) labour market.

3.2 Feedback from teachers/supervisors

The qualitative evaluation from the teachers/supervisors covered the whole course, including modules and projects. They found that the teaching methods in Colibri increase the quality of the learning offer (average 4.0 on a scale 1-5), that the teaching methods increase the relevance of the learning offer (average 4.4 on a scale 1-5), and that the teaching methods used in Colibri increase the labour market relevance of learning provisions and qualifications (average 4.4 on a scale 1-5). Besides the positive comments regarding working on real-life problems in an international and multidisciplinary environment, the ability to exchange best practices between

institutions is highlighted by several of the teachers. Also, it is highlighted that the blended approach makes it possible to give a highly international experience on a moderate budget, and in a way that is accessible also for students who are unable to travel for longer durations.

3.3 Feedback from company representatives

The qualitative evaluation from the companies covered the whole course, including modules and projects. The companies generally found that the teaching methods in Colibri increase the quality of the learning offer (average 4.1 on a scale 1-5), that the teaching methods increase the relevance of the learning offer (average 3.7 on a scale 1-5), and that the teaching methods used in Colibri increase the labour market relevance of learning provisions and qualifications (average 3.7 on a scale 1-5). The feedback from companies pointed a bit in different directions. As a general conclusion, the multidisciplinary work in a cross-cultural environment, focusing on real problems, and based on remote collaboration, was seen as a very positive supplement to the existing learning offer.

4 Learning points

Based on the experiences from the project work as described in section 2, together with the evaluations from students, teachers and companies as described in section 3, we have derived a number of learning points which will be described in the following. Where applicable we will also describe how we plan to take these learning points into account in future versions of the course.

Generally, students as well as teachers and company representatives were happy with the projects. Especially the aspect of international collaboration was highlighted as positive together with the work on solving real-world problems in interdisciplinary groups. However, we have derived the following learning points, indicating also

- When working with students from different institutions and learning cultures, it is important to be very precise regarding the expected outputs. This is especially true when only remote interaction is possible. It seems that students from different universities have different understandings of what a "project" is, and it is necessary to create a joint understanding of what the students are expected to deliver during this project.
- We found that discussing the learning objectives with students was useful for aligning expectations. We will consider working more structured on this part in the next edition of the course, and consider if we should require each group to specify in writing how they intend to reach each of the learning objectives.
- In the midway seminar, we tried to focus a lot on bringing the students together and introduce them to team work, different personalities and cultures, conflict handling, project planning etc. However, it seems like we could do even more, and also consider bringing the groups together before they start the course modules. This would also allow for more interaction in the groups from the beginning of the midway seminar.
- Some students found it initially difficult to figure out how their knowledge (whether it was from their previous education or Colibri modules) could be brought into use in the context of the projects. This might be something we could practice more during the midway seminar, e.g. through shorter workshops on problem solving.
- By creating the groups before they start the course modules, it would also be possible to discuss the technical roles of the group members even before the module selection, and to let them coordinate which modules to choose in order to support their different roles.
- Given that only remote interaction is possible we would also recommend to monitor and support the students in a structured way during the virtual collaboration phase. This can be done for example by providing templates for minutes and ask them to report on their progress in specific intervals. However, there is a trade-off between "forcing" the students to a specific structure, and asking them to organise the work themselves.

- Not only the students come from different backgrounds – so do the supervisors. A short supervisors guide with help and hints could be useful, especially if combined with discussions and reflections during the seminar to create a joint understanding of the supervisor role.
- It is our experience that the more concrete the problems are, the easier it is for the students to get hold on, especially given the relatively short time available for the projects. However, a part of working problem based is also that the students should not just be given a specific task. It would be helpful if company representatives were physically present also during the midway seminar, to help understand and narrow down the problems.
- Also, we note that the students were very positive about the training of presentation techniques. For many it was their first exam where they had to present in a foreign language and in front of a large audience.
- Before starting to work on the projects, the students followed different course modules to support the project work. It seems that the relation between courses and modules were not always clear. While not all modules were used in all projects, maybe this line could be clearer by keeping the content of the modules in mind when drafting the project proposals. However, if project proposals are adjusted there will often be a trade-off between how" designed" it is and how well it reflects the real challenges in the company.
- In this edition of the project, we assigned the projects randomly to the groups. If we have a clearer idea of which projects rely more on which modules, we can do the assignment so there is a better fit between the competencies in the groups and the projects they are assigned.
- Some students expressed that they would have preferred to choose the projects by themselves. This is worth considering, since it might create more ownership and enthusiasm among the students. On the other hand, there are two drawbacks. It would take time to discuss project choices, and we still might not be able to give everyone their first choice. Also, it could potentially create conflicts in the groups that could be hard to resolve given the limited time available during the midway seminar.

5 Conclusions

This paper has demonstrated how problem based learning can be done in a highly international and interdisciplinary environment, across universities, and through the combination of physical and virtual collaboration. Overall, the project was successful and received positive evaluations from the participants, particularly regarding the international and interdisciplinary dimensions, and regarding working on real life problems from real life companies.

We also gained important experiences which will help us improve the teaching methods during future offerings of the course. In particular, we will spend more time in the midway seminar to facilitate the collaboration, group work, and project planning. We will also try to create a better link between course modules and projects, and change the way we distribute projects between groups so they fit better to the student's backgrounds. On the other hand, we will focus more on training the student's problem solving abilities, and thus help them to bring their knowledge into play when facing concrete real-life challenges.

We found that it is both challenging and important to be very explicit about what exactly is expected from the students, as both students and supervisors have differing understandings of what a project is. We will try to work on this part, for example by discussing the learning objectives with the students in a more elaborate fashion.

Finally, we gained valuable experiences in how to combine project work and blended learning. There is a potential in improving especially the virtual part of the blended learning, e.g. through supporting the students better in structuring this part of the project work.

6 References

Colibri (2016): COLIBRI website, http://erasmus-colibri.eu, accessed 21 March 2016

Crawley, E.F., Malmqvist, J., Östlund, S. & Brodeur, D. (2007). Rethinking engineering education: the CDIO approach, Springer.

European Commision (2011): Supporting growths and jobs. An agenda for the modernisation of Europe's higher education systems. The European Union

Kapenieks A., Kirikova M. & Zuga B. (2002). Teamwork in e-learning development projects in teleworking environment. In: Proceedings of the TELEBALT'2002, ISBN 9955-9612-0-1, pp. 104-106.

Kolmos, A., Fink, F. K., Krogh, L. (2004). The Aalborg PBL Model: Progress, Diversity and Challenges. Aalborg University Press.

Lajoie, S. P. , Hmelo-Silver, C. E. , Wiseman, J. G. , Chan, L. , Lu, J. , Khurana, C. , Cruz-Panesso, I. , Poitras, E. , & Kazemitabar, M. (2014). Using Online Digital Tools and Video to Support International Problem-Based Learning. Interdisciplinary Journal of Problem-Based Learning, 8(2).

Lopez, J.M.G., Frick, J., Kirikova, M., Solé-Pareta, J., Pedersen, J.M., Tran,N. (2015) The Colibri Project: Overcoming diversity in blended e-learning activity preparation. Proceedings of the 43rd SEFI Annual Conference 2015: Diversity in engineering education: an opportunity to face the new trends of engineering.

Pedersen, J.M., Lopez, J.M.G., Kirikova, M., Zabludowski, L., Comellas, J.(2015). Three years of an intensive Programme: Experiences, Observations and Learning Points. Proceedings of the Seventh International Symposium on Project Approaches in Engineering Education (PAEE' 2015), 2015, 206-213.

Savin-Bade, M. & Wilkie, K. (edt.) (2006), Problem-based Learning Online. Open University Press, McGraw-Hill Education.

The Agile Games For Freshmen Students

Ghazi Khodjet El Khil[1], Zied Alaya[1], Kaouther Louati[1], Meriem Ben Aissa[1]

[1] ESPRIT School of engineering, Tunis, Tunisia

Email: ghazi.khodjetelkhil@esprit.tn, zied.alaya@esprit.tn, kaouther.louati@esprit.tn, meriem.benaissa@esprit.tn

Abstract

In our school, freshmen students have a week to prepare them to the active pedagogy required the organization of a week of adaptation, what we called "ice break". During this week new learners will work as a team. For this year and in order to strengthen working in groups and its management, we decided to integrate agile games. In this paper we will describe our approach and he results of this experience.

Keywords: Agile Game; Team Based Learning; Ice Break; Engineering Education; Soft Skills.

1 Introduction

Three years ago, ESPRIT, a Tunisian school of engineering, decided to adopt the active learning mainly with the 1st year students. The first week of school is devoted to introducing future engineers to active learning and adapting them with the different steps of the learning process. Through some simple project games, teachers introduce the different stages in the progress of a project regardless of its content. The main objective is to initiate freshmen students to the new educational reform. Group work, job sharing, exchanging ideas and preparing for evaluation are then revealed throughout this week of initiation. According to the distributed plan on their first program day, several checkpoints are programmed. These checkpoints allow learners to present their progress via deliverables.

Usually on Wednesday afternoon, a seminar is organized where speakers present their ideas on the theme: "Engineering Skills". The seminar aims to explain the different stages of the training process but students have not expressed a great interest in this conference whose appearance remains passive and boring compared to the overall atmosphere of the week of integration.

Since the seminar was not interesting for students, it was replaced this year by a workshop using some agile games. The objective is to help students learn the importance of the team work.

2 General Background

For the freshmen students, the school decided to prepare the transition from traditional learning modal to active learning. To do that, the first week of the academic year is dedicated to do an Ice Breaker activity. During this week, students will be divided in teams and have to achieve a little project. They will have coaching sessions, some milestones to achieve and a lecture about engineering skills. But the lecture was not interesting for students. More details about this approach can be found in this paper (Kaouther L., & Zied A., Ghazi K. E. K., Meriem B. A., Lamjed B., 2016). Also students confirmed in previous years that they have communication and confidence problems inside the team (Zied A., & Ghazi K. E. K., Lamjed B., 2015). This year the lecture was replaced with a workshop session to make students have a better understanding of the importance of this skills in the teamwork.

For the academic year 2015/2016, the choice was made to use Agile Games in the workshop. The Agile methodology is a way of conducting projects in the software development in a software company. This methodology helps companies be more responsive to the client needs. But since it needs more work in teams, some professional trainers developed Agile Games to help developers have a better understanding of this methodology and a better interaction with final client and inside the team (agilegamesfrance.fr, 2016). Other

Games for team building such as (Joël M, 2008) but it was easier for teachers to use agile games since it is in our software courses curricula.

We will describe three games that were used in the workshop with students and the results.

3 Strategy

Students were in groups of five or six members composed randomly by the school administration.

Table 1: Used Agile Games (agilegamesfrance.fr, 2016)

Name	1 - 2 - 3 Go!	Blind hen	Chairs game
Steps	1. Ask participants to stand up so they can all see each other 2. Hold your hands as if you are going to applaud. 3. Explain the following: "! I will slowly count to three, then I would say GO, When I say GO, everyone will type in their hands." Start the game: 4. Count slowly to 3, then slamming hard in your hands, take a break and then say GO! [A large should clap their hands before the GO...] 5.Repeat instructions (without focusing on those who applaud prematurely)	1. Ask participants to organize a path with chairs 2. One of the opponent team members must move the way alone eyes crowded 3. A second round with the help of a member of his team 4. A third round with the help of his team just with the voice 5. A final round alone	1. Ask the first group in a time T to overturn chairs 2. Ask the 2nd group in a time T to sit on chairs 3. Ask the 3rd group in a T time to put the chairs in a circle
Pedagogical Objectives	*illustrate how we act quickly after a first hypothesis *Importance of listening before acting with teamwork	*Importance of confidence *Importance to remember that we learn from others	*The importance of communication among team members *We can converge despite the different tasks we realize
Duration	5 to 10 minutes	15 to 25 minutes	5 to 10 minutes
Number of participants	Minimum 3 / no maximum limit	Minimum 3 /no maximum limit (2 groups)	Minimum 3 / no maximum limit (3 groups)
Participant Profile	Team	Team/Team	Team/Team/Team

The same team members work together from the first day of the academic year until the end of the first semester. Since there was more than 300 students, students were divided into 10 classes, each class with 6 teams and two tutors.

Three agile games was used. The aim of this games is to help students to be familiar inside their team and with their teacher. Agile games is used in our computer science curricula to help future engineer to learn how team

work is important and have some technique to solve some known issues in team work such as communication, the relationship between members, confidence. In the Table 1, there is a list of the used games with a small description and pedagogic objectives for each one.

Team building games are mainly used in the professional world. In the educational context we choose to use agile games knowing that our students will have during their studies in ESPRIT a course on agile methodology in software design.

The games help students learn and understand the importance of some soft skills in the teamwork. Here is a list of the objectives in these three games:

- Illustrate how we act quickly after a first hypothesis.
- Importance of listening before acting with teamwork.
- Importance of confidence.
- Importance to remember that we learn from others.
- The importance of communication among team members.
- We can converge despite the different tasks we realize.

4 Results

At the end of the semester, students answered to a survey and some of them expressed their opinion about the games. The results are described in the next paragraphs.

4.1 Survey results

Each year, students answer to an anonymous survey. The survey focuses on teamwork and overall satisfaction with questions concerning learning from others, communication among the team and confidence in working in a team.

The admissions criteria for students in ESPRIT have not changed in the two academic years 2014-2015 and 2015-2016. The program of the first year was not changed. The students of these two years come from the same educational system where teachers do not encourage working in groups and use a classical pedagogy.

In Figure 1 answers to the question: "I feel confident working in team". Students who agree or totally agree that they feel confident working in groups passed from 47% in the AY 2014-2015, Figure 1, to 56% in the AY 2015-2016. Also the percentage of students who disagree or totally disagree was reduced from 25% the AY 2014-2015 to 19% in the AY 2015-2016.

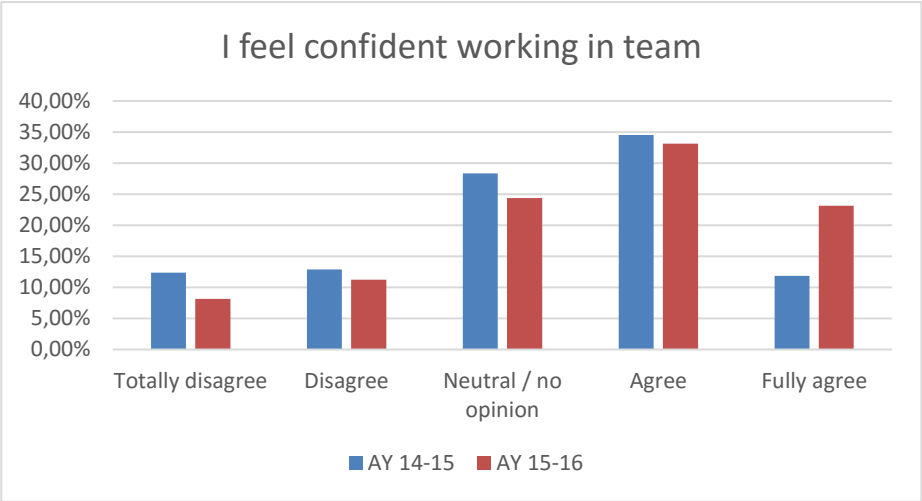


Figure 1. The confidence working in a team

In Figure 2, it's the average of the responses to the question: "I received useful and constructive comments of my team-mates". We notice an improvement of favourable opinions of students from AY 2015-2016 versus AY 2014-2015. About 51% of the students were between "AGREE" and "full AGREE" in AY 2014-2015 and it passed to 57% in AY 2015-2016. The average of students who are not satisfied is almost the same but the percentage of students who are neutral or without opinions decreased from 31% in AY 2014-2015 to 21% in AY 2015-2016.

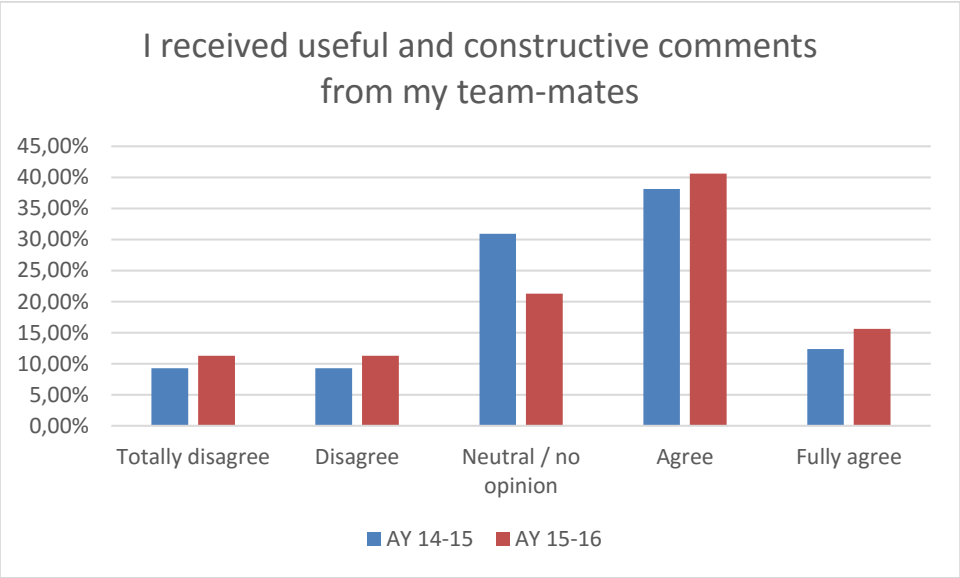


Figure 2. The learning from other team members

In the Figure 3 we perceive that the average satisfaction about communication inside the team is almost 53% in the AY 2015-2016 against 41% in the AY 2014-2015. This helped teams to have a better experience, learning from others and feel confident in working together.

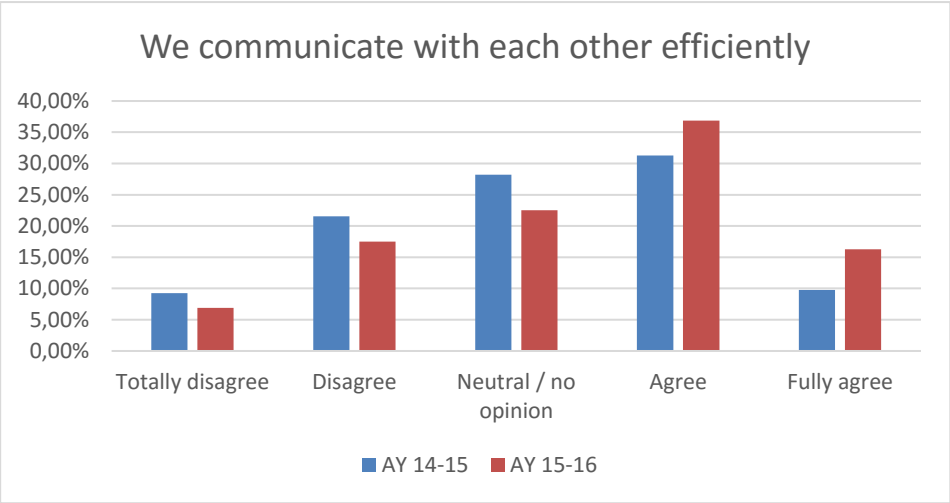


Figure 3. The communication among the team

4.2 Testimonies

In this new experiment, we tried to collect the maximum feedback from our students as well as teachers to assess the degree of assimilation of the new methodology and its maturity. In Table 1, we collected some different opinions we divided into positive and negative.

Table 2. Students Opinion

Positive opinion	Negative opinion
In my case I found that these games were fun to meet the other students for a first week in faculty	For the group work I think it didn't really helped because the teamwork we learn it with time and confronting problems together.
I think this is a new method to learn the way to work; these are games that involve improving the mind of the student. It is a good method.	I participated for the first time this year to agile games. I frankly think this experience is yet to mature and expand. Students have not really grasped the objectives of these activities
They were kind of fun actually but behind the fun was the true meaning of a group work. Thanks to that we know that alone we can't do anything we need a hand to overcome the hardship add to that we can learn from our mistakes and improve our skills thanks to our group members and their advices. They might be wrong like they can be right.	The games proposed are almost childish.
It is a good way to meet new friends and also to test our intelligence	Agile games must be more structured and give rewards.
It is a good method to Ice break between students and student-teachers	I think that agile games are great but the way in which they are applied is not enough to References understand agile methods.

As we can see in Table 1, positive opinion finds the games fun and helpful into easily interact with new colleagues and teachers. This fits well with the objective of the week. Students may have noticed the importance of teamwork and but only some of them understood the real objectives of the games.

The negative reviews focused mainly on the immaturity of this experience and these games do not have an impact on the group work.

Tutors should explain in the next year the global objective at the beginning and the objective of each game at the end. A better preparation with tutors should be done.

Also not all tutors had the opportunity to participate or to do these activities with their students. Using games in the first lesson as an ice break activity is also a good option (Annette E. L. , 2010).

In comparison these testimonies with the survey we notice that these agile games have a positive impact on the behaviour of students during group work.

5 Conclusion

In this paper, we described three agile games that we used as an ice break between students team members. The games helped students understand the importance of some soft skills in the teamwork such as: Importance of listening before acting with teamwork, importance of confidence, importance to remember that we learn from others, the importance of communication among team members and how we can converge despite the different tasks we realize.

The results of the study showed that overall the workshop with agile games positively influenced students to have a better communication inside the team, better learning from each other and have confidence working in a team.

While the results are encouraging, we found that many improvements to make this experience more mature. We should also think to use other games and use them to make students less reticent to the new way of learning for them that is based on PBL and team work and not classic lecture. Using games in the first week of a course is also another option that we are studying.

6 References

Annette E. L. (2010). The first lesson in the classroom – getting students engaged in active learning process. Improving University Science Teaching and Learning – Pedagogical Projects 2010, vol. 3. number 1. ISSN: 1904-2000, page 3 – page 17.

agilegamesfrance.fr (2016). http://www.agilegamesfrance.fr/index.php?title=Jeux, Accessed 2016/3/19.

Improving University Science Teaching and Learning, Pedagogical Projects 2010, Volume 3, Number 1, Department of Science Education University of Copenhagen.

Joël M, (2008) . http://riifr.univ-littoral.fr/wp-content/uploads/2008/10/doc-198.pdf

Kaouther L., & Zied A., Ghazi K. E. K., Meriem B. A., Lamjed B. (2016). First steps to active learning for training engineers. *Educon 2016*, Etisalat, BT and Khalifa University. 10-13 April 2016, Abu Dhabi, UAE.

Zied A., & Ghazi K. E. K., Lamjed B. (2015). Active learning for freshmen students in a software engineering education. *5th IRSPBL / IJCLEE 2015*, Mondragon University. 6-9 July 2015.

Targeted post-course survey of project organised course as an example of students' engagement in learning process

Lucyna Czarnowska[1], Zbigniew Żmudka[1]

[1] Institute of Thermal Technology, Silesian University of Technology, Gliwice, Poland

Email: lczarnowska@polsl.pl, zbigniew.zmudka@polsl.pl

Abstract

The modern way of becoming world-class experts covers the global citizenship education, which allows students from various countries to learn from each other by attending international courses. At the Silesian University of Technology (SUT) the educational program "Clean Fossil and Alternative Fuel Energy", supported by the Knowledge and Innovation Community (KIC), is carried out. In this program, outstanding students from around the world can participate and gain engineering knowledge and skills. Additionally, the KIC initiative is to improve the teachers' qualifications, since they influence young people education. The educators' awareness about available teaching opportunities should follow the international trends. According to UNESCO, "the global citizenship education includes issues such as environmental sustainability that require core transferable skills such as critical thinking, communication, cooperation, problem-solving, conflict resolution, leadership, and advocacy". The idea of the problem-based learning assumes that students acquire the knowledge and gain skills through a sequence of problems, learning materials, and other active learning activities facilitated by the educator. Based on this guidance PBL methodology was applied to project titled "Fundamentals of Municipal Energy". This subject was chosen from the regular courses at SUT conducted in the Polish language. At the end of this project, the targeted post-course survey was conducted. The survey was developed by the educator, who carried out the analysed project, to learn the students' expectations of the project. This survey consisted of 20 open and closed questions. The continuous assessment should lead to improvement of the educational process, which allows students to gain the skills required for their future careers. In the article, the description of the curse and the results of the targeted post-course survey are presented. The survey's results are promising and indicate that the PBL methodology could be implemented in the project for students enrolled in the KIC MSc program. The PBL implementation should lead to improvement of the educational process in student engagement in learning.

Keywords: Active Learning; Engineering Education; Targeted Post-course Survey; Problem Based Learning; PBL; Teacher Assessment

1 Introduction

The idea of problem based learning is widely described in the literature. The core description can be summarised by the following sentence: "Project-based learning (PBL) is a learning process characterized by the need to solve a complex ill-defined problem related with the professional practice, by a team of students, with the support of teachers" (Graaff & Kolmos, 2003, 2007).

The PBL very often is presented as a particular case of active learning, which was described as "Active learning (AL) is an umbrella term to different models of teaching (e.g. collaborative learning, experiential learning, problem-based learning, etc.). AL implies the design of pedagogical strategies to work a concept into participants' personal knowledge and experience to learn. It also involves students' reflection and monitoring of both, process and results of their own learning (Barkley, 2010)."

Modern and innovative pedagogy should have the benefits for students and academic teachers. Students attends the academic courses because they would like to have a better start in the professional life. However, academic teachers are primarily researchers who have knowledge in an area of their expertise; and secondly, they are the tutors, instructors and facilitators for students. Being a good academic teacher requires advanced knowledge (in selected area) and skills in transferring this knowledge to others. Teaching should be done with passion for raising students' curiosity in the field of expertise.

The variety of tools and technology that are now easily available allows to introduce new essential elements into academic teaching. However, to get acquainted with various tools and their efficient use takes time. Innovative teaching requires continuous development of academic teachers. Moreover, excellent education needs encouraging from the side of university authorities. To be able to improve and implement new ideas the time for preparing, analysing and reflecting is needed. The high performance of teaching can be obtained when teachers get familiarity with new pedagogical methodologies. Selection of appropriate teaching methods or complementary learning tools and platforms requires deep analysis in the longer term. Students and teachers could meet their expectations with modern and innovative pedagogy. However, firstly, teachers should be able to use these tools in practice.

Knowing some basic ideas of innovative academic teaching, teachers could develop current classes by introducing active learning. Teachers can make courses interesting and valuable for students and their professional life. Precise clarification of requirements and learning outcomes is an incredibly important part of these courses, for this reason, teachers should have time for summarizing each class with the critical thinking and reflection for future courses. The following activities would help to make courses more effective and interesting:

- Acquiring knowledge to created effective mid and final surveys.
- Preparing middle scientific tests and quizzes for ease and fast remembering the knowledge by students.
- Developing some essential recordings for helping students with the most challenging parts of the classes.
- Participating in additional scientific training.
- Participating in pedagogical events.
- Participating in discussion and seminars with others academic teachers (especially within the home university) on innovative pedagogy,

These activities would considerably increase teacher's ability and motivation for implementing an innovative way of teaching.

2 Course description

During winter semester 2015-2016, the methodology of active learning with the inclusion of problem based learning in the project "Fundamentals of municipal energy" (FMP) was applied. At the end of the project, students answered the summary survey; some of the students' answers are translated to present the outcome of this survey. In this section, the mere description of this project is described.

The course, for which the final survey was prepared, is delivered in a classroom environment to full-time students enrolled in the fifth semester of an Energy program. Project is conducted in Polish language. It is the 7-semester program to acquire the bachelor in science; however, the study can be continued on Master Energy Program. To reach this stage of university education students have acquired knowledge related to thermodynamics, programming, and drawing technical objects in AutoCAD. In the parallel to this course, the Heat and mass transfer is studied. The course is composed with two parts 1) the lecture, where students gain the theoretical knowledge and 2) the project, where students work on the given task. The PBL was implemented mainly during the project part of the course.

The aim of the project is to design a detached house in the Purmo OZC 6.5 Basic, and perform the calculation of the heat demand. Moreover, the selection of the type of heating should be specified, at the end the fuel demand should be calculated. In addition to the reference building five other places for house was considered, which allowed for more accurate analysis of the home and the materials from which it should made. The project also includes the design of the model in the AutoCad, which was then introduced into the target program to perform 3D model of this house. The project partially perform an audit for a single-family home, since the calculation of seasonal heat demand and heat loss were specified.

The selected part of the course includes two team presentations, mid technical group report, and a final report. Both presentations are considered as an important assessment. At the end of each presentations, the pro and coins of the presentation is discussed. The discussion includes presentation skills, team work skills and the material presented. During the first presentation, students present simple model concerning heat transfer through the selected parts of the house such as the door, window or wall. This part is directly related to the parallel subject and the practical application of the theory is pointed out. Students know that they should present model which is related to the real object using the base knowledge which is needed to understand this topic in the way that others can use easily. Models are developed in Visual Basic or Excel, which are well known by students from previous courses. Presenting their designs in front of class gave students a certain level of fear as they expected to be judge by the teacher as well as peers.

One of the aims of the course is to develop intellectual, affective and social skills. The intellectual skills are developed through the subject-specific academic work, such as a model of heat transfer through one of the building component. The affective skills are developed through group work as well as the selected building since they can use in the calculation the building they live in or the building they would like to live. The social skills are developed through group communication and group presentations. Students should communicate each other to make many decisions such as whose idea of the house is modelled, who presents the results, whether they are working to assess the best or the lower grade.

Groups of two / three students were created by the students themselves. At this level of study, students may develop to work based on friendship. This solution do not cause additional emotions that can be visible in the case when group members of different academic levels had to collaborate. These groups are small, so the cooperation does not cause too many problems. The problem with team work in such a small groups students can manage easily whereas sometimes the intervention of teacher is needed.

The academic goal of the course is to develop subject-specific knowledge by calculating the heat demand for a single-family house. Based on the heat demand the way how to meet the needs was evaluated. The goal of this task was to encourage students to find the proper solution. Some of the students also prepare the cost evaluation even though it was not pointed out in the guidelines for the project. Based on this, I can assume that the project results cause additional interests for students. Groups of students are expected to prepare a report and to present their partial concepts in front of a class. Students develop communication skills by sharing their partial work with peers.

There were about 40 students enrolled in the last offering of the course. About 17 groups of 2/3 students were required to calculate the heat demand based on the modelled house with an appropriate solution how to meet this demand. The problem topics that students are expected to address are provided in the following order:

1. selection of the proper house with plan and description of materials + discussion with the instructor;
2. preparation the draw of selected house in AutoCad;
3. preparation the calculation model of selected building part such as window, door, different types of walls + oral presentation;
4. preparation the design of the house in Purmo + discussion with the instructor;
5. calculation of heat demand in Purmo + oral presentation;
6. preparation of the final report+ discussion with the instructor.

The major elements that need to be addressed by each problem are presented to the students every week at the classes. Although students are expected to cover all these problems, each group is allowed to address each problem on its own. Students were obliged to present the model of heat transfer using Excel, VBA in Excel or other program; model of the house using the PURMO or screens from PURMO in Power Points.

The course enhance a novel mix of learning approaches in order to encourage the development of valuable qualities such as:

- capacity for analysis, (e.g. which house? where situated?)
- independence of judgment, (e.g. whose presentation was valuable and why?)
- curiosity, (e.g. how much the choice will costs?)
- teamwork, and (e.g. how to spread the tasks to prepare better outcome?)

- ability to communicate.

3 Final survey of "Fundamentals of Municipal Energy" project

The survey was prepared to find out what students think about the projects and the way how it was organized. All questions are presented below, and some are presented on figures which are screens of the survey prepared in Google Forms. To see the survey or to fill it out, visit:
https://docs.google.com/forms/d/14_4-zbEOm5aSGFyz4-JGP55hBor1uFObMy6_VwOA2M4/viewform?c=0&w=1&usp=mail_form_link

The survey was prepared in Google Forms because it is free, easy to use and access as well as well know tool. However, other online sites could be also used to prepare the survey (www.smartsurvey.co.uk, www.surveymonkey.com).
It should be pointed out that preparing the good survey is very demanding task. Developing good survey is as demanding as preparing the technical material for course. To get real assessment of the classes based on the survey it requires the specific knowledge in the range of:

- *open and closed questions oriented on specific purpose,*
- *statistical analysis of the closed questions and basic data such as numbers or yes/no answers,*
- *big data analysis for open questions.*

Fundamentals of Municipal Energy (PME) 2015-2016
This evaluation will help improve the content of PME project as well as the learning process.
Your comments and tips are much appreciated. Your extensive feedback will be used for developing this course.

1. During the PME project, much attention was devoted to discuss presentations of partial results. Did you have an opportunity to present the results to the class?
    - Yes/No
2. Do you find the presentations of partial results motivating to carry out the project systematically?
    - Yes/No
3. Do you think the ability to use an extensive manual is valuable in daily life?
    - Yes/No
4. Do you think the ability to use an extensive manual is valuable in daily life? Why?
5. Which of the following materials did you use to carry out the project in Purmo?
    - Purmo Manual
    - Purmo Instructional videos
    - Peers' knowledge
    - Simple experiments with options in the Purmo until obtaining reasonable results
6. Was it useful to know what should be performed to get the lower grade (3.0) or the higher ones?
    - Yes/No
7. In your opinion, is the acquired knowledge useful in your career (practical application)?
    - Yes/No
8. In your opinion, is the acquired knowledge useful in your career (practical application)?
    - Why or why not?
9. The knowledge of which other courses was useful to carry out the PME project?
10. What was the most interesting part of the project? Why?
11. What was the most difficult part of the project? Why?
12. Taking into account that you study to become energy engineer, which part of the project may be useful for you in the future?
13. What do you think about the form of the summary report template? In your opinion, did it help or hinder the final summary?

14. Did you find the size of the team appropriate to carry out the project?
    - Yes/No
15. Did you find the size of the team appropriate to carry out the project?
    - Why or why not?
16. Was it convenient to carry out the project every week during half of the semester instead of every two weeks during the whole semester?
17. Was the subject of the project interesting for you?
18. Please complete the following sentence. One information that I will remember from this project for a long time is …
19. Do you have any suggestions for improving PME project? If so, please leave them below.

4 Students' answers for final survey of "Fundamentals of Municipal Energy" project

In this section, the answers for the final survey are presented with additional explanations which should allow the reader to understand the context of the answer.

Responses to the questions no. 1 are as follows 53.3% of students did not present anything in front of the group previously, and 46.7% presented the result of their work during the previous classes. During this project, each student presented their work. Each section had at least two presentations, so in fact, everyone could present the results of the work section. Presenting the results of the teamwork was an obligatory requirement in order to obtain the final evaluation of the project. After each presentation, the teacher and peers made a brief summary of these presentations, in order to identify the strengths and weaknesses of the presenter and her/his presentation. The summary was performed to help students in the preparation of the next public speech.

Responses to the questions no. 2 are as follows 80% of students thought that the systematic presentations are motivating to carry out the project systematically. Students made the presentation on time. As the teacher of this group, it seems that the rules were given in a good form and no problem with time regime occurred during this course.

Responses to the questions no. 3 are as follows 60% of students thought that the ability to use an extensive manual is valuable in daily life. The software which was used to calculate the heat demand has the manual of nearly 1000 pages. Not all materials are needed to carry out the project; however, only few information about the software was provided during the classes. The manual was introduced with some tips how to use it in a fast way. Students needed to design the chosen houses within the software when the manual was not sufficient, or they were not sure how to use it the additional meetings were set. Some students did not know how to search the information in such extensive material, however during the additional meetings they learned how to do it. It seems that students sometimes do not know that searching for the information needed during classes are the same as just searching for something they do during their free time. The idea of the long manual is summarized by the students in the next question.

Response to the question no. 4 are as follows

- *It often happens that you have to use long manuals/tutorials/guidelines in the work.*
- *In future work, it will also be required, although it is better and more efficient to receive information directly from another person.*
- *For these instructions and other long texts, it is important to catch the most important and most useful information.*
- *Not necessarily. In many cases, there is someone who has developed particular problems. So we can find answers to short, specific questions without having to dig through all the instructions.*
- *Exercises with extensive manuals helps to intercept selectively the valuable information.*

Response to the question no. 5 are as follows: Purmo Manual - 11 students, Purmo instructional videos - 5 students, peers' knowledge - 8 students, simple experiments with options in the Purmo until obtaining reasonable results - 10 students. This question was formulated in a way that students could choose more than one option. This result shows that students do not use to work with movies for learning the subject. However, it should be noted that these videos were long about 3.5 hours in total, and the quality was not so high.

Responses to the questions no. 6 are as follows 94% of students thought that it is useful to know what should be performed to get the lower grade (3.0) or, the higher ones. During the project, students could develop one case of a house and it was for the lower grade (3.0), whereas to obtain higher grade more cases such as different localisations of a house on heat demand should be calculated, the demand for different fuels should be elaborated to fulfil the heat demand in selected localisations. The idea on the lower grade was to perform the calculation ones, whereas more elaborate results could be presented when more calculations were performed and the higher grade was possible to obtain with more work on the project.

Responses to the questions no. 7 are as follows 94% of students thought that the acquired knowledge is useful in your career (practical application). The project was closely related to the field of study of students. In their future career they should be able to calculate the heat or fuel demand of houses or different industry, this question was add to the survey to indicate that students understand the connection of this project to their future work if they continue their career in this direction.

Responses to the question no. 8 are translated:

- *Yes, since there are companies that professionally deal with the energy performance of buildings.*
- *It allows us to observe the place with the highest losses in the building and ways to mitigate them.*
- *Through this project, I obtained the skills of modelling approximate heat demand of the building and optimizing heat losses to the environment from the old buildings such as townhouses*
- *It showed me the practical application of energy audits.*
- *I marked "yes", but it is not enough (knowledge) to use it in real terms in working life (too little time spent on teaching to explore the topic both regarding theory and possibilities of the program). It can be more useful in everyday life to model your house / apartment and compare the demand for energy with the real needs on the basis of the empirical approach (to survive a winter in the house and see how much fuel was used compared to the calculated value). This is obviously a subjective observation.*
- *The project drew attention to various factors that affect heat transfer. It let to note a role of these factors, which is important not only for audits of buildings but also in the science. Moreover, finally, it turns on the economy of building.*
- *It gives me the knowledge of heat demand in buildings. Thanks to this project, we obtained any practical knowledge in this area (previously everything was always theoretical - calculated at exercises on thermodynamics, etc.), here is the tangible knowledge*
- *I can use this program and present knowledge in engineering work. Also, we had to look for information about the price and properties of materials.*
- *Yes, it may turn out that one of us will work models of heat demand in buildings.*

Response to the question no. 9, the knowledge of the following courses was useful to carry out the PME project: 1) Heat and mass transport, 2) CAD, 3) Information Technology, 4) Computer Fundamentals of Design, 5) Thermodynamics. The first course is parallel to the analysed project, and the knowledge is important since the heat transfer through the walls, windows, doors, roof, and another part of the building is necessary to understand to carry out the valuable results of the heat demand in the house. The second one was required to draw the basic figure of the house with the rooms, walls, windows, and doors. It was necessary since each section should perform calculations for a different house with different boundary conditions. The knowledge of the last subjected was needed to calculate the fuel demand for the previously calculated heat demand.

Sample answer to question no. 10. The most interesting part of the project for students were: the selection of isolation material and observation how it influence the heat demand; the stage, which allows at least partially familiarize with the audit of the building; the final results and their interpretation; modelling; methods of

reducing (heat) losses in the building; generally, the whole project is great; hard to say; analysis of the results; the stage of implementation and the comparison of results obtained by Purmo.

Sample answer to question no. 11. The most difficult part of the project for students were: modelling the house in the Purmo, transfer drawing from AutoCAD to Purmo; the beginning of the modelling - the work with the manual; each stage had similar difficulty; elimination of errors in the software; using the program which is not very intuitive and does not want to cooperate.

Sample answer to question no. 12. The most important part of the project (in relation to the chosen faculty) for students were: generally the whole project is great; selection of isolation materials and observation of changes in the heat demand of the house; final results and their interpretation; approximate cost of heating and the price for thermal energy, e.g.. from the power plant; hard to say; comparison of calculations obtained with Purmo.

Response to the question no. 13, in general, the answer was that the form of the summary report template helped the final summary of the report. Moreover, some additional information was obtained during this answer:

- *The regular work was very grated, every week we had something to prepare and present. Not as usual on other projects, where the teacher only imposes the deadline and do not check the current progress.*
- *Neither one nor the other. It was simply a form to gather our work together.*
- *Hard to say, we should try to summarize the project in our way and compare.*
- *Facilitation, because we did not have to wonder how to make a structure for this summary.*
- *Facilitation, since the desired content was clearly stated.*

Responses to the questions no. 14 are as follows 60% of students thought that the sections were appropriate. Moreover, according to the answers to the question no. 15 the number of people in the section should be equal 2; they do not use to work in bigger sections, so the sections were three people were working had more conflicts to solve.

Sample answer to question no. 16:

- *Facilitation, at the end of the semester it is better to concentrate on learning for exams (lectures)*
- *Facilitation, it relieves time during the period before the session and the session itself*
- *The impediment, when in one week you have to find time to model the whole house in PURMO and remove all errors. Besides this the project is "on plus", faster completion of one project allows us to focus on other subjects later.*
- *Facilitation due to other courses and the amount of material needed to work on from one class to another*
- *Facilitation, there was more motivation to work, and for the next half of the semester, we can focus on other subjects.*
- *Mobilized to work.*
- *At the same time facilitating and difficulty. The difficulty was that the whole time we had something to do with the project. However, the turnaround time and efficient work allow carrying out the result, in the fact that in the second half of the semester we can focus on other subjects.*
- *It seems that this is an individual matter. It depends on the amount of our activities per week and free time. For me, working every week is a good solution.*
- *Facilitation, greater mobilization, doing everything up to day with "fresh memory".*

The answer to question no. 17 was that the project is interesting. This question should be asked in another form, or students assume that the project is very interesting. As a teacher, I think that the project is very challenging for future energy engineer, so the answer was as it was expected.

Sample answer to question no. 18. One information that students will remember from this project for a long time are

- *In a family house, the greatest losses are usually on ventilation.*
- *How the selection of construction materials affects the heat demand of building.*

- *Good visual presentations are very important.*

Sample answer to question no. 19, suggestions for improving PME project are as follows:

- *It is good as is.*
- *More convenient and easier is to draw the house directly in the Purmo without using AutoCAD figures.*
- *Explain more details in Purmo (how to create layers of house, how to cope with the roof in the 3D model). Flexible hours of cooperation, encouragement in the form of initial assessments were very motivated.*
- *Reduce sections for max 2 persons (but it is probably unrealistic because the size of groups is imposed by the Dean).*

To see or discuss other answers contact the author of this report. All answers are in Polish language.

5 Summary

The survey's results are very promising and indicate that the PBL methodology could be implemented in the project for students enrolled in other programs of the Faculty of Energy and Environmental Engineering. The PBL implementation should lead to improvement of the educational process in student engagement in learning. Based on the results of the final survey students acquired knowledge and gained skills through a sequence of problems, learning materials, and other active learning activities facilitated by the educator as PBL assumes. What is more important students seemed to be happy with the obtained results, and during the second presentation they showed more interesting facts which they found during their work since they tried to get attention and recognition form their peers. Moreover their involvement increased during the semester.

Taking into account the experience gained during this course, I would recommend the pedagogical innovation could be done by preparing more detailed online surveys. This questionnaires should be consistent with the non-scientific parts of the project. Moreover, deep analysis of these surveys may help in understanding students thinking, and additionally, may help in improving innovative teaching process.

During current spring semester, the Moodle (an online learning platform) is used to help the exchanging files between teacher and students, in further plans the pedagogical innovation could be done by adopting online tools for technical/scientific tests/quizzes dedicated to lecture part of the subject. Repetition and variety of the activities are the key factors for reliable and broad knowledge. This platform also allows students to share files with each other and use the forum for exchanging the idea with teacher with time convinced for students thinking.

The pedagogical innovation that occurred within the analysed subject should be also done by continuous development of teacher expertise. The extensive professional preparation of academic teachers should go along with proper selection of materials, teaching methods and tools for his/her course. Participation in advanced courses and training that raise the scientific competence are crucial in scientist career. Increasing the knowledge of expertise should be one of the most important ways of development of innovative pedagogy. It should be noted that academic teacher has two roles to fulfil. He/she is both scientist and teacher so skills for both positions should be continuously developed.

The inspiration for the described course appeared during some courses that the author of this article attended. The discussion about the good practices which occurred during professional courses encouraged to work with students on the high level. The teacher inspiration motived students to work harder. The final results were better than were expected, students collected ideas and developed the main aim of the project with the economical calculations for each type of fuels. Moreover, some of the added economic results for various localisations. They developed very extensive houses since they wanted to know the results for real building that they live or would like to live in the future.

One of the steps of the pedagogical innovation could be done by a constructive discussion on the materials, methods and tools used in the teacher's department, or in a broader range, in teacher's faculty. Currently, at Silesian University of Technology, the Rector Regulation is implemented to assess the academic classes. The assessment of the various range of classes is made by the professors. In this way, each academic teacher

receives a feedback based on the evaluated course; this assessment should be used as the tool for further improvement. For each course, the assessment of the materials, methods and tools should be done to verify their application in modern and innovative pedagogy.

Teachers can learn from each other by analysing various approaches used during different classes. Learning from experiences of other teachers within one department or faculty could lead to the popularization of more efficient teaching practices. Moreover, Ph.D. students could be trained to give the constructive feedback of the conducted classes. Having feedback from both experienced professors, and young, demanding and opened to changes Ph.D. students would have even higher value on innovative pedagogy at the faculty.

6 References

Barkley, EF. 2010. Students engagement techniques: A handbook for a college university. San Francisco, CA.: Jossey-Bass A Wiley Imprint.

De Graaff, E., & Kolmos, A. (2003). Characteristics of Problem-Based Learning. International Journal of Engineering Education, 19(5), 657–662. Retrieved from http://www.scopus.com/inward/record.url?eid=2-s2.0-0242334100&partnerID=tZOtx3y1

De Graaff, E., & Kolmos, A. (2007). History of Problem-Based and Project-Based Learning. In E. De Graaff & A. Kolmos (Eds.), Management of change: Implementation of Problem-based and Project-Based Learning in Engineering. Sense Edtions.

De Graaff, E., & Kolmos, A. (2007). Management of change: Implementation of Problem-based and Project-Based Learning in Engineering. Management of change: Implementation of Problem-based and Project-Based Learning in Engineering (pp. 1–8).

Student's role in the Implementation of a Lean Teaching and Learning Model

José Dinis-Carvalho[1], Sandra Fernandes[2]

[1] Department of Production and Systems, School of Engineering, University of Minho, Campus of Azurém, Guimarães, Portugal
[2] Department of Psychology and Education / Portucalense Institute of Neuropsychology and Cognitive and Behavioral Neurosciences, Portucalense University, Porto, Portugal

Email: dinis@dps.uminho.pt, sandraf@uportu.pt

Abstract:

This paper presents a pilot study based on the application of lean concepts to teaching and learning in higher education. It is based on findings carried out within an optional course called "Lean Enterprise", which is part of the 5th year of the Integrated Masters degree program of Industrial Engineering and Management (IME), at the University of Minho, Portugal. The study aims to discuss students' active role in the improvement of teaching and learning. The main structure of the methodology used is based on the implementation of PDCA cycles of continuous improvement in each class. A set of standards were created at the start to make the continuous improvement effective. One of the standards created was the standard structure for the class. The classes followed a pattern established of 100 minutes per class, with a defined instant to start and a defined instant to finish. At the end of every class (total of 12 sessions), the students were asked to give feedback about the class performance. Data collection was based on online questionnaires to students, applied at the end of each class (for process evaluation) and also at the end of the conclusion of the course (overall evaluation). Findings based on students' perceptions suggest that the model applied was useful and contributed to improve teaching and learning, showing that students´ play a very important role in supporting teachers with feedback about course planning, delivery and assessment. Implications of the application of this model based on lean concepts to educational settings will be discussed in the paper.

Keywords: Active Learning; Engineering Education; Lean in Teaching.

1 Introduction

Lean philosophy named by Womack, Jones, and Roos (1990) to address the principles and concepts behind the Toyota Production System (Onho, 1988) is bringing higher productivity and competitively in organizations. Lean means doing more with less, respect for people, team work and continuous improvement. Starting to be applied in industry it is now applied in every type of organizations, from healthcare to construction, office work and education.

Lean principles and concepts can be applied in theory in any activity sector although its traditional tools may not. Applying lean in education organizations is more or less the same of applying it in offices and public services but applying lean philosophy in teaching and learning processes is a bit more difficult. Some work has already been done by Emiliani (2015) but a log way is still to be travelled in order to determine the more effective tools and techniques in order to materialize lean in this type of environments.

The objective of this article is to make a contribution to the knowledge on applying lean principles, concepts and tools in order to bring more effectiveness and efficiency to the teaching and learning process. This article describes a pilot study in the University of Minho in the Integrated Master Course Degree in Industrial Engineering and Management.

2 Literature Review

What is now known as lean philosophy started in industry in the decade of 1950 under the name Toyota Production System (TPS) (Ohno, 1988). According to the first published article written in English about Toyota (Sugimori, Kusunoki, Cho, and Uchikawa, 1977) the TPS was based on two basic concepts: the first concept is

the cost savings achieved by reducing production waste (activities with no value adding) and the second concept is treating workers as human beings and with consideration. In the context of TPS waste is any activity that does not add value to products or services. There are 7 types of classic waste very well described by Coimbra (2009): Overproduction; Materials waiting (inventories); People waiting; Defects; Excessive or inappropriate processing; Transport; and Motion. Although the second concept (treating workers as human beings and with consideration) is central in any lean implementation and success it can be used here as "respect for people" in general.

This production approach became known worldwide in the decade of 1990 through a famous book written by Womack, Jones and Ross (1990) although the lean principles were only expressed later by Womack and Jones (1996), being:

- Value - the value must be defined by the customer since the customer is the one that will pay for the product.
- Value Stream – Identification of all the steps needed to build a product from raw material to the customer.
- Flow - the products should flow through the various process steps without interruptions or delays at the rate that the customers need.
- Pull Flow – nothing is performed without being required by the next process or by the customer.
- Pursuing Perfection – the organization need to always find ways to improve, to do better and better all the time.

These principles are largely applied not only in industry but also in other organizations such as hospitals (Graban, 2011), offices (Keyte, 2004), construction (Alarcón, 1997) as well as in other sectors of activity. Education is also an activity where at least some lean principles and concepts may be applied.

A key lean concept applied in the experience documented here, is the continuous improvement. The continuous improvement model, often used in Lean environment to materialize the 5th principle of Lean (Pursue Perfection), is frequently based on PDCA cycles and the concept of Standard Work. The concept of standard procedures or Standard Work (TPPDT, 2002) is based on the assumption that if an operation or set of operations are carried out always in the same way then the result is always the same both in terms of quality and in terms of time spent (important for planning).

Taking as its starting point an opportunity for improvement or a problem to solve a particular case, the PDCA cycles can be summarized as follows: (Plan) the current situation is clearly defined and a plan is developed in order to make the desired change; (Do) the plan is executed to reach the desired state; (Check) verifying if the results is what was expected or not; and (Act) a decision taken about what to do in the next PDCA cycle. A new cycle will then be initiated. The PDCA methodology only work effectively if there is a default rule or procedure (Standard Work) assumed for the case in which the PDCA cycles are applied. Whenever the PDCA cycles result in an improvement then the standard procedure should be updated to ensure that the gains are maintained. Another relevant concept is the creating of flow (third lean principle). Flow is based on a likely unintuitive aspect of Lean thinking. The act of processing products in batches is naturally seen as a way of reaching high performance but that is not exactly true. Batch processing is the opposite of flow and in lean approaches flow is required as much as possible. Flow is achieved when products flow continuously along the system processes. Flow principle can be represented by water stream where the water flows continuously along the river bed (Cousineau, 2012) in opposition where there is water stagnation at some points along the process. The desirable limit of flow is called "One Piece Flow" which in fact reflects perfect flow since the items (products, parts or components) never wait to be processed, advancing from process to process in a perfect rhythm.

2.1 Lean in Teaching

Lean associated to education is commonly referred in the literature as the application of lean concepts, principles and tools in the university as an organization in the public sector (Ziskovsky and Ziskovsky, 2007) (Thirkell and Ashman, 2014). Another dimension of lean in education is the focus on how lean is or should be taught in universities (Fliedner and Mathiesona, 2009) (Alves, Kahlen, Flumerfelt, and Siriban-Manalang, 2014). The application of lean concepts and principles in the teaching and learning process which is the focus of this

article is not very popular in the literature and no much work is known in this subject. The intangibility and complexity of the learning process makes the application of lean philosophy a quite big challenge. The learning processes are difficult to be defined precisely and also very difficult to be evaluated. For these reasons the application of lean thinking in these processes becomes a very difficult task. Nevertheless, since lean thinking has being applied in more and more non-industrial environments, it also may bring improvements in teaching/learning environments. Emiliani (2015) has already proposed a model for lean teaching where some lean principles are applied with success.

The Lean Teaching model applied in this experiment was mainly based on: (1) A standard structure to be followed in every class, (2) PDCA cycles, and (3) Punctuality grading. The standard structure for a 100 minutes class is as follows:

- Discuss the evaluation results collected from students in the previous class
- Remember key points from the previous class (using visual information)
- Present the class plan to the students
- Identify the student learning outcomes for the current class
- Activity 1 (~30 min) Presentation of material or group work (active learning). Note that even presentation of material also must incorporate active participation of students.
- Activity 2 (~30 min) Group work if activity 1 was presentation or the other way around.
- Product evaluation – Groups of 3 students perform a test to verify the learning outcomes achieved. During the test, the students in each group will discuss and learn with each other.
- Process evaluation – Students will respond to a questionnaire.
- Each team presents the work performed since last project presentation. Feedback is provided by the teacher and by other students. This project work is assessed.
- Open discussion on lessons learned, improving opportunities and next steps.

The PDCA cycles are naturally implicit in the standard structure as long as the planning adjusted according to the Checking phase (product and process evaluation presented in the standard structure).

The punctuality grading is important to motivate the students to be present on time in order to make the standard structure feasible. It is also important to clarify the respect for people concept of lean and to eliminate the waiting waste (lean concept).

2.2 Student's role to improve teaching

In student-centred learning environments, such as project approaches and other cooperative learning environments (Fernandes, Mesquita, Flores & Lima, 2014; Johnson, Johnson, & Smith, 1998) students play an important role in the construction of their own knowledge, by being actively engaged in the learning process. Unlike traditional teaching methods, where the responsibility for learning rested with the teacher and where the learner played a passive role, active learning emphasizes the importance of the relationship between the student and the teacher in the learning process. Therefore, students also participate in the assessment process in a very dynamic way, as their feedback and continuous assessment will provide teachers with inputs to improve teaching and learning. The evidence collected from students will support decisions that allow changes and/or improvements in teacher performance and in the organization of the learning activities. Designing assessment methods that promote student learning include the use of several frequent tasks rather than one end of course assessment (or build in steps) and also providing timely and detailed feedback to students (Gibbs & Simpson, 2004). Feedback and formative assessment is crucial for effective learning (Yorke, 2003). Teachers must use feedback to evaluate how well the classes went and how they can be improved. Several sources of information may be useful here, such as student evaluations, open discussions with students, the teachers' own experience with the course, etc. All evidence collected from these sources can provide important inputs for improving the teaching and learning process. In summary, student's role to improve teaching is determinant for successful learning also.

3 Methodology

The objective of this study is to analyse student's role in the evaluation of a Lean Teaching and Learning (LTL) model implemented in a Lean Enterprise course at the University of Minho. It is based on a qualitative research approach aimed at analysing student's views and feedback in regard to the teaching and learning process based on the lean principles applied in the classroom context.

3.1 Context of the study

The study was carried out in the context of a course named "Lean Enterprise", which is part of the 5th year of the Integrated Master degree program of Industrial Engineering and Management (IME), at the University of Minho, Portugal. This is an optional course that involved 31 students. The students were male and female regular students aged in general from 22 to 24 years old. Only 2 of them were a bit older and having part-time jobs. Classes took place during September and October 2015. During the 6 weeks of the course duration, there was room for a total of 12 sessions of 100 minutes each. The aim of this course is to help students develop skills in the context of creating continuous improvement systems in companies and the application of concepts and Lean thinking in non-industrial processes such as lean office, lean accounting and in Lean leadership aspects. Applying concepts of lean thinking in the course makes a lot of sense since the course itself is about that. The methodology applied in the case presented here - Lean Teaching and Learning (LTL) - is inspired in concepts and principles of lean thinking as well as in some tools that have been developed to help the materialization of lean concepts and principles. This paper will give special attention to short term PDCA cycles in each class and long term PDCA cycles in each semester. This article is mainly focused on the long term PDCA cycle.

3.2 Data Collection and Analysis

Data collection was based on an online questionnaire applied to students at the end of the 12 sessions. This questionnaires aimed to collect student's feedback in regard to the course and the new model based on the lean concepts applied to the teaching and learning process. The questionnaire included 9 questions based on a Likert scale. Six out of these 9 questions asked students to justify their answers with an open field that allowed students to provide qualitative feedback. This mixed approach, considering quantitative and qualitative data, intended to provide the teacher responsible for the course and the researchers involved in the project with as much detail as possible in order to provide room for improvements. These improvements should support the PDCA cycles.

The online questionnaire included the following questions:

- Q1. Applying the same standard in every class was positive. Why?
- Q2. The applied standard work was the most adequate. Why?
- Q3. PDCA and Standard Work applied in the classes helped clarifying the concepts.
- Q4. Product evaluation (with online group tests) and process evaluation (with online surveys) was useful. Why?
- Q5. Being assessed every class (through tests and group work) was positive. Why?
- Q6. The contents lectured in classes were relevant for the industrial management and engineering profession. Why?
- Q7. The teacher played a key role in the course success. Why?
- Q8. The punctuality grading system promoted class quality.
- Q9. The project was relevant for learning effectiveness.

These questions were followed by 2 open-ended questions:

- Q10. Identify the most positive and less positive aspects of the course
- Q11. Other comments or suggestions

For data analysis, descriptive statistics (average results) was used to describe and discuss the quantitative data achieved in the questionnaires collected from students. This analysis was complemented with simple graphics that allowed a better understanding and comparison of results from different items included in the questionnaire. For the qualitative data analysis, these questions were analysed based on two main categories:

one related to lean concepts and practices; another, related to educational issues (see table 1). The analysis of results will be presented in the next section, flowing this categorisation.

Table 1. Questions categorised by lean and educational issues

Lean concepts and practices	Educational Issues
Q1. Applying the same standard in every class was positive. Q2. The applied standard work was adequate. Q3. PDCA and standard work applied in the classes helped clarifying the.. Q6. The course contents were adequate. Q8. The punctuality grading system promoted class quality.	Q4. Product and process evaluation was useful. Q5. Student assessment in every class was positive. Q7. The teacher played a key role in the course success. Q9. The project was relevant for learning effectiveness.

4 Results

The results obtained from the questionnaires are of both quantitative and qualitative. The quantities results are presented in Figure 1 in terms of average values. One of the questions with the highest scores (4.52 out of 5) was "The punctuality grading promoted classes quality". The students appreciated the fact that all students were at the classroom before the starting time and therefore the class time was effectively used. The reason was that 15% of the final grading system was based on punctuality. Interestingly, the students appreciated it. The other question with the same high score was "PDCA and Standard Work applied in the classes helped clarifying the concepts". In fact, the main structure applied in the classes is based on PDCA cycles and Standard Work concept and students recognized its application and usefulness.

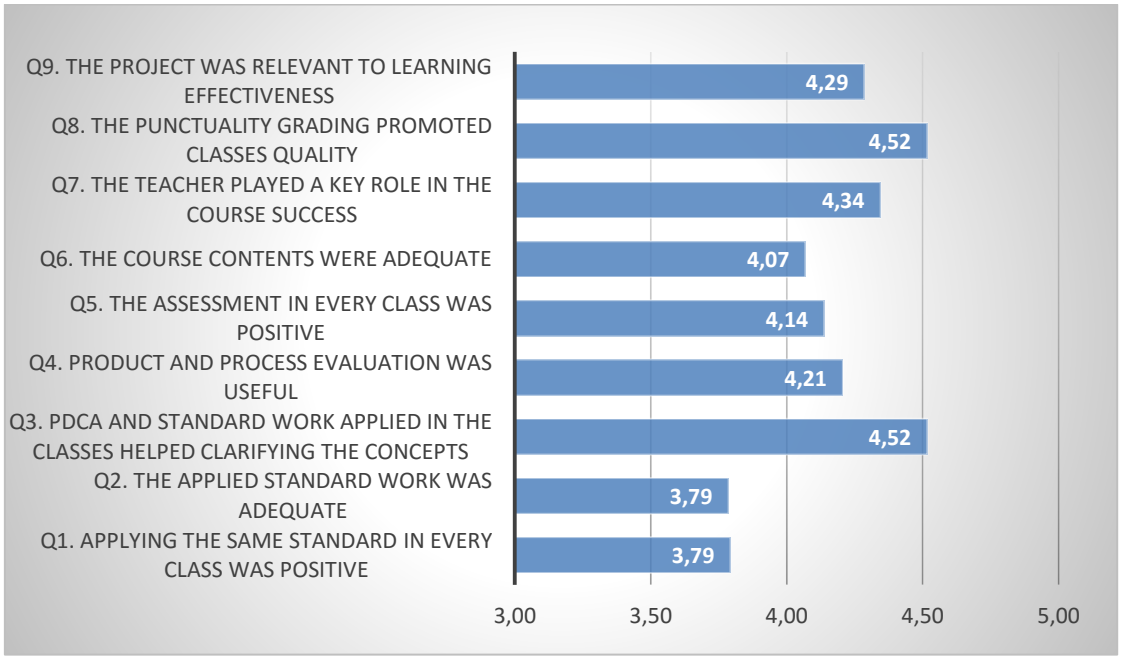


Figure 1. Average results obtained from the final Questionnaire

On the other hand, the answers with poorest score were "Applying the same standard in every class was positive" and "The applied standard work was adequate", both with 3.79 out to 5. This finding requires greater reflection and deeper understanding on how to improve and redesign the class structure standard in order to be more effective and satisfy students' needs.

4.1 Lean Issues/perspective

The lean issues/perspective is analyzed here based also on the quantitative results but with more focus on the comments from students in the open-end question.

4.1.1 Standard Work

A very popular practice in lean environment is the implementation of "standard work" concept as mentioned earlier in the article. The existence of a standard structure in every class was implemented expecting similar advantages as the ones known in other areas of activity. Two questions were put to the students in the following way: "Q1 – Applying the same standard structure in every class was positive" and "Q2 – The applied standard work was adequate". The average student evaluation on these question was 3.79 out of 5 (see Figure 1) being interestingly the same for both question and being the lowest feedback of all questions. Arguments in favor and against the use of standards exist in industrial or office environments and they were also found here. Although the majority of the answers from students were in favor of the use of standard, some students also express some disagreement. Examples of student comments (quotes) in favor of standards:

> "Creating routines is positive for good class organization"
>
> "Allow the knowledge on how the class was going to run"
>
> "Allow the development of habits that lead to more effective learning"

Examples of student comments (quotes) expressing some disagreement on the use of standards in class:

> "Important changing standards to create motivation"
>
> "Following a standard in a class is 'excessive strictness'"

Regarding the applied standard students mentioned the difficulty in meeting the time in many activities or the limited time assigned to some tasks that needed more time to be effective. Examples of comments were:

> "I think that it was adequate but there is always space for improvements"
>
> "The standard was not followed many times leaving some learning activities unfinished"
>
> "We should alternate with other standards"

From the feedback obtained from students and also from our own experience, the use of a standard structure in every class needs some improvements in order to be completely effective in the eyes of students (clients).

4.1.2 Team work and empowerment

Team work is very important in lean environments because it creates the necessary culture for problem solving and continuous improvement. Teams are critical in lean environments since without them lean is impossible to sustain. Teams are responsible to identify improvements opportunities and work together to find the appropriate solutions. Team work, promoted in every class, was recognized by students in comments such as:

> "It is important to develop interaction capacity in groups and having the perception that success is easier achieved with team worker…"
>
> "Team work it is an excellent way to work because it force us to interact, discuss ideas and reach to conclusions"
>
> "Team discussions promoted the exchange of ideas and helped clarify doubts than alone would be impossible to clarify"

Apparently students recognize that team work is an effective way of finding solutions for problems. This recognition is not only related to student life but also in real professional work in organizations.

4.1.3 PDCA cycles

PDCA cycles are essential to continuous improvement and they were used in the class room. The question Q3 ("PDCA and Standard Work applied in the classes helped clarifying the concepts") with 4.52 out of 5 had together with question Q8 the highest score. Students strongly recognized that the practical application of the

PDCA cycles in the class room helped in clarifying the concept. Examples of student comments regarding the PDCA cycles and its effectiveness in continuous improvement are:

> "The students were interested in learning because of the ´checking´ at the end of every class and that worked very well. The ´checking´ helped the teacher to understand what could be improved"
>
> "The teacher was concerned with the improvement of every class"
>
> "The check phase at the end of every class was important to confirm immediately if the concepts were actually learned"

4.1.4 Respect for people and Waiting Waste

Respect for people is a key issue in lean environments and the waiting waste is one of the 7 types of wastes found in production. In the questionnaire these issues were covered partially in que question Q8 ("The punctuality grading promoted class quality"). This issue was recognized with the highest score (4.52 out of 5) with comments such as:

> "… the punctuality grading was a positive factor since it allowed that all students were in class in time …"
>
> "one of the most positive factors in this course was the punctuality of the students"
>
> "the most positive aspect was the punctuality grading since resulted that all students were present on time and the class time was totally availed"

Regarding the respect for people some students added comments in the existing open-ended questions with comments such as:

> "The teacher was always kind and understanding"
>
> "One of the most positive achievements in this course was the exemplary conduct of students"

4.1.5 Creating Flow and Inventory Waste

Creating flow in production is a lot easy to understand than creating flow in teaching and learning. Some comments from students show the recognition of the advantages of flow in learning.

> "…testing and project presentations every week avoided the work being accumulated and continuous improvement"
>
> "…allowed us to assess our knowledge in the same day, helping to reinforce our knowledge. Having tests in every class requires us to be alert in every class, as opposed to other courses where we could study only before the final test"

4.2 Educational Issues

4.2.1 Product and Process Evaluation

In students' opinion, product evaluation and process evaluation were considered useful for learning. The main reasons mentioned by students are related to the importance of feedback provided by the mechanisms implemented. The online group test, used for product evaluation, at the end of each class, allowed students to reflect upon the contents and knowledge achieved during the class. Also, through the discussion of ideas with other students, students were able to clarify and understand concepts in a better and deeper way. This kind of learning leads us to conclude that cooperative learning and assessment strategies are very powerful tools that contribute to effective learning. Process evaluation, through the collection of data with an online survey at the end of each class, was rated very positively by students. Some of the issues explored in the online survey applied to students at the end of each session included dimensions such as: clarity of learning objectives, duration of class activities, teaching strategy used, assessment methods, group work, student involvement, teacher's role.

From an educational perspective, the concepts of continuous assessment and formative feedback (Black and William, 1998) are very evident in students' answers:

Students were interested in learning in all the classes due to the evaluation method and this became a great way to consolidate knowledge. The surveys helped the teacher to see if there was anything to improve and what it was!

With the surveys, we were helping the teacher to improve his lesson plan and improve things that did not go so well.

It was positive because we were able to give feedback to the teacher about what went right and wrong in class. It also allowed us to evaluate our knowledge of the class on the same day, consolidating knowledge, moreover, the fact we had tests every class required us to pay more attention in class unlike other courses that we only study just before the final test. The evaluation process also served as a tool for the teacher to improve the way he gives lessons, based on student's feedback.

Yes, with the tests we can see immediately if the concepts learned in class were effectively understood.

4.2.2 Continuous Student Assessment

Students were satisfied about being assessed at each class. Some of the reasons pointed out by students highlight the importance of discussing and sharing ideas with other students as a successful learning process that helps to clarify the understanding of concepts and also consolidate knowledge. At the same time, students state the advantages of continuous assessment which does not concentrate learning at a specific time at the end of the course. Besides these positive arguments related to the continuous assessment, other issues related to the cooperative assessment strategy used were also referred by students. The group assessments promoted the development of teamwork skills, student engagement and active participation in the learning process. These competences are aligned with the Bologna Process and student centred learning.

Student assessment at the end of each class allowed to consolidate and test knowledge from class to class. This discussion and exchange of ideas at the end of each class led to a better understanding. And the tests allowed us to summarize the general ideas about class contents from class to class.

I enjoyed the idea of having rotating groups, which allowed us to work with different team members.

The assessment strategies promoted teamwork and they were also a way to strengthen something that will be crucial for our future.

The assessment was a way to consolidate the class lessons. Having group presentations in all classes allowed us not to delay our work and improve continuously.

It makes students reflect upon their work in an immediate way and not delaying that reflection to a later phase.

The fact that students are assessed in every class gives me more motivation to study.

4.2.3 Teacher's role in the Learning Process

Student´s opinion in regard to teacher's performance is very positive. The teacher was kind and comprehensive with students. The teacher tried to improve performance at each class, based on student's feedback. Also the teacher's wide experience in Lean, due to contact with enterprises, allows the teacher to provide examples and link theory to practice. The idea of "practice as you preach" is very present in the classes.

He was kind and understanding, and was concerned with the improvement of every class.

Due to the teachers experience in the implementation and coordination of lean projects, this resulted in better teaching and learning.

Because of the fact that the teacher lives according to this philosophy, he deals with the activities from a Lean perspective, sets an example and shows improvements with this behaviour.

The teacher was important since we already have some experience in this area and sometimes que would add to our knowledge with his own experiences lived. This allowed a greater

understanding of knowledge and concepts. (And also for being kind and understanding with everyone)

The quotes reveal a good learning environment. The teacher motivated students and provided engagement in each class. The teacher showed enthusiasm and excitement for the contents being taught. The following quotes from students' answers confirm the important role played by the teacher in the teaching and learning process.

> The way he kept students motivated through different activities. Moreover, keeping the punctuality as an evaluation criteria was a very positive issue in this course as it made all students be in class in time to start. The teacher's support in the projects also contributed to the success of course.
>
> Tried to motivate students to be more proactive by creating a learning situations that promoted this involvement.
>
> The teacher knew, in a way, how to use the appropriate methods for teaching the course and knew how to motivate the audience.
>
> I agree, the teacher assumed a very important and motivating role for the next phase of our lives (world of work). In addition, he demonstrated commitment to the course and was willing to try new alternatives proposed by the students.
>
> For helping us to think "outside the box" and the teaching methods used.

5 Conclusions

From this empirical study one of the conclusions that is possible to draw is that some lean concepts and principles can be used in teaching and learning contexts to improve its effectiveness. In reality some of those concepts are already aligned with educational theories that focus on student centred learning, but some others are new in educational contexts. There is still a lot of improvements needing to be done but from this pilot study results show that concepts such as standard work, PDCA cycles, continuous improvement, elimination of waiting waste, reduction of inventory waste and creating flow, are bringing improvements in teaching and learning processes. The study also draws attention to the importance of student's role in providing feedback in regard to the learning process, understanding of course concepts and also teacher performance. By developing an on-going system that allows to collect data from students in a systematic way, teaching can be improved and learning can be made more effective.

Future work will focus on applying other concepts and tools, especially ways to improve students' empowerment and ways to introduce visual management, value identification and the identification of more non-value adding activities.

6 References

Alarcón, L. (1997). *Lean Construction*, A. A. Balkema, Rotherdam, Holand.

Alves, A. C., Kahlen, Franz-Josef, Flumerfelt, S. and Siriban-Manalang, A-B. (2014). The Lean Production multidisciplinary: from operations to Education. *Proceedings of International Conference of Production Research Americas* (ICPRAmericas), Lima, Peru, 31 July to 1 August

Black, P. & Wiliam, D. (1998). Assessment and classroom learning. *Assessment in Education*, 5 (1), 7–74.

Coimbra, E. A. (2009). *Total Flow Management*, Kaizen Institute, ISBN 978-0-473-14659-7

Cousineau, K. (2012). Why Business Leaders Apply Lean Before Six Sigma, http://www.opticompinc.com/why-business-leaders-apply-lean-before-six-sigma/

Emiliani, B. (2015). *Lean Teaching: A Guide to Becoming a Better Teacher*, CLBM, LLC, Connecticut, USA.

Fernandes, S., Mesquita, D., Flores, M. A., & Lima, R. M. (2014). Engaging students in learning: findings from a study of project-led education. *European Journal of Engineering Education*, 39(1), 55-67.

Fliedner, G. and Mathiesona, K. (2009). Learning Lean: A Survey of Industry Lean Needs, *Journal of Education for Business*, Volume 84, Issue 4, pp. 194-199, DOI:10.3200/JOEB.84.4.194-199.

Gibbs, G. & Simpson, C (2004). Conditions under which assessment supports students learning', *Learning and Teaching in Higher Education*, Issue 1.

Graban, M. (2011). *Lean Hospitals: Improving Quality, Patient Safety, and Employee Engagement*, CRC Press.

Johnson, D. W. & Johnson, R. T. & Smith, K. A. (1998). *Active learning: Cooperation in the college classroom*. 2nd edition. Edina, Minn: Interaction Book Co.

Keyte, B. (2004). *The Complete Lean Enterprise: Value Stream Mapping for Administrative and Office Processes*, CRC Press.

Ohno, T. (1988). *Toyota Production System: Beyond large-scale production*, Productivity Press, Portland, Oregon

Sugimori, Y., Kusunoki, K., Cho, F. and Uchikawa, S. (1977). Toyota production system and Kanban system: materialisation of just-in-time and respect-for-human system, *International Journal of Production Research*, 15(6), 553–564.

Thirkell, E. and Ashman, I. (2014). Lean towards learning: connecting Lean Thinking and human resource management in UK higher education, *The International Journal of Human Resource Management*, 25:21, 2957-2977, DOI: 10.1080/09585192.2014.948901

TPPDT, The Productivity Press Development Team. (2002). Standard Work for the Shopfloor. New York. Productivity Press.

Womack J, Jones D., Roos D. (1990). *The machine that changed the world*, Rawson Associates.

Womack, J.P., Jones, D.T., (1996). *Lean Thinking: Banish Waste and Create Wealth in Your Corporation*. Free Press, New York

Yorke, M. (2003). Formative Assessment in higher Education: moves towards theory and the enhancement of pedagogic practice. *Higher Education*. 45 (2), 201-228.

Ziskovsky B. and Ziskovsky J. (2007). Doing more with less – going Lean in Education, A white paper on process improvement in education, Lean Education Enterprise Inc.

A hands-on approach for an integrated engineering education

Luciano P. Soares[1], Paulina Achurra[1], Fabio Orfali[1,2]

[1] Insper Instituto de Ensino e Pesquisa, São Paulo, Brazil
[2] Faculdade de Educação, Universidade de São Paulo, São Paulo, Brazil

Email: lpsoares@insper.edu.br, paulina.achurra@insper.edu.br, fabioo1@insper.edu.br

Abstract

Modern day engineers are required to create solutions that address complex societal problems where pure technical knowledge is no longer sufficient to tackle such challenges. Today's professionals are required to rapidly iterate and prototype solutions, work in multidisciplinary teams, give and receive constructive feedback effectively, among others. These competences were developed, in an entirely new engineering program, through hands-on experiences since the first semester, allowing students to take part on real engineering activities with high degree of autonomy very early in their higher education courses. This is only possible if classes are not isolated topics but an integrated experience. The right culture that supports student's autonomy plays a fundamental role. Integrated, hands-on courses proved an extremely successful approach, measured by the technical level of projects and by the improvement in other competences. Students saw purpose in their learning, which translated in higher intrinsic motivation. Description and details of how this curriculum construction was developed is presented, with specific example of two courses' integration discussed in more details.

Keywords: Hands-on learning; Integrated learning experience; Curriculum development; Formative feedback.

1 Introduction

In the last years, much discussion has been focused on the abilities needed for the twenty first century engineer and whether current education is forming the broader professional needed today (Grimson, 2002). It has been recognized that these abilities should go beyond technical knowledge and should encompass interpersonal skills, incorporate design and entrepreneurial competences, develop the ability to be a life-long learner, among others (Crawley et al., 2014). Based on that, an effort was initiated to create an entirely new engineering program at Insper that pursues exactly this mission of innovating in engineering education, which would develop a set of competences going beyond pure technical knowledge. Some inspirational initiatives around the world were used as reference (Somerville et al., 2015; Bright & Phillips, 1999). In particular Olin College was a reference for this project, not only because they are committed to innovating in education and spread their experience with other schools around the world, but also because of the successful professional placements of their graduates, a clear indication that companies value the skills students develop at Olin and similar colleges.

The designed curriculum had some principles in mind: students would experience engineering since the beginning, they would learn through hands-on experiences, theory would be taught in context, and applied to real-world problems. These principles were embraced to avoid a common frustration on engineering graduates, the fact that they only encounter hands-on and real-world experiences after two or three years into their course, being one of the main causes of high dropout rates in engineering programs (Meyer, 2014). Project Based Learning (PBL) was a fundamental teaching approach used in the program (Adderley et al., 1975). It was probably the most challenging methodology for students and faculty but also brought the most significant results. Other pedagogical techniques were implemented, more noticeable: flipped classrooms, peer instruction and coding dojo. Another advantage of a hands-on approach is that it allows students to greatly interact with colleagues and professors, enabling students to develop skills the program is focusing on in a natural way. In contrast, when learning is heavily based on lectures, there is limited room for students to develop other skills.

Hands-on approaches that support development of soft skills are being used in many institutions. For the last 10 years, Franklin W. Olin College of Engineering has employed active learning and hands-on methodologies to develop several other competences (Olin, 2016). Their results are being used as reference in many other institutions around the world. In a more local context, the School of Engineering of Lorena Brazil reported

positive results for learning and development of transversal skills after PBL adoption, strengthening areas like teamwork, communication and project management (Pereira, 2015). Chagas (2015) also described the use of Project Based Learning in a fluid mechanics course, working in a space entirely designed in the school to allow students to experience a better learning dynamic with their hands-on experiments. Results showed students had a more active behavior, even students who had a traditional lecture-based background.

This work describes the decision process for integrating a hands-on approach in courses, with some emphasis on the Software Design (SofDes) and Modeling and Simulation of the Physical World (ModSim) courses, exploring how to balance the best educational techniques and also creating an environment that does not overwhelm the students, allowing them to have the best possible learning experience.

2 Delivering a New Engineering Curriculum

One of the challenges to incorporate modern pedagogies in established programs is the institutions' and faculty's inertia to change. In order to transform education, both students and faculty need to leave their comfort zone and professors have to recognize that the learning experience for the student must be very different to how they have learnt in the past. It probably involves professors exploring areas out of their core experience, and challenging believes about the best use of classroom time. Faculty needs to embrace this challenge, recognizing that the student is the protagonist of the learning process and the professor is not at the center of the class. These points are part of a set of assumptions defined and used as a reference for designing the new courses, among them faculty should design courses expecting students students engaged in the learning activities, and that they are there for the learning, not for the grades.

Many institutions report that changing the teaching culture is difficult and takes time (Miller, 2011), at the same time, there has been an increase on active learning methodologies adoption in the first year of many programs, indicating that this period might be a propitious time in the curriculum for implementing modern teaching techniques (Abele, Miller, & Stein, 2014). Given that an entire new curriculum was designed from scratch, setting the stage for the success of the new program since the beginning was critical. The challenge of changing the education paradigm became clearer when time to design and detail the courses arrived. The first semester should incorporate the principles mentioned earlier, focus on teaching core technical engineering knowledge using active learning pedagogies, and also include desired soft skills competences, the so called non-cognitive competences. This must be done in day to day class activities, in a way that was meaningful and non-artificial, and this must start in the first day of classes, letting clear for the students the teaching style that they have to get prepared for the rest of the course. Since traditional engineering way of taught is concentrated on delivering pure content, with laboratories activities very often planned in a way that students reproduce a certain experiment and collect data. PBL was successfully used to contextualize activities with open-ended authentic problems throughout the curriculum, the projects were most real as possible and students could see that what they are studying in a course is used in other practical courses and in their real life. Usually this also improves student's empathy with the activities, improving motivation.

Courses were planned from scratch to implement the modern techniques discussed. In this context, two aspects seem fundamental: it was necessary to test the activities before the start of the courses and plan the process of forming desired culture among students.

2.1 Prototyping the Courses

In the spirit of the new course, where prototyping and iteration are key aspects of the learning process, the engineering faculty invited several students during the previous years to the arrival of the first class to co-develop learning experiences and incorporate student perspectives in the curriculum. These students came from different backgrounds; some of them were local undergraduate students in business or economics, some were foreign engineering students from Olin College. Both groups of students were fundamental for curriculum design tasks and brought complementary views to the process. Not only they contribute with the student's perspective of the proposed activities but also raised questions of how relevant local attitudes towards learning were, how to better address them, and how they would influence the culture desired. From the faculty's point

of view, prototyping experiences in a low-stakes environment proved to be an invaluable tool to the process of creating courses from scratch. Figure 1 shows images of activities that were prototyped during this period.

Figure 1. Prototyping classes with students.

During this prototyping period, some key desired aspects to include in the program emerged: the first, and probably the most important, was seeing the student as a partner instead of the more traditionally hierarchical relationship; in addition, the role of the professor being more like a coach rather than merely an instructor; the importance of honest feedback; and the effect professor's attitudes had on student's intrinsic motivation also appear.

2.2 Culture Development

Culture formation during the first year is particularly critical. Student's beliefs and attitudes developed at the beginning of the program are likely to be carried on to following years and passed on to next generations. Discussions about course progress, difficulties and challenges were a common process for establishing a culture of students-professors partnership. Some of this discussions happened in special meetings that were devoted to discuss students' feedback. For these events, design-thinking techniques were used, giving a high sense of belonging to the students and helping on the development of transversal competences.

Faculty attitudes and beliefs towards students and learning are also critical to culture formation. Professors serve as students' role model directly influencing their behavior. In consequence, faculty should also be recruited considering their adherence to the project. Professors should be open to new paradigms and focused on the students learning in the broader sense, not only content delivery. Due the projects, the content is actually acquired by the students in each step of the project development, and one role of the professors is just point that students are learning by themselves and at the end of the course they have more knowledge about some topic, and more important, acquired skills not clearly noticeable, but are the fundamental tools to become an engineer.

Regarding on the culture development, some decision was also taken about which competencies should be more intensively addressed during the beginning of program. For instance, since students should work in many group activities during their course, it was intentionally concentrated teaming activities since the beginning. The earlier they understand the importance and complexity of working in teams is better, because they will have at least five years with intense team work activities, at the same time this is one of the most demanding competence the employers are asking for.

Other important aspects of culture are students' attitudes towards learning and prior beliefs. Students should learn because they want knowledge, not only motivated by grades: they should find joy in learning; they should learn how to learn collaboratively. In the first class, most students arrived with a very different mindset towards learning and one of main challenges was to address these differences. As reported by others (Stefanou et al., 2013), hands-on activities give the ideal context for these attitudes to flourish, and these activities should be conducted as most as possible at class time. Since hands on project development is the most important activity, it should be conducted in the most important time, that is the class time were all the students and faculty is concentrated on that.

Classroom layout (Figure 30) was also chosen to facilitate collaborative learning and professor-students interactions. One of the decisions was to have whiteboards around the classroom, movable tables and chairs

with wheels that will allow different class configurations for small to larger groups activities. This not only facilitates discussions but also allow the students to easily move to the white board and start a discussion with professor and the rest of the team group. Although traditional class set ups (amphitheater style) does not preclude interactions to happen, our experience is that it inhibits interactions and makes them rarer, on the other hand, this configuration puts students in the center of the experience, making a clear effort for a student center design.

Figure 2. Classroom activity.

3 Courses Integration

The first lesson learned is that reproducing course syllabus from other institutions does not work. Inspiration on successful experiences is clearly very valuable, but there are several local factors, like cultural style, professor experience, local high school curriculum, among others that create a need for *ad hoc* planning for courses and its integration. The strategy used for creating the courses was based on the backward design, were the outcomes are first decided in a way to make explicit the competences developed and then move back to activities, finishing with the course content topics (Wiggins & McTighe, 2005).

Integration across disciplines was another characteristic included by design in the curriculum. Courses were designed to move away from the "class collection" structure, to real integration among disciplines. The ModSim and SofDes courses are an example that was developed with this aim in mind. Students would be learning to program in the SofDes course and a week later they would be applying their new knowledge to simulate real world problems in the ModSim course. This integration is fundamental not only because it contributes to higher cognitive levels and leads to life-long learning, but also because greatly improve the student experience and motivation (Padgett, 2013).

This work focuses on two case courses, SoftDes and ModSim. The aim of the SoftDes course is to enable students to code and debug computer programs individually and in groups, and developing heuristics to solve the functional and non-functional requirements of a program. The program projects were specified with a user necessarily, thus it also required students identifying users needs. In ModSim course, it is expected that the student understands his environment and be able to model it. These interdisciplinary courses apply technical knowledge of physics, mathematics, and programming, and develop skills like teamwork and design, in a real world context.

Not only courses must be interdisciplinary, but should "talk to" other courses of the curriculum. One of the most noticeable decisions to integrate SofDes and ModSim was the programming language. Python was the common language chosen, in preference of the traditional Matlab for numerical simulations and C for software development, because it allowed students to focus on programing concepts instead of understanding the specifics of two languages.

3.1 Software Design

The SoftDes course was planned in a way that at the end of the course, students should be able to: develop computer programs; identify and implement computational algorithmic strategies; act in a self-managed team development by agile methods, and also to judge and prioritize their learning strategy. In order to delivery that, design is used as glue since students should consider the importance of the user when developing their solution.

As stated previously, our program involved hands-on experiences from the first day. As an example, the first day activity in SofDes was the development of a game allowing the students to have a sense not only of the contents covered in the course, but also of other skills developed during the course such as design, teamwork, learn to learn, stressing that the course was more than just technical knowledge.

Programming is a skill demanded in many engineering activities, but learning to program in any language takes time. In the same way you learn a new language such as English or Portuguese, the best results are achieved with intense conversation practice. Since conversation with computers is not viable, constant development of programming codes and feedback from professors and colleagues is an effective strategy to develop fluency in a programming language. These conversations can be divided in two types. One is for short, self-contained exercises, where students can practice simple constructions. However, as in spoken languages, the best results are achieved in more complexes, real life type conversations. In this case, projects provide a good environment for learning how to program. In both approaches, feedback to students is a fundamental tool to help them identifying their mistakes and correct them. This constant feedback may not be feasible for a single professor with many students in the class. In order to increase programing feedback, two approaches were used: coding dojo and pair programming (Sato et al. 2008). In both cases, a student can see their colleague code and give feedback in real time. Students learn collaboratively one supporting other. In parallel this course has a commitment on teaching teamwork skills. In the same way that programming needs constant feedback to improve, teamwork is also a skill that needs feedback with a high frequency. Students will face this challenge of working in team during their professional lives, and it is important that they learn how to give and receive feedback.

One decision for team development progression was to first start with individual projects. That way, every student could pass at least once for the entire process of software development, from few simple code lines, to more complex algorithms, improving student self-confidence on programming. In a second phase, students were proposed to work in pairs, which already create an environment that needs some communication with colleagues, but it is still simple to manage. The third project required larger groups, with 4 or 5 students. To help project dynamics, agile development techniques were taught and constant interaction among team members and professor were planned.

Autonomy progression was also carefully thought during the course. In the beginning, projects were presented to students with a complete specification, so they only had to concentrate in the implementation. As the course progress, projects have been intentionally getting less scaffolded and students had to better understand the requirements to choose what and how to do. The final project had only a few restrictions such as identify a real user, develop programming software with some graphical interface and adopt some team strategy, but in all other aspects it was open to students to decide the topic/application.

After some time into the semester, it is a good practice to pause and reflect on the course. Students can contribute highlighting important points for them that should be reinforced, and some practices that should be avoided. For the SofDes course, this period was about one third into the semester. Design thinking strategies were used during reflection, like writing notes on color post-it, which facilitates that every students contribute, in a non-threatening environment. Students should not be afraid of suggesting ideas and faculty should be open to receive feedback without judging it. In order to get a meaningful and productive reflection, both students and faculty should understand that this kind of dynamics is fundamental in creating a culture of collaboration, to ultimately develop a better course.

The original plan was to teach the course entirely using flipped classroom methodology. Students were required to do short readings, around 8 pages each week, to get the necessary knowledge for class activities. Unfortunately, not all students embrace material pre-reading. The most probably cause is the fact that first semester students are ill prepared for this kind of responsibility, they expect the professor to be in responsible for information transfer, and this knowledge transfer to happen during classes. As mentioned before, changing student's attitudes and beliefs brought from high school was a great challenge.

As the course is running in parallel with others, like ModSim class, development of important skills is shared. For instance, programming skills developed in SofDes would be necessary for programing numerical

simulations in ModSim. Presentation skills, worked mainly in ModSim were also needed and evaluated in SofDes final presentation. One more example is the skill to be a self-directed learner. On the first days of classes, students usually got stuck in a problem, and wait for the professor to arrive and help them to move on, instead of trying to search for a solution or asking for help from colleagues. Usually, programming user groups that are easily found through Google will have some answer close enough to the students' questions to help, but they were not used to do that. This attitude greatly evolved along the course. Students arrived with very little initiative and autonomy, but by the end of the semester, they were able to search for similar problems and transfer that knowledge to their problem. This is a highly demanded skill by the industry.

3.2 Modeling and Simulation of the Physical World

This course allowed students to experience the modeling and simulation cycle, which starts with the analysis of a real physical system, identification of relevant variables for characterization, the use of mathematical tools to represent the relationships between these variables, and numerical simulation of the mathematical model obtained. Students iterate through this cycle three times during the course. The course involved three different areas of knowledge: Physics, where thermal and mechanical systems are studied; Mathematics, with the use of difference and differential equations; Coding to implement mathematical models created, using for that Python. Programming need was the main point of contact with the Software Design discipline.

The course, inspired on an Olin College experience (Olin, 2016), had to be adapted. Two points were critical in this adaptation: the fact that the Calculus is not part of the majority of local high school curriculum and the limited student autonomy when faced with open-ended problems.

Regarding calculus, a plan was made to include math tracks in the engineering program. The strategy adopted reversed the order traditionally adopted: in the first discipline of the track, students investigate situations where they could apply mathematical tools to solve practical problems, letting the mathematical technical details to be developed in the following semester courses. In order to achieve this, the most basic concepts of calculus were discussed in the class, such as derivatives and linear approximations of functions, enabling them to understand the tools they can use, and allowing them to find solutions to the problems formulated in their projects through numerical simulation. Derivation techniques and analytical methods of differential equations resolution were to be seen only in the following semester, in the Mathematics of Variation course.

Engineering students' performance on concepts covered on the mathematics of variation course was higher than previous experiences with other students from a similar environment, that followed the traditional Calculus track, both in relation to content mastery and motivation for learning. The main difficulty of this inversion was managing the anxiety of students when they compare themselves to colleagues in other engineering programs, who were learning formal calculus techniques already in the first semester. Some sessions were necessary to clarify the strategy adopted and show all the content that would be seen in this and the future courses, establishing a correlation with the program adopted in other schools.

The issue of autonomy in classroom appeared soon during the first project of the ModSim course, both when doing research regarding their system under study and during studio classes where students had time to work independently on their projects. In the first case, it was necessary to create research orientation sessions during class, discussing criteria for websites and scientific works selection, as well as discussions on parameter estimation.

As in Software Design course, students showed to be very dependent on the professor guidance in studio classes, getting stuck every time that a doubt appeared and considering only the professor as possible help. Project planning techniques were discussed, so that student could organize their tasks in order to optimize their time, without teacher availability preventing them to continue their work. Results readily appeared in the second project, and even improved in the third project, with a higher autonomy.

4 Results

The results obtained in this first semester, shows that the motivation is high among the students. They address projects with a level of complexity that is usually only found in other engineering schools in students halfway

though their programs. It is possible confirm that the dropout rate is lower than other engineering program, with less that 10% of students leaving this new program.

After one full year, some important results were observed with respect to learning goals established at the beginning of the project. Students developed good presentation skills, as a result of frequently presenting their projects, with proper preparation and feedback from colleagues and faculty. Another aspect of interpersonal skills developed was the ability to raise their voices in a group. After several projects working in teams with different people in different courses, typically shy students start to communicate and share their opinions and points of view to colleagues, changing their behavior already in the first semester. On the other hand, peer evaluation is something students are still struggling with, some of them are not showing maturity to support their colleagues with honest and critical feedback. This ability should be practiced as soon as possible allowing the students to understand the process and gain confidence in the importance (Vicente, Dalila, & Lima, 2014).

Regarding other competences aimed to be developed, Design was present in other courses in the same semester, and was included in SoftDes course where students developed a final project that should take in consideration a real user. Students were less focused on external users and frequently put themselves as users. After the first semester a higher focus on a real user with needs and different points of view were developed. Design is distinctive characteristic of this engineering program, as such it is part of the curriculum since the beginning, being taught and explained since the first moment. Entrepreneurship was probably the most difficult competence to implement, some concepts were presented, but entrepreneurship is something that will be further developed in the curriculum, and a stronger emphasis is planned for specific courses in the fourth semester..

The learn-to-learn competence was intentionally and intensely developed. The average student arrived with very little autonomy, and after sometime they took initiative, understood the process of searching for information, getting support from colleagues, and prototyping/trying at least once, before running for the professor.

One challenge found refers to student assessment. Our program adopted the use of letter grades for assessment, a non-standard evaluation metric for most of the admitted students. Some courses based feedback to students solely on written feedback. Independent of the methodology, many students were nervous without the familiar numerical assessment. Constant feedback was fundamental to deal with this uneasiness.

The fact that the curriculum does not have a formal calculus course in the first semester lead to some students perceive the program as a watering-down of technical strength, communication and several discussions with students explaining the reason for that, showed that the issue was minimized and they could understand the value of the inversion.

5 Conclusion

After two years of planning and prototyping, the real students arrived in three classes with 30 students each with a very successful first year. The first lessons learned is the fact that first year students are motivated and technically ready to create advanced engineering projects. Being technically sound is, of course, a necessary condition. However, the importance of the cultural environment in which students create these projects is equally important. This is in accordance of earlier experiences found at Olin and at the iFoundry, University of Illinois (Goldberg & Sommerville, 2014).

The reality in Brazil is that most students are bound to have a cultural shock during their first semester because of high school traditional style. This required an extra effort from faculty to be constantly revisiting the program proposal, to constantly remind expectations for student's attitude, autonomy, initiative, and self directed learning. Part of this phenomenon is expected to decline in future years as the program gets better known, student's expectations and commitment will be better aligned with the program's mission and approach. Since the program is non-traditional in these aspects, recruiting and selection were also adapted to better communicate program goals and attract students with an orientation to competences developed in the program.

Prototyping earlier class activities with foreign and local students proved fundamental not only for the smoother running of classes, but mainly because of the impact it had on faculty. Experiences with new pedagogical techniques and new roles as coaches allowed to surface differences in professors beliefs about teaching, learning, and evaluating learning among others, that ultimately empower faculty to innovate in teaching engineering. The challenge now is for new faculty to embrace this innovative program, and create and deliver courses aligned with the program principles. The answer appears to be keeping the culture alive, having the faculty and students sharing common values and beliefs. One strategy that helps reinforce culture are NINJAS (term borrowed from Olin College teaching assistant meaning "Need Information Now, Just Ask) that are fundamental in emphasizing and modeling student's expectations and attitudes, and also bringing new faculty into the program beliefs.

Finally, integrating courses and competences proved an extremely successful approach, measured again by the technical level of projects and by the improvement in other competences such as their ability to be effective team members as well as their presentation skills. From the student point of view, it helped to have a more coherence experience where they could see purpose in their learning, which translated in higher intrinsic motivation (Stefanou et a. 2013). Students had deep and meaningful learning experiences, they learned collaboratively, they had fun learning.

6 Acknowledgement

This project consumed huge amount of work, research and dedication of a group of professor, students and staff that made this a reality. Insper supported the entire team, making clear the goal of creating something new. Several students from the business and economics courses were since the beginning participating and giving valuable feedbacks. The Olin partnership resulted in many visits that resulted in many refinements, and also allowed brave students to come to Brazil to collaborate with the project.

7 References

Abele, J., Miller, R. K., Stein. L. A. (2014). The Role of Collaboration in Spreading Culture Change in Teaching and Learning, Olin College of Engineering, May 2014.

Adderley, K., Askurin, C., Bradbury, P., Freeman J., Goodlad, S., Greene, J., Jenkins, D., Rae, J. and Uren, O. (1975). Project Methods in Higher Education. SRHE working party in teaching methods. Techniques group. Guildford, Surrey, Society for research into higher education.

Bright, A., Phillips, J R. (1999). The Harvey Mudd engineering clinic past, present, future. Journal of Engineering Education.

Chagas, R. L. C. P. (2015). The Impact to Implement a Model of Discipline in 100% PBL. Proceedings of Seventh International Symposium on Project Approaches in Engineering Education. Aalborg Universitetsforlag. 492 - 498.

Crawley, E. F., Malmqvist, J., Östlund, S., Brodeur, D. R., Edström, K., (2014). Rethinking Engineering Education The CDIO Approach, Springer International Publishing.

Goldberg, D. E., Sommerville, M. (2014). A Whole New Engineer. ThreeJoy Associates, Inc.; 1 edition

Grimson, J. (2002) Re-engineering the curriculum for the 21st century. European Journal of Engineering Education. Vol 27.

Meyer, M., Marx, S. (2014) Engineering Dropouts: A Qualitative Examination of Why Undergraduates Leave Engineering. Journal of Engineering Education, October, 2014. 10.1002/jee.20054.

Miller, R. K. (2011) The Challenge of Spreading Innovation in Teaching and Learning: Why Is It So Hard and What Can Be Done About It?, Olin College of Engineering, November 2011.

Olin (2016). Modeling and Simulation, http://www.olin.edu/academics/experience/modeling-simulation/

Padgett, R. D., Keup, J. R., Pascarella, E. T. (2013) The Impact of First-Year Seminars on College Students' Life-long Learning Orientations, Journal of Student Affairs Research and Practice, 50:2, 133-151.

Pereira, M. A. C. (2015). Project-Based Learning: Analysis after Two Years of its Implementation in the Industrial Engineering Course. Proceedings of Seventh International Symposium on Project Approaches in Engineering Education. Aalborg Universitetsforlag. 176 - 183.

Sato, D. T., Corbucci, H., Bravo, M. V. (2008). Coding Dojo: An Environment for Learning and Sharing Agile Practices. Agile, 2008. AGILE '08. Conference, 459 – 464.

Somerville, M., Anderson, D., Berbeco, H., Bourne, J. R., Crisman, J., Dabby, D., Donis-Keller, H., Holt, S. S., Kerns, S., Kerns Jr. D. V., Martello, R., Miller, R. K., Moody, M., Pratt, G., Pratt, J. C., Shea, C., Schiffman, S., Spence, S., Stein, L. A., Stolk,

J. D., Storey, B. D., Tilley, B., Vandiver, B., Zastavker, Y. (2005) The Olin Curriculum: Thinking Toward the Future, IEEE Transactions on Education, 48(1): 198-205.

Stefanou, C., Stolk, J. D., Prince, M., Chen, J. C., Lord, S. M. (2013). Self-regulation and autonomy in problem- and project-based learning environments. Active Learning in Higher Education, 14(2):109-122

Vicente, S., Romano, D., Sá, V. D. C., Lima, R. M. (2014). The Influence of Peer Assessment to the Teamwork Dynamics in Project-Based Learning. Proceedings of 6th International Symposium on Project Approaches in Engineering Education. Colombia.

Wiggins, G., McTighe, J. (2005). Understanding By Design. Assn. for Supervision & Curriculum Development, 2nd Expanded edition.

Sustainability in Engineering Programs in UMinho

Ciliana Regina Colombo[1], Anabela Carvalho Alves[2]

[1] Department of Production Engineering, Federal University of Rio Grande do Norte, Natal, RN, Brazil
[2] Centro ALGORITMI, Department of Production and Systems, School of Engineering, University of Minho, Campus of Azurém, Guimarães, Portugal

Email: cilianacolombo@gmail.com, anabela@dps.uminho.pt

Abstract

Rethink the interventions, human practices and their effects on the natural environment, for the preservation of life and biodiversity, threatened by the capitalist model of production, consumption and disposal, becomes each day more indispensable and then the understanding of the environmental crisis is gaining space in all segments of society. This understanding is increasingly founded on theoretical and epistemological assumptions, so that considering the role of universities as knowledge building space and other duties and responsibilities towards society, this authors papers understand fundamental the insertion of the environmental approach (greening) in its various fronts (education, research, extension and management). Following the line of several researches about the subject, as well as from research groups in Brazil and in Portugal to which authors are affiliated, this paper aims to identify how the issue of sustainability is taught in the various UMinho engineering programs. This study is part of a broader research, and thus it is limited to teaching, within the engineering scope of this university. It is, therefore, a case study, carried out by a documental research that aims to identify at the UMinho engineering programs that incorporate sustainability concepts into their curricula and, within these programs, identify the courses that possibly work aspects of sustainability and how they work these, particularly, if they use PBL to do this. Also, it is intended to find out about other activities that work the theme and that somehow subsidize the education for a more complete approach to sustainability through research and extension. The study, thus, provides an overview of the greening of engineering courses UMinho, and highlights those working the theme according to a systemic approach, problematizing, practical and integrative that already it was found in several studies be the most suitable to make professionals focused on sustainability.

Keywords: Engineering Education; greening of engineering courses, Sustainability.

1 Introduction

Sustainability is on the agenda, being one of the keywords in the spotlight. As a curiosity a google search with this keyword produced 115,000,000 results in just 0.47 seconds. Teaching and engage students in this issue is of primer importance as noticed by United Nations: *"Education for all has always been an integral part of the sustainable development agenda"* (United Nations, 2016a). This same organization launched a decade of 2005-2014 dedicated to Education for Sustainable Development (DESD) (UNESCO, 2005). This aimed the integration of the principles and practices of sustainable development into all aspects of education and learning, to encourage changes in knowledge, values and attitudes with the vision of enabling a more sustainable and just society for all. The collaboration of a vast number of stakeholders – across Member States, UN agencies, the education sector, the private sector and civil society – was demanded to work in partnership to reorient education systems towards sustainable development. The report "Shaping the future we want" wrap-up the conclusions of DESD (UNESCO, 2014).

As a follow-up of DESD, UNESCO launched the Global Action Programme (GAP) on ESD. The overall goal of the GAP is to generate and scale up actions in all levels and areas of education and learning to accelerate progress towards sustainable development. The GAP is twofold: to reorient and to strength education in all agendas, programmes and activities that promote sustainable development in order to everyone (educators, youth and local communities) to have the opportunity to acquire the knowledge, skills, values and attitudes that empower them to contribute to sustainable development and make a difference (United Nations, 2013).

In the context of GAP, a new initiative was created by the time of United Nations Conference on Sustainable Development, Rio+20. This initiative was called Higher Education Sustainability Initiative (HESI). It aims to stimulate commitments from higher education institutions (HEI) to teach and encourage research on

sustainable development, greening campuses and support local sustainability efforts. Almost 300 universities worldwide, joined the HESI, being compromised to 1) Teach sustainable development across all disciplines of study, 2) Encourage research and dissemination of sustainable development knowledge, 3) Green campuses and Support local sustainability efforts, and 4) Engage and share information with international networks (United Nations, 2016b).

More HEI must join this effort and a good beginning could be starting by diagnose the programs existent in the HEI by, for example, developing benchmarking studies (Allen et al., 2008) or reports (Ruscheinsky et al., 2014) that clarifies the situation. This gave the motte for this paper that it has as the main goal to identify in the various UMinho engineering programs and courses the issue of sustainability. To develop this study, the authors only use the information (study plans) provided in the UMinho website: https://www.uminho.pt/EN/education/educational-offer/Pages/Bachelor-degrees-and-integrated-master-degrees.aspx).

This paper is organized in the five sections. This first section introduces the theme relevance and the objectives of the paper. The second section introduces the study context, describing the concern of UMinho as a institution by the sustainability theme. The research methodology used is introduced in the third section. The fourth section is the core of the paper presenting the programs and courses that identifies as a contents sustainability issues. The last section presents some final remarks.

2 Study context

This study was developed in the University of Minho. The University of Minho (UMinho) is located in the North region of Portugal, and has about 20,000 students, of whom approximately 50% are MSc and PhD students. The University is on the top of the Portuguese Universities listed at the Times Higher Education ranking from The 100 Under 50 (2013, 2014) (www.timeshighereducation.co.uk/). This University has many projects with the goal to promote sustainability in the *campi* and in the around community such as the compromise to launch sustainability reports yearly, an Agency for Energy and Environment (AUMEA) (http://www.aumea.uminho.pt/); and a Landscape Laboratory (http://www.labpaisagem.pt/). Additionally, UMinho has many research units concerned with the sustainability, being the most recent, the Institute of Science and Innovation for Bio-Sustainability (IB-S).

The IB-S was originated as a new consortium between two research units from the University of Minho, the Molecular and Environmental Biology Research Centre (CBMA – http://cbma.bio.uminho.pt) and the Institute for Sustainability and Innovation in Structural Engineering (ISISE – www.isise.net). The IB-S main purpose is the development of cutting-edge research and innovation in Sustainability Sciences with special focus on the combined sustainability of built and natural environments. This consortium involves a highly multidisciplinary team that allows IB-S to tackle broader topics in the field of Sustainable Sciences where Civil Engineering and Biology can contribute together or separately. The IB-S embodies cutting-edge R&D activity in close collaboration with the business community directed to the innovation on sustainability issues, namely the development of solutions for complex problems for which presently there are scarce technical tools available (http://www.ib-s.uminho.pt/who.php). CBMA and ISISE are research units of excellence recognized by the Portuguese Government Foundation for Science and Technology (FCT - www.fct.pt). Their classification was achieved during the 2014 international evaluation process held by FCT (http://www.fct.pt/apoios/unidades/avaliacoes/2013/index.phtml.pt). Both units, together, gather 78 resident researchers and a fluctuating population of approximately 100 Post-Doc and PhD grantees.

The UMinho produces a sustainability report since 2010 following the Global Reporting Initiative (GRI) guidelines. These guidelines defined three dimensions for the performance indicators: environmental, social and economic that UMinho measure. Additionally, UMinho introduced a fourth dimension: cultural due to the strong emphasis in cultural activity (Ramísio, 2015). UMinho as an institution is concerned with sustainability and as a Higher Education institution has been also concerned that their curricula promotes opportunities for their students to learn, to research, to innovate and to reflect in sustainability contents and main issues.

The UMinho has eight Schools and three Institutes, specified below:

- School of Architecture
- School of Sciences
- School of Health sciences
- School of Law
- School of Economics and Management
- School of Engineering
- School of Psychology
- School of Nursing
- Institute of Social Sciences
- Institute of Education
- Institute of Arts and Human Sciences

The School of Engineering programs are the selected sample for this study and includes 13 Integrated Master degree and 26 Master degree (MSc). Integrated Master is the designation adopted by many Portuguese universities for some programs after Bologna Process (European Ministers of Education, 1999; Eurydice, 2010). An Integrated Master, normally, includes five years of study (three that corresponds to a 1st cycle and two more years that corresponds to a 2nd cycle of studies) in a total of 10 semesters. Each program has, normally, 300 European Credits Transfer System (ECTS) (30 ECTS by semester). ECTS is an instrument adopted by Europe after Bologna process to facilitate the comparability of degrees in Higher Education in the European space (46 countries). One ECTS represents, normally, 25-30 hours of student work. At the School of Engineering almost all programs that includes two cycles (except one) are Integrated Master. The Master program corresponds, to a second cycle of studies and normally, includes four semesters and 120 ECTS.

3 Research methodology

The research methodology used was a documental research, mainly, based in the information available on the websites of UMinho programs (http://www.eng.uminho.pt/Default.aspx?lang=en-US). The research questions that guide this research were:

1. to identify the engineering programs that includes sustainability concepts in the curricula;
2. in these, to identify the courses that includes sustainability concepts;
3. to identify, as much as possible, how the concepts are taught to the students, i.e., the teaching/learning methodologies and methods used, with particular attention to PBL use.

In order to compile the data collected from the websites, a excel file was built to register the Integrated Master degrees, the semesters and the courses. All Integrated Masters are organized in 10 semesters with 300 ECTS. It was decided do not include in this study the Master (second cycle) programs nor PhD programs (third cycle) because being a short duration program, normally they are very focused in a specific area.

4 Sustainability contents in UMinho programs and courses

This section presents and discusses the information provided in the websites of UMinho about the programs and courses. The Table 1 presents the results of the collection for the 13 Integrated Masters, and the number of courses with a name related with sustainability thematic. These programs were ordered by the number of courses related with sustainability and the corresponding number of ECTS.

Attending to this number, it was decided to classify in two groups the engineering programs: 1) programs very akin with inclusion of sustainability in many courses – Strongest; 2) programs with one or none courses with this topic - Weakest. Of course, some of the programs are more suitable to include these topics than others. It

is also important to refer that some courses includes the sustainability topic without the name of the course indicating this. This section is divided by these two groups followed by a short discussion.

Table 1. Number of courses related with sustainability in Master Integrated degrees

	Master Integrated in:	Courses related with sustainability:	Number of ECTS:
1	Civil Engineering	18	90
2	Biological Engineering	12	65
3	Materials Engineering	5	25
4	Polymer Engineering	2	10
5	Biomedical Engineering	1	5
6	Industrial Engineering and Management	1	5
7	Mechanical Engineering	1	5
8	Textile Engineering	1	5
9	Telecommunications and Informatics Engineering	0	0
10	Physics Engineering	0	0
11	Engineering and Management of Information Systems	0	0
12	Informatics Engineering	0	0
13	Industrial Electronics and Computers Engineering	0	0

4.1 Strongest engineering programs

In this category, the authors include Civil Engineering, Biological Engineering, Materials Engineering and Polymer Engineering.

Civil Engineering is very akin with sustainability themes and topics. This program is organized into eight semesters of common core. In these semesters, nothing is in terms of environmental issues was found. The following two semesters are for training in four specific branches. In these four branches the structure of the two semesters is: in the first two compulsory courses, three electives of the specific area and an optional area of any UMinho, and the second half of the final project. The branches are: Construction, Hydraulics and Environment; Planning and Transport Infrastructures and Structures and Geotechnics.

The profiles of Structures and Geotechnics and Planning and Transport Infrastructures do not present courses related with sustainability. However, the profiles of Construction and Hydraulics and Environment have compulsory courses focused in the sustainability theme:

Construction profile:

- Sustainable Construction
  - Quality, Safety and Environment management

Hydraulics and Environment profile:

- Water and wastewater treatment processes
- Water Management

It can be noted that these two profiles can be almost entirely focused on the area of sustainability if the student opt for courses with this approach. Also, by the number of optional courses, there would be the possibility of having a focus on issues environmental, however, it is important to note that none of this approach is worked in previous semesters. Among the subjects that students can choose, without compliance profile, with the possibility of working on environmental issues are, at least, 14 courses such as Environmental Impact Assessment, Design and Operation of Treatment Plants or Green Buildings.

According the description of the Biological Engineering program, the students are "(...) The graduates will be competent professionals able to collaborate with the cleanup and quality control sectors of these industries (...)". This program is, by its nature, sustainability focus. In the 7th semester the program is divided in two branches: Chemical and Food Technology and Environmental Technology. The branch of Environmental Technology presents six courses specific of the area in the 7th and 8th semester and obviously focused in the sustainability:

- Elements on Environmental Engineering
  - Laboratories of Environmental Technology
- Treatment of Water and Liquid Effluents
- Air Pollution
- Environmental Management
  - Solid Waste Treatment

Chemical and Food Technology branch does not seem to have sustainability courses. The 9th semester includes four optional sets with a different offer in terms of courses that varies according the branch. Some courses are related with sustainability:

  - Modelling of Environmental Systems
  - Molecular Biotechnology
  - Energy and Environmental
- Oenology
  - Clean Product and processes

Environmental Technologies

Materials Engineering program has three elective courses suitable for introduce sustainability issues: Composite materials, Solid Wastes Treatment and Metallic Recycling. Compulsory courses has Environment and Materials that involve sustainability topics and Materials Degradation that could involve sustainability topics.

Polymer Engineering has a course named "Integradora" in the first seven semesters. In the 8th semester it has two compulsory courses that involves environmental thematic: Natural and Biodegradable Polymers and Management and Environment in Plastic Industry. In the rest of the courses nothing is observed that indicates orientation for environmental issues.

4.2 Weakest engineering programs

In this category, it was introduced Biomedical Engineering, Industrial Engineering and Management, Mechanical Engineering, Textile Engineering, Telecommunications and Informatics Engineering, Industrial Electronics and Computers Engineering, Engineering and Management of Information Systems, Physics Engineering.

Biomedical Engineering is organized like the others Integrated Masters. In the last two years (4th and 5th) only one elective course includes environmental issues: Solid Wastes Treatment and Hospital Effluents.

The Industrial Engineering and Management (IEM) program also presents just one elective course designated as Eco-Sustainable Production. Others could be orientated to sustainability issues but it depends on the teacher. Additionally, IEM have a type of course that gives flexibility to do whatever the coordinator of this course wants. This type of course is Integrated Project that are suitable to do this. IEM program has three Integrated Projects: Integrated Project of Industrial Engineering and Management I (IPIEMI - 1st year, 1st semester) and Integrated Project of Industrial Engineering and Management II and III (IPIEMII: 4th year, 1st semester and IPIEMIII - 2nd semester) described in (Alves & Leão, 2015). These IPIEM projects involves all courses of the semester where it is developed.

Particularly, in the first semester of the first year, the project developed by the teams of students always approach sustainability issues (Moreira, Mesquita, & van Hattum-Janssen, 2011). Under the context of Project-Based Learning (PBL) the IEM students have been developing a sustainable product (e.g. bio alcohol, solar cooker, etc.) and the production system to produce this, where the students could develop sustainability competences (Colombo, Alves, Hattum-Janssen, & Moreira, 2014; Colombo, Moreira, & Alves, 2015). The courses involved are Introduction to Industrial Engineering and Management, Calculus, Linear Algebra,

Chemistry and Algorithms and Programming, involving a teachers teamwork and effort from different Departments and Schools (Alves et al., 2015). These authors also believe, by doing this, they are in the right path to achieve DESD (Colombo, Alves, van Hattum-Janssen, & Moreira, 2015).

The Mechanical Engineering program includes an elective course called Energy and Environment that is focused in environmental thematic. This program also presents a course "Integradora", like Polymer Engineering, in the first eight semesters (1st to 4th) that it serves for the students to develop a project. Nevertheless, by the description presented in the UMinho website, this course do not integrate a project like the one developed in the IEM program, i.e., the project is developed inside this course not recurring to the others courses in the semester.

Textile Engineering has one course focused in environmental issues: Environmental Factors in Textile Industry. It presents an interdisciplinary project from the 2nd to 8th semesters (Interdisciplinary Projects I-VII) where the students had the opportunity to explore sustainability issues. Particularly, in the Interdisciplinary Project IV, the theme of the project is very specific: "Quality and environmental and energy sustainability in the design and development of a textile product: coveralls".

Telecommunications and Informatics Engineering, Industrial Electronics and Computers Engineering, Engineering and Management of Information Systems, Physics Engineering do not present courses that indicates issues related with sustainability.

4.3 Discussion

It can be observed that some programs are naturally related with the environment as the programs classified as "Strongest" above. Nevertheless, in a program of 300 ECTS, only a small part is dedicated to sustainability issues even in the Civil Engineering program, the strongest one. Based only in the information provided in the UMinho website, it seems that many programs and courses remain without addressing this topic, in spite of having the potential to work sustainability issues.

However, there are others (e.g. classified here as "Weakest") that are not so directly related or indicate sustainability approach but they have been worked to include this, orienting the teaching with this focus. This depends on the teacher and pedagogical approach adopted for the course. For instance, developing projects in the courses and, more important, in a context of a learning methodology like PBL (IEM projects) it seems a better way to engage students in sustainability cause.

A consult to the various courses details referred above reveals that learning methodologies and methods are mainly based on traditional methods such expositive classes, groups work, case studies, discussion in the classes, assignments, tests, among others. Some courses also refer the use of simulation informatics tools and visits to laboratories. Laboratory courses are the courses that engage students in practical activities. All programs that includes Interdisciplinary Projects or "Integradoras" refer the project based teaching but none (except IPIEM courses) refer the specific learning methodology used.

The programs and courses presented here are a small sample of what has been done in UMinho but much more can be done to greening the campus of universities and educate for sustainable development. Many times, little is done to change curricula as this demands an effort almost titanic for teachers to individually endeavor, this should be an whole-institution effort as DESD last report (UNESCO, 2014) suggest. Other actions suggested in this report are:

- In order to advance whole-institution approaches to ESD, leadership development for senior university executives and governors should be expanded and promoted, including coaching, peer learning, action learning and mentoring support.
- New approaches to curriculum reform are needed, including capacity-building for academic staff, to move sustainable development beyond a specialist 'career' focus to a learning outcome and lifelong orientation across all fields of study. The increase in student demand for a sustainability centered education may be a significant driver for changes in curriculum and teaching practice and should be monitored more closely.
- Sustainability-related research should be more systematically tracked, noting in particular whether and how it is influencing change in policy and practice beyond the institutions. ESD research, as an

important area of academic pursuit, should be recognized and supported, and grounded in national ESD research agendas and plans.
    - Greening campus operations can be strengthened through mechanisms to share tools and approaches, including carbon footprint reductions.
- Collaboration and partnerships between university researchers and community stakeholders should be scaled up as mechanisms to deepen learning, strengthen the knowledge base on local social, environmental and economic issues and contribute to solutions for local-level sustainability.

Before promoting these actions, many challenges must be overcome, referred in UNESCO (2014) as: 1) translation of commitments into implementation requires coordinated change at multiple levels – in governance, planning, academic programmes, facility management and financial systems; 2) deeper innovation in staff development and across institutions is necessary to transform curricula and pedagogy and 3) disciplinary boundaries continue to be barriers to the exploration of complex issues, and to the preparation of learners with the capacity to address complexity.

These challenges that are, many times, difficulties have been testified by the authors of this paper in their experience with implementing PBL to develop projects akin to whole-systems sustainability solutions (product and production system design, green and eco-efficiency solutions of the supply chain) (Alves et al., 2016).

Another key sustainability player on the DESD are the students as Otieno (2013, cited in UNESCO, 2014, p. 119), President of the World Student Community for Sustainable Development (WSCSD) point out: *"The DESD inspired WSCSD's annual Student Sustainability Summits, Greening U and the Sustainable Village Initiatives through which students are actively engaged in hands-on projects aimed at environmental education, greening their campuses and empowering impoverished communities. Students are no longer regarded as 'spectators' but key sustainability players*." Students must be engaged to be pro-active and push the shift of a new thinking and practice in Higher Education Institutions.

As this citation demonstrates, if students are not spectators but sustainability key actors and change agents in the Higher Education Institutions how this could happen if these did not change learning methodologies and contents in the programs? The easier integration way to integrate sustainability is introducing a course or more about this issue and this could result better when more courses are integrated however this is not the most efficient way. According some studies and proposed by DESD, the sustainability issue is a theme interdisciplinary and to be effectively learned by the students should be worked in a much more involved way, i.e., must be worked in a transversal way in activities that involved diversified courses or knowledge learned in them. Being a model already implemented in various universities, namely Aalborg University, Denmark (Guerra, Holgaard, & Kolmos, 2013) and UMinho (Colombo, Moreira, & Alves, 2015), PBL has been revealed to be an efficient methodology to work sustainability in engineering programs.

Stand out however, that even worked with a methodology as the PBL, effective assumption of sustainability in professional practice will only occur if this is a theme worked throughout the course which requires that all those responsible for the training of future professionals, teachers, must have incorporated this issue at the core of each of the disciplines. So, it is can assume, all work must start the training of trainers (teachers) and this requires a transformation work part of a larger meaning to, is the coordination of the course that is a group of teachers, or even a request of students. As stated by Morin & Le Moigne (2000) the true reform (of education systems) will only happen when an awareness of the problems is realized. Of course, each individual must seek, individually and collectively, to open and contribute to the development of critical thinking.

It is understood that this training provides an opportunity to transform both in terms of subject content and methodology. Create teacher training programs can be a big step for the effective integration of sustainability in engineering education and in changing the means by which develops vocational training so that then reach what they say many of the profiles of graduates presented in web sites of the programs: critical professional, creative and ethical. It is important to promote teacher training as an initial step of the teaching of engineering change process, a formation that offers the means and methods to effect change, involving the paradigmatic and epistemological questions (worldview) and pedagogical (teaching- learning methods). Such methodologies and methods should include a learning process similar to the one founded in professional

future of graduates, namely, practical activities, hands-on approaches, projects among others. This means a model that it is interdisciplinary and not divided in courses based on a strong philosophy that promote content but also competence mastery (Flumerfelt, Alves, & Khalen, 2014; Flumerfelt, Kahlen, Alves, & Siriban-Manalang, 2015).

5 Conclusion

This paper objective was to analyze the UMinho engineering programs and courses on the point of view of sustainability integration. UMinho has some initiatives to greening the campus reported in the sustainability report. Also, many research centers are dedicated to this theme. Additionally, some programs are also worked to introduce this thematic.

Some of these are engineering programs that are more or less related with sustainability theme. According to the number of courses named-related with sustainability, the programs were classified as "Strongest" (four were identified in this category) and "Weakest" (nine belongs to this group). The sustainability theme is integrated in most courses using traditional approach instead of emergent methodologies, such as PBL active learning methodologies. PBL was also inserted in IEM projects and only in the first year sustainability is worked. With a different approach, some engineering departments indorse research and support communities' centers such as Wastes Valorization Centre that promote conferences in areas related with sustainability. An immense potential exist in many programs and course to work sustainability issues.

This study is a limited study because only retrieves information from the published study plans. As a future work and to know better the sustainability integration through PBL in the engineering courses of UMinho a deeper study needs to be undertaken.

6 Acknowledgments

The authors would like to express their acknowledgments to national funds by FCT Strategic Project PEst2015-2020, reference UID/CEC/00319/2013.

7 References

Allen, D., Allenby, B., Bridges, M., Crittenden, J., Davidson, C., Matthews, S., … Nolt-helm, C. (2008). *Benchmarking Sustainability Engineering Education: Final Report: EPA Grant X3-83235101-0*. Retrieved from www.csengin.org

Alves, A. C., & Leão, C. P. (2015). Action, practice and research in Project-Based Learning in an Industrial Engineering and Management program. In *Proceedings of the ASME 2015 International Mechanical Engineering Congress & Exposition (IMECE2015)*.

Alves, A. C., Sousa, R. M., Fernandes, S., Cardoso, E., Carvalho, M. A., Figueiredo, J., & Pereira, R. M. S. (2015). Teacher's experiences in PBL: implications for practice. *European Journal of Engineering Education*, 1–19. doi:10.1080/03043797.2015.1023782

Alves, A. C., Sousa, R. M., Moreira, F., Carvalho, M. A., Cardoso, E., Pimenta, P., … Mesquita, D. (2016). Managing PBL difficulties in an Industrial Engineering and Management program. *Journal of Industrial Engineering and Management*, *Accepted for publication*.

Colombo, C. R., Alves, A. C., Hattum-Janssen, N. Van, & Moreira, F. (2014). Active Learning Based Sustainability Education: a Case Study. In *Proceedings of Project Approaches in Engineering Education (PAEE2014)* (pp. ID55.1–9). Retrieved from http://repositorium.sdum.uminho.pt/bitstream/1822/30173/1/paee2014_submission_55.pdf

Colombo, C. R., Alves, A. C., van Hattum-Janssen, N., & Moreira, F. (2015). A study on impact of the UN Decade of Education for Sustainable Development on Industrial Engineering Education. *Dirección Y Organización*, *56*, 4–9.

Colombo, C. R., Moreira, F., & Alves, A. C. (2015). Sustainability Education in PBL Education: the case study of IEM. In *Proceedings of the Project Approaches in Engineering Education* (pp. 221–228).

European Ministers of Education. The Bologna Declaration of 19 June 1999 (1999). The European Higher Education Area.

Eurydice. (2010). *Focus on Higher Education in Europe 2010: The Impact of the Bologna Process*. Education, Audiovisual and Culture Executive Agency (EACEA P9 Eurydice).

Colombo, C. R., Moreira, F., & Alves, A. C. (2015). Sustainability Education in PBL Education: the case study of IEM. In *Proceedings of the Project Approaches in Engineering Education* (pp. 221–228).

Flumerfelt, S., Alves, A. C., & Khalen, F.-J. (2014). Lean Engineering Education: The DNA of Content and Competency. In *Proceedings of the 2014 IIE Engineering Lean and Six Sigma Conference Lean*.

Flumerfelt, S., Kahlen, F.-J., Alves, A. C., & Siriban-Manalang, A. B. (2015). *Lean Engineering Education: Driving Content and Competency Mastery*. ASME Press.

Guerra, A., Holgaard, J., & Kolmos, A. (2013). Project-organized learning and the development of competences in Engineering Education for Sustainable Development. *Erscp-Emsu 2013*.

Moreira, F., Mesquita, D., & van Hattum-Janssen, N. Van. (2011). The importance of the project theme in Project-Based Learning: a study of student and teacher perceptions. In *Proceedings of the 2011 Project Approaches in Engineering Education* (Vol. 53). doi:10.1017/CBO9781107415324.004

Morin, Edgar; Le Moigne, Jean-Louis (2000). A inteligência da complexidade. Trad. N. M. Falci. São Paulo: Peirópolis, 2000, p. 193 (In Portuguese).

Otieno, N. 2013. President, World Student Community for Sustainable Development, Kenya, personal communication. 25 October 2013.

Ramísio, P. J. (Coordenador). (2015). *Relatório de Sustentabilidade 2014 Universidade do Minho*.

Ruscheinsky, A., Guerra, A. F. S., Figueiredo, M. L., Leme, P. C. S., Ranieri, V. E. L., & Delitti, W. B. C. (2014). *Ambientalização nas Instituições de Educação Superior no Brasil: caminhos trilhados, desafios e possibilidades*. (EESC-USP, Ed.)*PhD Proposal* (Vol. 1). S. Carlos. doi:10.1017/CBO9781107415324.004

UNESCO. (2005). *United Nations Decade of Education for Sustainable development 2005-2014- Draft International Implementation scheme*. UNESCO.

UNESCO. (2014). *Shaping the Future We Want: UN Decade of Education for Sustainable Development (2005-2014)*. Retrieved from http://unesdoc.unesco.org/images/0023/002301/230171e.pdf

United Nations. (2013). *Proposal for a global action programme on Education for Sustainable Development as follow-up to the United Nations Decade of Education for Sustainable Development (DESD) after 2014*. *General Conference 37th Session Paris 2013*. Paris. Retrieved from http://unesdoc.unesco.org/images/0022/002243/224368e.pdf

United Nations. (2016a). *Education*. Retrieved from https://sustainabledevelopment.un.org/topics/education

United Nations. (2016b). *Higher Education Sustainability Initiative*. *Sustainable Development Knowledge Platform*. Retrieved from https://sustainabledevelopment.un.org/sdinaction/hesi

Serious game for help children with ADHD learning the basics math concepts

Alessandro P. Da Silva[1], Eduardo S. Ianaguivara[1], Luiz C. Campos[2]

[1] Virtual Environment and Assistive Technology Laboratory, University of Mogi das Cruzes, São Paulo, Brazil
[2] Pontifícia Universidade Católica de São Paulo / Faculdade de Ciências Exatas e Tecnologia, São Paulo, Brazil

Email: alessandrops@umc.br, eduardo_seige@hotmail.com, lccampos@pucsp.br

Abstract

The attention deficit hyperactivity disorder (ADHD) is the most common neuropsychiatric disorder among school-age children in the world. Children with ADHD have more difficulty on learning mathematics discipline. Studies show that the use of computational tools can provide greater opportunities for learning success for children with ADHD than the conventional method. However, the most of these tools have no care to the ADHD characteristics. Therefore, this paper describes the design and development of a computerized game with red-green axis colours to aid learning the basics math concepts to volunteers with ADHD. The gaming method used for the computational game proposed was the serious game, because this method is most used for teaching. But some studies point out the lack of component "fun" or entertainment in the development process of these games. Therefore was used the ICS gaming method which relating the "fun" component and characteristics of ADHD. The proposed game shows criteria recommended by APA (American Psychological Association) to retain the attention. In order to this, we used a graphic modeller of three-dimensional content for modelling, texturing, animating and developing the interaction of the characters and other objects in the scene. In the pilot test the developed software showed no logic errors or warnings in system debug and other game features showed expected results. The game also was evaluated by professionals on software development process which assessed the functional requirements. The developed game was validated by math teachers. They evaluated if the concept of math were presented clearly and objective. The tests also showed that the requirements set for the game were properly achieved, such as writing about the errors in the log. The computer games developed in this study provides quantitative records of the player performance and keeps the attention of ADHD volunteers in complete game, which can help learning the basics math concepts.

Keywords: Computerized game, serious game, math, ADHD.

1 Introduction

The Attention Deficit Hyperactivity Disorder (ADHD) can be defined as a neurobiological disorder characterized by behavioral patterns which are divided into three types: the inattentive, the hyperactive / impulsive and the combined (APA, 2013).

Usually, the therapeutic and pharmacological interventions are used to reduce and/or treatment of these behavioral patterns (Mattos et al., 2012). According to Ota and Dupaul (2002), the main psychostimulant has no effect in 47% of diagnosed and in many cases the use is not necessary.

This psychiatric disorder is classified as the most common in school-age children (APA, 2013). In the school setting, the ADHD has low academic performance, because the teaching learning tools haven't the resources to mobilize the child to the task being performed and the maintenance of their attentional focus (Silva and Frère, 2011; APA, 2013; Ianaguivara et al., 2015).

The mathematical discipline is one of the issues that children with ADHD have more learning difficulty (Mayes & Calhoun, 2006). This difficulty is shown in the most basic math skills such as numerical recognition, arithmetic and geometric shapes (Capano et al., 2008). A cause of poor school performance is the traditional assessment that allows the possibility of failure and rejection final result of evaluation. For ADHD the slightest possibility of failure becomes unacceptable task to perform (Mautone; Dupaul & Jitendra, 2005; Lucangeli & Cabrele, 2006 and Silva & Frère, 2011).

The use of computer games has been increased in the educational environment. This resource allows teaching complex tasks so that they are offered greater opportunities for success to ADHD than in the conventional method (Mautone, Dupaul & Jitendra, 2005).

Ota and Dupaul (2002) showed that the use of computer games as a tool in the evaluation of mathematical concepts has provided the double of solved problem than the conventional method.

However, the use of computer games can be put on doubt because it have been implemented for entertainment without following any educational or psychological method (Houghton et al., 2004; Demirbilek & Tamer, 2010; Hauge et al, 2012; Ianaguivara et al., 2015).

The Serious Game can be defined as a game development framework in order to prioritize the educational aspects and not just entertainment. The serious game can be divided into three main fields: educational, psychological and computational (Zyda, 2005; Hauge et al., 2012; Pourabdollahian et al., 2012).

The serious game use can bring benefits to education, because it uses the educational, psychological and computational content items required to aim a playful education (Yussof, 2010).

Studies point out the benefits of the serious game in math, spatial memory, geometry and engineering. Nowadays, this method is most suitable to the present educational needs (Pourabdollahian et al., 2012; Hauge et al 2012; Yuda, 2011).

Banaschewski et al., (2006) indicate that the attentional focus is directly related to colour perception, which is composed of two systems anatomically and functionally distincteds, the red-green axis and the blue-yellow axis.

People with ADHD have an injury in the retinal dopaminergic system, that reflects in the fast processing of coloured stimuli in the blue-yellow axis (Banaschewsky et al., 2006; Tannock, Banaschewski and Gold, 2006; Silva and Frère, 2014). Silva and Frère (2014) quantified the influence of coloured stimuli and showed that tasks that requires more attention must be submitted using the colours red-green axis ADHD.

This paper describes the development of a computer game following a serious game methodology to aid the teaching learning basic concepts of mathematics for children with ADHD using the colours red-green axis.

2 Methods

2.1 Development tool

The game developed in this study was produced using Blender 3D graphical tool (BLENDER, 2015). The main features of this software are based in the integrated tools for modelling, animation, rendering, mechanism to create game and modules of interactivity.

The Blender 3D graphical tool provides a module of interactivity (Game Engine) that allows the development of games from logical blocks (sensor – controller – actuator) or scripts typed in Python programming language. The models of this game were created using blueprints modelling technique (image of reference) and Boolean operation in geometric objects (3D graphics primitives) as cube, cylinder, sphere, pyramid and circle. Texture mapping can be defined as the method for adding detail of 2D surface texture (an image) to 3D model. The game developed in this research was used to texture mapping based in materials and shades to represent the refraction, roughness, reflection and translucency.

The animation´s objects were generated using the pose mode technique (Silva and Frère, 2014). Beyond that, key frames were used at the start and end of movement. The intermediate frames were interpolated by the graphical tool.

2.2 Software Engineering

In order to implement this application the authors have used the main stages of system development: gathering requirements, project analysis, implementation and testing (Pressman, 2010). The authors considered collect tips, interacted with character and complete challenges like functional requirements. By contrast, the

software interoperability sounds and animations were considered not functional requirements. The game was implemented following the software life cycle in cascade. All stages of the development are executed in sequence (Pressman, 2010). The used case context diagram of the game is shown in Figure below (Figure 1).

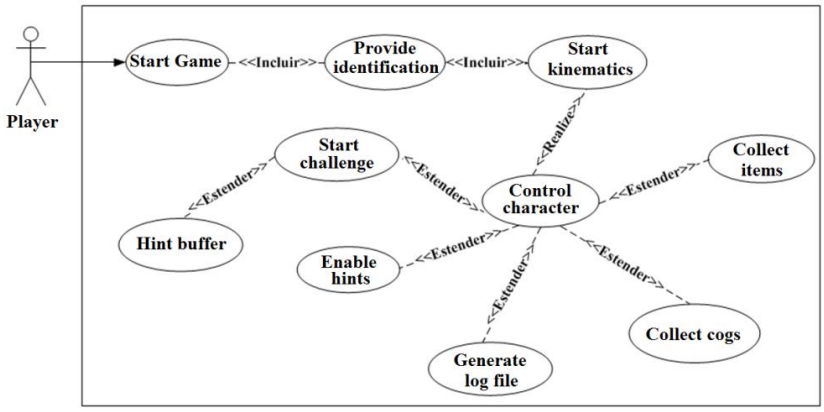


Figure 1. Use case diagram of the developed game

To aid assessment of basic math concepts, the authors included colours of red-green axis in objects' with important information (Figure. 2).

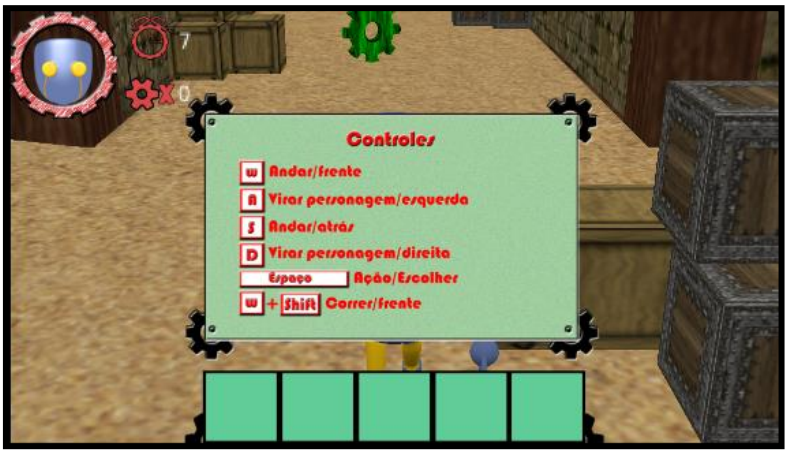


Figure 2. HUD's elements texturized with colour of green-red axis.

The basics math concepts selected for this study and its association with game's challenges are listed in Table 1.

Table 1. List of challenges of the game and math concepts selected.

Challenges	Math concepts
Choose the pathway that has even numbers	Numbers recognition in daily life
Choose the operator that increase power to the machine	Use of basic math signs (+, -, x, : and =)
Choose the smaller gear	Dimensioning of spaces considering the relationship between size and shape
Solve the puzzle of the bridge	Calculations of addition and subtraction, using personal strategies and conventional techniques
Put the batteries in increasing order	Comparison and classification of elements collected
Choose the geometric shape similar to activation key	Dimensioning of spaces considering the relationship between size and shape
Get the battery to decrease the machine power	Use of basic math signs (+, -, x, : and =)

Choose the fuel gallon with value between 7 and 9 litters	Using the decomposition of the numerical writing aiming the exact and approximate mental calculation
Arrange the shapes considering the geometry, size and value	Dimensioning of spaces considering the relationship between size and shape

In order to validate the developed game, were recruited three math teachers which rated if the math concepts were presented on clear and objective form. The basic math concepts used in this study following the National Curriculum Parameter (MEC, 1997). The game usability was evaluated by professionals on game development.

The software functionality also was evaluated by professionals on software development process which rated both the functional requirements (set inputs, processing and outputs) and non-functional requirements (reliability, response time and usability). For that, these evaluators used the black box testing and to assess the software's structure was used the white box testing (Myers, 2011; Koscianski, 2007). Psychological contents were evaluated by psychologists. They assessed whether the proposal was appropriate to ADHD features.

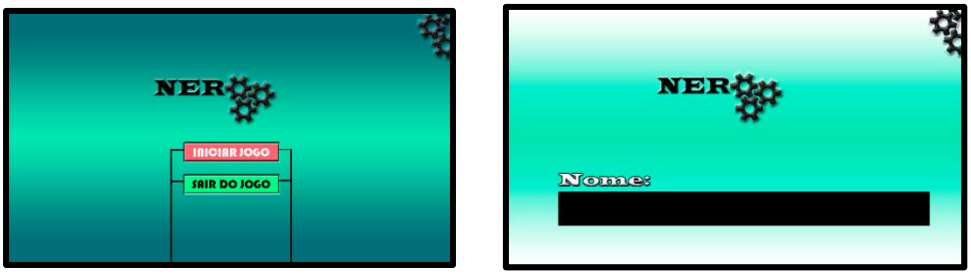
3 Results

3.1 The developed game

Scenarios with animated models have been developed with realistic textures, sounds and shadows creating a highly immersive graphical interface aiming keep the attention of hyperactive children (Figure 3).

Figure 3. Scenarios with animated objects.

Figure 4a shows the home screen of the game where the menu items are displayed: start game and leaving the game, and the name of the game. Choosing the play option, a screen is displayed to write the player name (Figure 4b).



a) b)

Figure 4. The developed game. a) Menu game; b) Screen of player name.

The developed game was implemented to provide rewards more frequently aiming retain children with ADHD more interested in the game. The Figure 5 shows the rewards screen.

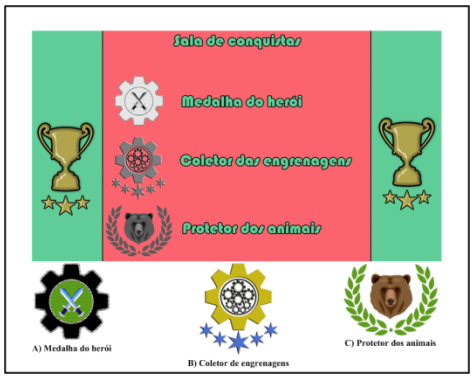


Figure 5. Screen of rewards

The view mode chosen was the third person (Figure 6), because the child can see more detail and characteristics of scenarios.

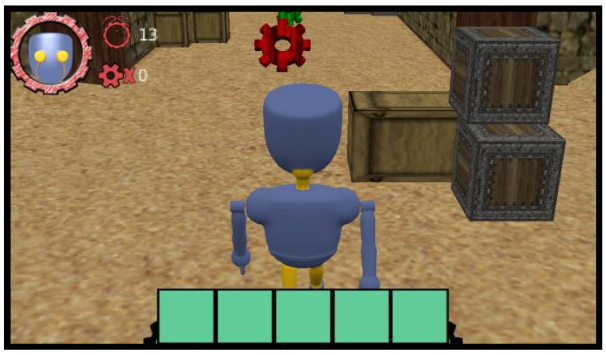


Figure 6. The game.

3.2 Development expert testing

To evaluate the game's usability a Likert scale adapted was designed (Barua, 2013). The evaluate tool was described in Table 2.

Table 2. Rules to evaluate the game usability.

Description	Index
Very good	5
Good	4
Regular	3
Bad	2
Very bad	1

To evaluate the usability of the game developed were recruited 3 experts in computer games development. Table 3 shows the results obtained from the evaluation by professionals in computer games development to metrics: organization of scenarios, kinematics, menu, visual effects, sound effects, animations, graphics (modelling), graphics (texturing), control of player's movements and lighting.

Table 3. Evaluation of usability by the computer games development professionals.

Software metrics	Expert 1	Expert 2	Expert 3
Organization of scenarios	4	4	4
Kinematics	4	5	4
Menu	4	5	3
Visual effects	4	4	4

Sound effects	4	5	4
Animations	4	4	4
Graphics – modelling	4	4	4
Graphics – texturing	4	4	4
Control of player's movements	3	4	5
Lighting	4	5	3

A modal analysis was performed for the items that make up the assessment tool to verify the usability of developed game. Therefore, the items Kinematics and the Sound effects showed a bimodal distribution for the response "Good". Analysing the items Organization of scenarios, animations, Graphics - Graphics and modelling - texturing were observed that all experts rated as "Good". Finally, the items Control of player's movements, menu and Lighting no showed modal distribution for the answers.

3.3 Experimental test of math content

The experimental test of math content was performed to verify that the content presented in the game challenges were appropriated for math PCN parameters. For that, the game was evaluated by math teachers in high school and college. The results are shown in Table 4.

Table 4. Experimental test of math content.

Metrics	Expert 1	Expert 2	Expert 3
Challenge 1	Observed	Observed	non observed
Challenge 2	Observed	Observed	Observed
Challenge 3	Observed	Observed	Observed
Challenge 4	Observed	Observed	non observed
Challenge 5	Observed	Observed	Observed
Challenge 6	Observed	Observed	Observed
Challenge 7	Observed	Observed	Observed
Challenge 8	Observed	Observed	Observed
Challenge 9	Observed	Observed	non observed

Regarding to educational content can be seen that all items were approved excepted challenges 1, 4 and 9 (Table 4) which according to expert they did not have the context of the "problem situation" well founded for the player wouldachieve challenge goal.

3.4 Psychology test

The developed game also was evaluated by psychology experts in order to verify if the game content was appropriated from the specialized literature used in the development. For that were recruited three teachers of educational psychology. The professionals evaluated the metrics: visual stimulus, sound stimulus, use of colours, quick challenges, educational objects and absence of punishment. The game performance in psychology content test shows 100% of agreement by experts according to the specialized literature.

4 Discussion and conclusion

The game has been developed in order to relate the existing elements in the development of computer games with the main elements of a serious game where both the psychological and educational elements are the main priorities. According to Pourabdollahian et al., (2012), the entertainment component is neglected in serious game, because the educational content is the major element of serious game. On the other hand, the developed game integrates the stages of development of commercial games to serious game giving priority to the design element.

The game developed relates the game mechanics with the learning mechanics as the finding of Barbosa et al., (2012). The developed game also integrates the mobilization model proposed by Keller (1987) and gameplay by Woo (2014).

Through instructional features defined by Arruda & Almeida (2014) and Rief (2015) mapped the needs of the person with ADHD, these features were incorporated into the game development process.

In the cognitive component mapped the features of people with ADHD regarding the use of feedback, play time, number of rewards and colours. The information gathered was used to feed the gameplay to the peculiarities of people with this disorder (Silva and Frère 2011; Ianaguivara et al., 2015).

Thus, it was possible to employ the use of rewards constantly and modulation of the displayed type of feedback to avoid overloading the memory of ADHD, or even cause their irritation and thus keep you focused on the task (Arruda & Almeida, 2014; Rief, 2015).

Visual cues direct players to the challenge by providing them cues about how to get success in the task. We applied the colours of green-red axis in hints to keep the attentional focus of ADHD (Silva and Frère 2011; Ianaguivara et al., 2015).

The game has no punishment for errors, time limit to complete the task and its progression is controlled by the player, that is, the player controls the speed of his own learning (Arruda & Almeida, 2014; Castro et al., 2014; Rief, 2015).

The game presented in the study involves this item by using secondary objectives at the end of the game. At the end of the game an achievements screen will be displayed and the player will receive a medal of completion and display the medals concerning the next goals of the game if the rerun. Importantly, the challenges are random, and also changes every time that the player starts the game.

The tests confirmed that the game developed is able to integrate the key elements of serious game development (educational elements, computational and psychological) to commercial game development method respecting the characteristics of ADHD.

The math operations remain in background of the game, what can aid in the teaching and assessment of the basic math concepts for children with ADHD.

5 Acknowledgement

We are grateful to Foundation for Support to Education and Research (FAEP) from University of Mogi das Cruzes (UMC), São Paulo Research Foundation (FAPESP – Process nº 2013/22947-0) and Coordination for the Improvement of Higher Education Personnel (CAPES), for financial support.

6 References

American Psychiatric Association (APA). Diagnostic and Statistical Manual of Mental Disorders 5. 2013.

Arruda, M, A & Almeida, M. Cartilha da Inclusão Escolar: Inclusão Baseada em Evidências Científicas. 2014. Disponível em http://www.aprendercrianca.com.br/384-cartilha-da-inclusao-2.

Banaschewsky, T; Rupert, S; Tannock, R; Albrecht, B; Becker, A; Uebel, H; Sergeant, J, A; Rothenberger, A. Colour Perception in ADHD. Journal of Child Psychology and Psychiatry, Vol. 47, no. 6, pp. 568-572, 2006.

Barbosa, A. F., Pereira, P. N., Dias, J. A., & Silva, F. G. (2014). A new methodology of design and development of serious games. *International Journal of Computer Games Technology*, *2014*, 8.

Barua, A. Methods for decision-making in survey questionnaires based on likert scale. Journal of Asian Scientific Research, 2013; 3(1): 35-38.

Blender. Disponível em: http://www.blender.org/foundation, 2015.

Castro, M, V; Bissaco, M, A, S; Panccioni, B, M; Rodrigues, S, C, M E Domingues, A, M. Effect of a Virtual Environment on the Development of Mathematical Skills in Children With Dyscalculia. Plos One. N.7, v.9, 2014.

Capano, L; Minden, D; Chen, S, X; Schachar, R, J; Ickowicz, A. Mathematical Learning Disorder in SchoolAge Children With Attention-Deficit Hyperactivity Disorder. Canadian Journal of Psychiatry, Vol. 53, no. 6, pp. 392-399, 2008.

Demirbilek, M; Tamer, S, L. Math Teachers Perspectives on Using Educational Computer Games in Math Education. Procedia Social and Behavioral Sciences, v. 9, p. 709-716, 2010.

Hauge, J, B; Pourabdollahian, H, B; Riedel, C, J, C, K, H (2012). Workshop on the Use of Serious Games in the Education of Engineers. Procedia Computer Science, n.15, p.340-341.

Houghton, S; Milner, N; West, J; Douglas, G; Lawrence, V; Whiting, K; Tannock, R; Durkin, K. Motor Control and Sequencing of Boys with Attention-Deficit/Hiperactivity Disorder (ADHD) During Computer Game Play. British Journal of Educational Technology, v. 35, n. 1, p. 21-34, 2004.

Ianaguivara, E, S; Candiago, A; Kawamoto, L, T; Rodrigues, S, C, M; Scardovelli, T, A e Silva, A, P. Virtual Environment to Aid the Assessment of Basic Math Concepts in Children with ADHD. Key Engineering Materials. nº 1. v.638. p.339-343. 2015.

Lucangeli, D; Cabrele, S. Mathematical Difficulties and ADHD. Exceptionality: A Special Education Journal, Vol. 14, no. 1, pp. 53-62, 2006.

Keller, J, M. Development and Use of the ARCS Model of Instructional Design. Journal of Instructional Development. N.3, v.10, p.2-10, 1987.

Koscianski A; Soares, M.S. *Qualidade de Software*, Novatec Editora, São Paulo, 2007.

Mattos, P.; Rohde, L, A; Polanczyk, G, V. O TDAH é Subtratado no Brasil. Revista Brasileira de Psiquiatria. v.34, p.513-516, 2012.

Mautone, J, A; Dupaul, G, J; Jitendra, A, K. The Effects of Computer-Assisted Instruction on the mathematics Performance and Classroom Behavior of Children With ADHD. Journal of Attention, Vol. 9, no. 1, pp. 301-312, 2005.

Mayes S. D e Calhoun S. L: Frequency of reading, math, and writing disabilities in children with clinical disorders, Learning and Individual Differences 16 (2006) 145 – 157.

Ministério da Educação (MEC). *Parâmetros Curriculares Nacionais (PCN): Matemática. Secretaria de Educação Fundamental*. Brasília, 1997. Information on portal.mec.gov.br/seb/arquivos/pdf/livro01.pdf.

Myers, G.J; Sandler C; Badgett, T. *The Art of Software Testing*, Hoboken, New Jersey, 2011.

Ota K. R e DuPaul G. J: Task Engagement and Mathematics Performance in Children with Attention-Deficit Hyperactivity Disorder: Effects of Supplemental Computer Instruction, *School Psychology Quarterly*, Vol. 17, No. 3, 2002, pp. 242–257.

Pressman, R. S. Software engineering: a practitioner's approach, 7th ed., McGraw-Hill, New York, 2010.

Pourabdollahian, B; Taischa, M; Kergaa, E (2012). Serious Games in Manufacturing Education: Evaluation of Learners' Engagement. *Procedia Computer Science,* n.15, p.256-265.

Rief, S, F. The ADHD Book Lists: A Practical Guide for Helping Children and Teens with Attention Deficit Disorders. John Wiley & Sons, 2015.

Silva, A, P; Frère, A, F. Virtual Environment to Quantify the Influence of Colour Stimuli on the Performance of Tasks Requiring Attention. *Biomedical Engineering Online*, Vol. 10, no. 74, pp. 1-31, 2011.

Tannock, R; Banaschewski, T; Gold, D. Color Naming Deficits and Attention-Deficit / Hyperactivity Disorder: A Retinal Dopaminergic Hypothesis. *Behavioral and Brain Functions*, Vol. 4, no. 2, pp. 1-8, 2006.

Yuda, M (2011). Effectiveness of Digital Educational Materials for Developing Spatial Thinking of Elementary School Students. *Procedia Social and Behavioral Sciences*, n.21, p. 116-119.

Yussof, A. (2010). A Conceptual Framework for Serious Games and its Validation. *Thesis for the Degree of Doctor of Philosophy. Faculty of Engineering, Sciences and Mathematics School of Electronics and Computer Science* - University of Southampton

Woo, J, C. Digital Game-Based Learning Supports Student Motivation, Cognitive Success, and Performance Outcomes. Educational Technology & Society, v.17, n.3, p.291-307. 2014.

Zyda, M. From Visual Simulation to Virtual Reality to Games. *IEEE Computer Society*. 2005.

Vietnamese Students Awareness towards a Project Based Learning Environment

Anna Lyza Felipe[1], Edouard Amouroux[1], Thanh Pham[1], Alex Stojcevski[1]

[1]Centre of Technology, RMIT University Vietnam

Email: anna.felipe@rmit.edu.vn, edouard.amouroux@rmit.edu.vn, pham.thanh@rmit.edu.vn, alex.stojcevski@rmit.edu.vn

Abstract

Student-centered teaching is among the most promising approaches in which students are actively constructing their learning by formulating their own questions and answering them. Project-based learning (PBL) is one of them where students work collaboratively as a team on a project and while the educator's position is switch from the center of attention to being a facilitator guiding students' learning. Project based learning is a well-suited approach to actively engage students with real world problems and challenges in order to acquire deeper understand. This approach has already shown good results in western country education systems but no application have been conducted in Confucian Heritage Countries (CHC). CHC students, and Vietnamese in particular, are more familiar with traditional learning approach where most class time is spent with the teacher lecturing and the students listen passively. There are many challenges for CHC students to adapt to student-centered teaching and the time needed to transition limits the benefits they acquire from such approach especially PBL. Thus, the transition process is critical for these students and specific arrangement have to be done by educators in CHC countries. In particular, emphasis has to be made on collaborative learning activities. This paper investigates how to introduce project-based learning environment to CHC students with a first application in Vietnam. Despite challenges in the early weeks of their studies, the preliminary results suggest that the PBL approach is well adaptable to CHC students and Vietnamese student were able to integrate its principles effectively.

Keywords: Project Based Learning, Active Learning

1 Introduction

There are many ways to conduct teaching and learning activities for higher education beyond the traditional lecture - tutorial duo with its formative quizzes and problem solving activities. Nowadays, active learning is seen as one of the most beneficial approach because it puts the students in command of their learning journey. Project Based Learning (PBL) is one of the active learning methods were the focus is evidently set on the conduction of project. PBL offers an approach that leads students toward a life after high school where content knowledge is just one aspect of the whole higher education learning experience (Downs, 2015). It allows student gain first hand experience to identify, build and present project. In projects, students learn how to engage in real-world problem, which also comply with the work integrated learning approach, to cooperate with their fellow students. Active learning, and especially PBL, has already shown great results in western higher education but have been barely tested in Southeast Asia (SEA) or Confucian Heritage Countries (CHC). In the present paper, the researcher will look into how active learning and project-based environment are perceived and adopted by the students in these contexts. Based on the initial observation it will discuss the specific challenges identified and provide preliminary recommendation based on the lecturers experience in Vietnam which is a key country as it is part of both CHC and SEA countries.

2 Project Based Learning

PBL is a student-centered learning approach in which students work collaboratively in groups that involves interaction and cooperation among learner. In this setting, students learn through hands-on activities focused by a project. During the process, the lecturer acts as a facilitator who monitors and validates the project, checks if it is running according to the pace and ultimately guides students to find the better solution from different sources rather than giving the answer to the problem (Smith, 2016). The PBL approach requires students to use a variety of skills that are essential, yet beyond the academic ones specific to the course, such as communication, teamwork, planning, etc., which provides significant opportunities for development of said

skills and also building self-confidence (Vere, 2009). Hence, the key advantage of this approach is to integrate such skills with creative and innovative interdisciplinary thinking.

Even though PBL is gaining momentum for the past 10-15 years in engineering education it was initially developed in the 1960s in the field of medicine (Mills & Treagust, 2003). Since its origin this teaching method in engineering and in IT by extension (which is implied for the remainder of this paper) integrates Dewey's philosophy of "learning by doing" (Belle, 2010). It focuses on practical learning organized around the analysis, explanation and solution of meaningful problem (Barrows, 2000; Torp & Sage, 2002; Hmelo-Silver, 2004). In PBL, it is usually formalised as a five-step process (Chandrasekaran & Stojcevski, 2013), as shown in figure 1. Formally, the steps are: (1) Project presentation & identification, (2) individual/team research, (3) design development, (4) building & testing & evaluation and (5) project delivery. This sequence provides scaffolding for students to apply their knowledge to solve realistic problem rather than problem-solving activities that are far too often abstract and do not provide valuable experience for the students. Several studies have been conducted in western countries and confirm that PBL is an effective teaching method, which is also appreciated by students (Blumenfeld et al. 1991).

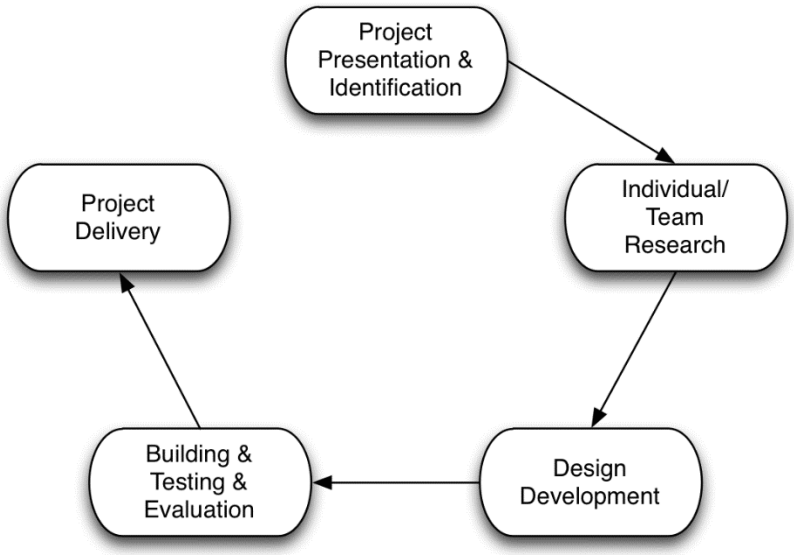


Figure 1. Five steps of Project Based Learning

Many studies show that it fosters deeper learning competencies, thus many educators in western countries are shifting to this teaching method (Litzinger et al. 2011). A key feature of PBL is that it aims to have observable improvements of students' performance and knowledge by breaking out of traditional practices through innovative and interdisciplinary student work. However, little work has been done to introduce PBL outside of the western countries. In particular, there are only few PBL implementations in SEA, for instance: Boondee, et al., 2011 and Kivela & Kivela, 2005. Despite specific localization challenges, notably the so-called CHC specificity in teaching and learning approach, the authors argue that PBL needs to be introduced in SEA countries and as a first step better pedagogical awareness in PBL practices is needed in order to contextualize this approach.

Asian students and more especially those from CHC are traditionally seen as high-achiever yet focusing on rote learning, being passive in class and expecting all the knowledge to be delivered by the teacher. Even though CHC students are usually more familiar with traditional, teacher-centered learning (Collins & Lorenzutti, 2015), such monolithic conception of Asian students has been successfully challenged. First, it appears that the initial focus on rote memorization is actually a first step in a process towards mastery (Tran, 2013). Second, Asian students are able to adapt very well to more active teaching/learning approaches (Volet et al.1994) and are actually demanding of such approaches (Littlewood, 2000). Nevertheless, high school teaching methods in Asia are still usually teacher-centered, thus not preparing them to a more active learning practices that are the norm in universities where PBL methods are used. In particular, based on observations and an internal student survey

conducted on first semester students at RMIT Vietnam, high school students have few pair work in class, rarely any group work, not even mentioning project based activities. Thus, the authors think that the first semester is a critical time for students to adapt to a more active form of learning: it should be focused on the transition from passive to active learning and introducing to project based learning which is aligned with previous finding at the same university (Collins & Lorenzutti, 2015) and the positive influence of active learning over student experience and persistence (Braxton, Milem & Sullivan 2000).

3 Current awareness of Project Based Learning in Vietnam

PBL implementation in engineering curriculum is gaining popularity in many countries such as Australia (Chandrasekaran & Stojcevski, 2013), Canada and Denmark (Litzinger et al.2011) but is still limited in Asian countries. In Vietnam, PBL has not been introduced formally but there is a trend towards active learning. In Vietnam, Intel is involved in engineering education and according to their report the learning methods are mostly passive: there was little to no active or student-centered teaching approaches and especially project-based ones (Intel 2013). More broadly, the Higher Engineering Education Alliance Program (HEEAP) recently audited the country's current engineering education system. Vietnamese and American Universities and several international corporations with the *in fine* objectives to support the systematic transformation of Vietnamese engineering education conduct this alliance jointly. It is worth highlighting two action items of the alliance in their first pilot, HEEAP 1.0 (2008-2013), are: (1) designing multidisciplinary and problem-based curriculum and (2) train Vietnamese academics to new active learning and teaching methodologies. Outcomes from this phase indicate the early success and positive feedbacks where active learning techniques such as cooperative learning were well received by the students. The students were also reported to enjoy the new activities and projects as well as learn in HEEAP classes (Intel, 2013). Following these initial outcomes, it is reasonable to say that there is a demand for active learning methods at national level.

In the case at RMIT University Vietnam, active learning is already the norm (RMIT 2016). In particular, project-oriented teaching is frequent in the Centre of Technology (CoT) even though they do not meet the PBL specifications *per se*. Practically, the center have applied the concept in many courses at various time in the curriculum: (a) in the very first semester with Building IT Systems (BITS), (b) later in semester 3 with Engineering Management (EM) and (c) during the last academic semester with Software Engineering Project Management (SEPM). In order to evaluate the students' perspectives about the learning environment the researchers conducted a focus group in addition to the institution formal course experience survey (CES). It shows from the surveys that the students are aware of various aspects of the project-oriented courses: benefits of active learning, collaborative tasks, learning process and assessments. Figure 2 shows the CES results in two different semesters where the majority of students highlighted their appreciation for different aspects of project oriented courses currently offered at COT. From the lecturers' experience, students, noticeably freshmen, are able to quickly develop their understanding about the project based learning activities and adapt successfully yet progressively to such teaching method. Moreover, since the center project oriented courses share several similarities with the PBL approach, the current awareness level will enable lecturers to build up from there to a clear awareness towards PBL in the future.

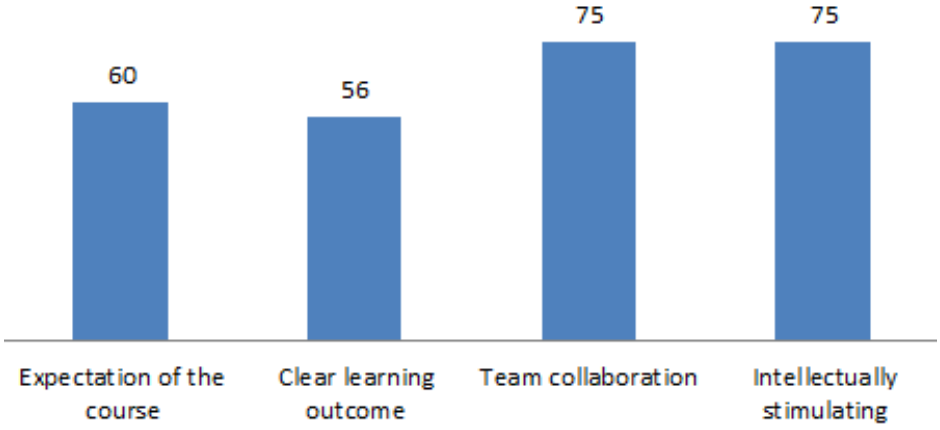


Figure 2. Course Experience Survey result across 2 semesters in 2015:

"Best aspect of the Project Based Learning Course"

Specifically, the center current projected-oriented courses all have similar learning processes as the five steps one proposed in PBL: Project definition, research and design of solution, project implementation, reporting and presentation. In practice, students identify and carry out research on design issues and possible solutions. During this process, the lecturers act as facilitators to support and direct the groups towards feasible solutions to the project. It is also important to note that collaboration and group work are mandatory for the above courses, which is also another major factor that fosters active learning and requires the students to develop their soft skills. Even though there are several similarities between the center current teaching practices in project-oriented courses with PBL, these are still *ad-hoc* ones and do not apply the whole PBL process. In BITS there is no project presentation, the project topics are always researched and proposed by the students before being approved by the lecturers. The rationale here is to have students to identify and address the existing problems in their local contexts and community. In addition, there is no project delivery per se in that course as the course learning outcomes focus on technical self-learning and discovery of teamwork skills. In SEPM and EM there is no clear distinction between the learning issue identification and the project research steps as suggested by PBL.

4 Preliminary outcomes

The current awareness level of Vietnamese students towards project-based learning environment is indeed limited even at an international university such as RMIT Vietnam. Vietnamese students usually struggle in their first project course as observed in BITS and EM courses. Thus, it is of utmost importance for the lecturer to be aware of the students' background, usually lacking any form of active learning experience. The difficulties mentioned in the students' interviews are that they initially do not really understand the course learning objectives (CLOs) and how they are assessed; for instance on teamwork, learning capabilities demonstrated. Therefore, it would be advised to the lecturer to adapt her course design and delivery to allow the students to progressively adapt to a much more active learning environment. On the other hand, those students who already conducted at least a project before were much more comfortable with project planning and process as observed in SEPM. Nevertheless, there is a clear need for project process alignment so that students do not loose time to adapt to a different process each time they enroll in a project oriented course. This is especially important when many courses are project oriented such as in a technology curriculum.

In addition, when introducing such a new learning paradigm, it is important to remind the benefits of general good practices. In particular, it was mentioned during the student focus group that reflective journal, review of past student work, peer review and supportive tutorials (focusing on the project conduction) were of particular interests to the student. The reflective journal were deemed very useful by the students as they reviewed their

progress over the semester both in term of technical learning and project management skills such as planning, teamwork, and so on. Review of previous semester student works are usually really appreciated by the students as it gives them a clear grasp of what is expected but also the level of expectation. It was also confirmed by the students that the weekly project review meeting with the lecturer were crucial to keep the project on track in accordance with PBL practice. Moreover, the authors think that support tools and processes are also essential for the proper project implementation even though there was mixed comments on them. This issue is usually specific to the first project course they enroll in. With clearer introduction and support the use of such tools will be even more beneficial and more easily adopted by students. Finally, it would also advise to provide a clear vision at the program level which may start at the very beginning of their study where active learning and specifically project based learning should be introduced. The difference of this learning approach along the process and the technical tools can be presented during sessions like the first year induction.

5 Conclusion

There have been from none to little active learning teaching methods in the Engineering education field in Vietnam which is aligned with current practices in SEA. The country however is heading towards more active approaches thanks to the efforts of organization like HEEAP and RMIT University Vietnam. Despite specific challenge related to standard practice at the high school, we demonstrated that project oriented learning is adaptable and beneficial for CHC and SEA students. Through the current practices in Technology programs at RMIT Vietnam, students have learnt that project-oriented courses and activities do benefit and support students learning, and the current work share many similarities with PBL philosophy. Consequently, we think that PBL should be introduced in Vietnam shortly with acceptable localization and contextualization challenges.

6 References

Bell, S., (2010). Project-based learning for the 21st century: Skills for the future. *The Clearing House*, *83*(2), pp.39-43.

Blumenfeld, P.C., Soloway, E., Marx, R.W., Krajcik, J.S., Guzdial, M. and Palincsar, A., (1991). Motivating project-based learning: Sustaining the doing, supporting the learning. *Educational psychologist*, *26*(3-4), pp.369-398.

Boondee, V., Kidrakarn, P. and Sa-Ngiamvibool, W., (2011). A learning and teaching model using project-based-learning (PBL) on the web to promote cooperative learning. European Journal of Social Sciences, 21(3), pp.498-506

Braxton, J. M., Milem, J. F., and Sullivan, A. S., (2000) "The Influence of Active Learning on the College Student Departure Process: Toward a Revision of Tinto's Theory." Journal of Higher Education, 71(5), 569–590.

Chandrasekaran, S., Littlefair, G. and Stojcevski, A., (2015), September. The role of the facilitator in a project/design based learning environment. In*Interactive Collaborative Learning (ICL), 2015 International Conference on*(pp. 21-24). IEEE.

Collins, W., and Lorenzutti, N., (2015). Transition Issues Encountered by Newly Enrolled Students at RMIT Vietnam.

Down, R (2015). http://bie.org/blog/project_based_learning_with_students_with_disabilities

Hmelo-Silver, C.E., (2004). Problem-based learning: What and how do students learn?. *Educational psychology review*, *16*(3), pp.235-266.

Intel(2013). http://www.intel.com/content/dam/www/public/us/en/documents/white-papers/HEEAP_v3.pdf

Kivela, J. and Kivela, R.J., (2005). Student perceptions of an embedded problem-based learning instructional approach in a hospitality undergraduate programme. *International Journal of Hospitality Management*, *24*(3), pp.437-464.

Littlewood, W., (2000). Do Asian Students really Want to Listen and Obey. ELT Journal,. 54(1): p. 31-36.

Litzinger, T.A., Lattuca, L.R., Hadgraft, R.G., Newstetter, W.C., (2011). Engineering Education and the Development of Expertise Journal of Engineering Education, 100(1), 123–150.

Mills, J.E. and Treagust, D.F., (2003). Engineering education—Is problem-based or project-based learning the answer. Australasian Journal of Engineering Education, 3(2), pp.2-16.

Smith, L., (2016) http://asiasociety.org/project-based-learning-tops-traditional-instruction

Tran Thi Tuyet, (2013). "The causes of passiveness in learning of Vietnamese students", VNU Journal of education research, vol. 29, No. 2 pp72-84.

Vere, I. D., (2009). Developing creative engineers: a design approach to engineering education, The 11th International Conference on Engineering and Product Design Education, Brighton, United Kingdom

Volet, S., Renshaw, P., & Tietzel, K. (1994). A short term longitudinal investigation of cross-cultural differences in study approaches using Biggs' SPQ questionnaire. British Journal of Educational Psychology, 64, 301–318.

How to create an ecosystem for engineering education to prepare future professionals to sustain in a fast changing and dynamic environment?

Ricardo A. Abdoel[1], Ilona Verwaal[1]

[1] Fontys School of Engineering-Objexlab, Eindhoven, The Netherlands

Email: r.abdoel@fontys.nl, i.verwaal@fontys.nl

Abstract

Preparing the professional of the future demands an approach in which the impact of emerging technologies and its influence on three main factors - human, environment and facilities - are considered. We build and facilitated an educational playground where multidisciplinary teams consisting of a diversity of learners, lecturers and researchers work together in close collaboration with the industry on real world applied research projects while using and learning about emerging technologies. We know that technology is a means – not a goal - to add value to society. To incorporate this insight as a mindset, could be a valuable asset for innovative experiences and development in engineering education (curriculum design). It also gives new insights in how to implement technology enhanced active learning to engage and support learners in to taking full control of their study- and professional career development (ownership). This mindset results in a new educational and sustainable ecosystem consisting of a model (CETS) and roadmap with the following goals: Stronger and intensive cooperation between industry, education and government (University-Business Cooperation, Triple Helix) creating partnerships for applied research and engineering projects; Attractive, up to date and state of the art engineering programs; Further professionalizing of the universities work force. By implementing the 'Connecting Education Technology and Science'-model we have achieved the following goals in two years: We build a strong network of knowledgeable companies which are more than willing to participate and contribute in our education; We developed educational programs together with the industry and interdisciplinary business units from Fontys UAS which make cooperation more approachable; We build an open educational playground in which the human factor, environment, and facilities are interconnected and offer new opportunities for future developments and research in teaching and in learning. The ecosystem is an inspiration and source for other organizations to join and to co-create new educational and technological developments. We explore new ways of teaching- and learning methods and develop supporting (ICT) technology to create an educational environment which give learners control over their own learning needs and learning path.

Keywords: ecosystem, emerging technologies, talent development, customized learning

1 Introduction

There is a great shortage and demand for professionals with specialized technical skills (Brainport, 2014), but currently, technical skills are not the only requirements the industry is calling for (Engineering, 2004). Engineers are expected to be skilled and have knowledge of a broad professional spectrum: multidisciplinary team work, communication, sustainability, (local) manufacturing, combining art, design and engineering, innovation and creativity and global markets (entrepreneurship) are just a few examples (Engineering, 2004).

Universities face a challenge to educate and prepare engineering professionals for jobs increasingly involving multidisciplinary skill sets and for jobs that even do not exist yet (Dunn, 2011) (Forum, 2016). To succeed in both today's world and the future, we need to think and act differently (Kotter, 2014). This raises the question of how universities can adapt to fast changing technologies and the increasing demand for more, distinctive and broader qualified engineering professionals who are able to adapt and persist in the evolving digital economy.

Fontys University is fully aware of the dynamics and significant (economic) potential of the high-end and high-tech industry. Therefore, in 2014, a Centre of Expertise "Fontys Objexlab" was set up to improve and facilitate the link between education and applied research. Fontys University plays an important role in the regional innovation system as an industry partner and it is leading the way in higher education in advanced emerging

technologies. To set up Objexlab the "Connecting Engineering Technology and Science" model (C.E.T.S. model) was used to formulate goals (Abdoel, Kawarmala, & Verwaal, 2014).
In 2016 we can confirm that all goals of the Centre of Expertise were achieved. We achieved stronger and intensive cooperation between industry, education and government by branding, PR, marketing and being present at relevant fairs and conferences. The core team of lecturers have been visiting fairs and conference and following training programs to professionalize themselves in the field and keep themselves updated. This knowledge will be applied directly in education and passed on to students. Currently, several applied research projects have started in collaboration with companies, lecturers and students. New knowledge and skills have been offered as workshops and training for the industry (Abdoel, Kawarmala, & Verwaal, 2014).
At present, two minor programs are developed and executed to answer to the need for updated and state of the art engineering bachelor programs in which learners develop competences, characteristics and skills required for jobs in the industry. For the near future, Objexlab aims to facilitate national and international learners to become the professional engineer of the future by developing curricula (bachelor, associate degree, minor) in which applied research is sustainably embedded (Abdoel, Kawarmala, & Verwaal, 2014).
Now that Fontys Objexlab is ready to operate fully, the next step is to employ the interaction and effects of the three factors: human, environment and facilities. To do this, a common ground starting point, or a vision on education ecosystem, was developed to elaborate the C.E.T.S. model for designing educational programs.
The present paper describes the models for developing and executing new education programs. These models for developing (3C model) and executing (Circle of Five) education, are elaborations of the C.E.T.S. model, particularly focusing on learning in education and applied research. The implementation of this new approach towards learning was measured and analyzed and will be presented in this paper.

2 Vision on education programs

Fontys Objexlab aims to design and develop programs, in which learners are triggered to develop a pro-active attitude, develop a healthy research mentality, manage their own time, to strive for excellence, to be meaningfully and actively engaged, take full advantage of opportunities, to focus quality and to challenge and relevance of the subjects they are studying or researching. To create common ground with a variety in multidisciplinary educational designers, the 3C model was introduced.

2.1 Starting point for developing education: 3C model

The 3C model consists of three elements Objexlab focusses on in developing educational programs: Collaboration, Co-Creation and Control. New education programs should include more *collaboration* in multidisciplinary student teams with the industry to work on real world applications using and learning about emerging technologies. Another rather new approach to designing education, is that the industry and other institutes are invited to *co-create* educational programs. The past two years this model has been an inspiration and source for other organizations and bachelor programs from different disciplines and institutes to join and to co-create new educational and technological developments (Abdoel, 2015). Finally, the design of the education should give learners *control* over their own learning needs and learning path.

2.2 Starting point for execution of education: Circle of Five

The Circle of Five focusses on changing the mindset and seeing the bigger picture. In this case this works two ways. Educators should practice what they teach. It means giving the example as a good role model. Other than that the learner should experience and be purposeful engaged to change their mindset to prepare themselves for the future.
Focus on the positive
We believe that learners are motivated and become self-aware when we focus on the positive of their learning journey. Focus on what they know and their progression and not on what they don't know (yet) and what went wrong. With focus on positivity, we want to support talent development and self-directedness of every learner.
Trust gives ownership
We trust our learners to take their own responsibility for their learning path. We give personal attention and freedom to learners who need freedom and give guidance and coaching to learners who need guidance and

coaching. We believe that a motivated learner is able to assess himself on his competences for work, life and society. A motivated learner sees education as a privilege not as an obligation.

Providing challenge for every learner

This means not too difficult and not to easy assignments and variation of theoretical and active learning opportunities (specialist vs generalist). Also this means that the level can vary from learner to learner (self-paced, personalized learning combined with talent development). We believe that a learner is challenged by growth and attention for his/her unique talents and their personal ambitions.

Cohesion in development of education

Every educational program should start with the "big picture" and should be approached holistically. Cohesion in modules, subjects and study activities increases the learning potential for learners. Learning is multidimensional, therefore, in developing the modules and educational activities, peer consultation and involvement of experts from the industry and the learner's vision is seen as high value for our education in design, creation, development and execution.

Lean education

We prefer education as lean and transparent as possible in organization, structure, and in the design and development of programs and learning activities. We benchmark and back-up our programs with sound research and similar programs which have proven their quality in practice (Emiliani, 2015).

The 3C model and Circle of Five were used to design and execute three minor programs.

2.3 Minor programs with emerging technologies

The following minors were developed in 2015. The first minor "Smart Product Development with Additive Manufacturing" (SPDwAM) is a technical minor (specialist). The second minor "From Idea to Product with 3D printing" (FI2Pw3DP) is a broad minor (generalist) focusing on 3D printing and combining multidisciplinary aspects, such as Business and Design, of this technology in one program. The third minor is a "hybrid" minor "the Engineering minor". Students can choose a module and a project for 14 ECTS of "SPDwAM". The residual 16 ECTS consists of a combination of different modules from different engineering disciplines (automotive, electrical, mechanical and mechatronics).

In development and execution of all minors, preferences of the industry were taken into account, as well as the T-shaped competence model as presented in Figure 31 **Invalid source specified.**.

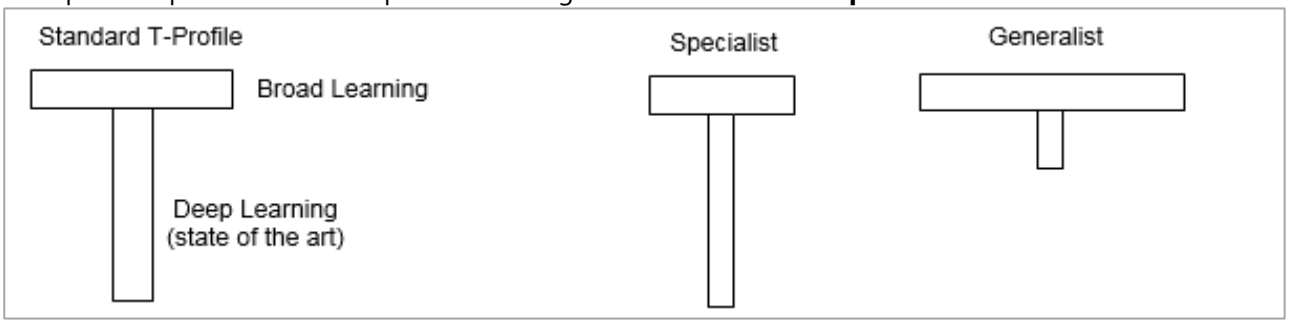


Figure 1. T-shaped competence model

The minors SPDwAM and FI2Pw3DP were designed, developed, executed and supervised by the educational designers of Objexlab. See Table 1 for a summary of characteristics of the minors.

Table 1. Summary of the three minors.

	Minor SPDwAM	**Minor FI2Pw3DP**	**Engineering Minor**
Development starting point	3C model	3C model	Hybrid
Executional starting point	Circle of Five	Circle of Five	Hybrid
Current educational designers and lecturers	6 lecturers of the Mechanical Engineering Department	15 lecturers of 9 different Fontys institutes with different technical and non-technical backgrounds	6 lecturers of the Mechanical Engineering Department + 3 lecturers of Fontys School of Engineering

Current students	5 Mechanical Engineering, 4 Automotive, 2 Mechatronics of Fontys School of Engineering	27 National Bachelor students with 12 different technical and non-technical backgrounds	20 Mechanical Engineering, 12 Mechatronics of Fontys School of Engineering
EC	30 EC	30 EC	14 EC SPDwAM / 16 EC Traditional
Duration	Feb 2016 – Jul 2016	Feb 2016 – Jul 2016	Feb 2016 – Jul 2016
Status	Pilot	Pilot	Embedded in Curriculum
Requirement	Propaedeutic exam + technical basic knowledge	Propaedeutic exam	Propaedeutic exam + technical basic knowledge
Team cooperation in product development	Multidisciplinary	Interdisciplinary	Multidisciplinary
Purpose	Trans-disciplinary	Multidisciplinary	Trans-disciplinary

The cross reference or connection of the competences, character qualities and skills with the learning activities and the expected/desired outcome were incorporated by implementing a diversity of active learning activities in different environments. For example: competition, guest lectures, company visits, poster presentations, pitching and storytelling, mini-symposium, visiting fairs and conferences, company projects, in-class assignments, weekly tutor meetings, peer assessments, progress and reflection by updating a weekly blog on a website, pressure cooker assignments, etc.
In the next chapter we research to what extent minor students recognize the vision of the education ecosystem in their minor program and if there are differences in groups in recognizing the vision of the education ecosystem in their minor program.

3 Method

3.1 Data collection

This research was carried out to obtain insight in the extent of recognition of the proposed vision of the education ecosystem, by students who are currently following one of the three minors: Smart Product Development with Additive Manufacturing (SPDwAM), From Idea to Product with 3D Printing (FI2Pw3DP) and the Engineering Minor. Additionally, we are interested if and which of these minor-groups differ from each other in recognizing the vision of the education ecosystem.

3.2 Respondents

A total of 70 minor students (11 SPDwAM, 27 FI2Pw3DP and 32 Engineering minor) were approached to fill out a questionnaire with statements about the proposed education ecosystem (3C model and Circle of Five). The questionnaire was distributed by e-mail in March 2016 after four weeks of education (at 25% of completion of the minor program) as a baseline measurement. At the end of the semester (July 2016) a second measurement will be executed to analyze and correlate the final minor grades of the students and their feedback to the baseline measurement.

3.3 Measurement instruments

Google Forms was used to design a questionnaire about the vision of the education ecosystem. The questionnaire consists of 40 items, formulated as statements, with answers from 'totally disagree' to 'totally agree' on a 5-point Likert scale. The questionnaire consists of several categories to distinguish the 3C model, Circle of Five and the Desired Outcomes. The 3C model is divided into three categories: Collaboration (Col), Co-Creation (Coc) and Control (Con). The Circle of Five is divided into five categories: Focus on the Positive (FOP), Providing Challenge for Every Student (CFES), Trust Gives Ownership (TGO), Cohesion in Development (CID) and Lean Education (LED). The last part of the questionnaire consisted of eight statements concerning Desired Outcomes: Pro-Active Attitude (PAA), Research Mentality (RM), Manage Time (MT), Strive for

Excellence (SFE), Meaningfully and Actively Engaged (MAE), Take Full Advantage of Opportunities (TFAO), Focus on Quality (FOC) and Subjects Relevant and Challenging (SRC).

3.4 Analysis

To check the internal consistency of the questionnaire Cronbach's Alpha was calculated with IBM SPSS Statistics 24. To find an answer to the first research question "To what extent do our current minor students recognize the vision of the education ecosystem in their minor program?" percentages and mean scores were calculated of every category. To find an answer to the second research question *"Are there differences in groups in recognizing the vision of the education ecosystem in their minor program?"* we performed a one-way ANOVA and a post-hoc Scheffe test to find out which groups differ from each other on which category.

4 Results

4.1 Statistics

Response rate

Out of 70 distributed questionnaires a total of n = 44 respondents participated (response rate 63%). The respondent groups consist of 10 minor SPDwAM students (91% response rate), 10 minor FI2Pw3DP students (37% response rate) and 24 Engineering minor students (75% response rate).

Internal consistency reliability analysis

To check the reliability of the questionnaire we calculated Cronbach's Alpha for the categories of the 3C model, the Circle of Five and the Desired Outcomes. Additionally, we calculated Cronbach's Alpha for the whole questionnaire education ecosystem. We consider a Cronbach's Alpha of ≥ .70 as an indicator of sufficient reliability. Cronbach's Alpha ≤ 0.50 is seen as insufficient reliability. The results are listed in Table 2.

Table 2. Internal consistency reliability analysis.

	Cronbach's Alpha
education ecosystem	.930
3C model	.573**
Collaboration	.683**
Co-creation	*
Control	.788
Circle of Five	.931
FOP	.795
CFES	.861
TGO	.719
CID	.839
LED	.405**
Desired Outcomes	.818

* No Cronbach's Alpha was calculated for Co-creation as it consisted of 1 item.

** LED has a critical value for Cronbach's Alpha.

Table 2 shows all Cronbach's Alpha scores. The items of the 3C model are considered as marginally sufficient. The scale of Collaboration (Col) has a just below .70 reliability. The scale of Lean Education (LED) is considered insufficiently reliable. We will take these findings into account when it comes to drawing conclusions. In general the questionnaire as a whole can be seen to be reliable (.93).

Percentages

To obtain insight in the extent of recognition of the proposed vision of the education ecosystem, we counted the answers in every answer category and calculated the percentages. Figure 2 shows the percentages found for every category of the questionnaire. Positive answer categories (score 4 and 5) and negative answer categories (score 1 and 2) are clustered.

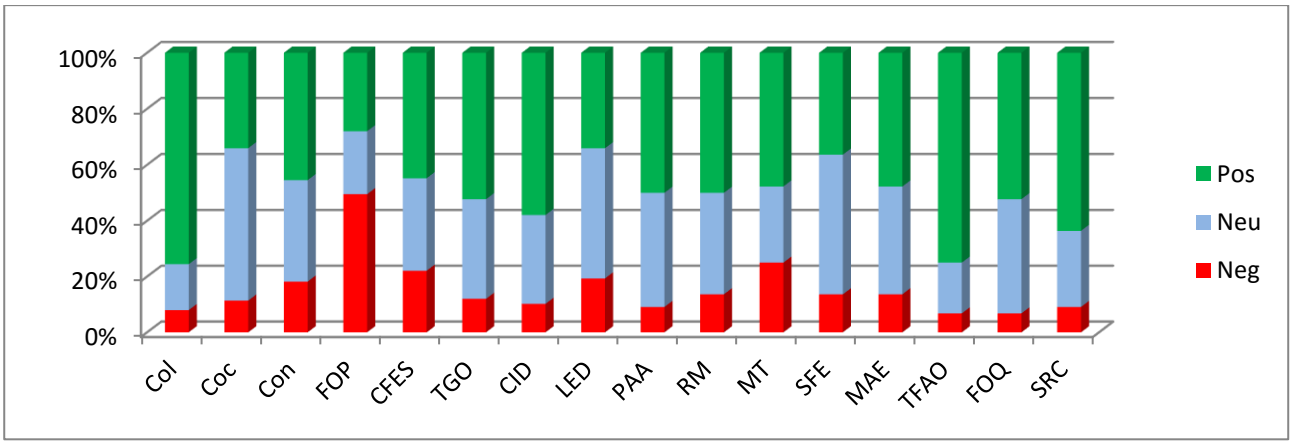


Figure 2. Percentages of all students on education ecosystem questionnaire.

Figure 2 shows that students score high on recognizing Collaboration (Col, 75.6%), Take Full Advantage of Opportunities (TFAO, 75%) and Subjects are Relevant and Challenging (SRC, 63.6%). In addition, the Collaboration statements *"I recognize interdisciplinary teams in working on projects"* and *"I recognize using emerging technologies (like 3D printing)"* have high scores. Students indicated that Focus on Positive (FOP, 77.2%) and Managing Time (MT, 25%) are not recognized in the minors. Students are neutral on recognizing Co-creation (Coc, 54.5%) in the minors.

Mean scores

To obtain insight in the extent of recognition of the proposed vision of the education ecosystem we calculated mean scores and percentages of each of the respondent groups. Figure 3 shows the mean scores of the students on the constructs of the 3C model and Circle of Five.

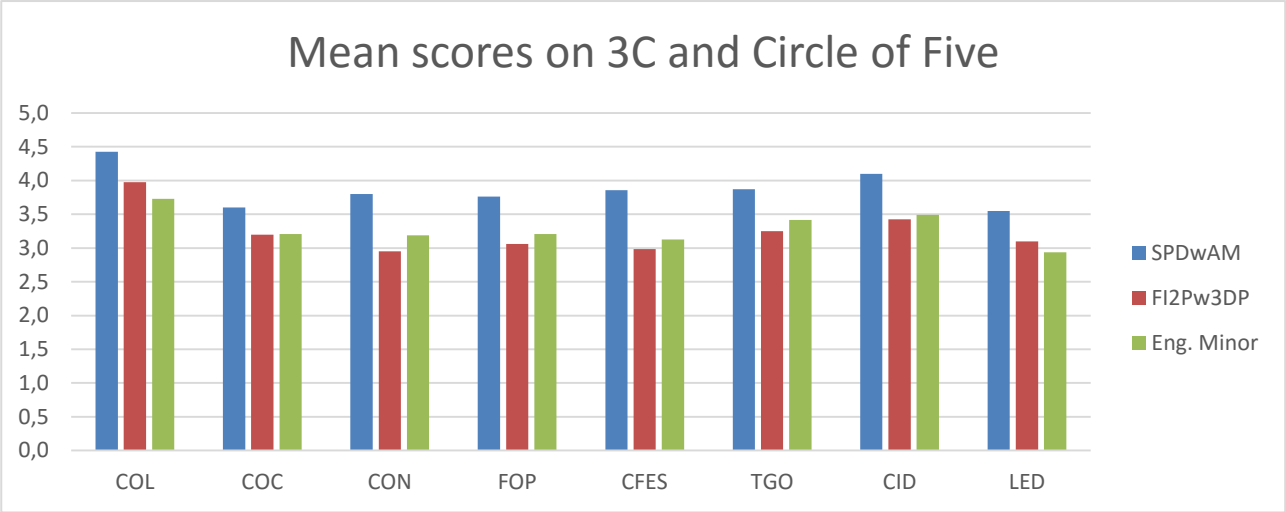


Figure 3. Mean scores on 3D model and Circle of Five.

Figure 3 shows that both SPDwAM and FI2Pw3DP students score high on Collaboration (≥ 4.0). Furthermore, the SPDwAM students also score higher than 4.0 on Cohesion in Development (CID). Finally, the Engineering minor students score ≤ 3.0 on Lean Education (LED).

On the items concerning the Desired Outcomes the following mean scores were found:

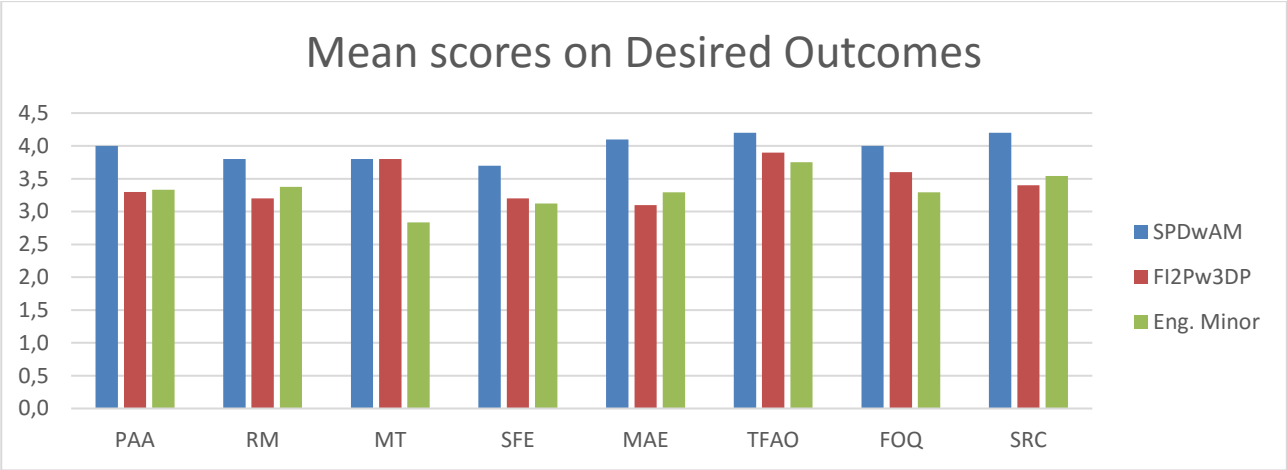


Figure 4. Mean scores on Desired Outcomes.

Figure 4 shows that SPDwAM students score above 4.0 on Pro-Active Attitude (PAA), Meaningful and Actively Engagement (MAE), Take Full Advantage of Opportunities (TFAO), Focus On Quality (FOQ) and Subjects Relevant and Challenging (SRC). Furthermore, the Engineering Minor students score below 3.0 on Managing Time (MT).

4.2 Comparing the groups

A one-way ANOVA was performed for the three groups: SPDwAM, FI2Pw3DP and Engineering Minor. The F-values were calculated to find out if the groups differ on recognizing the 3C Model, Circle of Five, Desired Outcomes and the vision of the education ecosystem.

The critical value for the respondent groups is F(2,41) = 3.23. If significant differences were found, a Scheffe post hoc test was performed to distinguish which groups differ from each other.

Table 3. Anova on 3C Model, Circle of Five and Desired Outcome

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
3C Model	Between Groups	16.673	2	8.337	.743	.482
	Within Groups	459.758	41	11.214		
	Total	476.432	43			
Circle of Five	Between Groups	1853.051	2	926.525	5.450	.008*
	Within Groups	6969.858	41	169.997		
	Total	8822.909	43			
Desired Outcomes	Between Groups	197.851	2	98.925	5.617	.007*
	Within Groups	722.058	41	17.611		
	Total	919.909	43			
Vision on Education Ecosystem	Between Groups	3556.673	2	1778.337	6.121	.005*
	Within Groups	11911.758	41	290.531		
	Total	15468.432	43			

Table 3 shows that the respondent groups significantly differ on their overall recognition of the Circle of Five, Desired Outcomes and the vision on the education ecosystem, because the F-value is > 3.23. The Scheffe post-hoc test showed the following significant differences (alpha ≤ 0.05): on Circle of Five a difference between the

SPDwAM group and the FI2Pw3DP group (0.022) and a difference between the SPDwAM group and the Engineering Minor Group (0.017) was found. On vision on education ecosystem a difference between the SPDwAM group and the FI2Pw3DP group (0.016) and a difference between the SPDwAM group and the Engineering Minor Group (0.010) was found. On Desired Outcomes the SPDwAM group and the Engineering group differed (0.022).

5 Conclusion

Collaboration and Take Full Advantage of Opportunities are best recognized in our minor program. There seems to be room for improvement left in Lean Education according to the Engineering Minor students, however, the low reliability of the category has to be taken in account. Although we see that the students predominantly recognize the vision of the education ecosystem, we also see a great amount of students are neutral in their answers. A possible explanation could be that the survey has been taken on 25% execution of the minor program.

In general, all groups recognize the vison of the education ecosystem. However groups may differ in the extent of recognizing the educational vision. Although the facilities and the environment for all minor groups are similar, the groups perceive the education ecosystem differently. A likely explanation lies in the human factor of the C.E.T.S. model.

In further research we will explore the human factor on developing, executing and perceiving the education ecosystem.

6 References

Abdoel, R. (2015). *3D Technology connects Fontys Institutes.* Eindhoven: Fontys Objexlab.

Abdoel, R., Kawarmala, S., & Verwaal, I. (2014). Connecting Higher Education, Business and Research to develop a Future Educational Ecosystem. *SEFI Conference Birmingham UK* (p. 10). Eindhoven: SEFI.

Brainport. (2014). *Human Capital Agenda Brainport 2020 Zuid-Oost Nederland.* Eindhoven: Brainport.

Dunn, J. (2011, October 25). *Edudemic-Students of the future*. Retrieved from http://www.edudemic.com/students-of-the-future/: http://www.edudemic.com/students-of-the-future/

Emiliani, B. (2015). *Lean University, Lean Teaching.* Kensington: The Center for Lean Business Management, LLC.

Engineering, N. A. (2004). *The Engineer of 2020: Visions of Engineering in the New Century.* Washington D.C.: The National Academies Press.

Forum, W. E. (2016). *New Vision for Education: Fostering Social and Emotional Learning through Technology.* Geneva: World Economic Forum.

Kotter, J. P. (2014). *Accelerate.* Boston: Harvard Business Review Press.

Weggeman, M. (2010). *Leidinggeven aan professionals? Niet doen!* Schiedam: Scriptum Management.

Implementation of the PBL approach to the "Foundations and Earth Works" Discipline: a Brazilian Experience

Kurt André Pereira Amann[1]

[1] Department of Civil Engineering, Centro Universitário FEI, São Bernardo do Campo, São Paulo, Brazil

Email: kpereira@fei.edu.br

Abstract

This paper aims at presenting the experience and evaluating the results from the implementation of the Problem Based Learning approach to the discipline "Foundations and Earth Works" from the Civil Engineering Course at FEI, a Brazilian University at the metropolitan region of São Paulo. Despite this limited experience, the principles of PBL were introduced and compared with other PBL models. The students' performance after the implementation was compared with the previous studies taking a similar test into consideration. It was possible to verify that the scores increased slightly, but the failure ratio had an interesting reduction, which depends on the class behaviour. This result allows the proposal of its implementation to other disciplines in the course.

Keywords: Problem Based Learning approach; curriculum change; evaluation of PBL implementation.

1 Introduction

The Problem Based Learning (PBL) approach has been a very interesting learning philosophy to be adopted in engineering courses, although it requires a change in students' and professors' behaviour for its implementation.

Dahms (2014) relates the elements of this change process, from a traditional learning environment centred and controlled by professors to a new environment, which is centred and controlled by students. Therefore, the professor's role changes from a 'teaching situation' (based on a behaviourist learning theory) to a 'learning situation' (based on a social constructivist learning theory), who becomes a facilitator of the student's individual process of building knowledge.

Therefore, professors and students should be emotionally and cognitively prepared (or trained) for these changes; however, this can be difficult for both parts. In general, only interested professors must involve themselves in starting this process because it is not recommended to force anybody to do something that he or she is not confident or happy to undertake (Dahms, 2014).

On the other hand, it is important to consider that, in PBL, the individual knowledge's construction is an active learning process. It is made by analysing information from different sources, in social interaction with peers, many times being a new challenge for students. The majority of students have only experienced passive individual learning and they can have difficulty to handle collective and collaborative knowledge processes. In these cases, a natural reaction is to develop a negative attitude, which can undermine the PBL's implementation initiative (Kolmos et al, 2009).

Intending to implement PBL, various models are presented in the references. However, most of them answer the institutional level, which is certainly the ultimate goal. Li et al. (2009) state that PBL also implies a new way of designing and developing the curriculum, which is not just constructed based on isolated disciplines and subjects (as in the Positivist Philosophy), but it is interdisciplinary, designed and integrated through a problem or project. On the other hand, Dahms (2014) comments that very few institutions can start planning a complete curriculum from scratch, then the change is naturally a gradual process, which can start on a small scale and gradually spread from a course to a department or institution. Therefore, it is possible to introduce a short problem-oriented project as a student activity at the end of an already existing course, being important to include it as an interdisciplinary proposal.

In this context, this paper presents the motivation, the challenges and the results of a first personal experience on implementing PBL conducted by the author, and applied to a single discipline of the Civil Engineering Course in a Brazilian University.

2 The Motivational Context for Change

The Centro Universitario FEI is an 80-year-old recognized institution specialized in Engineering, Computation Science and Business Administration courses, located in São Bernardo do Campo, in the Metropolitan Region of São Paulo, Brazil, since the 1960's. The region is a cluster of carmakers and other industries, and has a high economic importance to the country. The Civil Engineering course at FEI is a relatively young course, created with the Positivist curriculum in the 1980's, reviewed in the 1990's and again in 2000's (and under revision now). Many disciplines have practical activities in laboratories and others, such as seminars, discipline projects, technical visits, and an interdisciplinary end course project. Apart from these aspects, it is a traditional course.

The Foundations and Earth Works discipline is filled with calculations, technical and specific contents. It is placed at the seventh (of tenth) semester of FEI's Civil Engineering Course, and it has been a traditional professor-centred discipline taught by the author, who is a researcher of the subject. In this situation, considering all others traditional disciplines in the course, students have already consolidated the traditional and passive approach, sounding almost impossible to improve the skills through an isolated change of approach.

The author was always interested in experiencing new and various educational approaches and PBL has always been his great interest of study. However, the challenge and the consumption of time involved in crafting the problem and reorganizing the discipline activities precluded the approach change; however, a specific circumstance almost forced this change.

After the author's participation in an Active Learning Workshop and after a week of tests in the first semester of 2014, a well-known class of unruly students of this discipline refused to be quiet during a carefully prepared slide presentation. This event, added to another extremely quiet and passive class, brought low self-esteem and showed that something should be done.

Then, during an entire week, six case studies and a lot of self and peer assessment questionnaires were prepared to be applied in the following class. Although it seems an anti-pedagogical action, because it was taken in the middle of the semester, it was apparently the only viable way to continue the discipline.

Therefore, it was the beginning of this experience reported here.

2.1 Disseminating the experience to implement the change

Although PBL must be the basis for a new curriculum proposal, the challenge of its implementation on a single discipline was carried forward as a bottom-up strategy to start the course change.

Dahms (2014) warns that when the change is dependent upon few people in the bottom-up strategy, there are risks of returning to the traditional approach, either due to change of position or fatigue, being needed as well the top-down managerial support for a sustainable change. Li et al. (2009) also comment that it is required to change the teachers' personal perception about the teaching-learning process, or the institutional change is likely to transform into a new format with the old teaching style. Then, the challenge's focus should be staff development.

On the other hand, Dhams (2014) quotes Barrows (1996): "Once anyone is involved as a PBL tutor working with students and has the opportunity of seeing what the students can do when given the permission to think and learn on their own, he or she usually becomes a convert".

In this way, the better staff development should be to provide and disseminate the experience, and this is the author's current role.

3 PBL Models and the Proposal's Construction

It is important to note that the first experience was not a full PBL proposal, and it is even now under development. It is maybe possible to classify it just as an Active Learning experience, as more researches have been made to model it as an authentic PBL experience.

Some PBL models researched by several authors can support this proposal's construction.

In a broader sense, Li et al. (2009) present four principles to define a PBL curriculum in any case: a) problem-centred; b) student directed learning; c) social approach; and d) interdisciplinary learning. These are considered the main characteristics of a PBL proposal.

Kolmos et al. (2009) present the Savin-Baden (2000, 2007) PBL models, based on five different problem epistemologies. Among these, it is possible to cite the two most interesting for the discipline: II) PBL for professional work; and III) PBL for interdisciplinary understanding. Each of these models has six dimensions that stress a combination of learning methodology, knowledge construction and scientific approach. Inspired on Savin-Baden models, Kolmos et al. (2008) developed an alignment model for the seven PBL curriculum elements: 1) objectives and knowledge; 2) types of problems and projects; 3) progression and size; 4) students' learning; 5) academic staff and facilitation; 6) space and organization; and 7) assessment and evaluation. This alignment must be observed and it could be applied to a discipline or a course.

Therefore, it is possible to detail the proposal's construction by applying these elements.

3.1 Objective and knowledge

The methodological objective of PBL is to build knowledge in social collaboration. Therefore, students must develop general competences as instrumental competences, interpersonal competences and systemic competences. Additionally, students must develop the specific and technical competences of the discipline. They must also develop disciplinary and interdisciplinary knowledge considering the interaction with other disciplines or subjects.

3.2 Types of problems, duration and facilitation

The six case studies mentioned in the previous item were initially prepared based on a mix of some PBL varieties from Barrows' taxonomy. Kolmos et al. (2009) cite Barrows (1996) who developed his taxonomy focusing on the question of teacher control versus student control in the classroom. Those authors stress that this taxonomy only addresses the course or unit level and does not address the department or institutional level, which is perfect to analyse the presented experience.

As the students need some initial experience in the PBL approach, the problems are well defined at the beginning. Nevertheless, the proposal has no traditional lectures, and it deserves some comments about the methodological details.

After the first experience, with the six case studies, in the following semester the starting problem was: "how could professors make students learn without traditional expository lectures?" This problem arouseds because although the PBL approach can have lectures, the preferable model proved to be "without lectures" after the disrespectful class behaviour.

Dahms (2014) draws a comparison among the University of Maastrict, Republique Polytechnic of Singapore and Aalborg University, considering different PBL parameters. It is interesting to note that the Republique Polytechnic does not have classes, but it only introduces the problems that need to be solved on the day.

Linking this models, it was possible create the proposal with some steps.

3.2.1 Preparation for Active Learning

On the first day, for instance, after some quick words about the discipline's program and the PBL methodology, the teams are presented to the discipline subjects through some online papers in Conference Proceedings which need to be summarised and discussed in the following class.

The problem to work be addressed is: "how are the paper's subjects linked to the discipline program?" As suggested by Kolmos et al. (2009) the teams can freely choose their papers, stimulating their autonomy.

Then, this method is repeated as a preparation in the two following classes with some variations, and students are asked to study the new subject before the following class.

Afterwards, an integrated list is made, excluding the same types with different names. Later, this new list is redistributed to the teams which includes a new problem: "what are the characteristics of the tests listed?" The students must research about utility, executive method, interpretations of results, costs, application to project's foundation, which will be presented with a few slides in the following class. This is a means to ensure the student has direct learning as exposed by Li et al. (2009).

3.2.2 Solution of problems through the Jigsaw technique

After this warm-up activity, which is aimed at preparing the students to face the discipline's greatest problems, the following subject is shallow foundations. This subject has many details, which are divided into six different topics.

The jigsaw technique is used to distribute these topics among the teams to research and elaborate a summary. In the following class, the teams are split up and the members are redistributed in new groups in which each student is an "expert" in one of the six topics. Then, different cases are distributed with problems to solve following the process of shallow foundation design, where all the six topics and the geotechnical investigation subject are also needed. The challenges for students are to solve the problem and to learn collaboratively changing their knowledge. This strategy reinforces the collaborative learning and the social approach as presented by Li et al. (2009).

3.2.3 Open problems regarding piles and Interdisciplinary Project about Foundations

After the first test, the professor hears the impressions and suggestions from the students and makes some adjustments. Then, they start to choose the types of pile foundations and, in the following week, the professor applies a number of open-problems regarding pile foundation to the teams. These problems should be solved in the following 4 weeks and compared using peer assessment after the solutions are presented. No innovation problems or ill-defined problems are proposed at this moment yet. It has no traditional lectures, but the discussion of the well-defined problem solutions aims at supporting the final project.

Therefore, the students must do a final project, in which they have to choose and design a foundation for the building chosen by the team to develop the Reinforced Concrete discipline. They designed these building in the Architectonic Design discipline, being chosen by the team to calculate the foundation using loads and data from the Reinforced Concrete design, which ensures the centred problem approach and the interdisciplinary learning stressed by Li et al. (2009). The soil investigation report used in the project must be obtained from commercial investigation enterprises, being an open problem (as the types of problems of Kolmos et al., 2009) and providing a professional collaboration.

3.3 Academic staff, space and organization

The staff development is in fact the most important component of the PBL implementation. For instance, the author has always been interested in this subject; however, he spent ten years studying active learning on his own to be able to deploy his first PBL experience, not for lack of knowledge, but for lack of confidence.

Intending to implement the approach in other disciplines, the professor's training is very important, especially with regard to guiding the teamwork organization. Receiving criticism from students is natural, and it demands psychological preparation to deal with this. It is also important to control the students' anxiety in their search for individual knowledge, since the tests' scores depend on this (in this experience, not in a full PBL approach).

3.4 Students' learning and assessment

Kolmos et al. (2009) made two important questions: "do students expect to acquire knowledge transmitted by the professor or do they expect to build their own collaborative knowledge through a process of innovation?"

and "do they collaborate to acquire individual knowledge or do they collaborate to construct collective knowledge?"

The author created a questionnaire to understand the students' behaviour under self and peer assessment, which will discussed follow.

3.4.1 Evaluating questionnaires for self and peer-assessment

The author started to acquire experience on self and peer-assessment by applying some simple qualitative questionnaires to ask the students their impressions about the approach, the team member's dedication and the team's performance in the activities.

The first questionnaire was applied after the Jigsaw activity. It is important to remember that these teams has to solve large problems, however, the members were randomly selected (not chosen by friendship) and each member had studied different parts of the subject, forcing some interaction. The second questionnaire hads the same questions, but it focused on the open problems.

The issues are summarized below and the possible answers for the "a", "b" and "c" issues are "good", "satisfactory" or "below expectations":

a) How do you assess your performance in the proposed activity?
b) How do you assess your relationship with your team?
c) How do you assess the outcomes reached by your team?
d) From zero to 10, how would you rate your team and each member's performance? Name each member (if you wish) and highlight his or her rating.
e) How do you intend to overcome those difficulties in order to obtain the team's and each member's best performance in the future? What opportunities for improvement do you identify?
f) Comment on the proposed Jigsaw/ Problems regarding piles activity.

The Figure 1 presents the results of issues 'a', 'b' and 'c' applied to different classes at in the 1st and 2nd semester of 2015.

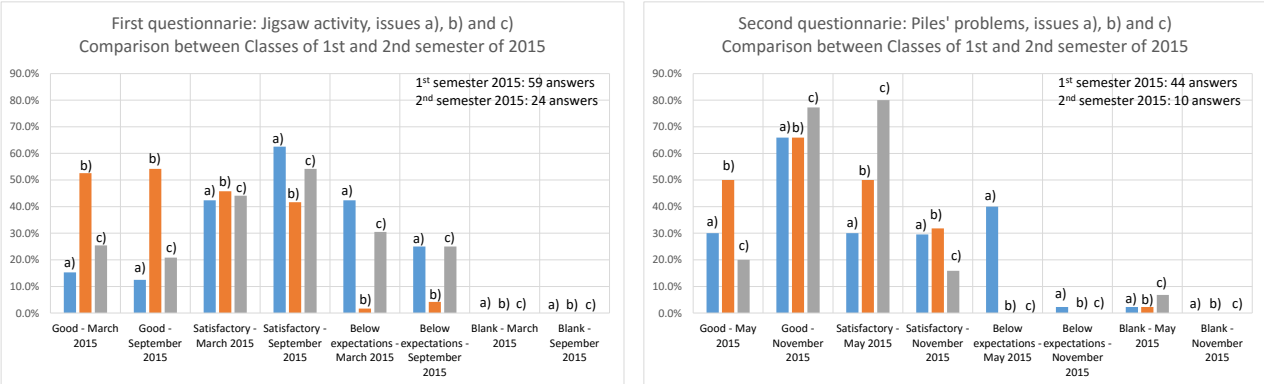


Figure 1. Results of first and second questionnaires (issues 'a', 'b' and 'c') for two classes in 2015.

It is interesting to see that in the first activity, which was the jigsaw, has many students choose "satisfactory" or "below expectations" in the issues 'a' and 'c'. This denotes the difficulties faced by them to construct the knowledge collaboratively in a different team, although they considered a "good" or "satisfactory" team relationship (issue 'b'). In the second activity, which was the open problems regrading piles, most of the students chose "good" or "satisfactory" in the issues 'a' and 'c', denoting the improved performance of the teams. A part of the class in the first semester, presented as "May-2015", did not have affinity with the method and chose "below expectations", but the impressive final result of this class indicates that they learned the discipline's very well, as will be demonstrated afterwards.

The issue 'd' is the first trial attempt of peer-assessment by the author. Figure 2 shows the general distribution of scores assigned by the student's for each of their team's members. It is possible to see a gradation in the percentage of students in function of the scores when analysing the Jigsaw chart. This indicates that the

students probably made a serious evaluation to assign the scores, if we analyse the distribution into the teams. However, the class of March 2015 presents 20 teams with the same score assigned to all its members against only two teams in the class of September 2015 in the same situation, and 3 that have only 1 member with different score. This affect the analysis and show that it is necessary a previous training of the students in necessary to understand the importance and the assessment methodology.

In the "problems regarding piles" chart, it is clear that there is a distortion in the number of students who scored 10 in the class of May 2015. In fact, again, 20 teams in this class has all their members with a maximum score, being 14 teams with the same score 10, 4 teams with score 9 and 2 with score 8. The class of November 2015 has no team members with the same score, which is the expected behaviour.

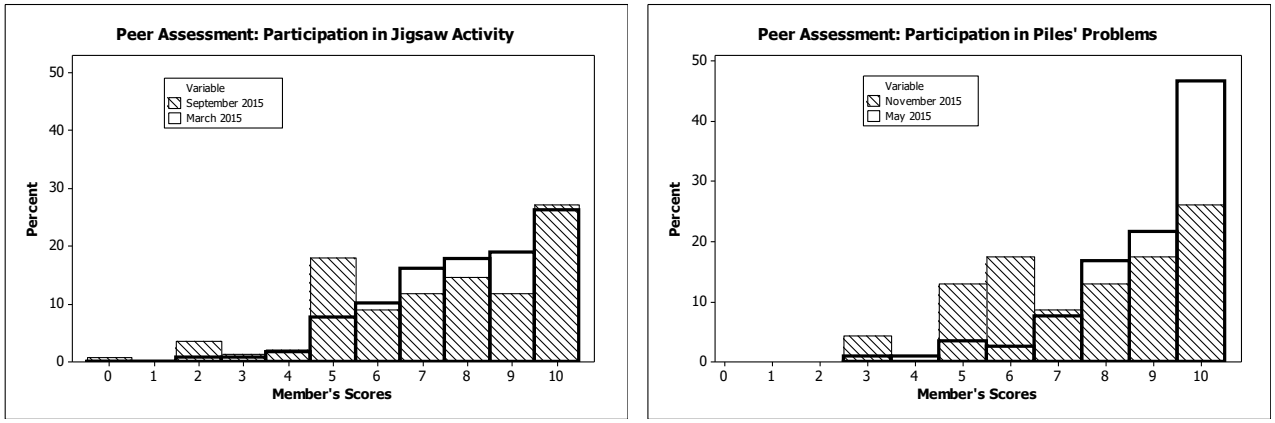


Figure 2. Results of first experience on peer-assessment for two different classes in 2015.

Another interesting finding is that the students tend to assign many scores above 5 when they assess their colleagues because they identify themselves with the colleagues' difficulties. This indicates that an intense work is necessary to train the students before risking a true peer-assessment.

The answers for issue 'e' were extensive; however, in summary, they indicated that students understood the importance of dedication, time to study and members' collaboration to solve the problems. It demonstrates that the proposal is feasible.

The answers for issue 'f ' could be summarized as "opposed" to the activity, "approved with restrictions" and "approved". The Figure 3 shows the results.

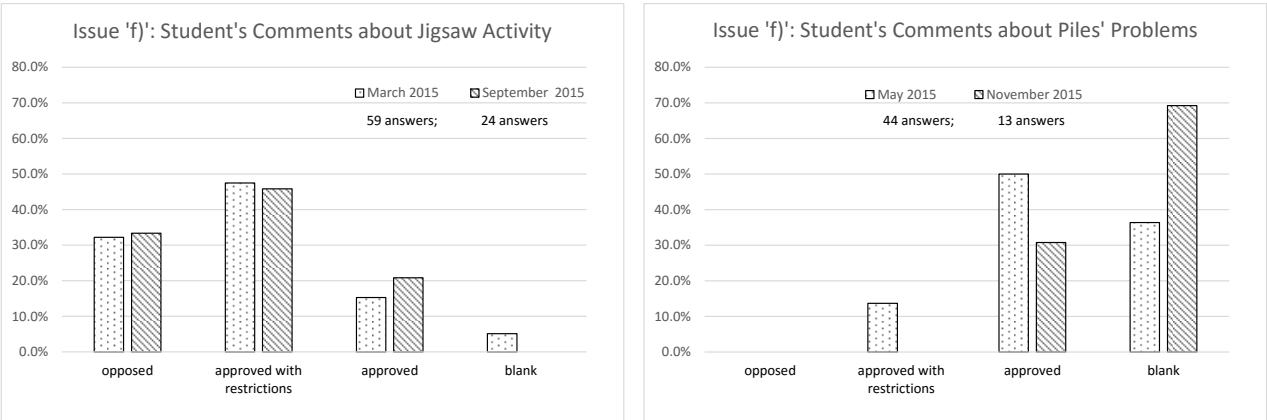


Figure 3. Summary of answers of issue 'f' for two different classes in 2015.

The majority of the restrictions were regarding the Jigsaw activity, and the oppositions and restrictions refer to the professor's desire to apply some previous traditional classes to prepare the students to face the proposed problems. After the first test, some quick comments are now made at the beginning of the classes, and this

has been sufficient to obtain good performance, as the right chart shows. Nobody was opposed to "Problems regarding piles" activity; many students approved or did not comment.

3.5 Evaluation and outcomes

According to Kolmos et al. (2009), individual and group assessment methods assess different types of knowledge and skills, being drivers for students' learning. Unfortunately, in this experience the students' evaluation is still done by two individual tests and the final project, made in-group, as most of the traditional disciplines at FEI. This allows us to compare the average students' performance after the PBL experience with the previous history, in terms of the specific technical objective of the discipline, as it will be showed. The scores range from 0 to 10, and approving scores are greater than 5.

It is important to note that the tests always include decision-making issues, and the evaluation of an interdisciplinary context was needed, even before the PBL experience.

The teams' evaluation still considers the final product of the developed project more than teamwork organization assessment. Nevertheless, a new experience will be made this year to include the group's organization and teamwork in the assessment. In addition, students are heard on their suggestions after the activities. The PBL experience's outcome is (still) individual learning (assessed by individual tests), and the full report is about the "project of building foundations", but the presentation learning is beginning to be considered interesting.

Although this is not a full PBL experience, with its wider benefits to the curriculum, such as full interdisciplinary and collaborative knowledge construction to innovation, it is important to know how good this experience is in comparison with the traditional lecture approach, considering a form of evaluation which is similar to the old one.

Figure 4 shows a temporal analysis, semester by semester, and the evolution of the average of the scores of the class.

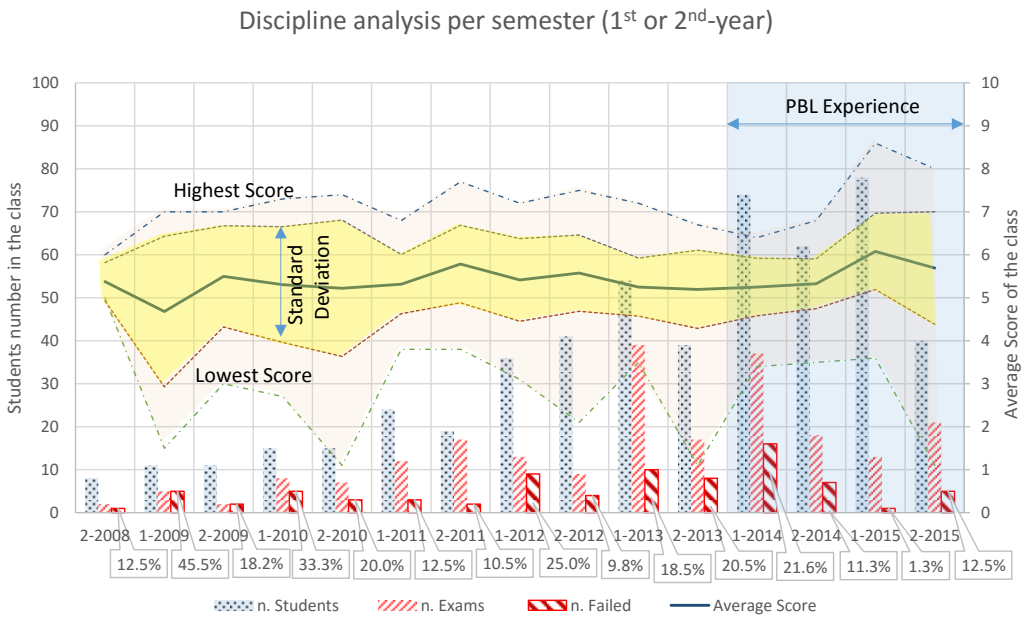


Figure 4. Temporal analysis of the average score of the class and number of failed students.

It is possible to see that the average score of the class rose only slightly after the beginning of the PBL experience. However, we can note that the highest score obtained increased, indicating the motivation of the best students of the class. It is important to see that the number of students per class increased in this period, making the facilitation more difficult.

Note also the class of 1-2015 with 78 students and the incredible low number of students who failed (only 1 student). This exceptional class joined the proposal and had an excellent outcome. In contrast, the next class only had 40 students, the professor had two monitors to help him in the facilitation. However, the class was strongly divided and did not work well in teams, harming the collaborative knowledge construction. The cooperation was encouraged, but students did not fit the proposal. This indicates that the professor needs more training in PBL or we can understand that the class's behaviour strongly influences the outcome.

An interesting drop of the average student's failing ratio was noted, from approximately 21% to 12%. However, a statistical analysis using comparison between averages of two variables with the Student's t statistics results in a $t_{critical}$ (bi flow)=2,364 and the calculated t=1,686. Then, the hypothesis of equal average was accepted and there are not still significant difference. In fact, it still has few points to define a tendency, but it is expected that the new average ratio remains over the time.

4 Conclusion and final remarks

This paper presented an experience of implementing PBL in a single discipline of the Civil Engineering course at FEI-Brazil. A reduction and a comparison with some curricular PBL models were carried out, and a technical sheet showed the application of most PBL principles in this limited case of study, which is still under an improvement process.

It is clear that the teacher must be prepared to overcome his or her personal barriers to develop the role of facilitator of the collaborative learning process.

Despite being limited, the outcome considering the specific technical objectives of the discipline was apparently increased, but the collaborative knowledge construction was evaluated. The self and peer-assessment should be implemented considering a previous students' preparation. Apparently, the class's behaviour regarding the collaborative knowledge strongly influences the specific technical outcomes.

However, the most interesting aspect is the drop of the average ratio of the failing students, from 21% to 12%, and we expect this remains overtime.

Many improvements must be made in order to increase the outcome and to spread the experience to other professors so that a change in the whole course can be possible.

5 Acknowledgements

The author would like to thank Centro Universitario FEI, FAPESP and CNPq for the opportunity to participate in this conference.

6 References

Dahms, M. L. (2014). Problem Based Learning in Engineering Education. In Villas-boas, V., Giovannini, O. (eds.) *Procedings of ALE-2014, 12th Active Learning Workshop: Attracting Young People to Engineering*, ABENGE. Caxias do Sul, Brasil. 2014. 10 - 20.

Kolmos, A., De Graaf, E., & Du X. Y. (2009). Diversity of PBL– PBL Learning Principles and Models. In Du X. Y., De Graaf, Kolmos, A., (eds.) *Research on PBL Practice in Engineering Education*. Sense Publishers, Rotterdam, The Netherlands. 2009. pp10-32.

Li, H., Du, X., & Stojcevski, A. (2009). Educational transformation to PBL- what has changed. In R. Gabb (Ed.),*Proceedings of the 2nd International Research Symposium on PBL*. Victoria University Press.

Savin-Baden, M. (2000). *Problem-Based Learning in Higher Education: Untold Stories*, Society for Research into Higher Education and Open University Press.

Savin-Baden, M. (2007). Challenging Models and Perspectives of Problem-Based Learning in Graaff,E. de & Kolmos, A.: *Management of Change; Implementation of Problem-Based and Project-Based Learning in Engineering*. 9-29. Rotterdam / Taipei: Sense Publishers.

Contribution of universities to sustainable development

María Olga Bernaldo[1], Gonzalo Fernández [2], Ivan Oliver Hilliard [3]
[1] School of Enginnering & Architecture, Universidad Europea de Madrid (Spain)
[2] School of Enginnering & Architecture, Universidad Europea de Madrid (Spain)
[3] Faculty of Social Science & Communication, Universidad Europea de Madrid (Spain)

Email: mariaolga.bernaldo@universidadeuropea.es, gonzalo.fernandez@universidadeuropea.es, ivanoliver.hilliard@universidadeuropea.es

Abstract

This article came from a study developed by the sustainable engineering research team at the Universidad Europea de Madrid (Spain) based on different university approaches to sustainability and as well as university social responsibility reports. Both aspects are analyzed and assessed and special attention has been given to benchmarking of Spanish and European universities in these assessments and reports. The aim is to better understand how to advance and measure sustainability in a university and the important role that students may play. Participation of the students in the diagnosis and the action plan for developing a more sustainable university is essential in this study. Extracurricular activities and curricular projects are focused on the development of knowledge, competences and values related with sustainability, and contributing to a more sustainable university. Strategies focused on sustainability at the university have important impacts on future social development.

Keywords: Education for Sustainable Development; Higher Education Institutions; Competencies and values; GRI.

1 Introduction

The concept of Sustainable Development (SD) was described in 1987 in the Report of the Brundtland Commission as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. The importance of implementing a SD model in every human activity is clear, but perhaps no more so than in the education of the next generation (UNESCO, 2009). Education plays a key role in training each future generation, and the link with sustainable development is therefore clear, even before the definition provided in the Stockholm Declaration in 1972. As Higher Education Institutions (HEI) are where future decision makers are being formed, there is a need to understand how much of an emphasis HEI's are placing on SD in higher education (UNESCO, 2009).

Higher Education Institutions (HEIs) have been involved from the beginning with the Millennium Development Goals and SD, running campaigns and offering solidarity. The literature reflects an important consensus on the role of higher education institutions in building a better future, to ensure sustainable livelihoods, future opportunities for young people, and the possibility to transform current behaviors and habits (Calder and Clugston, 2003; UNESCO, 2009; Terron et al., 2015). Some authors consider Education for Sustainable development (ESD) as a new paradigm, and the current system as part of the problem, by favoring individualism and encouraging current patterns of behavior and consumption. ESD aims to establish a new paradigm to meet social needs (Terron et al., 2015), being designed by the Sustainable Education Network for Development as "the process of acquiring knowledge, skills and attitudes needed to build fair and equitable local and global societies, living within the environmental limits of our planet, both now and in the future" (EAUC, 2013).

Many higher education institutions have begun their journey towards ESD, but it is proving a difficult path (Ferrer-Balas et al., 2010; Jones et al., 2010; Lozano, 2012). This is reflected in the fact that most universities are far from a complete integration of ESD either in the activities of the University or in the course contents (Wade, 2008; Hannover Research, 2011; Wright and Wilton, 2012). In fact, by 2011 only 15 of more than 14,000 universities worldwide had published a sustainability report (Lozano, 2010).

ESD should be integrated in all areas of a university's reach, including education, research, community outreach programs, campus operations, assessment, stakeholder communication, and institutional framework (Lee et al., 2013). The objective of this integration in the university sphere is to be a proactive agent, by involving students and the university community in processes to facilitate personal transformation and a different view of the

world. In this process, learning, teaching, practical application and different social needs should be linked (Segalas et al., 2009).

For some authors, the development of SD competencies is considered one of the main drivers to achieve true ESD. This can be considered as an approach focused principally on academic programs, but also on all areas that impact on a student's knowledge, skillset, and values (Segalas et al., 2009). In this regard existing evaluation systems used to analyze the university as an institution can be considered highly relevant, allowing the development of strategies which contribute to sustainable development. It is therefore essential to involve students in proposed improvements and actions and their evaluation, through integrator projects both in the classroom and beyond (Bernaldo and Fernandez, 2013).

2 Objectives and Methodology

The purpose therefore of this paper is to show the progress made by the sustainability research team of the Universidad Europea of Madrid in the identification of tools for sustainability assessment, the analysis and benchmarking of university CSR reports, and the efforts to involve students in both the diagnosis and the action plans proposed by using integrated projects and project-based learning, both in the classroom and through extracurricular projects linked with external associations and alumni clubs projects. This approach incorporates academic programs, as well as development of student knowledge, skillsets, and values

As can be seen in Figure 1, the aim is to integrate sustainability into university thinking both through a institutional and curricular focus, with and through student input, and acting comprehensively at the university and student body level, for the purpose of aligning HEI with sustainable development parameters. The steps include identifying existing assessment sustainability tools, and subsuquent analysis to detect indicators that permit comparison between different universities. Concurrently, university sustainability reports and the information thay contain are analysed. The role of students in each of these stages and planning improvement actions are transversal to the proposed methodology

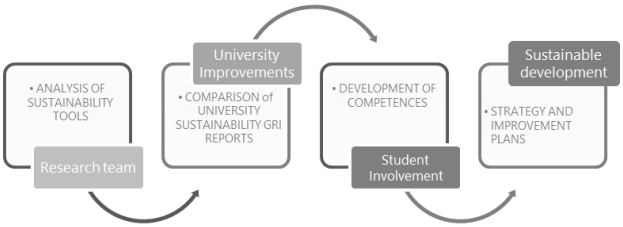


Figure 1. Project outline.

3 Sustainability Assessment Tools

Seven tools have been analyzed to assess the degree of sustainability in universities. The following section briefly describes each one:

- AISHE (Auditing Instrument for Sustainability in Higher Education), developed by Niko Roorda (Avans University, Holland) as part of his strategy to implement "System Integration of Sustainable Development" (SISD) in universities (Roorda et al., 2009), in order to monitor progress in sustainability in different areas by defining 20 evaluation criteria.

- SAQ (Sustainability Assessment Questionnaire), developed by the University Leaders for a Sustainable Future (ULSF) association, to analyze the current situation of the institution and future planning on sustainability issues by studying seven critical dimensions.

- USAT (Unit-based Sustainability Assessment Tool) developed in the doctoral thesis of Muchaiteyi Togo, supervised by Heila Lotz-Sisitka in Rhodes University, for its use in the "Swedish/Africa International Training Program (ITP) on Education for Sustainable Development in Higher Education" promoted and financed by UNEP, (United Nations Environment Program), to assess the presence of sustainable practices at the departmental level and get a more accurate assessment of the institution as a whole.

- STARS (Sustainability Tracking Assessment & Rating System) developed by the Association for the Advancement of Sustainability in Higher Education (AASHE), designed for publishing university reports and issuing the relevant certificates in a format comparable between universities.

- SUSTAIN TOOL (Program Sustainability Assessment Tool), developed by Washington University (St Louis) for use with different programs and in different fields, to assess the level of sustainability in different areas of an organization.

- GESU, developed by a working group on Environmental Quality , Sustainable Development and Risk Prevention of the Spanish University Rectors' Conference (CRUE).

- CGE – CPU, developed by the Sustainable Development committee of the French Conference of University Presidents (CPU) for evaluating universities and adapting them to the objectives of the "Grenelle Law".

As shown in the Table 1, the scope of these methodologies partially overlaps with certain aspects common to all.

Table 1.- Scope of sustainability analyzed through different tools.

AREA		AISHE	SAQ	USAT	STARS	Sustain Tool	GESU	CGE-CPU
SOCIAL	VISION & MISSION	X	X	X	X	X	X	X
	COMMUNICATION	X	X	X	X		X	X
	CONTRATING			X	X	X	X	
	WORK CONDITIONS				X	X	X	
	PUBLIC PARTICIPATION				X	X	X	X
	COMMITMNET TO THE COMMUNITY			X	X	X	X	X
	REVISION AND EVALUATION MECHANISMS	X			X		X	X
CURRICULAR	STUDY PLANS	X	X	X	X	X	X	X
	PEDAGOGICAL FOCUS	X		X			X	X
	RESAERCH & GRANTS	X	X	X	X	X	X	X
	WORK EXPERIENCE	X	X	X	X		X	X
	TRAINING OF ACADEMIC PERSONNEL	X	X	X	X		X	X
ENVIRONMENTAL	GREENHOUSE GAS EMISSIONS	X		X	X		X	X
	WASTE & RECYCLING	X	X	X	X	X	X	X
	WATER	X	X	X	X	X	X	X
	ENERGY	X	X	X	X	X	X	X
	TRANSPORT	X	X	X	X	X	X	X
	BIODIVERSITY	X	X	X	X	X	X	X
	SERVICES	X	X	X	X	X	X	X
	BUILDINGS	X	X	X	X		X	X
ECONOMIC	FINANCE & INVESTMENTS				X	X		
	PURCAHSES	X	X	X	X	X	X	X
	INDIRECT IMPACTS				X	X		

The identification and analysis of these tools has highlighted the lack of an unambiguous and specific definition for university sustainability and the existence of a multitude of applicable methodologies in higher education. The biggest differences worth noting include the approach to the data collection, the resulting accuracy of that data, and the support documentation requirements. This lack of consensus on assessment methodologies of sustainability in universities makes it difficult for any individual university to choose valid indicators

In the accompanying figure (Fig. 2) there is a classification of tools and methodologies based on the use of indicators, ranging from more general to more specific, and their level of application, from the academic programs to the university as an educational institution.

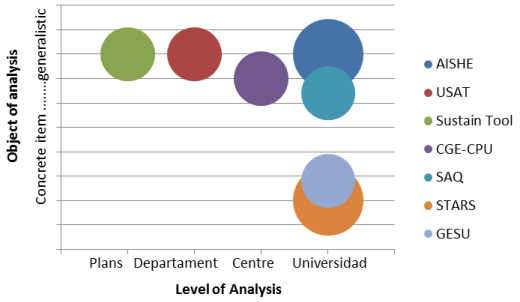


Figure 2. Characteristics of the object of analysis and application level of the indicators used by evaluation tools of sustainability in universities.. Source: author compiled.

The number of indicators in each of the assessment tools varies widely, being in some cases very large, as shown in Table 2.

Table 2.- Number of indicators considered in sustainability tools analyzed. Source: author compiled.

AISHE	SAQ	USAT	STARS	SustainTool	GESU	CGE - CPU
20	35	75	204	37	178	44

Therefore it has been necessary to select the indicators to be used to evaluate the different universities. This selection is based on the scope of each indicator, the possibility of using it in a comparative analysis, its ease of deployment and its ability to reach the curricular sustainability. In applying these assumptions, four of the tools are eliminated- SustainTool, SAQ, USAT and CGE – CPU, leaving three tools from which the indicators are drawn- AISHE, STARS, and GESU.

According to these three tools the Ideal University has to sustainably manage all aspects of their organization reach, from promoting concrete actions and policies to integrating concepts of sustainability in all areas of organization, and from specific programs to the general operation of the University.

The evaluation of the Universidad Europea through these tools has been done by organizing a group of experts from all sectors related to sustainability at the institution, as well as teachers and students. Results were obtained by carrying out profile-segmented surveys, which collect responses related to each professional profile or position held in the organization, supplemented by personal interviews with members of the expert group. The group of experts then studied these responses to ensure a consensus on the meanings behind each one.

The results show that the highest score obtained was in the section on environmental management and the lowest in policies. Positive results include the availability of staff for research and teaching, and the conceptualization of sustainability and its implementation in curriculum-related skills (critical thinking, problem solving, decision making, adapting to change, and cooperative work in interdisciplinary teams). By contrast, the main weaknesses of the Universidad Europea concerns the integration of sustainability issues in specific course programs (especially local issues), the demand from students of these courses, and the low weight given sustainable development in research, in that SD criteria are not considered when deciding research priorities nor when evaluating research outputs.

4 University sustainability reports

The most prevalent guidelines for producing sustainability reports, the Global reporting Initiative (GRI) was created with the aim of increasing the quality, rigor and utility of sustainability reports. Companies from all sectors apply it to evaluate the three pillars of sustainability, the so-called "triple bottom line" of economic, social and environmental aspects based on a continuous dialogue between the relevant stakeholders, which in a university setting must include the essential role of the student. Universities, as representatives of the link between society and business, transmitters of knowledge and trainers of people and future professionals, must lead the incorporation of sustainability in the organizational governance, planning and management, and its integration of all areas covered by the reporting process.

The comparative analysis was carried out between seven European universities with the aim of analyzing the response levels of each university and the establishment of an improvement plan. The analysis was made based on the last two reports published by the universities, allowing not only an assessment of their performance but also an evaluation of response levels over time.

The attached table shows the responsiveness of the 48 major social and environmental indicators of GRI reports divided into 5 categories. As can be seen the level of response is generally low.

The attached table shows the responsiveness of the 48 major social and environmental indicators of GRI reports divided into 5 categories. As can be seen the level of response is generally low.

Table 3.- Response Levels

Response level percentage to mandatory indicators						
University	**Total**	Labor practices	Human rights	Society	Product responsibility	Environmental
Carl von Ossietzky	**54,2**	70	44,4	37,5	25	70,6
Eth Zürich	**33,3**	40	0,0	25	25	58,8
Hogeschool University Brussels	**16,7**	20	0,0	0	25	35,3
University of Cádiz	**35,4**	70	11,1	25	25	35,3
University do Minho	**39,6**	40	44,4	50	25	41,2
University Politécnica de Madrid	**14,6**	10	0,0	12,5	25	29,4
Universidad Europea	**72,9**	100	77,8	75	50	58,8
Average	**38,10**	**50,00**	**25,40**	**32,14**	**28,57**	**47,06**

This table shows that most universities generally do not meet the requirements of GRI in terms of providing the information required, and generally there is much information not included in the reports. This is particularly relevant given that the GRI indicators analyzed were those which were obligatory under the GRI 3.1 version of the guidelines, which all the reports are based on. European University is the

When analyzing the results by categories of indicators (environment, society, human rights, etc.) it is clear that some categories had significantly higher response rates than others. Labor practices (50%) and environmental (47.06%) were significantly higher than the rest of the categories. These differences offer interesting interpretations of the way in which universities face and prioritize their responsibilities. The fact that the environmental category has a high (relative) response rate should not be surprising, as it is probably the area with more advanced legislation, besides being a subject of growing concern to the general public. Besides, action in this area often carries rapid and clear cost reductions. Additionally, most environmental indicators affect factors directly related to a university's operations and therefore directly controlled, whereas in other categories, many indicators relate to secondary factors or even issues outside the organization direct control. For example, in the category of human several indicators relate to how suppliers measure their own human rights performance, which while possible, is not always easy to know how and how far up the supply chain this question should reach.

Another reason for thee variation in response rate could be complexity; for example in the society category three of the six indicators refer to issues related to corruption which may be more difficult to manage than a

relatively simple water or energy reduction program. In general, it appears that progress in different aspects of responsible administration is uneven, and more advanced in some aspects than others

These results lead to the postulation of a number of proposals and enhancements for each of the reporting universities, as well as other universities planning to produce GRI reports in the future:

- Identify indicators where each university is at the forefront or where it already complies 100% (full compliance), and drivers who have contributed to this success, to incorporate the know-how in the next strategic plan.

- Initiate the collection of data for indicators in which the university has not yet submitted information.

- Prepare a communication plan on the progress already made for both internal and external stakeholders.

5 Project-Based Learning towards a more Sustainable University

This research project (sustainable universities) is been developed over four years with the aim to generating new sets of values in the students, taking into account their role as future decision makers. In this sense, talking about sustainability in a classroom is clearly positive, but the focus of this project has been on learning by doing, both through and around the student. How are students going to learn sustainability if the university is not sustainable? In this sense, and during these years, we have worked using a bottom-up approach (from professors and students) to analyze what we mean by sustainability, how it can be assessed, is what aspects the university must improve, and how to measure and benchmark all this. This article provides a rounded summary of the project, but more information can be reached in Bernaldo et al. (2016) and Fernandez et al. (2014). The steps were developed as extracurricular activities hand in hand with students associations of different engineering degrees. The next step has been the development of strategies to drive forward the sustainability of our university community, to make them part of our positive outputs, and to generate an overall greater contribution to sustainable development.

In this sense, two important lines of project-based learning of sustainability issues have been developed within the university:

- Extracurricular activities, through volunteer projects, or cooperation on development projects. This is an important part of our sustainability action plan, aimed at integrating students into real engineering projects with an added value for different societies. In the current year the Engineering School are operating the following projects:

  - Cerro Verde (Honduras), working in electricity power, supply and sanitation projects, accessibility, and school building.
  - Molo (Kenya), working in school buildings, basic education and practical training in social sciences and architecture.
  - Lodwar (Kenya), developing a radio station in Lokitaung.
  - GatLang (Nepal), working on technology infrastructure, training in new tools to improve internet access, seismic studies and development of a guide to handle with this issue is being proposed.

- Curricular activities, by working horizontal and vertical transversal projects into different courses, following the results of the assessment of our university regarding curricula sustainability. To improve sustainability curricula results in the future, we are working with our students in the classroom in the following activities:

  - Cooperation for development projects (related to similar extracurricular activities). E.g. in final degree projects, or in courses related with supply and sanitation, electricity, building, infrastructures, and structural analysis.
  - The development of a sustainability competence-based map in the engineering degrees, based on transversal sustainability competencies identified in a previous study: critical thinking, adaptation to change, decision-making regarding sustainability, problem solving, and multidisciplinary team work

(Fernandez et al., 2014). The process to integrate these skills into the curricula includes creating the Project-Based Engineering School as an action plan towards sustainability and learning progress. Two sustainability skills are developed in each project. In the first year, students develop a basic engineering project, and in the second year they carry out a field engineering project (e.g. in civil engineering degree, students develop throughout the year a road, incorporating planning, design, geotechnical calculations and structural analysis, which combines four different courses in the same year). In the third year, they develop a specialty project through different subjects, coordinated by a group of professors. And finally, in the fourth year, the final degree project tries to reflect all the five sustainability skills.

The outcome is a project-based learning synergized with the goal of creating a more sustainable university which contributes to global sustainable development. Additionally, our students are aware of where we are as a university, where we want to be, and they help us to drive forward this goal. We believe that working with students and professors is the way to create and implement sustainability while showing students that they can learn from the example of their own institution.

6 Conclusions

This article combines three different aspects of the nexus between universities and sustainable development. On the one hand, it provide a template for analyzing which aspects of the universities operations and reach are advancing in terms of sustainable development, through a synthesis of seven tools with different application foci and effectiveness, although developed for the same objective. Secondly, it analyses how universities tend to report these advances, through an analysis of small number of available GRI reports produced by universities around Europe. Thirdly, a number of activities are presented using learning-by-doing as a tool to enable students to develop their understanding of, and implication with, the emphasis on SD in general, but also SD in universities.

This research shows that it is possible to measure the contribution of universities to sustainable development based on sustainability assessment tools, to measure progress in CSR activities, and to propose new objectives towards a sustainable university.

All three are necessary and relevant for the promotion and achievement of a future where sustainable development is a key factor underlying human activity. Without the inclusion of education actors, particularly those where young professionals are formed, such a future is unlikely. While much more needs to be done, this paper has tried to highlight different aspects of the issue, and provide the groundwork upon which future projects can advance.

7 References

AASHE. 2014. Stars Technical Manual Version 2.0 Administrative update two, January 2014. Denver, USA.

Aguilera, A., Mendoza, M., Racionero, S., Soler, M., 2010. El papel de la universidad en comunidades de aprendizaje. Revista universitaria de formación del profesorado, 67.

Bernaldo, M.O., Fernández, G, 2013. Tomorrow´s sustainability: Devising a Framework for Sustainability Education of Future Engineers and Architects. International Congress of Sustainable Building SB13, Contribution of Sustainable Building to meet EU 20-20-20 Targets. Guimaraes, Portugal, 30 Oct- 1 Nov, 2013.

Bernaldo, M.O., Berzosa, A., and Fernández, G., 2016. Sustainability Qualitative Assessment Tools for Higher Education Institutions: Which is adequate for reporting sustainability efforts? International Journal of Sustainability in Higher Education. In press.

Calder, W., and Clugston, R.M, 2003. International efforts to promote higher education for sustainable developmente. Plann Higher Educ., 31 (3), 30-44.

Environmental Association for Universities and Colleges, 2013. Embedding sustainable development in the curriculum. Retrieved from: http://www.eauc.org.uk

EAUC, 2013. Embedding Sustainable Development in the Curriculum. The environmental Association for Universities and Collegues, http://www.eauc.org.uk/sorted/embeddin_sustainable:_development_in_the_curric

Fernández-Sánchez, G., Bernaldo, M.O., Castillejo, A., Manzanero, A.M. and Esteban, J., 2014. Proposal of a theoretical competence-based model in a civil engineering degree. Journal of Professional Issues in Engineering Education and Practice - ASCE, 141(2): C4014001.

Fernandez, G., Berzosa, A., Oliver, I., Romero-Requejo, J. and Bernaldo, M.O., 2014. Recomendaciones y líneas de optimización para la Universidad Europea de Madrid. Proyecto UEM 2013 01. Madrid, 2014.

Ferrer-Balas, D., Lozano, R., Huisingh, D., Buckland, H., Ysern, P., and Zilahy, G., 2010. Going beyond the rhetoric: System-wide changes in universities for sustainable societies. J. Cleaner Prod., 18(7), 607–610.

Hannover Research, 2011. Embedding sustainability into university curricula, Washington, DC.

Lee, K., Barker, M., and Mouasher, A., 2013. Is it even espoused? An exploratory study of commitment to sustainability as evidenced in vision, mission and graduate attribute statements in Australian universities. J. Cleaner Prod., 48(1), 20–28.

Jones, P., Selby, D., and Sterling, S., 2010. Sustainability education: Perspectives and practices across higher education, Earthscan, London.

Lozano, R., 2010. Diffusion of sustainable development in universities' curricula: An empirical example from Cardiff University. J. Cleaner Prod., 18(7), 637–644.

Lozano, R., 2012. Organizational learning and creativity as means to foster sustainability in universities. Higher education for sustainability: A global overview of commitment and progress.Higher education in the world 4. Higher education's commitment to sustainability: From understanding to action, Vol. 4, William Clowes Printing Company, Surrey, U.K.

Ortega,. M.L., 2014. Una guía para la colaboración entre ONGD y Universidad. Fundación Etea para el desarrollo y la colaboración. Edita: Universidad Loyola Andalucía. Campus Etea.

Roorda, N., C. Rammel, S. Waara, U. Fra Paleo., 2009. AISHE 2.0 Manual: Assesment Instrument for Sustainability in Higher Education, Edition 2.0. Second draft, retrieved from https://www.box.net/s/0dglhugzyyzta4kkfb83.

Segalás, J., Ferrer-Balas, D., Svansgtrom, M., Lundqvist, U. and Mulder, K.F., 2009. What has to be learnt for sustainability? A comparison of bachelor engineering education competences at three European universisties. Sustainable Sci., 4 (1), 17-27.

Terrón, M.J.,, Bernaldo,O., Fernández, G., 2015. Complementing the engineering degrees with a volunteer program abroad: a different PBL experience. International Symposium on Project Approaches in Engineering Education PAEE, 6-9th July, 2015. Mondragon, Spain.

Togo, M. & Lotz-Sisitka, H., 2009. Unit Based Sustainability Assessment Tool. A resource book to complement the UNEP Mainstreaming Enviroment and Sustainability in African Universities Partnership. Howick, Share – Net

ULFS, 2009. Sustainability Assessment Questionnaire (SAQ) for Colleges and Universities. Association of University Leaders for a Sustainable Future. Wayland USA.

UNESCO, 2009. Education for Sustainable Development and Climate Change.Policy Dialogue 4, París. http://unesdoc.unesco.org/images/0017/001791/179122e.pdf

Wade, R., 2008. Education for sustainable development. Policy and Practice 6:30-49.

Wright, T.S. A., and Wilton. H, 2012.Facilities management directors, conceptualizations of sustainability in higher education.J. Cleaner Prod., 31 (1), 118-125.

Washington University. 2013 .The Program Sustainability Assessment Tool v2. St Louis, MO. Retrieved from http://www.sustaintool.org.

Managing students with different backgrounds within the same Master program

Duarte M. Sousa[1], Marta R. Abrantes[2], Edgar C. Fernandes[3], J. A. C. Falcão de Campos[3], Jorge S. Matos[4], M. Fátima Montemor[5]

[1] Department of Electrical and Computer Engineering, Instituto Superior Técnico, Universidade de Lisboa, Lisboa, Portugal
[2] Instituto Superior Técnico, University of Lisbon, Lisboa, Portugal
[3] Department of Mechanical Engineering, Instituto Superior Técnico, University of Lisbon, Lisboa, Portugal
[4] Department of Civil Engineering, Architecture and Georesources, Instituto Superior Técnico, University of Lisbon, Lisboa, Portugal
[5] Department of Chemical Engineering, Instituto Superior Técnico, University of Lisbon, Lisboa, Portugal

Email: duarte.sousa@tecnico.ulisboa.pt, marta.abrantes@tecnico.ulisboa.pt, edgar.fernandes@tecnico.ulisboa.pt, falcao.campos@tecnico.ulisboa.pt, jorge.matos@tecnico.ulisboa.pt, mfmontemor@tecnico.ulisboa.pt

Abstract

Instituto Superior Técnico (IST) - Universidade de Lisboa offers Master programs that enrol students from all over the world, with different backgrounds and distinct expectations. In particular, over 80% of the students enrolled in the Master program in Energy Engineering and Management (MEEM) are international students in a double degree mobility program under the KIC InnoEnergy Master Programs (CFAFE, ENTECH, RENE and SELECT). These students come from different continents, having not only different technical backgrounds (typically they own Bachelor degrees in Chemical, Civil, Mechanical, Electrical and Energy Engineering) but also distinct cultural frameworks. The students under the KIC InnoEnergy Master Programs stay at IST during 2 consecutive semesters and are integrated in MEEM that offers 5 specializations and runs in four semesters. All the students are mobility students, starting at IST for the first 2 semesters or arriving at IST for the last 2 semesters. The different backgrounds and students' expectations require to offer tailored curricula to each student. Moreover, because the students are in a double diploma mobility scheme, the set of courses offered at IST during the two semesters must match with the two semesters in the partner University. These requisites require individual and tailored approaches that are only possible by managing strategies that actively promote the interaction between the students and the academic staff. Under this framework, there are crucial steps in the integration of these non-harmonized students in the same Master program, as, for instance, to identify the specialization profile for each student, and accordingly design the corresponding individual curriculum. Consequently, the local set of courses needs to be well-adapted overviewing the four semesters at two different universities. Furthermore, the curricula of the KIC master programs should present a global consistency that supports its differentiation taking advantage of pedagogical approaches and a pro-active development of courses.

Keywords: Tailored curricula; Mobility students; Management; Internationalization; Master programs.

1 Introduction

The level of internationalization of Master programs in several countries covering a huge range of topics and specializations has increased significantly over the past few years. The "internationalization" in student mobility programs can be analyzed from different perspectives, such as the sharing of courses between institutions of different countries or the number of students exchanged. In Portugal, in particular at Instituto Superior Técnico (IST), the internationalization of the Master courses has evolved progressively contributing to the development and implementation of new pedagogical and management approaches in the offered engineering programs. Among other possible examples, the Master program in Energy Engineering and Management (MEEM) can be seen as a case study since over 80% of the students enrolled in the MEEM are international students in mobility under the KIC InnoEnergy double degree Master Programs [www.kic-innoenergy.com].

The Master in Energy Engineering and Management provides cross training in this area of expertise, ensuring a sound scientific basis for the competences required for professional qualification in the energy field. The model and the structure adopted for the MEEM is based on the following principles:

- The Master of Engineering and Energy Management gives professional skills founded on a sound scientific basis.

- The areas of expertise are relevant areas of professional intervention.
- All areas of specialization are multidisciplinary and provide soft skills to traditional engineering specialties.
- The scope of the areas of specialization, as a whole, reflects the broad spectrum of competences existing in IST.

The students that enrol in the MEEM can join five specializations in the energy field (Fig. 1).

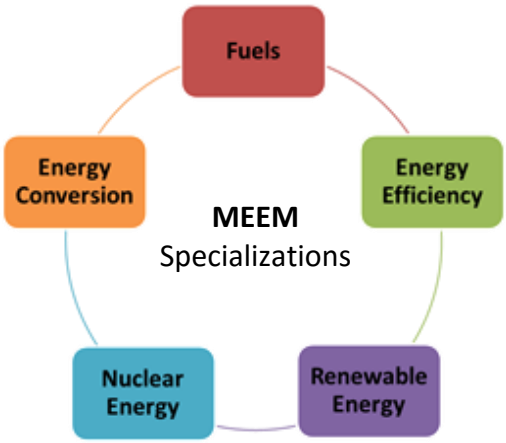


Figure 1. Specializations of the MEEM.

The specializations and the courses offered within the MEEM is, in addition to the technical subjects, providing interdisciplinary in Economy and Innovation and emphasizing skills related with entrepreneurship and leadership.

A key point related with the MEEM is its connection with the KIC InnoEnergy Master School, which offers seven Master programs combining technical skills in energy engineering and entrepreneurship. These Master programs allow combining the experience and expertise of studying in 11 top Engineering schools in Europe. IST, throughout the MEEM participates in the following Masters (Fig. 2):

- CFAFE - MSc Clean Fossil and Alternative Fuels Energy
- ENTECH - MSc Energy Technologies
- RENE - MSc Renewable Energy
- SELECT - MSc Environomical Pathways for Sustainable Energy Systems

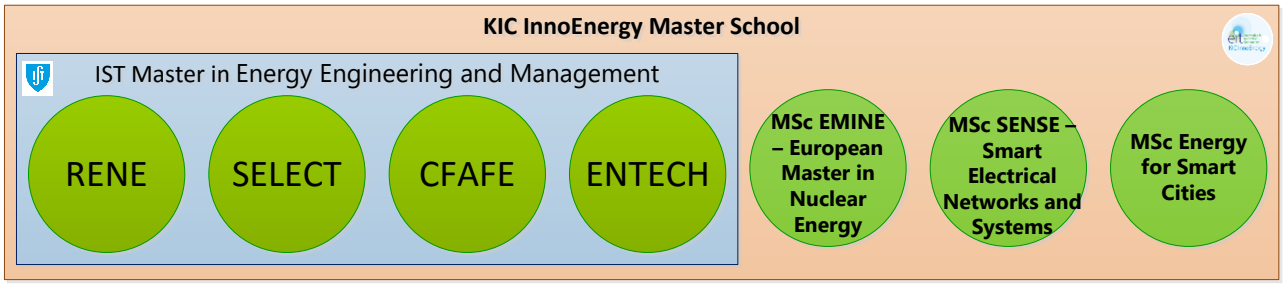


Figure 2. KIC InnoEnergy Master programs

The students admitted in the KIC InnoEnergy Masters come from all over the world, having different backgrounds and expectations. Being mobility programs organized to run during 2 years (4 semesters), the students can enrol in the MEEM as first or second year students. Under this context, these Masters require planning and management, posing short and mid-term challenges for the teaching and administrative staffs of the institutions involved.

2 MEEM overview (2010-2015)

The MEEM receives students under mobility programs since 2010. The number of students has been continuously increasing, as can be seen in figure 3.

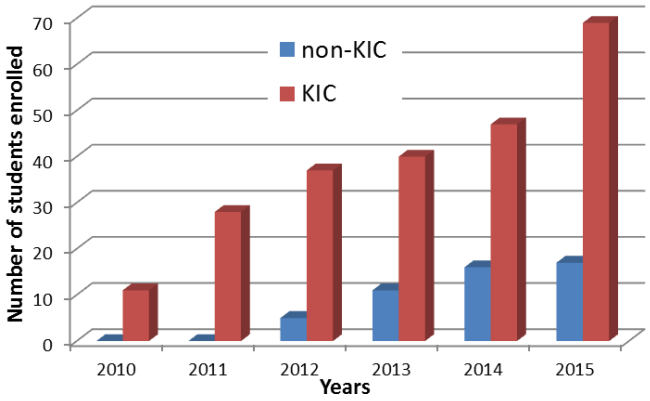


Figure 3. Number of students enrolled in the MEEM in the years 2010-2015.

Considering the overall period from the year 2010 to the year 2015, the MEEM has been mainly supported by KIC students interested in the energy field (Fig. 4).

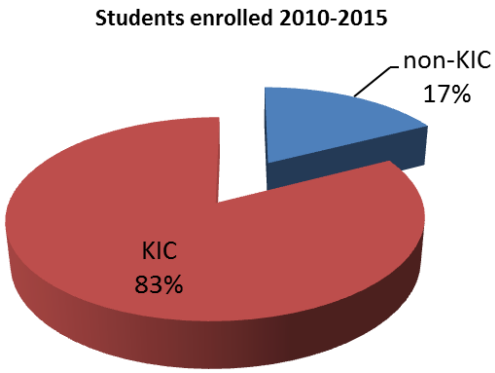


Figure 4. KIC vs. National students enrolled in the MEEM (2010-2015).

Analysing the origins per continent of the KIC InnoEnergy students enrolled in the CFAFE, ENTECH, RENE and SELECT Master courses in the academic years 2014-2015 and 2015-2014, there is a considerable dispersion, as it may be seen in Fig. 5 and Fig. 6.

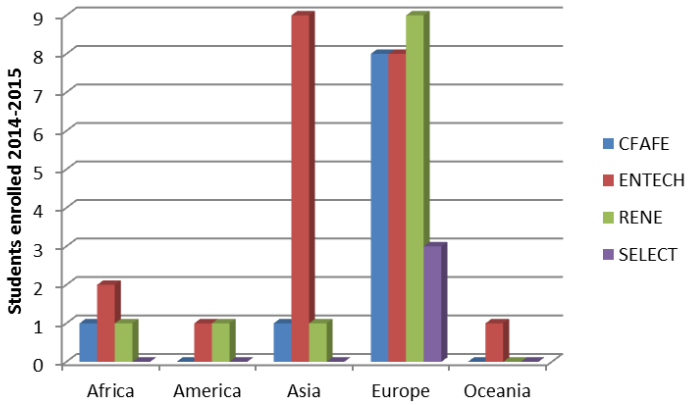


Figure 5. Origins of the KIC InnoEnergy students at IST per continent- academic year of 2014-2015

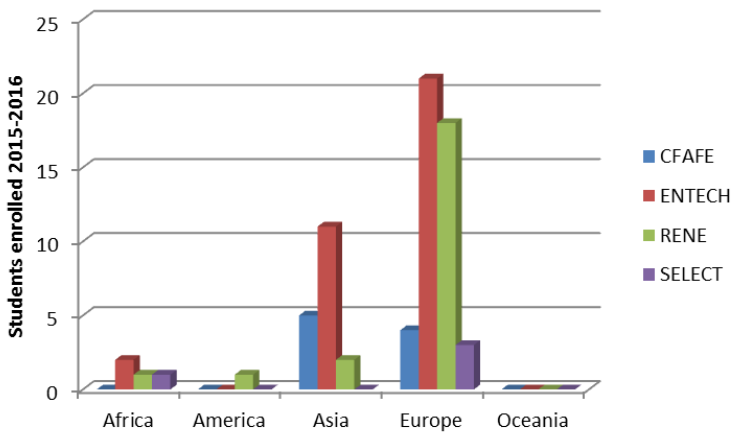


Figure 6. Origins of the KIC InnoEnergy students at IST per continent- academic year of 2015-2016.

Globally, about 2/3 of the KIC students come from European countries, and 1/4 from the Asia region, as can been seen in Fig, 7 and Fig. 8, for the academic years 2014-2015 and 2015-2016, respectively.

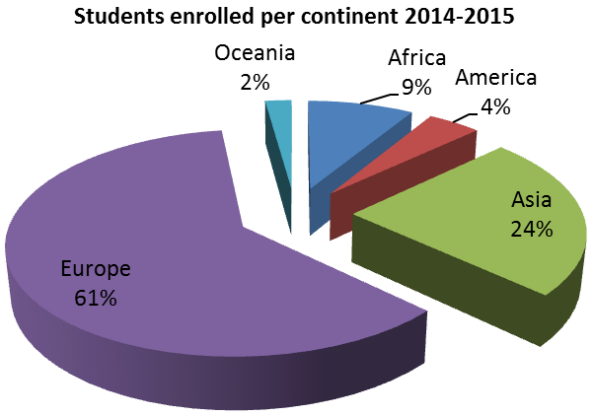


Figure 7. Global distribution of the KIC InnoEnergy students at IST per continent- academic year of 2014-2015.

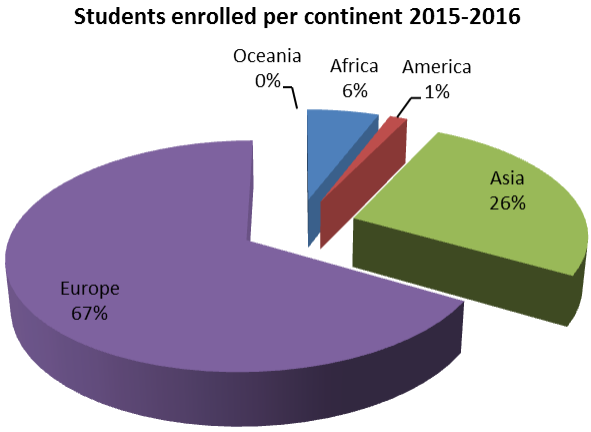


Figure 8. Global distribution of the KIC InnoEnergy students at IST per continent- academic year of 2015-2016.

Considering the figures for the period 2010-2015, there is a similar profile for the students joining the MEEM with respect to the continental origins. However, the previous figures have to be complemented with other type of information, for instance, the data on the backgrounds of the students, i.e., the BSc. degrees owned and where were awarded. As a simple and illustrative example, Fig. 9 lists the courses and number of origins for the students of the SELECT master that have been at IST from 2010 until the present. The 16 SELECT students were from 8 different BSc courses, which were obtained in 14 different institutions.

Having the SELECT panorama as reference, which can be easily extended to the other KIC InnoEnergy Master programs, the integration of this type of students in a common master program is a challenge but, at the same time, an opportunity to develop innovative pedagogical and administrative approaches.

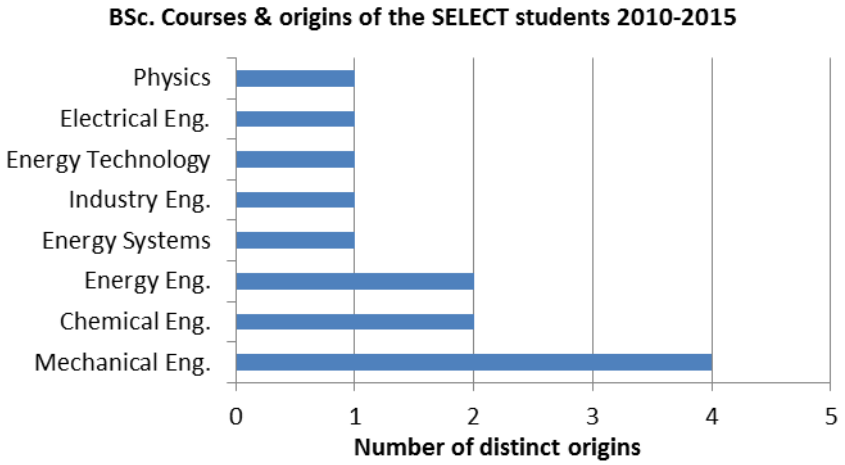


Figure 9. BSc degrees and origins for the SELECT students enrolled in the MEEM at IST from 2010 to 2015.

3 Management challenges and structure

The management of international students by high education institutions is not a recent issue, but has become more relevant since it involves the collaboration and the exchange of students between different institutions at the same time. The KIC InnoEnergy programs operate under these conditions, taking advantage of the expertise owned by a large group of institutions and promoting the students mobility. At IST, the staff involved in the MEEM has been implementing procedures in order to fulfil the students expectations and to develop and provide improved educational programs.

The running and management of these programs can be planned in different phases starting with the selection of the students and ending when the diploma is delivered. For each generation of students, the overall process is implemented considering an average duration of 36 months.

Considering only the pedagogical point of view, it is planned a face to face involvement with the students during 24 months. From the experience collected at IST since 2010, the core challenges that have been faced are:

- joining international and national students;
- joining students with different backgrounds;
- preparation of the teaching staff to lead with students with distinct backgrounds and cultural origins;
- updating and adapting of the courses contents according to the nature of the students and in order to fulfil their expectations;
- Adequacy of the curricula.

In addition to the challenges above, the major and ultimate challenge has been the preparation of individual study plans, considering both the students background and expectations.

The complexity of this challenge is amplified giving that the KIC InnoEnergy students only stay at IST during 2 semesters, i.e., can join the MEEM in the 1st year or in the 2nd year of the KIC InnoEnergy mobility program. In addition, the matching of the study plans during the 4 semesters of the master course should be assured and verified in advance.

From this pedagogical and educational experience, one fact stands out: since 2010, 232 study plans were set individually for KIC Energy students composed from a portfolio of about 100 courses. To the non-KIC students (49 up to date) the approach was similar. This approach deserved and will deserve attention contributing to

the (always) open discussion about the mission of the high education institutions and the role of their pedagogical, scientific and administrative staffs.

The management of this type of master courses is a process that ends after delivering the dual degree diplomas. Considering only the pedagogical point of view, the flowchart of the study plans development is summarized in Fig. 10.

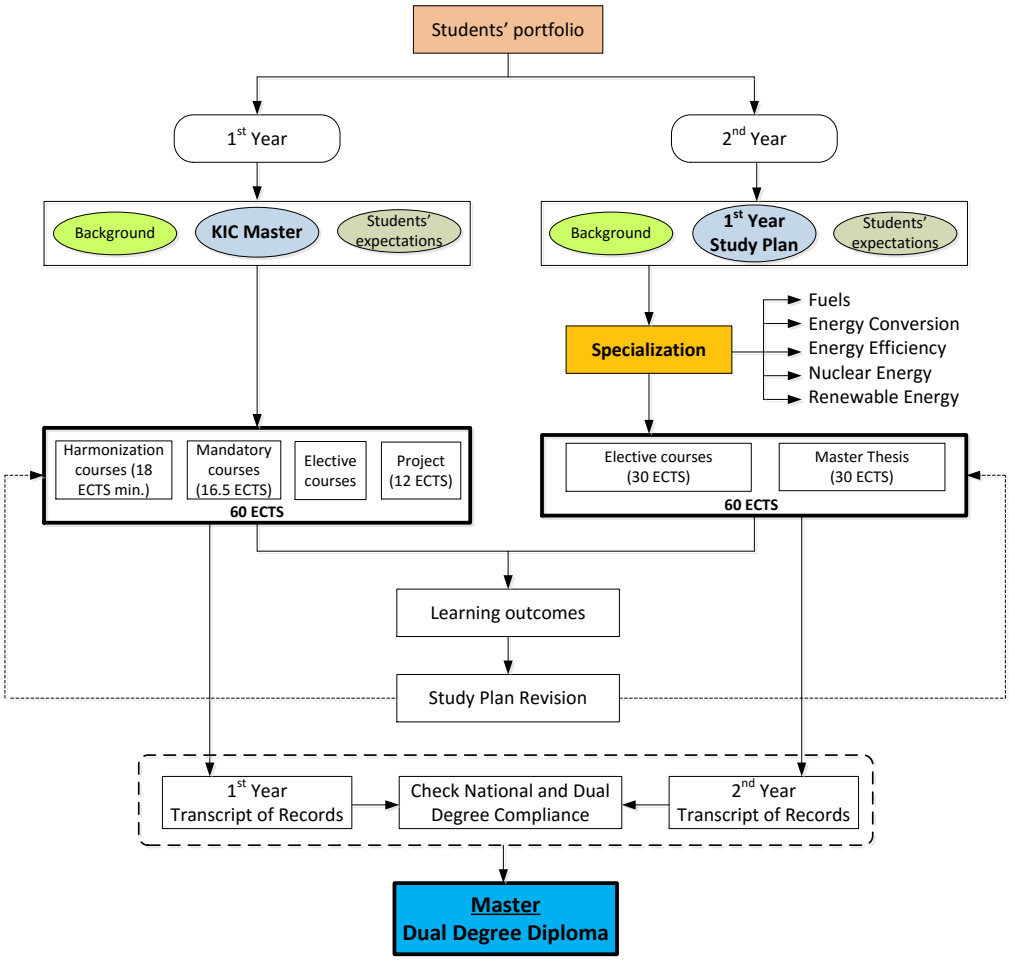


Figure 10. Flowchart of the study plans development.

It should be pointed out that these procedures require a close and permanent collaboration with the partner institutions involved, raising the level of involvement and confidence between them. In order to meet the identified challenges at IST, the pedagogical/scientific committee of the MEEM originates from different departments that support the MEEM, at the same time is bridging the relationships between the KIC InnoEnergy Master School and the other institutions involved at the educational level. It should also be mentioned that the pedagogical staff of the MEEM has been tutoring individually the students in mobility during their stay at IST.

4 Conclusion

The management of an international master course should be seen as an ongoing challenge not only from a pedagogical but also from an administrative viewpoint, constituting a long term project from the selection phase until the graduation moment. For the example described, a master's degree involving students in mobility between multiple institutions, the level of demand increases requiring coordination that goes beyond the individual practices of the various institutions.

The internationalization of the high level educational institutions is fostering distinct and innovative practices concerning the pedagogical approaches, courses contents, teaching methodologies and organizational

challenges. In the present case, the emphasis is placed in the definition of individual tailored study plans. It is expected that the number of students joining this type of educational programs will increase in the coming years. This type of management and procedures requires resources and is time consuming. The coming years will require a deepening of the collaboration between the institutions involved in the KIC InnoEnergy Master programs. New educational and management challenges will arise contributing to the mission of the high education institutions.

5 References

www.kic-innoenergy.com

https://fenix.tecnico.ulisboa.pt/cursos/mege

Student handbook – Mestrado em Engenharia e Gestão da Energia 2015/2016, Instituto Superior Técnico,2015 [Available: https://fenix.tecnico.ulisboa.pt/cursos/mege/manual-do-aluno]

M. Daniels, L. Barker, A. Cajander, G. Laxer, D. Moore. (2005). Work in progress - managing cross-cultural differences in an open ended group project course. *IEEE 35th Annual Conference Proceedings Frontiers in Education*, T4D – 22.

Yung-Pin Cheng, Janet Mei-Chuen Lin. (2010).A Constrained and Guided Approach for Managing Software Engineering Course Projects. *IEEE Transactions on Education*, 53(3), 430 – 436.

José Luis Martín Núñez, Edmundo Tovar Caro, Jesús Sánchez López, Pilar Martínez García. (2014). Education quality enhancement through open education adaptation. *2014 IEEE Frontiers in Education Conference (FIE) Proceedings*, 1-4.

C. M. Wigal. (2005). Managing and aligning assessment knowledge. *IEEE 35th Annual Conference Proceedings Frontiers in Education*, T3C – 13.

B. Klingenberg, E. Lauria. (2007). Teaching the Global Dimensions of Technology Management: A Framework for Course Development. *PICMET '07 - 2007 Portland International Conference on Management of Engineering & Technology*, 1484 - 1490.

J. Puustjärvi, L. Puustjärvi. (2014). Education management in healthcare communities. *2014 IEEE International Conference on Industrial Engineering and Engineering Management*, 350 - 354.

Enrico Zio. (2015). A multi-disciplinary, multi-cultural educational experience: The PhD school on vulnerability, risk and resilience of complex systems and critical infrastructures. *2015 IEEE First International Conference on Reliability Systems Engineering (ICRSE)*, 1-3.

A. L. Monheim. (2007). An Engineering Manager's quick-start guide to managing personalities. *2007 IEEE International Engineering Management Conference*, 300 - 303.

Peter Nilsson, Pietro Andreani, Krzysztof Kuchcinski, Joachim Rodrigues, Henrik Sjöland; Markus Törmänen, Lars-Erik Wernersson, Viktor Öwall. (2014). Lessons from ten years of the international master's program in System-on-Chip. *IEEE 10th European Workshop on Microelectronics Education (EWME)*, 187 - 192.

Maartje Van den Bogaard, Erik de Graaff, Hannelore Dekeyser. (2009). Making connections: A blended learning approach to the Delft UT international master students introduction program. *2009 39th IEEE Frontiers in Education Conference*, 1 - 6.

Laurent Montes, Panagiota Morfouli. (2007). International Master Degere in Micro and NanoTechnology for Integrated Systems. *2007 IEEE International Conference on Microelectronic Systems Education (MSE'07)*, 155 - 156.

Juho Heiskari, Mika Helenius. (2010). Experiences from the Launch of a New International Master's Program in Service Design and Engineering. *2010 IEEE International Conference on Service Sciences*, 28 - 33.

Daria V. Starodubtseva, Oxana M. Zamyatina, Oxana M. Zamyatina, Yulia O. Goncharuk, Oxana M. Zamyatina. (2015). Curriculum design and development of master's educational programs in IT area (through the example of international development of master programs "Applied computing" and "Product life cycle technological process efficiency" of TEMPUS SUCCESS and ACES projects). *2015 IEEE International Conference on Interactive Collaborative Learning (ICL)*, 393 - 396.

Efraín O'Neill-Carrillo, Cristina Pomales-García, Agustín Irizarry-Rivera, Emilio Contreras. (2015). A novel, international masters program to address the sustainable energy challenge. *2015 IEEE Frontiers in Education Conference (FIE)*, 1 - 6.

Use of Large-Sized Handout (LSH): A Template for Group Learning and Active Learning

Hideaki Aburatani[1], Kyohei Kuroda[1], Misuzu Okada[1], Shigeyoshi Nakamura[1], Shinya Maki[2], Takashi Yamaguchi[2], Makoto Ichitubo[3]

[1] Department of Creative Engineering, National Institute of Technology, Kitakyushu College, Japan
[2] Department of Science of Technology Innovation, Nagaoka University of Technology, Japan
[3] Department of General Education, Nagaoka University of Technology, Japan

Email: abura@kct.ac.jp, kkuroda@kct.ac.jp, okada@kct.ac.jp, snakamura@kct.ac.jp

Abstract

In active learning, it is important that students are engaged and interacting with learning contents in various ways that can promote their activities for learning. Thus, handout materials, such as templates and graphic organizers, are very important which guides students toward the learning process and goals. In addition, the use of Information and Communication Technology (ICT) enables the students to share ideas and information with other students and teachers through the Internet. The instructional scaffolding provided via the Internet (e.g. Learning Management System: LMS) is very useful, however, there is no doubt that the writing process in the classroom is still very effective and important. In this study, 'large-sized' paper handouts printed using large format printers are proposed: Large-Sized Handout (LSH). The LSH, typically larger than A3 size, is an integrated copies of usual size ones with some templates and/or additional instructional information. For example, a problem set is given with related movie file URL, a problem solving template, and/or other assessment templates. The LSH is shared by small groups with 4 to 6 students for enhancing the collaborative group learning. The students try to solve the problem collaboratively using materials provided in the LSH. Therefore, the LSH can be easily introduced into the traditional lecture-based classroom. Different from use of several handouts or a big blank paper, the LSH enables the students to share, grasp and gaze the object and their learning process at all times during class. From the results of class survey, it is shown that the LSH is an easy-to-use template for promoting students to collaborate in the group and to implement the active learning. It is suggested that the LSH can provide an effective learning scaffolding in group learning and active learning.

Keywords: Handout; Large format printer; QR code; Collaborative learning; Scaffolding.

1 Introduction

There is no doubt that we are facing with the rapidly changing world that is filled with volatility, uncertainty, complexity and ambiguity (i.e. VUCA world). In order to improve the preparation of our students to meet high demands in rapidly changing world, we have to change our educational approach (Grassberger & Wilder, 2015). The 21st century skills, a set of essential abilities, are what our students need for their future. One of the most effective pedagogical approaches to foster the 21st century skill is "active learning." In active learning, different from traditional lecture-based learning, the students are engaged and interacting with learning contents in various ways. On the other hand, the rapid developments of computer technology and Information and Communication Technology (ICT) have changed teaching and learning in the classroom (Zhang & Quintana, 2012). Since the active learning can be encouraged using ICT, use of tablet-PC, Powerpoint slides, accessing contents on the Internet, and Learning Management System (LMS) are very popular in today's classroom. In spite of that ICT tends to be recognized as a key part of active learning, use of paper handout materials (e.g. problem set worksheet, KWL templates, graphic organizers, etc.) that guide students toward the learning goals provide very important and effective scaffolding, because the writing process is very effective approach (Hayes, 2006, Chapter2). If we consider the paper handout materials from the viewpoint of complementary and synergy use of ICT, there is a promising possibility for combining the paper handout materials and ICT to enhance learning process.

The purpose of this study is to develop effective paper handout materials that promote active learning with being supported by ICT as well as collaborative learning strategies (Warwick, Mercer, & Kershner 2013), (Choo, Rotgans, Yew & Schmidt, 2011). There are three key features of handout materials: printing quality,

design and size, in addition to the learning content. As printer and photocopier technologies have evolved, there is a less need for further improvement in printing quality of the handout. Therefore, the design and size of handout are of concern for this study. Regarding the size of handout, since large format printers have become popular in schools, it is relatively easy to prepare handouts larger than A3 size. Although large sheets of blank paper are popular to be used for such as brainstorming, group works or presentation in active learning, large-sized printed handouts have not been commonly used in the classroom. The handout that we suggest and discuss in this study is Large-Sized Handouts (hereafter referred to as LSH) that are designed for the group learning. The LSH is discussed from the viewpoints of implementation of collaborative learning, uses of ICTs, and the amount of learning content.

2 Idea of Large-Sized Handout

2.1 The concept of Large-Sized Handout

Handouts are paper-based resources used to support teaching and learning. Therefore, the use of handouts is effective in active learning (Bellanca, 1999). Figure 1 shows components and the concept of LSH. The LSH is not a simple large-sized handout, but can be defined as an integration of usual handouts with some templates, information and instructions which guide the student. As the proposed LSH is for the group learning, it is designed to be shared by small groups with 4 to 6 students. The students try to solve the problem with other group members using instructional materials provided in the LSH. These components are free to be arranged depending on lecture plan and students' experience. As it is a large size paper, there is enough space on the paper used to write notes in freely, ensuring individual approach with writing down their solutions or ideas as record of their learning process.

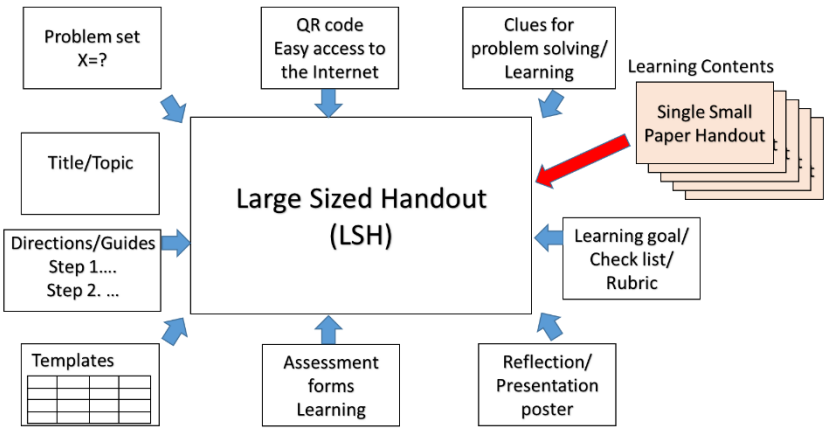
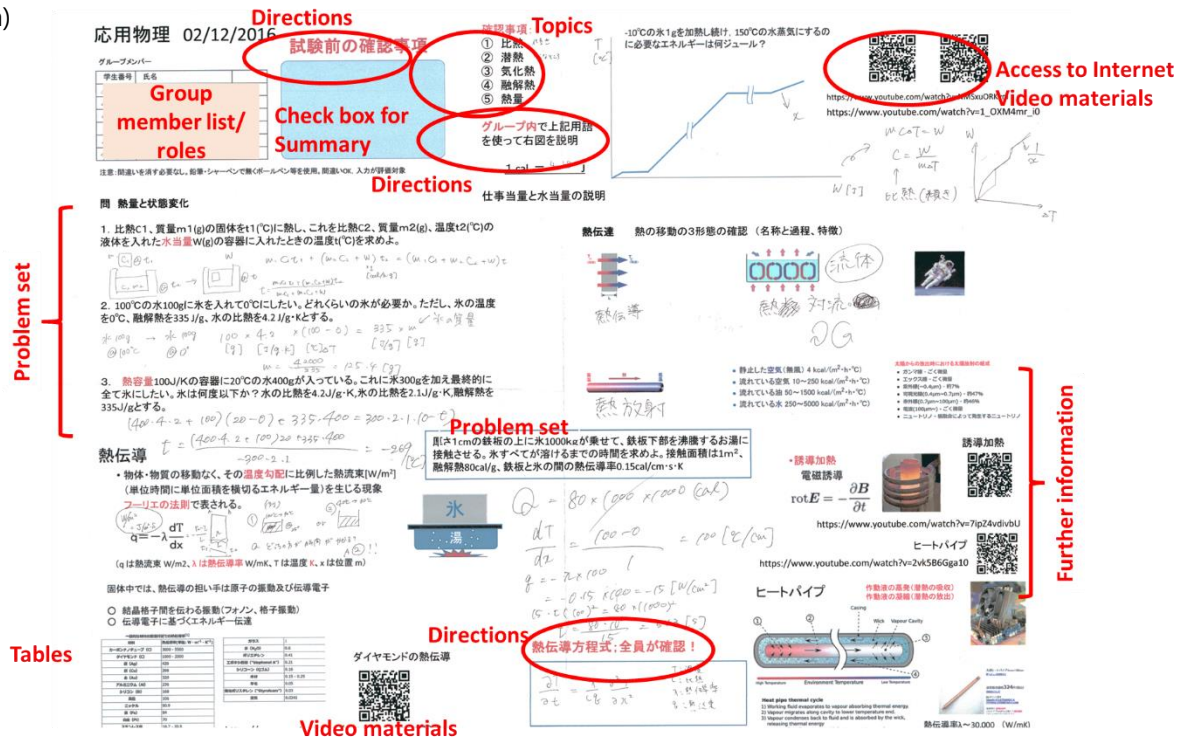


Figure 1 The concept of Large-Sized Handout (LSH).

Figure 2 (a) shows an example of A1-sized LSH used in a physics class and a picture of students working on the LSH (Fig. 2(b). In this case, topic was basic thermal properties of matter. The example LSH consists of nine Powerpoint slides combined in sequence. In the class, these Powerpoint slides were also used for giving a lecture as well as instruction at each stage. The LSH contains title (& topic), a student name field, learning contents, problem sets, figures, tables, Quick Response (QR) code for accessing website, instructional directions, guides and learning goal. Since the duration of class is 90 minutes, roughly a time of 10 minutes is allotted for each slide. In the case of use of separated handout papers, they may need to tidy up visually and logically connected their works (handout papers), when the students finish their task and move to next stage, resulting in a discontinuity of activities. In contrast, the LSH can maintain the trace of their activities and the students can use it for the next stage of their learning easily. Teachers also can monitor the progress of students' learning and control the pacing of classroom activities by checking their LSHs.

(a)



(b)

Figure 2 An example of use of LSH:

(a) A1-sized LSH for Applied physics class (4th year class)

(b) A picture of students working on the LSH

2.2 Promoting learning Process

Although the learning contents provided in the LSH are the same ones used in a usual class, the all contents are shown in LSH at the beginning of class. Thus, the students can grasp what they will learn at the beginning of the class as an introduction process. In addition, the students can always check their progress, and gather the information form the materials in the LSH and look for further information. Different from use of several separate handouts, one big paper handout enable the students to share the learning objects and their process with other group members at all times during class. In this case, a copy of PPT slides is provided for individual note-taking. Although we did not use a Learning Management System (LMS) for LSH , scanned copies of LSH with students' works shared through the web are supposed to be effective to promote their group learning. When students are not familiar with active learning, it seems that the scaffolding and guides provided in the LSH could help them reach the learning goal. It is also suggested that the components of LSH should be arranged and customized depending on the students' experience.

2.3 Quick access to the Internet

In the classroom, a quick access to the Internet without interrupting students' activity is important. A QR code, a 2-D barcode which can be read by an ICT device, is one of the solutions for that requirement. Many interesting and effective ways of use of QR code in the classroom have been suggested (Rivers, 2009) (Jones, 2011). There are many free QR code generators available on the Internet as well as Microsoft Word and Excel. The large size of LSH that provides enough space to work on is compatible with the use of QR code which requires a certain particular size in the handout. In the example, the QR code is used to connect to websites to show related movies. The students used their smartphone or tablet PC to watch the video in the group and checked those repeatedly as needed. There is no doubt that movies and computer-generated animations help students gain a better understanding of physical phenomena. It seems that the movies on smartphone beside the problem or guiding templates help the student understand how to solve the problem and to understand. The QR code is also used to show text information in an unreadable form unless an ICT device is used. Even in the group, each student has their own learning speed and favorable process. In contrast of giving the answers all at once, the students can manage their learning progress using clues and answers given in the form of QR code. Figures 3 (A) and (B) show examples of the answers and clues as QR codes. For a multiple-choice type question, QR codes are designed to look different from each other. Thus, student cannot make a guess at the answer.

(A) X^2+3X+2=0, What are X → Clue X^2+3X+2 =(x+1)(x+2)=0, Thus X=-1, -2

(B) Multiple choice: If X^2+3X+2=0, what are X?

a) X= Try it again b) Incorrect C) X= Correct!

Figure 3 Use of the QR code: (A) clue and answer, and (B) 3 choices for a multiple choice question.

2.4 Reflection and Presentation

In the active learning, reflection is a very important and essential for successful learning processes. At the beginning of the class, the LSH is a just teacher prepared handout, but it will become products of students' learning works at the end of class. Figure 4 shows temporal variation of the use of LSH. The LSH is used as a poster for presentation as well as a reflection material. The students reflect on what they learned with the group members.

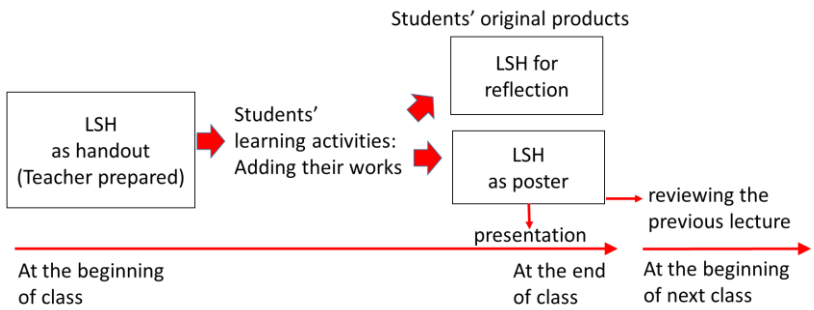


Figure 4 Temporal variation of the LSH in learning

The students can also give a presentation to summarize what they learned using their LSH to the class. The LSH is also suited to recapitulate the previous lecture at the beginning of next class. The LSH is an all over learning platform that expands its functional role across classes.

2.5 LSH for PBL and Language Learning

The LSH seems to be suitable for the Problem Based Learning (PBL) (Grady, Yew, Goh, & Schmidt, 2012). A trigger problem with problem solving templates and supportive information in the LSH will help the student understand and solve the problem, especially when the students are not familiar with PBL. The LSH with contents in a foreign language can be used for language learning. In the example (Fig 2(a)), the movies in English are provided as English study. Figure 5 shows a LSH used in for a PBL in English class. This LSH is originally designed for international student exchange activity. Since the LSH is a big paper, there is enough space to write down contents in two different languages. The LSH in a bilingual form is supposed to be used for international student exchange activities such as a collaborative PBL trial.

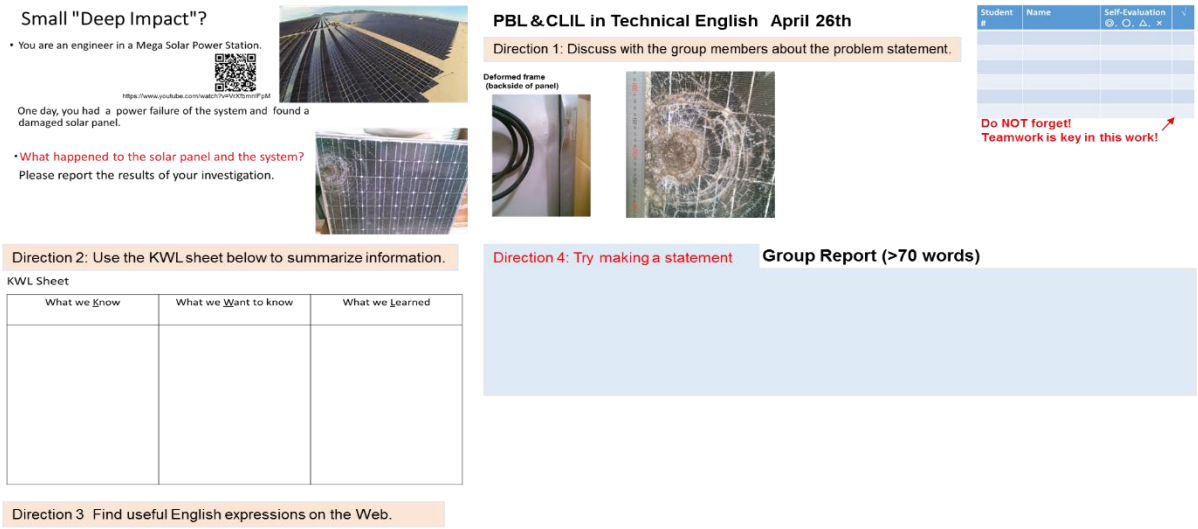


Figure 5 An example of LSH for PBL and language study.

3 Results and Discussion

3.1 Class survey result I

A primitive class survey was conducted for physics classes of 3rd and 4th year from viewpoints of the effectiveness of LSH for group learning and which components of LSH they are interested in. (The college of National Institute of Technology in Japan is a 5-year school for the student aged 16 or elder and provides associated bachelor degrees.) The survey questions and results are shown in Table 1 (a) and (b). It is shown that the 3rd year students gave higher positive responses than those of the 4th year students for all questions except Q6 and Q7. As they were not familiar with group learning, this result is supposed to be due to the class tendency. Since the Q6 inquires their interest for movies in English and Q7 is for use of QR code, these activities are supposed to be too early for the 3rd year students. In the breakdown of results (Table 2), it is shown that the students with middle-grade gave relatively higher positive response than those from the rest of students for both classes. The students with higher-grade seem to be less interested in the group learning, because the group learning tends to give less learning contents. It also seems that the students with lower-grade have a tendency to hesitate to join the discussion. Their comments endorse these assumptions. Totally, 30 percent of students mentioned their concern about the group learning: less learning content or insufficient preparation for the examination due to group learning (17%) and unevenness of work/activity in the group (13%). These results indicate that the facilitation and feedback during and after the class were not sufficient enough to encourage them to manage their learning and to consolidate their learning outcomes. Although there is a non-negligible number of students expressing their concern about less learning contents, the class observation reveals that they were well involved in group learning when they shared time watching movies and discussing. It seems that the LSH worked as a learning platform for the student to guide them to collaborative active learning.

Table 1. (a) Survey Form (translated one)

Response : Disagree 1 ← 2 ← Neutral 3 → 4 → Agree 5
1. Comparing with use of several separate handouts with teacher's direction, does the LSH make your collaborative study easier?
2. Were you an active learner when you studied using the LSH?
3. Choose <u>two good features</u> of the LSH from the followings : 1. QR code, 2. Movies, 3. color figs & pictures, 4 printed directions and note, 5. large size, easy to read, 6. Others
4. Comparing with usual style, does the LSH help you grasp the learning contents and their relationship?
5. Were the movies useful to understand the phenomena you learned?
6. Was watching movies in English interesting?
7. Was the QR code useful?
8. Was the group learning more memorable than listening the lecture?
9. Do you think the experience of group learning promotes students' peer teaching?
10. Does the use of LSH make implementation of group learning and active learning easier?

(b) Survey results: Average points

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
4th	3.0	3.2		3.1	3.7	3.3	4.1	3.3	3.1	3.4
3rd	3.8	3.7		3.5	4.0	3.0	3.4	4.2	3.9	4.0

	QR Code	Movies	Color fig.	Directions	Large size	Other
4th year	6 (%)	9(%)	19(%)	36(%)	20(%)	6 (%)
3rd year	11 (%)	25(%)	25(%)	16(%)	21(%)	3(%)

Typical students' comments:

Negative: ・Concern about the examination / lack of explanation. (17%)

・Unevenness of work in the group / Activities depending on the group members. (13%)

Positive: ・Very interesting learning experience / It is good, but needs improvement. (15%)

From the survey results, it is shown that the 3rd year students think that the LSH helps their group and active learning (4.0 for Q10). They also recognized that the group learning is more memorable than listening the lecture (4.2 for Q8). In contrast, the 4th year student are found to prefer to study individually (3.3 for Q8 and 3.4 for Q10), because they are concerned about the insufficient preparation for the examination or unevenness of work in the group. This results indicate improvements of facilitation and supports are need in that class.

Table 2. Survey results sorted by students' grade: Average points (except Q3)

4th year	Q1	Q2	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Students w/ High grade	2.7	3.0	3.1	3.7	2.9	4.4	3.1	2.9	3.3
Students w/ Medium grade	3.3	3.4	3.1	3.6	3.5	4.0	3.6	3.4	3.5
Students w/ Low grade	3.1	3.2	3.1	3.7	3.3	3.9	3.3	2.9	3.5
3rd year	Q1	Q2	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Students w/ High grade	3.6	3.5	3.6	3.8	2.8	3.3	4.1	3.8	4.2
Students w/ Medium grade	3.8	3.9	3.5	4.0	2.9	3.6	4.3	4.1	3.8
Students w/ Low grade	4.0	3.8	3.5	4.1	3.2	3.3	4.3	3.7	4.0

3.2 Class survey II: Principal Component Analysis

In order to clarify the effectiveness of LSH, we compared the LSH (LSH group) and a combination of a big blank paper with separate handouts (Blank-paper group). The LSH shown in Fig. 5 was used for this study. The group members were chosen based on their English grades to balance group. The results of a self-evaluation and a peer to peer evaluation are shown in Table 3. It should be noted that the LSH group gave higher average values than those of the Blank-paper group for all items.

Table 3. The results of self-evaluation and a peer to peer evaluation.

Q. Have the following skills been improved through the activities of group work?

	Q1. Critical Thinking		Q2. Collaboration		Q3. Communication		Q4. Creativity		Q5. Problem seeking and solving	
Group	LSH	BLANK	LSH	BLANK	LSH	BLANK	LSH	BLANK	LSH	BLANK
Average	4.15	4.12	4.53	4.22	4.47	4.24	4.24	3.93	4.29	4.13
SD	0.41	0.51	0.44	0.53	0.46	0.58	0.58	0.50	0.55	0.52
SEM	0.09	0.11	0.10	0.12	0.10	0.13	0.13	0.11	0.12	0.11
N	21	21	21	21	21	21	21	21	21	21
p	0.8466		0.049		0.1638		0.07		0.3526	

	Q6. Logical thinking		Q7. Information gathering		Q8. Consensus building		Q9. Team work		Q10. Engineering design	
Group	LSH	BLANK	LSH	BLANK	LSH	BLANK	LSH	BLANK	LSH	BLANK
Average	4.22	4.12	4.37	4.26	4.13	3.92	4.54	4.24	4.21	4.04
SD	0.61	0.45	0.52	0.41	0.58	0.39	0.39	0.54	0.58	0.33
SEM	0.13	0.10	0.11	0.09	0.13	0.08	0.08	0.12	0.13	0.07
N	21	21	21	21	21	21	21	21	21	21
p	0.5366		0.4822		0.161		0.0478		0.2626	

Figure 6 (a) and (b) show the results with Welch's T-test and Principal Component Analysis (PCA) using the generic skills scores by third-party evaluation (Valle, Petra, Martínez-Gonzáez, Rojas-Ramirez, Morales-Lopez, & Piña-Garza, 1999). In Fig. 6 (b), PC1 in PCA reflects the average scores of student. It should be noted that the students in the LSH group showed relatively higher evaluation scores than those of the blank-paper groups. Although students who are good at English might give better results in each group, it is deemed that the use of LSH helped the students improve their skills. The scores of collaboration (Q2) and team work (Q9) in LSH group are also found to be statistically higher than those of the blank-paper group based on Welch's t-test ($p < 0.05$). Therefore it indicates that the use of LSH promotes the group work. In addition, the obtained higher score of creativity (Q4) from the LSH group (4.47> 4.24) with P=0.07 is also supposed to be a significant difference, because of PC2 of PCA plots reflecting each factors (Fig. 6(b)). From these results, it is shown that the use of LSH can help not only the students work in the group, but also try to think more creatively.

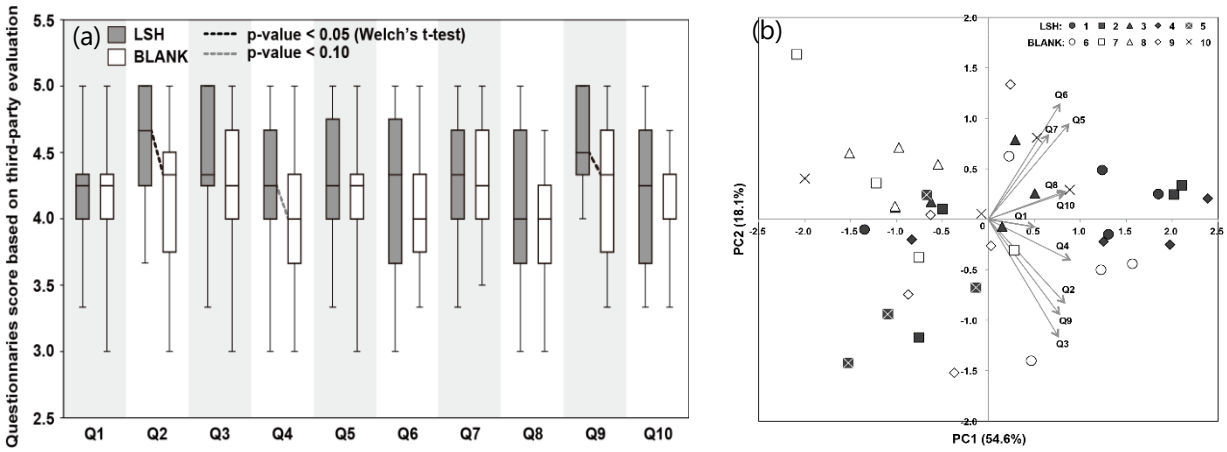


Figure 6 Results of (a) evaluation with Welch's T-test and (b) PCA analysis

4 Conclusion

In this paper, a new type of paper handout named "Large-Sized Handout (LSH)" is discussed. The LSH is a large sized paper with integrated handouts, templates, instructions and so on as a learning platform. From the class survey, it is found that the LSH is effective for implementation of collaborative active learning. As the contents needed for learning process are provided in one big paper, the student can focus on their work and collaborate with other group members. The LSH enables the students to share, grasp and gaze their learning throughout the class without interrupting their learning activities. It is shown that use of QR code is effective way to combine the writing process and information provided by ICT. In addition, the LSH seems to be suitable for PBL and language study. As the learning contents are given in one big paper, the teacher can monitor the progress of students' learning and control the pacing of classroom activities easily. It is shown that the proposed LSH is a useful teaching and learning template for the implementation of group learning and active learning.

5 References

Grassberger, R, & Wilder, S., (2015). Impacting student learning using a living case study, Higher Education, Skills and Work-Based Learning, 5(4), 369-382

Zhang, M., Quintana, C., (2012), Scaffolding strategies for supporting middle school students' online inquiry processes, Computers & Education, 58(1), 181–196

Hayes, R., J., (2006), New Directions in Writing Theory, Handbook of Writing Research, Guilford Publications, 28-40

Warwick, P., Mercer, N., & Kershner, R. (2013), 'Wait, let's just think about this': using the interactive whiteboard and talk rules to scaffold learning for co-regulation in collaborative science activities. Learning, Culture and Social Interaction, 2, 42-51

Choo, S.,S., Rotgans, J., I., Yew, E .,H., Schmidt, H., G., (2011), Effect of worksheet scaffolds on student learning in problem-based learning, Adv Health Sci Educ Theory Pract, 16 (4), 517-528.

Bellanca, J. A., (1999). Active Learning Handbook for the Multiple Intelligences Classroom (Shoebox Curriculum) ,Corwin.

Rivers, D. J., (2009). Utilizing the quick response (QR) code within a Japanese EFL., jaltcalljournal,Vol. 5, No. 2, 15–28.

Jones. B., (2011). 40 Interesting Ways to Use QR Codes in the Classroom, http://aftech.pbworks.com/f/40_Interesting_Ways_to_Use_QR_Codes_in_the_Cla(1).pdf

Grady, G., Yew. E., Goh, K., P., L., Schmidt, H., (2012). One-Day, One-Problem: An Approach to Problem-based Learning, Springer.

Jolliffe, I., T., (2002), Principal Component Analysis, Springer-Verlag New York

Valle, R., Petra, L., Martínez-Gonzáez, A., Rojas-Ramirez, J., A., Morales-Lopez, S., & Piña-Garza, B., (1999), Assessment of student performance in problem-based learning tutorial sessions, Medical Education, 33(11), 818–822.

PAEE/ALE'2016 Full Papers Submissions (Portuguese)

Submissions accepted for the PAEE/ALE'2016 papers sessions in Portuguese.

Teaching Skills Identification for the Use of PBL in Industrial Engineering Undergraduate Level

Sidnei S. Silva[1], Elon L. da Silva[1], Vitor W. B. Martins[1], Renato M. das Neves[2]

[1] Department of Production Engineering, State University of Pará - UEPA, Campus VIII, Marabá, Brazil
[2] Technological Institute, Federal University of Pará - UFPA, Belém, Brazil.

Email: sidnei-abu@hotmail.com, elonlopes@hotmail.com, vitor.martins@uepa.br, neves@ufpa.br

Abstract

Given the discussion on the teaching skills necessary for teaching Engineering, this study contextualizes the fact that the professional who teaches the disciplines of Engineering have a basically technical training, and in general because of that, finds it difficult to transmit didactically their knowledge. However, their training and performance facilitate their adaptation to the use of technological tools focused on undergraduate education. This research aimed to identify the teaching skills to be leveraged to facilitate the use of Problem-Based Learning method - PBL in undergraduate education in Production Engineering. The study followed the strategy to consider the perceptions of students and teachers of undergraduate course in Production Engineering in an institution of higher education. For this, a structured questionnaire involving nine skills desirable for the use of PBL in undergraduate courses in engineering was applied. Data were treated and measured according to the average of the responses of students compared to the responses of teachers in order to identify which skills should be made possible. The results and contributions of this study, it was found that of the nine competencies addressed in the questionnaire used items consensual decision making, decision making and critical analysis are the skills that need to be leveraged to ensure the use of PBL in undergraduate education Engineering of the institutions analysed.

Keywords: Problem-Based Learning; Education in Production Engineering; Professional qualification.

Identificação de competências docentes para o uso do PBL no ensino de graduação em engenharia de produção

Sidnei S. Silva[1], Elon L. da Silva[1], Vitor W. B. Martins[1], Renato M. das Neves[2]

[1] Departamento de Engenharia de Produção, Universidade do Estado do Pará - UEPA, Campus VIII, Marabá, Brasil
[2] Instituto Tecnológico, Universidade Federal do Pará – UFPA, Belém, Brasil.

Email: sidnei-abu@hotmail.com, elonlopes@hotmail.com, vitor.martins@uepa.br

Resumo

Diante da discussão sobre as competências docentes necessárias para o ensino em Engenharia, a presente pesquisa contextualiza o fato do profissional que leciona as disciplinas em Engenharia ter uma formação basicamente técnica, e em geral por conta disso, encontram dificuldades em mediar o processor de construção de conhecimento de forma didática. No entanto, sua formação e atuação facilitam sua adaptação ao uso de ferramentas tecnológicas voltadas para o ensino de graduação. A presente pesquisa teve como objetivo identificar as competências docentes a serem potencializadas para facilitar a utilização do método Problem-Based Learning - PBL no ensino de graduação em Engenharia de Produção. O estudo seguiu a estratégia de considerar as percepções dos discentes e docentes do curso de graduação em Engenharia de Produção em uma Instituição de Ensino Superior. Para isso, foi aplicado um questionário estruturado envolvendo nove competências desejáveis para o uso do PBL no ensino de graduação em Engenharia. Os dados foram tratados e mensurados de acordo com a média das respostas dos discentes, comparando com as respostas dos docentes, a fim de identificar quais competências devem ser potencializadas. Como resultados e contribuições deste estudo, identificou-se que dentre as nove competências abordadas no questionário utilizado os itens "Tomada de decisão consensual", "Tomada de Decisão" e a "Análise crítica" são as competências que precisam ser potencializadas para garantir o uso do PBL no Ensino de Graduação em Engenharia das Instituições analisadas.

Palavras-chave: Aprendizagem Baseada em Problemas; Educação em Engenharia; Engenharia de Produção; Formação Profissional.

1 Introducão

Cury (2008) afirma que o modelo tradicional de ensino adotado na Educação em Engenharia em sua maioria está apoiado na transmissão de conhecimentos, que normalmente focaliza os aspectos conceituais das diversas teorias, sem a sua necessária contextualização. A reprodução desses conhecimentos é valorizada por meio do estímulo à memorização, pela prática repetitiva dos mecanismos e da lógica de funcionamento dos modelos conceituais e pela aplicação de técnicas e métodos como forma única de solução de problemas.

Nesse modelo quando se fala em dificuldades de aprendizagem a primeira lembrança que nos vem são os erros cometidos pelos alunos. Mas ainda que consideremos a influência de outros fatores na aprendizagem, tais como hábitos de estudo, aspectos psicoemocionais e situação sócio econômica, é possível entender muitas das dificuldades através da análise de erros. No entanto, a dinâmica de ensino estabelecida nesse modelo tradicional de ensino em Engenharia pouco privilegia a análises e construção de conhecimentos através das análises desses erros.

O professor acaba por assumir o papel de detentor e transmissor do conhecimento, o aluno assume passivamente o papel de receptor das informações fornecidas pelo docente enquanto o conteúdo é ministrado de forma fragmentada e pouco contextualizada desfavorecendo assim, o processo de ensino e aprendizagem envolvendo o educando.

Nesse contexto Alves (2014) descreve que a aprendizagem baseada em problemas (ABP) apresenta-se como uma alternativa de modelo de ensino - aprendizagem baseado no modelo de transmissão/recepção, que fragmenta os conhecimentos científicos em disciplinas isoladas. Ao utilizar um problema como iniciador do processo de aprendizagem, a ABP facilita a introdução da interdisciplinaridade no âmbito educacional.

No entanto, para o desenvolvimento desse método é necessário que o docente apresente algumas características profissionais importantes para mediação da construção do conhecimento através da ABP. Diante deste cenário, esta pesquisa objetivou identificar as competências docentes a serem potencializadas para o uso da ABP no ensino de graduação em Engenharia de Produção.

2 Referencial teórico

Abaixo, serão abordados os tópicos para o embasamento teórico necessário à pesquisa, são apresentados os desafios no ensino de Engenharia de Produção, o método da Aprendizagem Baseada em Problemas e em paralelo a importância do mapeamento de competências docentes.

2.1 Os desafios do Ensino em Engenharia de Produção

Até os anos 60, de uma maneira geral, o corpo docente das escolas de engenharia no Brasil era formado por renomados engenheiros, matemáticos e outros especialistas, com dedicação parcial ou apenas horista. A docência era incorporada pela repetição dos modelos dos mestres. As reformas da educação, a partir de 1968, estabeleceram uma nova ordem, contribuindo para sistematizar a pesquisa e estruturar os cursos de pós-graduação, modificando o perfil do engenheiro-docente, que atualmente é mestre ou doutor, com conhecimentos especializados, dividindo sua atuação entre ensino, pesquisa e extensão (PINTO et al., 2003).

Ainda assim, pode-se observar que a maioria dos docentes de engenharia, até recentemente, eram profissionais que atuavam no mercado de trabalho e exerciam a docência, muitas vezes, por "hobby" ou por ter espírito altruísta, entre outros. Em alguns casos, eram convidados a ser docentes e aceitavam por puro diletantismo ou devido ao prestígio que a função lhes conferia. (PINTO et al., 2012).

Macambira (2012) explica que na ABP o professor assume o papel de motivador da inteligência coletiva dos alunos com os quais está interagindo, centra suas atividades no acompanhamento e gestão das aprendizagens: problematiza, desafia, incita a curiosidade, a troca de saberes e assim proporciona a autonomia do processo da aquisição de novos conhecimentos.

2.2 Aprendizagem Baseada em Problemas - ABP

Originado na escola de medicina da Universidade Mc Master, Canadá, em meados dos anos 1960, a ABP (Aprendizagem Baseada em Problemas) ou originalmente PBL (Problem-Based Learning) é essencialmente um método de ensino-aprendizagem que utiliza problemas da vida real (reais ou simulados) para iniciar, enfocar e motivar a aprendizagem de teorias, habilidades e atitudes. A ABP, como outros métodos de aprendizagem ativa, está pautado no pressuposto de que o conhecimento é construído em vez de simplesmente memorizado e acumulado.

A adoção da ABP é justificada por seus idealizadores como uma resposta à percepção dos professores de que os alunos estavam saindo do curso com muitos conceitos, mas pouca capacidade de utilizá-los e integrá-los à prática cotidiana (BARROWS, 1996).

Apesar de sua origem na formação em medicina, a ABP tem sido utilizada como uma alternativa à educação de outras profissões (Duch et al., 2001) ou mesmo em outros níveis educacionais (Glasgow, 1997). Parece não haver limites ao emprego da ABP em termos de área de conhecimento (Coombs&Elden, 2004).

2.3 Competências docentes

As recentes transformações no mundo globalizado têm trazido consigo novas exigências para os profissionais emergentes. Maseto (2012) destaca que consequentemente novas habilidades e competências têm impactado sobre a atuação do professor, que deixa de ser um transmissor de conhecimentos e passa a ser um orientador de seus alunos no seu progresso intelectual. E nesse aspecto o autor destaca que o Brasil pouco se atentou para a necessidade de capacitação pedagógica específica para atuar no Ensino Superior.

Para Perrenoud (2014), a noção de competência não descarta a importância dos saberes, porém, compreende ainda a sua aplicação. Nesse sentido o autor afirma que competência não reside nos recursos (conhecimentos, capacidades...) a serem mobilizados, mas na própria mobilização desses recursos. A competência pertence à

ordem do saber para mobilizar. Para haver competência, é preciso que esteja em jogo um repertório de recursos (conhecimentos, capacidades cognitivas e capacidades relacionais). O autor nomeia e acentua as competências julgadas prioritárias, por, segundo ele, serem coerentes com o novo papel do docente e com a política educativa.

Para realização desse estudo, as competências docentes a serem desenvolvidas foram definidas após análise das discussões apresentadas no referencial teórico desse trabalho. Nesse sentido, destacam-se as contribuições da obra de Perrenoud (2014), que serviram para adaptação do questionário elaborado por Neves (2006). Nesse aspecto, o questionário abordou as seguintes competências:

1. Condução de Reuniões/Encontros: que verifica da capacidade do docente em coordenar a reunião de forma operacional para que os problemas sejam solucionados no tempo previsto.

2. Gerenciamento de Conflito: capacidade de minimizar o conflito, agindo coletivamente na solução para o problema.

3. Liderança de Grupo: capacidade de influenciar sobre as atividades de outros indivíduos, ou de um grupo, para a realização de um objetivo em uma determinada situação.

4. Resolver Problemas: processo de aquisição de um conjunto apropriado de respostas coletivamente à uma nova situação.

5. Tomada de decisão Consensual: capacidade de envolver a contribuição de todos, permitindo que o grupo chegue ao consenso.

6. Trabalho em Equipe: capacidade de coordenar, motivar e encorajar o grupo para atingir o consenso e comprometimento.

7. Tomada de Decisão: capacidade de tomar decisões fundamentadas em fatos e dados, obtendo e implementando soluções de acordo com os objetivos organizacionais.

8. Análise Crítica: capacidade de examinar criticamente os processos de produção desenvolvidos, visando à melhoria contínua.

9. Comunicação: capacidade de trocar ou discutir idéias, de dialogar de forma clara, precisa e objetiva, com vista ao bom entendimento das pessoas.

3 Método de Pesquisa

Gil (2008) afirma que Pesquisas Exploratórias são desenvolvidas com o objetivo de proporcionar uma visão geral, de tipo aproximativo, acerca de determinado fato. Para ele, esse tipo de pesquisa é realizado especialmente quando o tema escolhido é pouco explorado e torna-se difícil sobre ele formular hipóteses precisas e operacionalizáveis. Em relação ao estudo de caso Gil (2008) afirma que esse vem sendo utilizado com frequência cada vez maior pelos pesquisadores, visto servir a pesquisas com diferentes propósitos, tais como: a) explorar situações da vida real cujos limites não estão claramente definidos; b) descrever a situação do contexto em que está sendo feita determinada investigação; e c) explicar as variáveis causais de determinado fenômeno em situações muito complexas que não possibilitam a utilização de levantamentos e experimentos.

Este artigo foi estruturado contemplando uma Instituição de Ensino Superior do setor público que trabalha com o curso de Engenharia de Produção no município de Marabá, no estado do Pará - Brasil. Para isso, realizou-se o estudo envolvendo toda a comunidade discente do curso. Já para os docentes aplicou-se o questionário a todos os professores titulares específicos do curso de Engenharia de Produção, considerando a fala de Nitsch, et al. (2004), que destacam que o engenheiro que se transforma em professor descobre um novo ambiente para o qual não foi formado e onde muito lhe é exigido.

Após aplicação de questionário junto a docentes e discentes dos cursos de Engenharia de Produção, quantificou-se em gráficos os resultados desses questionários.

O tratamento dos dados da pesquisa foi realizado através da utilização do programa Microsoft Excel 2007. O software permitiu avaliar os dados da pesquisa de acordo com os de questionários aplicados. Além disso, o ele possibilitou um tratamento detalhado com criação de vários modelos de análise, facilitando a tabulação desses resultados. Os resultados demonstram as respostas dos docentes e as percepções das suas competências diante de sua prática profissional em comparação com a opinião dos discentes em relação a essas mesmas competências dos docentes.

O recurso Google Formulário utilizado na pesquisa com os docentes também foi de fundamental importância, pois à medida que os professores iam respondendo o questionário foi possível visualizar em percentual, com a ajuda do recurso, as respostas obtidas.

4 Resultados

São apresentados os dados coletados na organização e os resultados obtidos por meio dos métodos indicados na bibliografia.

4.1 Caracterização da IES e do curso analisado

A IES funciona há 22 anos no Estado do Pará. Nasceu da fusão de faculdades de Enfermagem, Medicina, Educação Física e Educação. Desde então, desenvolve ações de ensino, pesquisa e extensão nas áreas da Saúde, da Educação e da Tecnologia. Atualmente está presente em dez das doze regiões de integração do Pará. Sendo cinco campi na capital e outros em outros municípios do estado.

Atualmente em Marabá, o curso apresenta 6 turmas, dessas 5 fizeram parte da pesquisa, excluindo-se 1 turma por se tratar de alunos recém ingressados e por conta disso sem a experiência mínima necessária para fazer avaliação das competências docentes necessárias no ensino de graduação do curso. Dessa forma buscou-se aplicar o questionário a todos os alunos matriculados nas demais turmas, que totalizam 148 alunos, no entanto, devido à ausência de alguns desses no momento da pesquisa, foi totalizado a participação de 125 alunos, o que representa uma amostra significativa de aproximadamente 84,45%.

O curso de Engenharia de Produção ofertado na cidade acontece de forma modular, ou seja, o conteúdo da disciplina é apresentado de forma condensada, definindo-se a quantidade de dias trabalhados de acordo com a carga horária da disciplina. Dessa forma, as disciplinas têm em média 2 semanas de execução, sendo esse o tempo que o docente tem para realizar as aulas propostas e as avaliações. Na cidade existem uma ausência de mão de obra qualificada para ministrar as disciplinas do curso, por conta disso, a grande maioria desses profissionais são deslocados de outras cidades, especialmente da capital Belém, para ministrar as disciplinas em Marabá. Além disso, outra dificuldade registrada no curso é o fato de muito desses docentes não apresentarem vínculo efetivo com a IES, fazendo com que o número de professores do quadro da universidade gire com frequência.

Destacados essas limitações, após levantamento dos profissionais que se enquadram nos critérios da pesquisa, ou seja, professores titulares do curso de Engenharia de Produção que ministraram disciplinas na cidade foram identificados 11 profissionais para fazer parte da mesma. No entanto, apenas 5 atenderam à solicitação para responder o questionário, que, foi aplicado com o auxilio do recurso Google Formulário.

4.2 Identificação das competências

Os dados apresentados a seguir foram obtidos após a tabulação das informações levantadas junto aos professores e alunos do Curso de Engenharia de Produção na cidade de Marabá. As turmas onde a pesquisa foi realizada estão identificadas pelas letras A, B, C, D e E que são definidas de acordo com o tempo em que estão realizando o curso. O gráfico1 apresenta o resultado geral apresentado após a aplicação do questionário para identificação de competências docentes que precisam ser potencializadas para a utilização da ABP no ensino de graduação em Engenharia de Produção na cidade de Marabá.

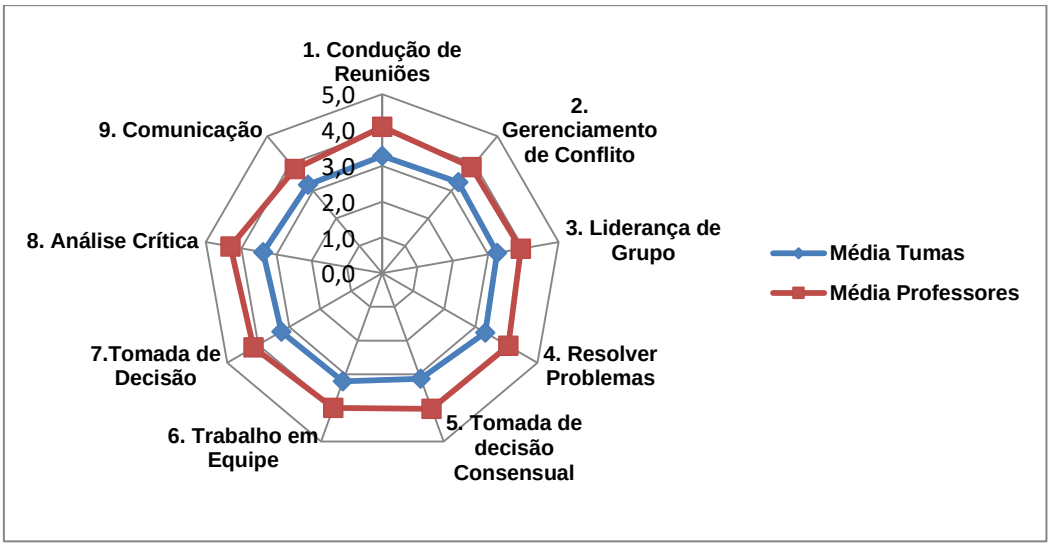


Gráfico 1 – Avaliação média geral de competências docentes. Fonte: Autores, 2016.

Como pode-se observar para todas as nove competências analisadas, a média da avaliação realizadas pelos alunos se apresenta de forma inferior à média das notas atribuídas pelos professores para essas mesmas competências, ou seja, de modo geral, para nenhum dos itens observados professores e alunos apresentam uma mesma percepção sobre o trabalho docente, no entanto, destaca-se que mesmo ocorrendo essa variação em todos os itens, essa variação não se apresenta de forma tão discrepante, oscilando entre 0,6 e 0,9.

No que se refere a menor variação, registra-se no item 9 Comunicação, onde a turma D atribui nota 3,45 aos professores, enquanto esses se auto avaliam com média 3,8, o que representa uma variação de 0,35.

De fato essas duas turmas são as que apresentam a maior variação média em suas avaliações, abaixo o gráfico 2 apresenta a avaliação média da turma B.

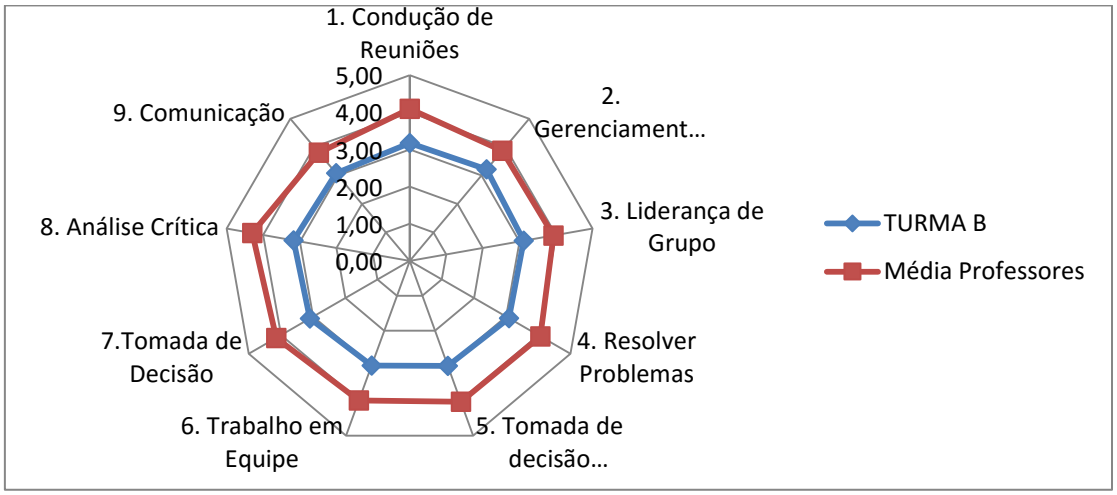


Gráfico 2 – Avaliação turma B geral de competências docentes. Fonte: Autores (2016)

Em média a variação na avaliação da turma B em relação à avaliação dos professores é de 0,9, com destaque para a competência 8 Análise Crítica com maior distorção. Essa turma é formada por alunos que desempenham suas atividades acadêmicas a bastante tempo na faculdade, logo, a quantidade de docentes que já desenvolveram suas atividades nessa turma é bem superior ao registrado na turma D que apresenta uma menor distorção na avaliação das competências docentes. De fato, maior criticidade desses alunos pode estar diretamente relacionada à sua insatisfação com esses docentes.

Como pode-se observar a competência 2, Gerenciamento de conflito, é a que apresenta a menor variação em relação à percepção dos docentes e discentes do curso com variação de 0,65. O gráfico 3 apresenta o resultado obtido pela média da avaliação da avaliação da competências docentes apresentados pela turma D.

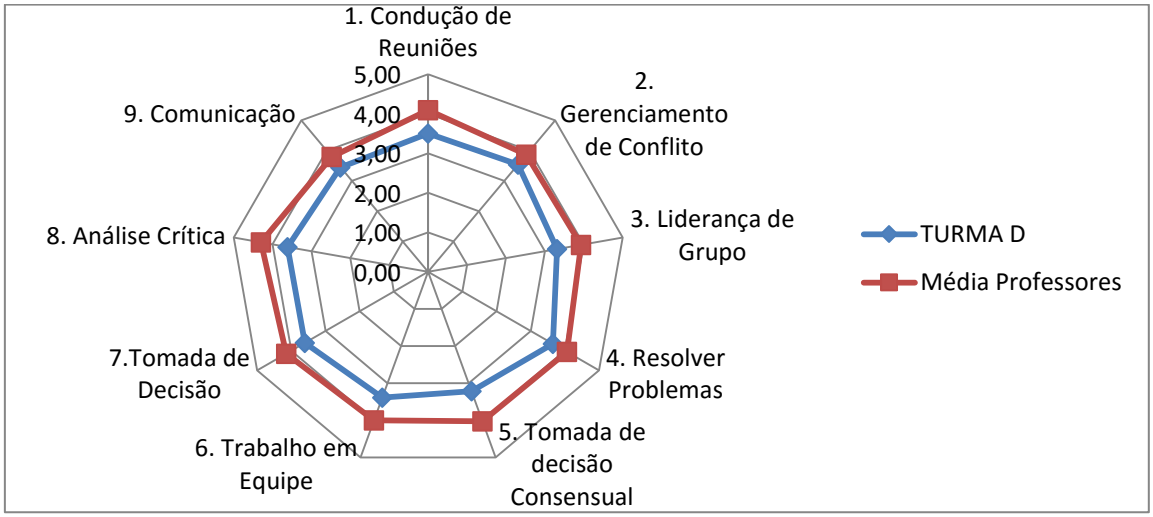


Gráfico 3 – Avaliação turma D geral de competências docentes. Fonte: Autores (2016)

Como observa-se a competência 2, Gerenciamento de Conflito, apresenta a menor distorção entre professores e os alunos da turma com apenas 0,33 de distorção. Sendo a competência 8, Análise Crítica, a que apresenta a maior variação com o registro de 0,69, ainda assim, mesmo com essa variação apresentada pela turma o valor médio da avaliação da turma é bem superior ao registrado pela turma B. Nesse aspecto, vale ressaltar que a turma D é uma turma com bem menos tempo de universidade, logo, a quantidade de docentes por ela avaliada é bem inferior em comparação com as demais turmas.

5 Conclusões

Como se pode observar ao longo da revisão da literatura existente a ABP demonstrou ser uma interessante alternativa ao modelo de ensino e aprendizagem baseado na transmissão e recepção de conteúdos, modelo esse, que como destacado por alguns autores, fragmenta os conhecimentos científicos em disciplinas isoladas.

Dessa forma, a viabilidade da implantação do método é justificada à medida que o ambiente da ABP envolve situações distintas daquelas encontradas no dia a dia em sala de aula com métodos de ensino pautados na repetição de conteúdos e com pouca interação entre o educando e o produto do conteúdo trabalhado.

No entanto, por conta disso, faz-se necessária a capacitação docente para trabalhar com o método mesmo com aqueles professores que possuem experiência no modelo convencional de ensino, pois a grande maioria desses professores utiliza basicamente dois modelos de aula: a expositiva e as discussões conduzidas. Diante disso, o objetivo principal deste trabalho foi alcançado, identificando de fato, as competências docentes que precisam ser potencializadas para utilização da ABP no ensino de graduação em Engenharia de Produção.

Dessa forma, após realização da pesquisa, no que se refere ao desenvolvimento dessas competências, os dados obtidos sugerem a necessidade desse desenvolvimento para todas as 9 competências avaliadas, uma vez que há uma distorção na percepção geral dos alunos em relação a auto avaliação realizada pelos professores no que se refere a essas competências. Ou seja, para nenhuma das 5 turmas avaliadas os docentes apresentam o mesmo nível em relação à avaliação realizada pelos professores. Ainda assim, deve-se ressaltar que dentre essas nove competências, 3 delas, a saber a competência 5 Tomada de decisão consensual, competência 7 Tomada de Decisão e a competência 8 Análise crítica, foram definidas pela pesquisa como as que merecem uma atenção especial, pois apresentaram resultados mais críticos dentre as nove analisadas, com o registro de uma variação de 0,9 entre a avaliação de professores e alunos do curso de Engenharia de Produção.

Como propostas de pesquisas futuras, destaca-se: Identificar as competências para cada docente para utilização da ABP no ensino de graduação em Engenharia de Produção; desenvolver as competências docentes para o uso da ABP no curso de Engenharia de Produção; capacitar os docentes para utilização ABP no ensino de graduação em Engenharia de Produção; e, estudar as mudanças curriculares necessárias para implementação do método ABP no ensino de graduação em Engenharia de Produção.

6 Referências

ALVES, V. A. S; Identificação de competências docentes para o uso do PBL no ensino de química. Trabalho de Conclusão de Curso em Licenciatura em Ciências Naturais – Química, Universidade do Estado do Pará, 2014.

BARROWS, HOWARD S. "Aprendizagem baseada em problemas em medicina e além:. Uma breve visão geral" Novos caminhos para o ensino e aprendizagem 1.996,68 (1996): 3-12

COOMBS, G .; ELDEN, M. Introdução ao especial aprendizagem baseada em problemas como investigação social: questão PBL e gestão da educação. JournalofEducation Management, v. 28, n. 5, p. 523-535, 2004.

CURY, A. C. H; Uma análise holística do perfil pedagógico do docente e suas estratégias de ensino e relacionamento: Uma aplicação no ensino de Engenharia de Produção. 307f. Tese (Doutorado em Engenharia de Produção), Programa de Pós Graduação e Área de Concentração em Engenharia de Produção da Escola de Engenharia de São Carlos da Universidade de São Paulo, 2008.

DUCH, J., S. E. G, E. E. O poder da aprendizagem baseada em problemas: um prático "como fazer" para o ensino de cursos de graduação em qualquer disciplina. StylusPublishing, LLC., 2001

GIL, A. C. Métodos e Técnicas de Pesquisa Social.6º Edição. São Paulo: Atlas, 2008

GLASGOW, N. A. Novo currículo para novos tempos. Thousand Oaks: Corwin, 1997.

MACAMBIRA, P. M. F. A aprendizagem baseada em problemas (ABP): Uma aplicação na disciplina “gestão empresarial” do curso de engenharia civil. In: Congresso brasileiro de ensino de engenharia – COBENGE, Belém/PA, 2012.

MASETO, M. T. Competências pedagógicas do professor universitário. 2. ed. São Paulo: Summus, 2012.

NEVES, R. M. Desenvolvimento de competências de gerentes intermediários através da adaptação da Aprendizagem Baseada em Problemas – ABP. Tese de doutorado, Programa de Pós Graduação em Engenharia Civil, UFRGS, Porto Alegre, 2006.

NITSCH, J. C. et al..Engenheiro-professor ou professor-engenheiro: reflexões sobre a arte do ofício. In: Congresso brasileiro de ensino de engenharia – COBENGE, Brasília, 2004.

PERRENOUD, P. 10 novas competências para ensinar: convite à viagem. Trad. Patrícia Chitoni Ramos. Artmed Editora Ltda. Porto Alegre.2014.

PINTO, D.P; NASCIMENTO, J.L; PORTELA, J.C.S; SILVEIRA, M.H; MARTINS, P.D; OLIVEIRA, V.F. Engenharia: pratica docente e formação de professores.In:Congresso brasileiro de ensino de engenharia – COBENGE, Belém, 2012.

PINTO, D.P; OLIVEIRA, V.F. reflexões sobre a prática do engenheiro-professor.In: ICECE - International Conference on Engineering and Computer Education. Santos, SP, 2003.

VALENTE, G. S. C; VIANA, L. O. O ensino de nível superior no Brasil e as competências docentes: Um olhar reflexivo sobre esta prática. Práxis Educacional/ Revista do Departamento de Filosofia e Ciências Humanas da Universidade Estadual do Sudoeste da Bahia, Vitória da Conquista, v. 6, n. 9. p. 209-226. jul./dez. 2010.

Ethics and Civic Education in the Curriculum of Engineering Courses in Portuguese Higher Education System

Fátima Monteiro[1], Carlinda Leite[2], Cristina Rocha[2]

[1]Instituto Superior de Engenharia de Coimbra – IPC (Coimbra, Portugal)
[2]Faculdade de Psicologia e de Ciências da Educação – UP (Porto, Portugal)

Email: fatcmont@isec.pt; carlinda@fpce.up.pt; crocha@fpce.up.pt

Abstract:

There are various authors who state that higher education is only complete when the student, in addition to acquiring their area know-how, knows how to use it wisely. This demands students to have ethical and civic values and skills. Taking into account the role of engineering in society, and the broad field of its intervention that interferes with multiple dimensions of human existence and sustainability, it is imperative to consider the consequences of their actions (positive, negative and even dangerous). Therefore, the various professional organizations in this area have come to recognize the need and importance of ethical, deontological and civic education of engineering students. The study presented here aimed to know how the Portuguese higher education institutions in the field of Engineering, incorporate in the curriculum the ethical and civic education of their students. The study covers all public institutions of higher education that have engineering courses, representing 28 institutions (13 universities and 15 polytechnics). In order to accomplish this, the study gathered various courses official curricula and through an analysis process identified how ethical, moral and deontological education is present in the engineering courses. From the conclusions it should be noted that 68.5% of the Portuguese public institutions engineering courses do not include in their curriculum any curricular units with objectives within the ethical, moral and deontological education. The University study plans that have education in this area show that: 14% incorporate specific optional curricular units; 42% address this issue in generic curricular units (mostly mandatory); and 44% have cross-curricular units (mostly mandatory). In the Polytechnic higher education, only 9 courses have ethics and civic education curricular units. The following happens with these courses: 62.5% incorporate specific curricular units (mostly mandatory); 12.5% include mandatory generic curricular units; and 25% have mandatory cross-curricular units. The fact that only 4 courses (from the 184 courses studied) have specific curricular units in this training area as mandatory should also be noted.

Keywords: Engineering Education; Ethic and civic education; Curriculum, Curricular units.

A Formação Ética e Cívica nos Currículos dos Cursos de Engenharia do Ensino Superior Português

Fátima Monteiro[1], Carlinda Leite[2], Cristina Rocha[2]

[1]Instituto Superior de Engenharia de Coimbra – IPC (Coimbra, Portugal)
[2]Faculdade de Psicologia e de Ciências da Educação – UP (Porto, Portugal)

Email: fatcmont@isec.pt; carlinda@fpce.up.pt; crocha@fpce.up.pt

Resumo:

São diversos os autores que sustentam que a educação superior só estará concluída quando o estudante, para além de adquirir os conhecimentos técnicos específicos à sua área de saber, os puder usar de forma sábia, o que exige que esteja munido de valores e competências de análise ética e cívica. Tendo em conta o papel da engenharia na sociedade e o amplo campo da sua intervenção em múltiplas dimensões da existência humana e da sua sustentabilidade, é imperativo considerar as consequências da sua ação (positivas, negativas e, até perigosas). E tendo também esta questão por referência, várias entidades profissionais desta área têm vindo a reconhecer a necessidade e importância da formação ética, deontológica e cívica dos estudantes de engenharia. É tendo esta problemática como ponto de partida, que o estudo que aqui se apresenta tem como objetivo dar a conhecer como é que as instituições de ensino superior Portuguesas, na área da engenharia, incorporam nos currículos a componente de formação ética e/ou cívica dos seus estudantes. O estudo abrange todas as instituições públicas de ensino superior que possuem cursos de engenharia, o que corresponde a 28 instituições (13 universitárias e 15 politécnicas). Para a sua concretização, o estudo recolheu os currículos oficiais dos diversos cursos e, através de um procedimento de análise documental, identificou a presença e o tipo (específica, genérica ou transversal) de formação ética, moral, deontológica e/ou cívica que os caracteriza. Das conclusões salienta-se que 68% dos cursos de engenharia das instituições públicas portuguesas não têm previsto no seu currículo nenhuma unidade curricular com objetivos orientados para a formação ética e/ou cívica dos estudantes. Dos cursos universitários que apresentam formação neste âmbito: 16% incorporam unidades curriculares específicas, optativas; 37% enquadram esta formação em unidades curriculares genéricas (maioritariamente obrigatórias); e 47% inclui esta componente em unidades curriculares transversais (maioritariamente obrigatórias). No ensino Politécnico, apenas 9 cursos apresentam formação ética e/ou cívica, sendo que 56% destes incorporam unidades curriculares específicas, maioritariamente obrigatórias; 22% incluem unidades curriculares genéricas obrigatórias; e 22% apresentam unidades curriculares transversais obrigatórias. É de salientar ainda o facto de só 4 cursos (no total dos 184 cursos estudados) apresentarem unidades curriculares específicas a este domínio de formação com carácter obrigatório, sendo todos eles do ensino superior politécnico.

Palavras-chave: Cursos de engenharia, Educação ética e cívica, Currículo, Unidades Curriculares

1 Introdução

São muitos os documentos internacionais e nacionais que salientam ou referem a necessidade do ensino superior incluir na sua missão a formação ética, moral e/ou cívica dos seus alunos. A nível internacional, a UNESCO e a Comissão Europeia (nomeadamente no âmbito do Ano Europeu da Cidadania pela Educação (2005) e do Processo de Bolonha (2005)) têm produzido diversos documentos que acentuam esta necessidade. Neste âmbito, salientam-se os referenciais de qualificação definidos na Conferencia de Bergen (2005), que apontam para que os estudantes, no final da sua formação, devem ser capazes de fazer "reflexões sobre questões sociais, científicas e éticas relevantes", dentro do respetivo campo de saberes (Conselho da Europa, 2005).

Tendo em conta o papel da engenharia na sociedade, a vasta área da sua atuação e as potenciais consequências da sua ação (quer positivas, quer negativas ou mesmo perigosas), as várias entidades que agregam ou acreditam estes profissionais também têm vindo a reconhecer a necessidade e importância da formação ética e deontológica dos estudantes dos cursos de engenharia (Finelli at all, 2012). Em Portugal, a Ordem dos Engenheiros (OE) e a Ordem dos Engenheiros Técnicos (OET) também reconhecem esta necessidade (OE, 2002; Carapeto & Fonseca, 2012). A OET reconhece que os engenheiros são profissionais

com importância "determinante para o progresso económico e social", salientando a necessidade da sua formação estimular a que o engenheiro, "para além de saber utilizar o seu engenho e arte", também se deva preocupar "com a dimensão ética da sua conduta, aspeto que é atualmente tão importante na profissão como o domínio das disciplinas técnicas" (Carapeto & Fonseca, 2012,p.6).

Ehrlich (2000) salienta que tradicionalmente a formação na área das engenharias era considerada como moralmente neutra, pelo que não necessitava da consideração de valores. No entanto, esta perspetiva de aparente neutralidade das engenharias, não encarava um aspeto fundamental: os modos e os fins para que o conhecimento especializado poderá ser usado na prática (Davis & Feinerman, 2012). Neste mesmo sentido, são vários os autores que consideram fundamental a necessidade do ensino superior na área das ciências exatas interligar os conteúdos académicos com o desenvolvimento ético, moral e cívico (Ehrlich, 2000; Magalhães, 2006; Colon, 2013; Nussbaum, 2014). Todos os autores estudados defendem que existe uma clara relação entre ética, moral e cidadania, considerando estes aspetos inseparáveis, e como tal, qualquer formação para a cidadania implica também a formação de valores (Ehrlich, 2000; Jacoby, 2009). Para Martha Nussbaum (2014), é ainda necessário ultrapassar a visão da formação ética de engenheiros que vise apenas a componente deontológica, mas abranger uma preparação global para a vida e como tal também para a cidadania.

Os investigadores Pešec e Petković (2014) consideram que a ética é a própria essência de todo o processo de formação dos estudantes do ensino superior. Para tal, salientam que, ao fim de poucos anos de formação, os estudantes terão de enfrentar dilemas e serão forçados a tomar decisões que podem afetar a sociedade e pôr em causa a sustentabilidade, o bem comum e vidas humanas no âmbito da sua atividade profissional como engenheiros. Destacam também que os engenheiros serão colocados perante questões que, pela sua complexidade, vão muito para além das simples dúvidas sobre o certo e o errado, em que a ética é frequentemente ignorada em face da pressão economicista dos lucros e das pressões sociais.

De acordo com Ehrlich (2000), Barbara Jacoby (2009) e Davis e Feinerman (2012), ao nível do ensino superior, são usadas diversas metodologias para promover a formação ética, cívica e deontológica dos estudantes. No âmbito dos cursos de engenharia, segundo Davis e Feinerman (2012), destaca-se o recurso a 3 principais metodologias: unidades curriculares específicas; módulos que têm uma larga inserção em unidades curriculares de áreas técnicas, que versam casos específicos; e inserção de mini formações nas diversas unidades curriculares que compõe o plano curricular. Uma outra forma de abordagem da formação ética na engenharia, embora menos usada, é a promoção do serviço público em regime de voluntariado, exercido em formato extracurricular no contexto das engenharias, mas valorizado no certificado de formação. Diversos estudos referem esta metodologia como promotora da responsabilidade social e do sentido ético dos estudantes (Conlon, 2013; Rovira, 2003). Mas, na perspetiva de Kim Spiezio (2009), o desenvolvimento cívico e ético deve permear toda a vida das instituições de ensino superior. Nesta mesma perspetiva, Barbara Jacoby e Elisabeth Hollander (2009) defendem que a formação cívica deve englobar toda a comunidade académica, pois o envolvimento e empenho explícito das instituições de ensino superior potenciam o envolvimento e empenho dos seus estudantes.

Como é evidente, a atenção dada a estas questões está intimamente relacionada com a conceção da missão do ensino superior e com o projeto político-pedagógico das instituições deste nível de ensino, e que será substancialmente diferenciado em função da perspetiva e do modelo que se defenda (Magalhães, 2006). A nível institucional, este projeto influenciará as linhas gerais de orientação para a construção curricular dos diversos cursos ministrados por cada instituição de ensino superior. A par deste efeito, cada docente, com a sua conceção das missões do ensino superior, exerce também influências na configuração curricular e nos modos de concretizar a sua prática docente. Importa, portanto, também considerar o papel dos professores na configuração do currículo no ensino superior e da sua influência na conceção curricular, influenciando-o através da interpretação das propostas internas e externas e das suas próprias conceções (Leite, 2011).

Do atrás exposto destaca-se o papel central do currículo no processo educativo e como tal no ensino superior, o que justifica a necessidade de se promover uma análise curricular que permita caraterizar as formas como a formação ética e cívica é incorporada nos cursos de engenharia. Como se infere, a formação ética e cívica dos estudantes dos cursos de engenharia é uma problemática atual que constitui um desafio à organização curricular mas que se encontra pouco estudada em Portugal no âmbito do ensino superior (Estrela, 2010). Foi

pois neste enquadramento que se considerou importante realizar um estudo sobre a formação ética e cívica dos estudantes de engenharia. Assim, o estudo que aqui se apresenta tem como objetivo dar a conhecer a panorâmica do lugar da formação ética e cívica nos planos curriculares dos cursos de engenharia em Portugal, evidenciando como é que as instituições de ensino superior portuguesas implementam curricularmente esta componente de formação.

Sendo a formação na área da engenharia, em Portugal, realizada quer pelo ensino universitário, quer pelo ensino politécnico, o estudo abarca estes dois subsistemas. Refira-se que, a nível nacional, 46% das instituições de ensino superior que promovem cursos na área da engenharia são do ensino universitário e 54% do ensino politécnico. O ensino superior politécnico leciona cursos que conferem o grau de licenciatura, com uma duração de 3 anos, correspondendo a 180 ECTS. O ensino universitário pode lecionar cursos conferentes do grau de licenciatura (3 anos – 180 ECTS) ou de mestrado integrado, com a duração de 5 anos, correspondendo a 300 ECTS.

2 Metodologia

No sentido de conhecer como é que as instituições de ensino superior Portuguesas (na área da Engenharia) implementam curricularmente (ou não) a formação ética e cívica, procedeu-se a uma recolha dos planos de estudo dos cursos de engenharia, quer do ensino superior politécnico, quer do ensino superior universitário, para identificar a sua presença, ou ausência.

A recolha de dados foi realizada no ano letivo 2015/2016 e abrangeu os cursos do 1º ciclo (licenciatura) e de mestrado integrado, de 28 instituições (13 universitárias e 15 politécnicas), num total de 184 cursos (126 licenciaturas e 58 mestrados integrados), correspondendo ao universo dos cursos de engenharia existentes no setor público em Portugal. Na tabela 1 apresenta-se a distribuição dos cursos pelos dois subsistemas (politécnico e universitário) e por tipo de curso (licenciatura e mestrado integrado). Esta recolha dos planos curriculares oficiais dos diversos cursos foi feita através da página oficial de cada instituição e do Diário da República e, posteriormente, sujeita a uma análise de modo a identificar as opções curriculares propostas no âmbito da formação ética, moral, deontológica e/ou cívica dos estudantes.

Tabela 1. Cursos abrangidos pelo estudo em função do subsistema de ensino superior.

	Licenciaturas	Mestrados Integrados
Ensino Politécnico	86	
Ensino Universitário	40	58

O estudo dos dados recolhidos foi feito com base num procedimento de análise documental que permitiu identificar a presença de unidades curriculares (UC) neste domínio de formação. Neste âmbito, foram selecionadas as UC cuja designação indicava que o seu conteúdo não era do foro técnico da área da engenharia em questão, bem como as UC que eram explicitamente de formação ética, moral, deontológica e/ou cívica. As UC selecionadas foram então alvo de uma análise do seu conteúdo programático, por forma a detetar ou confirmar a presença de conteúdos de formação no âmbito abrangido por este estudo.

As UC identificadas, cujo conteúdo programático remete para a formação ética, deontológica e/ou cívica, foram, neste estudo, agrupadas em três grupos:

- Unidades Curriculares específicas – quando a UC se centra totalmente na formação ética, deontológica e/ou cívica;
- Unidades Curriculares genéricas - quando o conteúdo relativo à formação ética, deontológica ou cívica é incorporado no âmbito de uma UC de conteúdos programáticos diversos e genéricos;

- Unidades Curriculares transversais - quando o conteúdo relativo à formação ética, deontológica ou cívica é incorporado no âmbito de uma UC classificada pela instituição como sendo de conteúdos transversais aos diversos cursos.

A análise efetuada incluiu uma orientação de caráter quantitativo e também de ordem qualitativa, interpretativa.

3 Resultados e Análise dos resultados

Do ponto de vista da totalidade dos 184 cursos de engenharia existentes no ensino superior público português, 68% dos cursos não apresentam nenhuma UC que inclua objetivos e conteúdos de formação ética e/ou cívica e 32% dos cursos apresenta pelo menos uma UC que foque esta vertente formativa.

A tabela 2 apresenta os resultados relativos à presença de UC no âmbito de formação ética e/ou cívica nos diversos cursos de engenharia e nos dois subsistemas de ensino, de acordo com o tipo de UC e o seu regime de funcionamento.

Tabela 2. Número de cursos de engenharia com presença de UC no âmbito da formação ética e/ou cívica, em função do subsistema de ensino superior e do tipo de curso.

Tipo de UC	Regime de frequência	Ensino Universitário		Ensino politécnico
		Licenciatura	Mestrado integrado	
Específicas	obrigatório			4
	opção	1	7	1
	facultativo			
Genéricas	obrigatório	3	11	2
	opção		6	
	facultativo			
Transversais	obrigatório	5	23	2
	opção	1	1	
	facultativo	2		

Da tabela 2 verifica-se ainda que, ao considerar os cursos do ensino superior politécnico, apenas 10% apresentam pelo menos uma UC que inclui este domínio de formação. No caso dos cursos do ensino superior universitário, 50% incluiu nos seus currículos pelo menos uma UC que incorpore uma componente de formação ética e/ou cívica.

Assim, e considerando a globalidade do ensino superior português no domínio da engenharia:

- 7% dos cursos apresentam UC específicas a este domínio de formação;
- 11% apresentam esta componente de formação incorporada em UC genéricas;
- 14% apresentam esta componente de formação incorporada em UC transversais;
- e 68% não apresentam nenhuma UC nesta área.

Considerando todas as 69 UC que fazem parte dos currículos dos cursos de engenharia e que focam a formação ética e/ou cívica, 43% destas são classificadas como transversais, 35% como genéricas e 22% como específicas. Quanto ao regime de frequência, e considerando a totalidade das UC com componente de formação ética

e/ou cívica, é de salientar que a maioria das UC (74%) são de caráter obrigatório, 23% são de opção e apenas 3% são facultativas.

Considerando o ensino superior politécnico e o universitário em separado, a distribuição das UC de acordo com a sua tipologia é apresentada na tabela 3, e quanto ao regime de frequência na tabela 4.

Tabela 3. Percentagem das UC em função da sua tipologia e do subsistema de ensino.

	Ensino Politécnico	Ensino Universitário
UC específicas	56%	16%
UC genéricas	22%	37%
UC transversais	22%	47%

Tabela 4. Percentagem das UC em função do seu regime de frequência e do subsistema de ensino.

	Ensino Politécnico	Ensino Universitário
Obrigatórias	89%	70%
Opção	11%	27%
Facultativas		3%

Assim, no caso do ensino superior universitário, as UC que predominam são as de carácter transversal, de frequência obrigatória. De salientar que, ao contrário do ensino politécnico, as UC específicas são as que têm menor representatividade (16%) no ensino universitário e todas estas apresentam um regime de frequência de opção. Neste subsistema de ensino existem também UC de frequência facultativa, correspondendo a UC que não fazem parte dos 180 ECTS necessários para a conclusão do grau académico em causa (licenciatura), ou seja, que têm um carácter extracurricular.

Dos dados obtidos constata-se que a maioria (68%) dos cursos não apresenta nenhuma UC que inclua formação ética e/ou cívica no seu currículo. Dos 148 cursos analisados, só 32% dos cursos apresentam pelo menos uma UC de frequência obrigatória, e só 2% incluem pelo menos uma UC obrigatória e específica a esta temática. Tais factos evidenciam a reduzida presença da formação ética e/ou cívica nos cursos de engenharia, podendo este ser um indicador da diminuta importância ou reconhecimento dado a este domínio de formação nos cursos de engenharia em Portugal.

É o ensino politécnico que manifesta a menor presença (10%) de UC que incluem formação ética e/ou cívica nos currículos dos seus cursos. No ensino universitário, metade (50%) dos seus cursos apresentam pelo menos uma UC que foque esta temática. Tendo em conta esta substancial diferença, importa equacionar se este facto se deve à diferente duração dos cursos ou se estará eventualmente relacionado com o perfil dos dois subsistemas. Assim, importa analisar esta questão comparando cursos com a mesma duração temporal (tabela 5): ao considerar apenas as licenciaturas na área da engenharia do ensino universitário e do ensino politécnico, 30% dos cursos do ensino universitário apresentam pelo menos uma UC de formação ética e/ou cívica, em contraste com 10% dos cursos do ensino politécnico. No que aos mestrados integrados diz respeito (ensino universitário), 64% destes apresentam pelo menos uma UC que inclua este domínio de formação.

Tabela 5. Percentagem dos cursos que apresentam UC na área da formação ética e/ou cívica função do subsistema de ensino.

	Ensino Politécnico	Ensino Universitário
Licenciaturas	10%	30%
Mestrado Integrado		64%

Estes dados parecem indicar que a duração do curso (de 3 ou 5 anos) pode ser um aspeto que potencie a formação no domínio da formação ética e/ou cívica. Contudo, é necessário ter em conta que as exigências e competências definidas para os mestrados integrados também são diferentes das definidas para uma licenciatura, logo um acréscimo de anos de formação está também associado a um acréscimo de conteúdos e conhecimentos a incluir no currículo do respetivo curso. Mas, de facto, ao considerar apenas as licenciaturas, constatamos que o ensino universitário, do ponto de vista curricular, parece apostar mais nesta vertente de formação do que o ensino politécnico (30% no ensino universitário, e 10% no politécnico). Salienta-se assim, o que parece ser uma diferenciação do ensino superior politécnico e universitário face a este tipo de formação, podendo estar na sua origem as diferentes conceções da missão do ensino superior [Magalhães, 2006].

Tendo em conta a totalidade das UC que incluem formação ética e/ou cívica, é de salientar que só 19% são de carácter específico, mas destas só 6% são simultaneamente específicas e obrigatórias (correspondendo a 4 UC do ensino politécnico). Assim, embora o ensino universitário pareça dedicar mais atenção a este tipo de formação, é no ensino politécnico que encontramos UC específicas ao tema da formação ética e/ou cívica com um carácter obrigatório.

No ensino universitário, a formação ética e/ou cívica surge maioritariamente incorporada em UC transversais de frequência obrigatória. Será, no entanto, necessário avaliar o peso relativo desta componente de formação na globalidade do programa previsto para cada UC, para melhor se poder avaliar a presença da formação ética e/ou cívica nos currículos destes cursos.

4 Conclusões

Verificou-se que a presença de UC que incluam formação ética e/ou cívica nos cursos de engenharia é ainda reduzida (68% não apresentam nenhuma UC nesta área de formação), e que esta predomina no ensino universitário. No conjunto dos dois subsistemas, a presença de UC específicas e obrigatórias é baixa (2%), o que poderá ser um indicador da diminuta importância atribuída a esta formação nos cursos de engenharia.

Ao nível da presença de UC sobre a temática em estudo, nos currículos dos cursos de engenharia, verificou-se também uma diferenciação entre os dois subsistemas existentes no ensino superior em Portugal, sendo o ensino politécnico o que apresenta menor presença de UC neste âmbito de formação. Tal facto poderá estar alicerçado nas diferentes orientações e conceções da missão dos subsistemas politécnico e universitário, pelo que a sua compreensão exige estudar as missões destes dois subsistemas de ensino superior por forma a avaliar o peso da tradicional associação do ensino politécnico a uma formação de carácter profissional, e do ensino universitário a uma formação mais teórica e científica (Imaginário & Castro, 2011), bem como o peso das associações profissionais que regulam a formação em engenharia.

Quanto ao ensino universitário, constatou-se que prevalecem UC transversais obrigatórias. Será, no entanto, necessário averiguar o peso relativo da componente de formação ética e/ou cívica nas UC transversais para melhor se poder avaliar a real dimensão da componente de formação ética e/ou cívica nos currículos. Este facto é preponderante no caso do ensino superior universitário pois 47% das UC são transversais, ou seja, só incluem alguns tópicos sobre esta temática.

5 Referências bibliográficas

Carapeto, Carlos & Fonseca, Fátima (2012). Ética e deontologia – Manual de formação. OET – Ordem dos Engenheiro Técnicos.

Conlon, E. (2013). Broadening engineering education: bringing the community in: commentary on "social responsibility in French engineering education: a historical and sociological analysis". Science And Engineering Ethics, 19(4), 1589-1594. doi: 10.1007/s11948-013-9476-x

Conselho da Europa (2005). The framework of qualifications for the european higher education area - Bergen conference of european ministers responsible for higher education, 19-20 May 2005.

Davis, M. & Feinerman, A. (2012). Assessing graduate student progress in engineering ethics. Science & Engineering Ethics, 18(2), 351-367. doi: 10.1007/s11948-010-9250-2

Ehrlich, Thomas (2000). Civic responsability and higher education. Americam Council on Education e Oryx Press.

Ehrlich, Thomas (2000). Civic responsability and higher education. Americam Council on Education e Oryx Press.

Estrela, Teresa (2010). Ética e pedagogia no ensino superior. In Leite, Carlinda (org.). Sentidos da Pedagogia no Ensino Superior (11-27). CIIE/Livpsic, 2010, Isbn: 978-989-8148-44-5

Finelli, C., Holsapple, M., Eunjong R., Bielby, R., Burt, B., Carpenter, D. & Sutkus, J. (2012). An assessment of engineering students' curricular and co-curricular experiences and their ethical development. Journal of Engineering Education, 101(3), 469-494.

Imaginário, Luís & Castro, José (2011). Psicologia da formação profissional e da educação de adultos – Passos passados, presentes e futuros. Porto: Livpsic.

Jacoby, Barbara (2009). Civic engagement in today's higher education: na overview, In Jacoby, Barbara (org). Civic engagement in higher education: concepts and practices (5-30). Jossey-Bass Books.

Jacoby, Barbara & Hollander, Elisabeth (2009). Securing the future of civic engagement in higher education. In Jacoby, Barbara (org). Civic engagement in higher education: concepts and practices (227-249). Jossey-Bass Books.

Leite, Carlinda (2011). Questões do currículo no ensino universitário: O que distingue a organização e o desenvolvimento do currículo deste nível de ensino?. In Leite, Carlinda, Pacheco, José, Moreira, António & Mouraz, Ana (2011). Políticas, fundamentos e práticas do currículo (278-287). Porto Editora.

Magalhães, António M. (2006). A identidade do ensino superior: a educação superior e a universidade. Revista Lusófona de Educação, 7, 13-40

Nussbaum, Martha (2014). Educação e justiça social. Edições Pedago.

OE - Ordem dos Engenheiros (2002). Estatuto da Ordem dos Engenheiros (Aprovado pelo Decreto-Lei n.º 119/92, de 30 de Junho). Retrieved from http://www.ordemengenheiros.pt/fotos/editor2/ordem/atribuicoeseorganizacao/estatutos_da_ordem_dos_engenheiros.pdf

Pešec, B. & Petković, Z. (2014). Assessing higher education students ethicality. Procjena Eticnosti Studenata, 12(3), 263-269. doi: 10.7906/indecs.12.3.6

Rovira, Josep (2003). Prácticas morales - Una aproximación moral. Ediciones Paidós Ibérica.

Spiezio, Kim (2009). Engaging general education. In Jacoby, Barbara (org). Civic engagement in higher education: concepts and practices (85-98). Jossey-Bass Books

Encouraging Women in Science

Carlos M. Sacchelli[1], Tatiana R. Garcia[1], Susie C. Keller[1], Kellen Luiza Silva[1]

[1]Departamento de Engenharias da Mobilidade, Universidade Federal de Santa Catarina, Campus Joinville, Joinville, Brasil

Email: carlos.sacchelli@gmail.com, tatiana.rgarcia@gmail.com, susie.keller@ufsc.br, lkelen.silva@hotmail.com

Abstract

The jobs in the labor market in the area of Science and Technology has increased year after year. However, it is observed that the few students who choose careers in this area mostly are men, thus causing a great inequality. In 2012 in Brazil, the Engineering area courses relied on only 20.8% of female students and the courses of the area of Sciences, Mathematics and Computing, with 10.6%, evidencing the great predominance of male and as a result, the labor market also predominantly male. Thus, seeking to promote science and technology among women, there were some national actions, including a project funded by the Government, called "Girls in Science". The actions of this project had focused primarily on female students of high school in order to goad them into S & T area, high school teacher and students of engineering courses. The aim of this article is to present and discuss the activities of the project developed at the Federal University of Santa Catarina and its results. The activities were developed in the laboratory of Innovation and Product Development. The students who participated in the activities showed great motivation and interest for the issues and projects in which they were involved.

Keywords: Women; Science and Technology; Engineering.

Incentivando as Mulheres na Ciência

Carlos M. Sacchelli[1], Tatiana R. Garcia [1], Susie C. Keller [1], Kellen L. Silva[1]

[1] Departamento de Engenharias da Mobilidade, Universidade Federal de Santa Catarina, Campus de Joinville, Joinville, Brasil

Email: carlos.sacchelli@gmail.com, tatiana.rgarcia@gmail.com, susie.keller@ufsc.br, lkelen.silva@hotmail.com

Resumo

As vagas no mercado de trabalho na área de Ciência e Tecnologia – C&T tem aumentado ano após ano. Contudo, observa-se que os poucos estudantes que optam por carreiras nesta área, em sua grande maioria são homens, ocasionando assim, uma grande desigualdade. No ano de 2012, no Brasil, os cursos da área de Engenharia contaram com apenas 20,8% de estudantes do sexo feminino, e os cursos das áreas de Ciências, Matemática e Computação com 10,6%, ficando evidente a grande predominância do sexo masculino, e como consequência, o mercado de trabalho também com predominância masculina. Desta maneira, visando incentivar a Ciência e Tecnologia entre as mulheres, foram realizadas algumas ações nacionais, entre elas um projeto financiado pelo Governo, denominado "Meninas na Ciência". As ações deste projeto tinham como foco principal estudantes do sexo feminino do ensino médio, a fim de incentivá-las para a área de C&T. Também participaram deste projeto, professoras do ensino médio e alunas de cursos de engenharia. Assim, este artigo tem como objetivo principal apresentar e discutir as ações do projeto desenvolvido na Universidade Federal de Santa Catarina e seus resultados. As atividades foram desenvolvidas no laboratório de Inovação e Desenvolvimento de Produtos. As alunas que participaram das atividades demonstraram uma grande motivação e interesse para os assuntos e projetos em que foram envolvidas.

Palavras chave: Mulheres; Ciência e Tecnologia; Engenharia.

1 Introdução

Em 2010, a Confederação Nacional da Indústria (CNI), juntamente com a Pontifícia Universidade Católica do Rio (PUC-Rio) e o Serviço Nacional de Apoio a Indústria (SENAI), descreveu a importância da engenharia no contexto atual: a engenharia revela-se como um instrumento não único, mas de suma relevância para a superação da atual crise mundial. Embora esta se apresente com uma face nitidamente econômico-financeira, envolve uma rede de complexidades que exige soluções para além do escopo deste estudo (Formiga, 2010).

Nesse contexto, há um consenso de que estão faltando profissionais adequados da área de Engenharia para promover, auxiliar e sustentar o crescimento econômico, mesmo que a formação dos futuros engenheiros esteja em constante mudança. Para exemplificar isso, uma Sondagem Especial realizada pelo CNI em 2013 aponta que 63% das empresas dizem que a produção é afetada pela falta de engenheiros (Branco, 2013), o que confronta os 55% de 2010. Além disso, o CONFEA estima que existam hoje no Brasil cerca de 770 mil engenheiros (Confea, 2015), adicionando, ainda, em torno de 40 mil engenheiros que se formam a cada ano. Contudo, a China forma em torno de 650 mil, a Índia 220 mil, e a Rússia 190 mil por ano, demostrando uma grande vantagem em relação ao Brasil.

Afunilando ainda mais, se estima que na região Sul do Brasil existam aproximadamente 130 mil engenheiros, sendo essa, a segunda região com mais profissionais da área no Brasil (perdendo apenas para a região Sudeste). Desse total, 45 mil situam-se no estado de Santa Catarina, sendo apenas 6,5 mil mulheres.

As estatísticas não escondem que as mulheres são minoria na engenharia e a tentativa de diminuir essa diferença de gênero foi a maior motivação deste trabalho. Houve a percepção de que o incentivo através de experiências práticas, com o auxílio de oficinas, equipamentos e projetos de pesquisa poderia despertar o interesse pela área de Ciência e Tecnologia de jovens estudantes do ensino médio. Assim, neste trabalho serão apresentadas e discutidas as ações e resultados do projeto realizado com as jovens estudantes, com o objetivo de incentivá-las para continuar seus estudos na área de tecnologia.

2 Mulheres na Ciência

Em meados do século XVII, quando a tradição mágica ainda fazia um impacto substancial nas camadas populares, a obra de Copérnico, as descobertas de Galileu e Kepler e a filosofia mecanicista triunfaram, trazendo à tona a Revolução Científica. Contudo, nessa época, toda e qualquer mulher que se interessasse pela ciência – principalmente a química – era declarada bruxa, com grandes chances de acabar queimada na fogueira. Outros motivos que fizeram a mulher também se resguardar das áreas científicas foram a origem desses estudos, os quais foram dados em âmbito militar, ou então através de trabalhos pesados, os quais também eram poupados das mulheres (Tosi, 1997).

Em Guerra, Rossi e Peggi (2006) também há referência que algumas cientistas como Maria, a Judia (273 a.C.) alquimista que vivia no Egito e que inventou o processo de banho-maria, se escondiam por trás dos homens por causa dos preconceitos enfrentados. Também nesta linha há Anne-Marie Lavoisier (1758-1836) casada com Antoine Lavoisier, que traduzia os trabalhos de seu marido do inglês para o francês, acompanhava as experiências, fazia anotações e ilustrou inúmeras publicações. A primeira mulher de Einstein, Mileva Maric (1875-1948), física, era quem resolvia os problemas matemáticos para o marido, sendo que para alguns cientistas, ela seria coautora da teoria da relatividade.

Impossível falar da participação das mulheres na ciência sem citar Marie Sklodowska, mais conhecida como Marie Curie (1867 – 1934). Ao lado de seu marido, Pierre Curie, Madame Curie realizou importantes descobertas no campo da radioatividade e encontrou dois novos elementos químicos, o rádio e o polônio. Além de ter sido a primeira mulher a receber um Nobel, Marie foi também a primeira pessoa a ser laureada duas vezes com a honraria: o Nobel de Física em 1903 e o Nobel de Química em 1911.

Contudo, mesmo com alguns exemplos de destaque, as mulheres, segundo o Censo da Educação Superior realizado pelo Inep (2012), nos cursos das áreas de Engenharia, Produção e Construção, dos 3.767 ingressos, apenas 20,8% foram do sexo feminino. Nota-se, nesta pesquisa, que nas áreas de exatas ainda se observa que a predominância é masculina.

Segundo dados do Censo da Educação de 2013, o Brasil contava com cerca de 7,3 milhões de estudantes matriculados em cursos superiores. Na Figura 1, observa-se a distribuição percentual por área. É possível constatar que, na área de saúde e educação, as mulheres aparecem em números expressivos, 76% e 73%, ocorrendo o inverso nas áreas de Ciências (31%) e Engenharia (31%) (Mec, 2015).

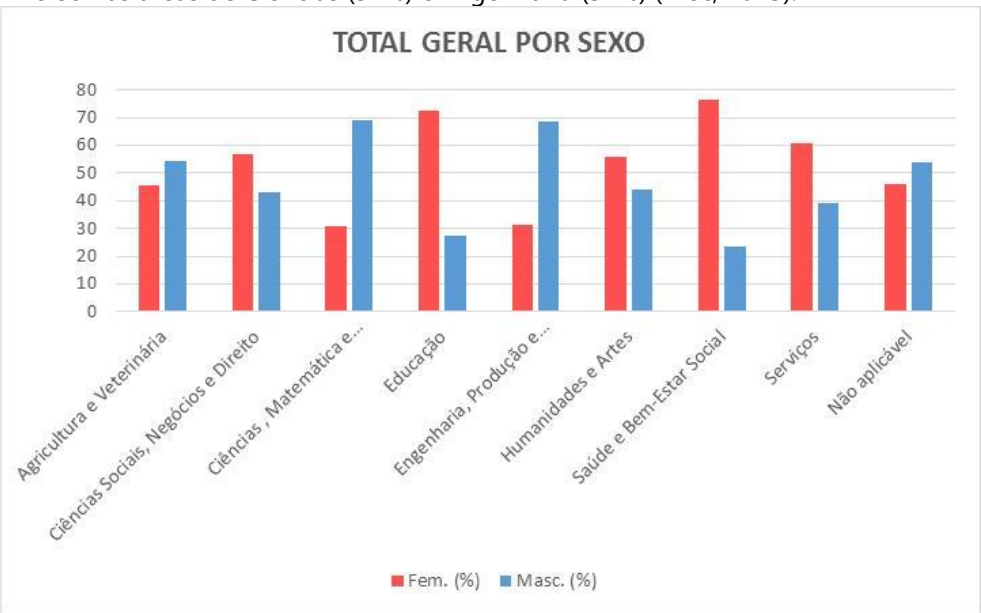


Figura 1. Distribuição de alunos matriculados em Universidade no ano de 2013 no Brasil.

Na Universidade Federal de Santa Catarina, a porcentagem de homens e mulheres, segue a mesma tendência nacional. Segundo dados de 2016, a Universidade possui em torno de 25 mil estudantes matriculados em cursos de graduação. No Centro Tecnológico – CTC, onde estão os cursos de engenharia, cerca de 30% dos matriculados são mulheres, ocorrendo o contrário no Centro de Ciência da Saúde – CCS, com mais de 70% de mulheres, e no Centro de Comunicação e Educação – CCE com 65% de mulheres, como pode ser observado na Figura 2. A Figura 2 nos mostra também, que nos Centros de Filosofia e Humanas- CFH e Centro Socioeconômico – CSE, as distribuições entre homens e mulheres, são semelhantes.

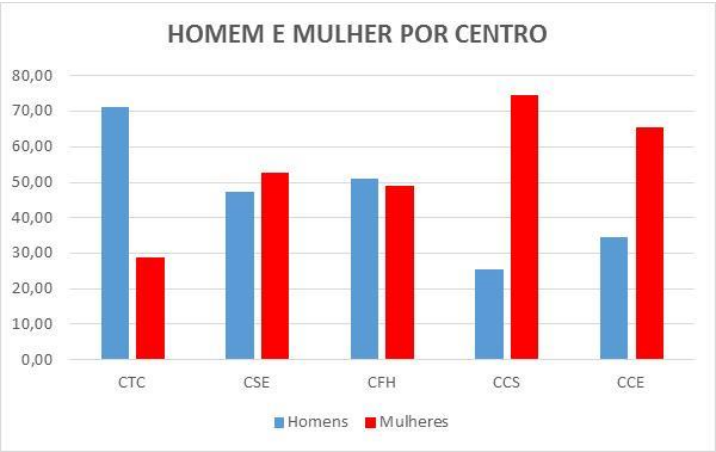


Figura 2. Distribuição dos estudantes por sexo matriculados nos Centros da UFSC.

Estes dados refletem a predominância masculina em alguns cursos e a feminina em outros, motivados talvez por fatores culturais. Desta maneira é muito importante realizar ações para desmistificar esta "herança cultural", demonstrando que a área de tecnologia pode e deve ter participação do sexo feminino.

3 Projeto

Com intuito de motivar estudantes do sexo feminino do ensino médio a desenvolverem pesquisas na área de tecnologia, o projeto Meninas na Ciência foi apresentado na Escola de Educação Básica Oswaldo Aranha (escola pública de Joinville) para que fosse realizada uma seleção com as estudantes interessadas. Após a seleção, as atividades foram realizadas no ano de 2014/2015, com quatro alunas com idades entre 15 e 17 anos. Também foi selecionada uma professora para acompanhar as alunas e uma estudante de engenharia da Universidade, sendo os encontros realizados nas quartas-feiras à tarde, no Laboratório de Inovação e Desenvolvimento de Produtos – LiD.

Nos primeiros encontros realizaram-se uma série de oficinas tecnológicas, ministradas por bolsistas do Laboratório, com kits didáticos e materiais de apoio, para que as alunas pudessem conhecer e interagir com os temas a serem trabalhados futuramente.

A primeira oficina desenvolvida foi sobre pontes, onde as bolsistas foram convidadas a montar diferentes tipos de pontes com kits didáticos, conhecendo assim diversos conceitos básicos de engenharia Civil de Infraestrutura. Na Figura 3a, observam-se as alunas e a professora na oficina de pontes.

A segunda oficina realizada foi sobre jogos, onde o Jogo da Mobilidade foi apresentado para as participantes com intuito de promover a dinâmica em grupo e estimular a aprendizagem de novos assuntos de forma lúdica, envolvendo principalmente noções sobre transporte e logística.

O Jogo da Mobilidade é um jogo de tabuleiro (Figura 3b) que possui dois caminhos distintos que levam ao mesmo objetivo. Cada jogador deve levar uma quantidade de soja de uma cidade para o porto, optando pelo

meio de transporte (rodovia ou ferrovia). No caminho há obstáculos. Ganha o jogo aquele que obtiver o maior lucro (Voigt, 2013).

a) b)

Figura 3. a) Participantes da oficina de pontes e b) jogo da mobilidade.

Outro tema trabalhado nas oficinas foi o de energia, sendo apresentadas as diversas formas de produção e abordando princípios de engenharia. Nestas oficinas foram utilizados kits de Energia Eólica, Solar e Hidráulica (Figura 4).

Figura 4. Oficinas de energia.

A última oficina foi sobre satélites artificiais, sendo discutidos conceitos de física e engenharia para que as participantes compreendessem como estes objetos ficam em órbita, quais são os seus componentes, bem como uma discussão em relação ao lixo espacial. Após a discussão, foi proposta a criação de satélites com materiais recicláveis, com objetivo de colocá-los em órbita através de um simulador. Durante a montagem as alunas observaram que deveriam ter cuidado com detalhes como peso, tamanho e formato (Figura 5).

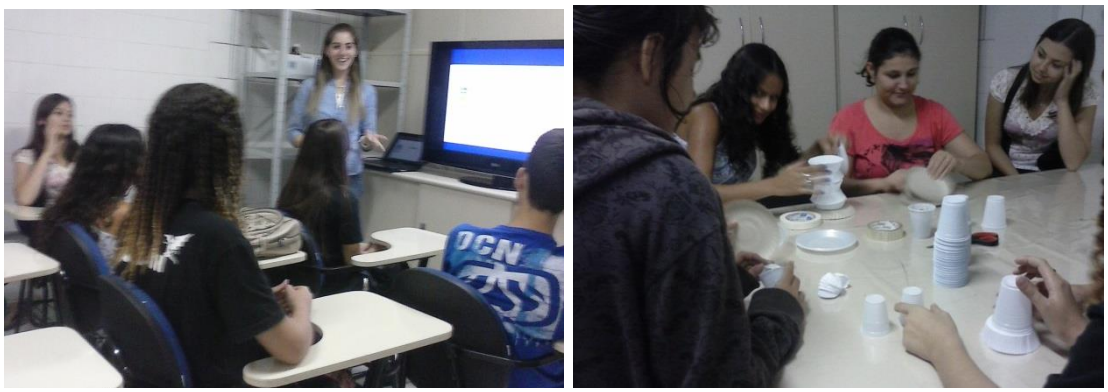


Figura 5. Oficinas de satélites.

Após a realização das oficinas propostas, foram determinados temas para uma pesquisa e apresentados os seus respectivos professores orientadores. Sendo os seguintes temas abordados: Energias sustentáveis, Jogos Educativos e Satélites.

Em paralelo as atividades de pesquisa as bolsistas participaram do Curso Básico de Robótica, desenvolvido ao longo de dez encontros, tendo como objetivo ensinar e apresentar às participantes noções básicas sobre programação em Lego e suas aplicações. Ao final do curso foi proposto um desafio envolvendo a robótica e o meio ambiente. Este desafio constava em desenvolver e programar um robô com peças de lego capaz de realizar a limpeza do Rio Cachoeira, simbolicamente ilustrado em um tablado, com resíduos físicos e químicos no seu leito. O robô deveria ser capaz de percorrer o circuito montado e coletar cada resíduo e deixá-lo no devido local de tratamento. A equipe vencedora seria aquela que o robô coletasse o maior número de resíduos, em menor tempo e com menor número de punições durante a execução do desafio. Tal atividade mostrou a diversidade e possibilidade de inúmeras aplicações da robótica, estimulando os participantes a conheceram mais as inovações tecnológicas que surgem a cada dia.

No decorrer do projeto foram realizadas reuniões para apresentação dos resultados obtidos por cada bolsista em suas pesquisas aos seus orientadores. Tais reuniões também possibilitaram que os orientadores respondessem a possíveis dúvidas e assim pudessem orientar as alunas na continuidade das atividades.

Na sequencia as bolsistas participaram também do Curso de Fabricação Sustentável, com duração estimada de dez encontros, tendo como objetivo apresentar ideias de sustentabilidade e motivar a percepção da vida útil de diversos materiais. Foram estudados desde os diferentes métodos de fabricação até o seu descarte e formas de reciclagem.

No curso, os participantes tiveram a oportunidade de aprender a utilizar um software CAD, desenvolvendo um chaveiro com o tema sustentabilidade, e depois acompanharam a fabricação dos mesmos em uma impressora 3D.

No curso também foram abordados os temas de biomateriais e processos de soldagem e injeção, sendo realizadas aulas de laboratórios. Durante o curso foram realizadas duas visitas técnicas, em uma Cooperativa de Reciclagem, para conscientização do tema de reciclagem. A segunda visita foi realizada em outra cidade, onde os participantes tiveram a oportunidade de conhecer um Museu de Ciência e Tecnologia interagindo com o espaço de tecnologia.

No fim do projeto, as alunas realizaram uma apresentação sobre as atividades de pesquisas desenvolvidas durante o ano aos seus orientadores.

Ao final do projeto também foi solicitada uma avaliação, onde todas as alunas do ensino médio e a professora consideraram as atividades propostas muito interessantes e motivadoras, sendo que todas mencionaram que tem grande interesse em continuar seus estudos na área de Ciência e Tecnologia.

Abaixo alguns relatos:

"O Projeto Meninas na Ciência nos deu muitas oportunidades, conhecer lugares e acima de tudo mudar nossos conceitos. O curso foi de grande valia, acredito que deveria ser oportunizado a outros professores. Durante o projeto ficou claro a motivação dos estudantes ao aprendizado quando o assunto é de interesse dos mesmos".

"Participar do projeto foi muito gratificante e produtivo, pois pude aprender diversas coisas voltadas para a área da engenharia, principalmente nas oficinas que foram realizadas no decorrer de nosso projeto. Tive a oportunidade de apresentar meu trabalho no seminário que ocorreu na UFSC de Florianópolis e pude expor ele na feira de tecnologia da Universidade."

"O curso para mim foi uma chance de ter novas experiências, aprendizados e também a ver com outros olhos a engenharia, o curso despertou meu interesse a novas áreas. Ensinou-me diversas coisas, a como apresentar e pesquisar. As aulas foram no laboratório e a convivência com os professores e bolsistas da UFSC foram ótimos. Foi uma honra participar desse projeto".

4 Conclusão

Ao proporcionar para as estudantes do ensino médio o contato com algumas das atividades desenvolvidas na universidade, buscou-se demonstrar que a ciência e tecnologia pode ser um campo promissor para trabalho, e que não é exclusivamente voltada para estudantes do sexo masculino.

A intenção do projeto Meninas na Ciência foi também de instigar e motivar a produção científica das estudantes do ensino médio, incentivando a entrada das mesmas nos cursos de engenharia e tecnologia. Observa-se que a realização deste projeto influenciou e intensificou a intenção das bolsistas em ingressarem em uma universidade.

Chega-se a conclusão que o desenvolvimento deste projeto proporcionou para as estudantes uma grande carga de conhecimento e visualização das atividades profissionais da área de tecnologia, podendo desta maneira influenciar em suas escolhas futuras. Os objetivos propostos pelo projeto foram atingidos de maneira geral, chegando a bons resultados através da assiduidade e comprometimento de todas as estudantes e da professora, contribuindo desta maneira para proporcionar um maior incentivo de participação das mulheres na ciência.

Agradecimentos

Os integrantes do projeto agradecem ao CNPq e à UFSC pelas bolsas e recursos disponibilizados para execução do projeto.

5 Referências

Branco, F. C. (2013). Falta de Trabalhador Qualificado na Indústria. *Sondagem Especial – Industria de Transformação e Extrativa*. 3(2), outubro.

Confea–Conselho Federal de Engenharia e Agronomia. (2015). *Estatísticas do SIC*. Disponível em: <http://ws.confea.org.br:8080/EstatisticaSic/>. Acesso em novembro de 2015.

Formiga, M. M. M. (2010). *Engenharia para o Desenvolvimento: Inovação, Sustentabilidade e Responsabilidade Social como Novos Paradigmas*. Brasilia: Senai/DN.

Guerra, G.; Rossi, J. C.; Pileggi, M. (2006). *Ciência, substantivo feminino*. São Paulo: CLA.

Inep–Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira. (2012). *Censo da Educação Superior 2012: Resumo Técnico*. Brasilia: INEP.

Mec-Ministério da Educação.(2013). *Relatório de estudantes matriculados em 2013*. Disponível em: <http://www.mec.gov.br>. Acesso em março de 2016.

Tosi, L. (1997). *Mulher e Ciência: a Revolução Científica, a Caça às Bruxas e a Ciência Moderna*. França: Université Pierre et Marie Curie.

Voigt, A. L.; Keller, S. C.; Sacchelli, C. M.; Garcia, T. R. (2013). *Jogo da Mobilidade: Uma nova forma de aprendizagem de conceitos de transportes*. Anais: XLI COBENGE. Gramado: Ed. UFRGS.

Challenges of Maintaining Student Engagement in a 100% PBL Discipline: Evaluating the Percentage of Individual Note and Projects Developed in the Team

Renata L. C. Perrenoud Chagas[1]

[1] Departmento de Engenharia Civil, Centro Universitário Salesiano de São Paulo, Unisal - Lorena, Campus São Joaquim, São PAulo, Brasil

Email: renataperrenoud@hotmail.com

Abstract

This article proposes discussion about motivation and engagement impact on students, comparing the individual assessment percentage composition through differentiated activities and projects in Fluid Mechanical in 2014 and 2105, with different classes, allowing survey about difficulties and successes on PBL methodologies implementing civil and mechanical engineering courses, according to the engineer profile required by the market, providing learning quality gains in project management, teamwork, interpersonal relationships and communication, complementing the students education. Since 2012, the Salesian University Center - UNISAL LORENA has adopted the pedagogic proposal to work with active methodologies focusing on learning process improvements. In this year was created the LMI (Innovative Methodologies Laboratory), which focuses on seeking for new techniques in active methods, study and bring it these new reality to our courses and students, allowing teachers to be multipliers of these methodologies. These methodologies used in 2013 and 2014 were PEER INSTRUCTION (Harvard model by Professor Mazur), TBL (University of Missouri model by Professor Larry Michaelsen) and writing across the curriculum (MIT model, by Professor Jennifer Craig). In the end of 2014, PBL methodology (Based Learning Project, Olin College Model, USA, by Professor Jonathan Stolk and Professor Rui Lima, the University of Minho, Portugal) was implemented in Fluids Mechanical discipline Civil and Mechanical Engineering and taking in semester 70% of review by grade deliverables through projects and 30% by individual assessment. In 2015, there was a changing in this process. There is needs to continuously improvement, comparing and seeking the results, with different weights, to stablish balance and structure disciplines in order to get students engagement.

Keywords: engagement; motivation; projects; evaluation.

Desafios de Manter o Engajamento do Estudante em uma Disciplina 100% PBL: Avaliando o Percentual da Nota Individual e Projetos Desenvolvidos em Time.

Renata L. C. Perrenoud Chagas[1]

[1] Departmento de Engenharia Civil, Centro Universitário Salesiano de São Paulo, Unisal - Lorena, Campus São Joaquim, São PAulo, Brasil

Email: renataperrenoud@hotmail.com

Resumo

Este artigo propõe *discutir* o impacto causado nos estudantes quanto a motivação e engajamento, comparando a composição da avaliação dos alunos através de pesos diferenciados de trabalhos individuais e em times, na disciplina Mecânica dos Fluidos trabalhadas em 2014 e 2105, com turmas distintas, permitindo um levantamento sobre as dificuldades e sucessos na implementação da metodologia PBL em cursos de engenharia civil e mecânica, de acordo com o perfil do engenheiro exigido pelo mercado, proporcionando ganhos de qualidade de aprendizagem em gerenciamento de projetos, trabalho em equipe, relações interpessoais *e* comunicação, complementando a formação do aluno. Desde 2012, o Centro Universitário Salesiano - UNISAL LORENA tem adotado a proposta pedagógica de trabalhar com metodologias ativas, com foco em melhorias no processo de aprendizagem de seus alunos. Neste ano foi criado o LMI (Laboratório de Metodologias Inovadoras), que se concentra em buscar novas técnicas de métodos ativos, estudá-los e trazê-los à realidade de nossos cursos e alunos, permitindo aos professores serem multiplicadores dessas metodologias. As metodologias utilizadas em 2013 e 2014 foram a PEER INSTRUCTION (modelo de Harvard pelo Professor Mazur), TBL (modelo da Universidade de Missouri pelo professor Larry Michaelsen) e a escrita através do currículo (modelo do MIT, pela professora Jennifer Craig). No segundo semestre de 2014, a metodologia PBL (Aprendizagem Baseada em Projetos, modelo de Olin College, EUA, pelo do professor Jonathan Stolk e do professor Rui Lima, da Universidade do Minho, Portugal) foi implementado e trabalhado na disciplina Mecânica dos Fluidos nos cursos de Engenharia Civil e Mecânica, *composta de* 70% da nota do semestre através de projetos entregáveis e 30% da nota para avaliação individual e evolução do aluno. Em 2015, houve uma inversão desse processo. Surge a necessidade de avaliar os resultados dos semestres com os respectivos pesos diferenciados, comparar e buscar um ponto de equilíbrio para estruturar a disciplina de maneira a melhorar o aproveitamento do engajamento dos estudantes.

Keywords: engajamento; motivação; projetos; avaliação.

1 Introdução

O fenômeno da globalização influencia fortemente a estrutura e as práticas das organizações, bem como as percepções e o desempenho dos seus agentes. Neste sentido, o mercado de trabalho vai sofrendo igualmente mutações constantes, atribuindo-lhe uma nova configuração caracterizada pela maior competitividade e instabilidade (LIMA, R. M., 2008)

Surge a necessidade de termos um pensamento diferenciado na comunidade acadêmica para que possamos formar alunos/profissionais que sejam capazes de promover ações e realizar investigações, trabalhar em equipe, gerir problemas e apresentar soluções. Habilidades profissionais envolvem conhecimentos técnicos e capacidade de desenvolver e buscar novos conhecimentos bem como a capacidade de desenvolver atividades seja de pesquisa ou de projetos em grupos (MOHAN et al., 2010).

Com isso, temos que trabalhar de uma maneira diferenciada dentro da Universidade, de modo a despertar em nossos alunos uma visão que possibilite aplicar, na prática, habilidades e competências técnicas necessária à realidade.

A motivação desenvolvida nos estudantes é um fator preponderante para o sucesso da aplicação e desenvolvimento do PBL dentro de uma disciplina, pois o aluno precisa entender os benefícios de trabalhar desenvolvendo conceitos através da aplicação real em projetos. Se há motivação, o aluno tem um maior engajamento na disciplina, consequentemente, consegue melhorar seu desempenho. De acordo com Pintrich

e DeGroot, 1990**,** a auto-aprendizagem é impulsionada por vários elementos primários: motivação para aprender, estratégias cognitivas e metacognitivas e persistência.

O apoio do professor e uma sala de aula com condições climáticas saudáveis são absolutamente essenciais para o desenvolvimento do aluno, e inclinações naturais destes para a aprendizagem podem ser facilmente interrompidas caso não haja suporte. Estudos mostram que a percepção positiva dos alunos na realização autônoma de sua tarefa, quando há suporte docente, podem levar a aumentos na motivação intrínseca, auto-regulação, percepção de competência, interesse, engajamento e desempenho acadêmico (Stolk, J. At al, 2010)

O Centro Universitário Salesiano de São Paulo, Unisal - Lorena, foi credenciado no CDIO em maio de 2016 e possui o NAP (Núcleo de Assessoria Pedagógico), criado em 2003, com a finalidade de assessorar pedagogicamente o corpo docente da instituição. Em 2012, criou-se o LMI (Laboratório de Metodologias Inovadoras), cujo foco é buscar e conhecer novas técnicas de metodologias ativas e trazê-las à realidade dos nossos cursos e nossos alunos, capacitando inclusive, professores para que sejam multiplicadores de tais metodologias. Hoje NAP e LMI (logo mostrado na figura abaixo), atuam conjuntamente de maneira a estruturar pedagogicamente as metodologias ativas em busca de maior motivação aos nossos alunos

Laboratório de Metodologias Inovadoras

núcleo de assessoria pedagógica

Este artigo tem a finalidade de comparar o sistema de avaliação da disciplina Mecânica dos Fluidos 100% PBL, ao se atribuir pesos diferenciados na nota individual e em grupo, através do desenvolvimento de projetos avaliando o desafio de manter o engajamento e a motivação intrínseca dos estudantes nessa relação.

2 Metodologia

Descreve-se de maneira sucinta, o modo ao qual a metodologia foi implementada e os procedimentos metodológicos utilizados durante o processo.

Segundo o modelo de Olin College e seguindo modelo Standard 11 CDIO (avaliação do aprendizado), para desenvolvermos e implementarmos o Project Based Learning em uma disciplina e obter engajamento dos alunos deve-se:

- Considerar diferentes objetivos que podem ser atingidos com projetos.
- Ter atividades para envolver o aluno e levá-lo a atingir as metas.
- Conduzir as atividades a um produto (exemplo um modelo de negócios).
- Avaliar através do desenvolvimento de um processo contínuo.

Seguindo esses princípios, a metodologia PBL foi implementada integralmente na disciplina, tendo sido realizado um estudo prévio, no período de um semestre, por um colegiado a fim de realizar a adaptação da ementa tradicional ao novo modelo, que tem como etapas:

- Levantamento e estudo da ementa original,
- Divisão da ementa em três grupos, focando a aplicação de projetos diferenciados,
- Definição e divisão de conceitos chaves por grupo,
- Definição dos projetos a serem desenvolvidos e estudados durante o semestre,
- Elaboração de um cronograma de atividades a serem cumpridas pelo aluno,
- Processo de Avaliação.

Foi necessário desenvolver uma estratégia de planejamento e comunicação clara com os alunos para que houvesse entendimento sobre o paradoxo de se buscar conhecimento através da curiosidade, do trabalho em equipe em detrimento às aulas expositivas, único processo conhecido, difundido e culturalmente disseminado no Brasil.

3 A Avaliação

Alguns autores, em oposição à concepção autoritária na qual a avaliação é vista como um instrumento disciplinador, gerador de uma aprendizagem de submissão, de dependência e de reprodução social, tem se dedicado a investigar, discutir e propor a avaliação num enfoque crítico, dialético, diagnóstico e formativo (FREITAS, 1995, VASCONCELLOS, 1995; LUCKESI, 1995; dentre outros). Eles questionam as práticas de avaliação vigentes nos sistemas de ensino e suas relações com concepções conservadoras de educação de caráter puramente seletivo e classificatório. Para eles, a avaliação deve ser concebida como ferramenta importante no acompanhamento da aprendizagem do aluno e não mais como instrumento de controle no interior da sala de aula.

Pensando dessa maneira, a avaliação da disciplina em questão, foi elaborada para acontecer ao longo do desenvolvimento das atividades realizadas em sala de aula, do desenvolvimento dos projetos, com enfoque de avaliar o engajamento dos estudantes tanto nas atividades individuais, como nas atividades em grupo. Assim, temos um processo contínuo de acompanhamento, onde são oferecidas atividades aula a aula que são realizadas individualmente ou em grupo e cada uma dessas atividades gera um entregável a ser avaliado.

A ferramenta institucional de apoio é o Moodle (Modular Object-Oriented Dynamic Learning Environment), que é um sistema de administração de atividades educacionais destinado à criação de comunidades *on-line*, em ambientes virtuais voltados para a aprendizagem colaborativa. Este espaço é utilizado para trabalhar listas de exercícios, videos, textos para leitura prévia, enfim, nos auxiliar a direcionar e tutoriar o aluno no seu aprendizado, motivando-o na busca do conhecimento.

O processo avaliativo se deu em dois semestres de dois diferentes anos e com critérios distintos, como mostramos na tabela abaixo:

Tabela 1 - Tabela do percentual da nota individual e em grupo aplicada aos alunos de Mecânica dos Fluidos.

	Percentual da nota da nota	
Ano	Individual	Em Grupo
2014	30%	70%
2015	70%	30%

Houveram fatores que nos levaram a alterar o percentual das notas para observar e comparar os resultados.

4 Resultados Observados

A avaliação semestral da disciplina Mecânica dos Fluidos 100% PBL, divide-se em avaliação individual dos alunos e avaliação dos projetos realizados. Chamamos de avaliação individual todas as atividades realizadas semanalmente em sala de aula, ou atividades realizadas em laboratório com entrega de relatório, listas de exercício, pesquisas, entre outras. Atividades estas, onde o professor guia o aluno em busca do conceito a ser estudado e aplicados na realização do projeto. A avaliação em grupo acontece na elaboração, construção e apresentação dos três projetos que compõem a disciplina.

Ao trabalharmos inicialmente com 30% do percentual da nota individual e 70% do percentual da nota na avaliação dos projetos, observou-se que os alunos não tinham motivação para frequentar as aulas e somente o faziam devido a cobrança de presença. Os projetos eram realizados em grupo de quatro a cinco estudantes e nem todos participavam efetivamente de sua construção.

Surgiu então a preocupação de que sem haver a motivação dos alunos em estarem presentes em sala de aula para um acompanhamento efetivo do professor no desenvolvimento das atividades haveria uma falha na avaliação desse aluno e possivelmente uma falta do conceito em sua formação.

Dessa maneira no semestre seguinte houve uma inversão desse percentual, passando a ser trabalhado 70% do percentual da nota individual e 30 % do percentual da nota na avaliação dos projetos. A tabela abaixo mostra o resultado explícito na média da nota final dos alunos matriculados na disciplina nos curso de engenharia nos anos de 2014 e 2015.

Tabela 2 - Média da Nota final de Mecânica dos Fluidos nas Engenharias.

Curso das Engenharias	Média de notas 2014	Media de notas 2015	Diferença %
Elétrica	7,71	8,1	4,81
Eletrônica	6,27	6,8	7,79
Civil A	6,16	8,28	25,60
Civil B	7,38	7,54	2,12
Mecânica	7,68	7,35	-4,49

Pode-se observar que há um aumento percentual em 4 das 5 classes trabalhadas, sendo que apenas na turma da mecânica houve uma diminuição percentual da média da turma. Essa variação pode ser observada no gráfico abaixo:

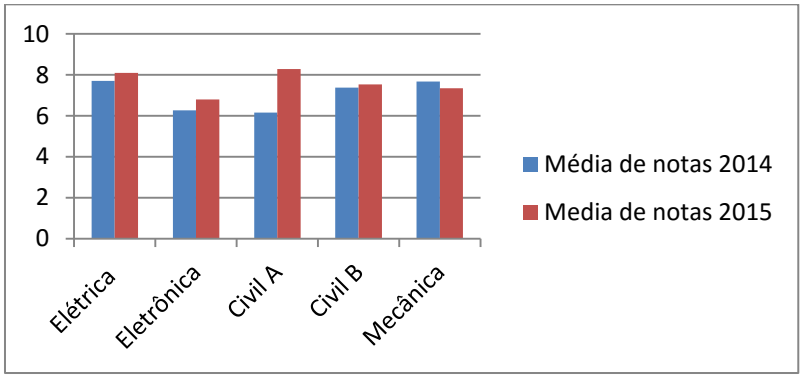


Figura 1 - Gráfico das médias das notas de 2014 e 2015.

Se olharmos para a média das notas por curso e fizermos uma comparação entre os anos de 2014 e 2015, podemos ter a diferença percentual das notas mostrada para cada uma das salas por curso, podendo observar o percentual negativo representado pela turma da Engenharia Mecânica, como mostra a figura abaixo:

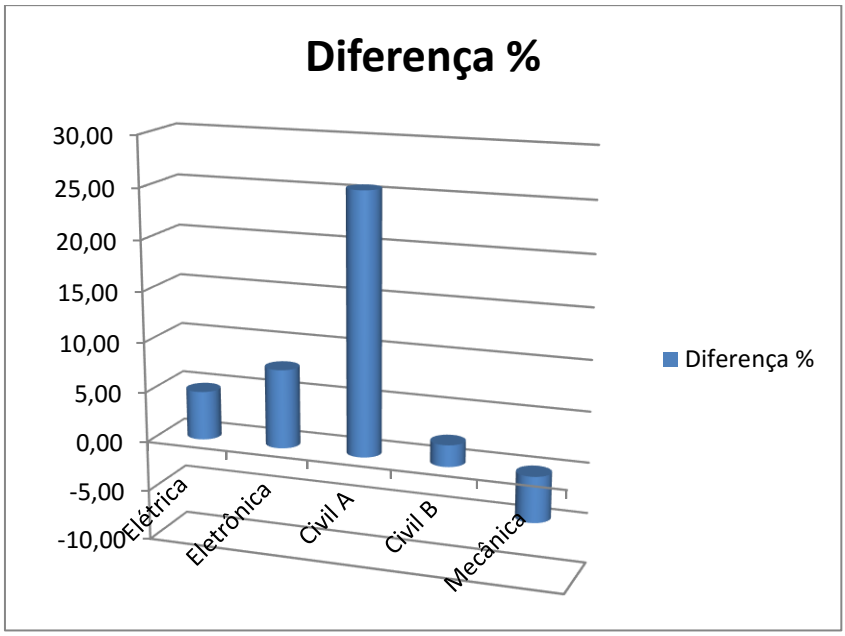


Figura 2 - Diferença percentual entre a média das notas por curso de 2014 para 2015.

Entretanto, vale destacar que de 2014 para 2015, o número de alunos em todos os cursos manteve a mesma média de 55 alunos por curso, sendo que na turma da mecânica, onde mostramos o percentual negativo, houve um aumento expressivo. Em 2014 tínhamos apenas uma turma com 55 alunos e em 2015 a mecânica era composta por uma sala de 87 alunos.

Ao realizar a média aritmética de nota de todos curso das engenharias, podemos observar que a média geral dos curso de engenharia na Unisal Lorena aumentou comparativamente de um para outro apresentando um aumento de 7,54 %.

Tabela 3 - Média geral das notas das Engenharias Unisal Lorena.

Média Geral das Engenharias	Nota
2014	7
2015	7,6
Diferença %	7,54

Com esses dados pudemos fazer as análises dos semestres letivos e chegar a algumas conclusões sobre as diferenças mostradas.

5 Conclusão

A quantidade e velocidade de informação as quais temos acesso hoje, associada a facilidade que a tecnologia nos traz, possibilita uma busca diferenciada pelo conhecimento. Com isso torna-se imprescindível a substituição do modelo de aprendizado clássico pelo modelo de metodologias ativas, onde o aluno sai do papel passivo e se torna ativo, responsável por atingir diferentes níveis de aprendizado.

Avaliar, nos dias de hoje, não é tão simples. Pois com a facilidade que o aluno dispõe de acesso a informação, torna-se necessário pensar em uma avaliação construtiva, que por definição, a própria avaliação venha a contribuir ou faça parte da construção do conhecimento oferecido ao discente.

Sendo assim, observamos que em 2014, o aluno não estava sendo devidamente motivado a construir seu conhecimento, pois o peso da nota do projeto era muito maior do que a contribuição individual. Assim o aluno trabalhava em grupo e não era possível medir com maior precisão o ganho de aprendizado individual.

Ao trabalhar, em 2015, com esse percentual invertido, o aluno teve que focar na presença na sala de aula para realização de trabalhos individuais que eram realizados semanalmente. Consequentemente, na semana

seguinte havia um feedback e um fechamento do assunto trabalhado e o aluno teve que aumentar seu empenho na realização das atividades individuais.

Com isso, nota-se o aumento da média das notas em todas as classes de mecânica dos fluidos de 2014 para 2015 exceto na turma da mecânica. Fato que deve-se ao número de alunos dessa turma ser muito maior em 2015 do que em 2014. Fato este, que dificultou o trabalho mais próximo dos alunos pelo professor.

Entretanto, vale ressaltar que acredita-se que esse percentual trabalhado ainda não é o ideal, pois ao tratarmos o trabalho em equipe, ou seja, a elaboração e apresentação dos projetos com apenas 30% do valor da nota, causa uma certa desmotivação do trabalho, pois o aluno investe tempo e dinheiro para a montagem dos projetos.

Como sugestão para o próximo semestre deve-se buscar um ponto de equilíbrio entre essas valores percentuais, possivelmente 50% para cada uma das etapas.

6 Referências Bibliográficas

Freitas, L. C. (Org.). Crítica da organização do trabalho pedagógico e da didática. Campinas, SP: Papirus, 1995 (Coleção Magistério: Formação e TrabalhoPedagógico) .

Lima, R. M., Mesquita, D., Pereira, G. (2008). Engenharia e Gestão Industrial em Portugal: Uma Visão da Procura Profissional. 5º Congresso Luso-Moçambicano de Engenharia, 2º Congresso de Engenharia de Moçambique, 2-4 Setembro 2008.

Luckesi, C. A avaliação da aprendizagem escolar. São Paulo: Cortez, 1995.

Mohan, A.; Merle, D; Jackson, C; Lannin, J.& Nair, S. S. 2010 Professional Skills in the Engineering Curriculum. IEEE Transactions on Education. November 53(4), 2010

Pintrich, P.R. and DeGroot, E.V., "Motivational and Self-Regulated Learning Components of Classroom Academic Performance", Journal of Educational Psychology, Vol. 82, No. 1, pp. 33-40, 1990.

Stolk, J., Martello, R., Sommerville, M. ando Gueddes, J."Engineering Student's Definitions of and Responses to Self-Directed Learning. INternational Journal Of Engineering. Ed. Vol. 26 N. 4, pp 900-913

Vasconcellos, Celso dos S. Avaliação da aprendizagem: práticas de mudança – por uma práxis transformadora. São Paulo : Libertad, 1998.

Replication of Fluid Mechanical Discipline in Fully PBL Focusing on Student Learning Evolution Assesment

Joselito Moreira Chagas[1]

[1] Electrical Engineering Department, Salesian University Center of Sao Paulo, Campus Sao Joaquim, Lorena, Brazil

Email: joselito.moreira.chagas@gmail.com

Abstract

This article proposes to present a replication model of fully Fluid Mechanical subject in PBL - Project Based Learning in electrical and electronic engineering course at UNISAL LORENA, Brazil, whose project was initiated in 2013. The focus is introducing innovative methodologies for student´s learning continuous improvement with effective application PBL methodology on subject. For effective implementation PBL methodology in the field, it conducted a preliminary study in order to define a student´s systematic assessment throughout all long semester through individual and groups assessment by presented papers and enable feedbacks each one. The subject was divided into three large projects working on key concepts groups, 9 complementary activities involving laboratories, research and studied experiments and 4 individuals studies activities and concepts interpretations and practical experiments analysis. The projects presented by the students had allowed development in subject´s practice concepts, teamwork, hands-on planning and execution project, meeting deadlines, writing and interpretation processes etc., according engineering profile required by the market to solve problems and achieve goals. This article proposes to advance founding in the ideal student's assessment model that working in group, with projects and active learning methodologies. The assessment process is critical to know actual condition about how much students have learned, critical for system feedback and allow continuous improvement throughout all student teaching-learning process. The introduction of new assessment practices will be critical to consolidate the learning model based on projects and their replication.

Keywords: Project development; student assessment; hands-on, teamwork; feedback; formative assessment.

Replicação da Disciplina Mecânica dos Fluidos Totalmente em PBL com o Foco na Evolução do Aprendizado e Avaliação Plena do Aluno

Joselito Moreira Chagas[1]

[1] Departamento de Engenharia Elétrica, Centro Universitário Salesiano de São Paulo, Campus Sao Joaquim, Lorena, Brasil

Email: joselito.moreira.chagas@gmail.com

Resumo

Este artigo propõe apresentar um modelo de replicação da disciplina Mecânica dos Fluidos totalmente em PBL, Project Based Learning, no curso de engenharia elétrica e eletrônica, cuja proposta foi iniciada em 2013 no UNISAL Lorena. O motivo principal está em se trabalhar na proposta pedagógica com a introdução de metodologias inovadoras para a melhoria continua do processo de aprendizagem do aluno, com a aplicação efetiva da metodologia PBL na disciplina. Através de um estudo prévio e planejamento das atividades para definir uma sistemática de avaliação ao longo do semestre, foram propostos projetos e atividades nos principais conceitos para se obter a eficácia da avaliação individual e em grupo e possibilitar constantes feedbacks ao longo de cada projeto. Desta forma, foram definidos 3 grandes projetos de trabalho em grupo, destacando os principais conceitos e respectivas apresentações. Além disso, foram definidas 9 atividades complementares envolvendo laboratórios, pesquisas e resultados de experimentos estudados e 4 atividades individuais de práticas de estudos experimentais para análise e interpretação. Os projetos apresentados pelos alunos proporcionaram o desenvolvimento prático dos conceitos da disciplina, permitiu o trabalho em equipe, exercitou o "hands-on" desde o planejamento até a conclusão do protótipo, o cumprimento de prazos estabelecidos, o desenvolvimento e interpretação de conceitos e processos entre outros. Toda esta estratégia em conformidade com o perfil do engenheiro exigido pelo mercado de trabalho para solucionar problemas e atingir metas. O artigo propõe avançar na busca pelo modelo ideal de avaliação do aluno que trabalha em grupo, com projetos, com metodologias ativas de aprendizagem. O processo avaliativo é fundamental para ter a real condição sobre quanto o aluno aprendeu, para que haja a realimentação do sistema e possibilitar a sua melhoria contínua durante todo o processo de ensino-aprendizagem. A introdução de novas práticas avaliativas será fundamental para consolidação do modelo de aprendizagem baseada em projetos e suas respectivas replicações.

Palavras chave: Desenvolvimento de projetos; avaliação do aluno; trabalhos práticos; trabalho em equipe; feedbacks; avaliação formativa.

1 Introdução

O jovem do mundo de hoje está acessível a um universo de informações inimaginável: redes sociais, banco de dados, acessos a diversos museus e bibliotecas virtuais ao redor do mundo etc., que o torna conectado, informado e perceptivo que ele está no comando da informação existente.

Para eles é comum realizar diversas atividades simultaneamente. Eles efetivaram uma revolução que torna necessário novos sistemas de gestão, buscas por novas formas de aprendizagem. O advento da internet e da grande bolha de dados disponíveis no mundo permitem provocar esta revolução do conhecimento no ciclo de aprendizagem do aluno nas universidades. A necessidade de atenção ao meio ambiente e a sobrevivência do planeta neste século, exige uma formação crítica do jovem, curiosa, que permeie a busca por inovações e sustentabilidade a respeito da vida.

A avaliação da aprendizagem é um processo abrangente da existência humana, que implica uma reflexão crítica sobre a prática, no sentido de captar seus avanços, suas resistências, suas dificuldades e possibilitar uma tomada de decisão sobre o que fazer para superar os obstáculos. É uma forma de acompanhar o desenvolvimento dos educandos e ajudá-los em suas eventuais dificuldades. (VASCONCELLOS, 1995, p. 43).

“Quando tratamos de questões educacionais, a avaliação representa parte fundamental para que o processo de ensino e aprendizagem se concretize. Em uma sala de aula, é perceptível o papel importante desempenhado pela avaliação, elemento que regula as relações professor-aluno-conteúdo. Contudo, embora a avaliação seja parte integrante e indispensável no processo de aprendizagem, muitas dificuldades enfrentadas no dia-a-dia podem ser atribuídas a ela, como a memorização de conteúdos a troco de notas; aulas pouco produtivas em termos de conhecimento trocado entre docentes e alunos; baixo desempenho nas avaliações associado ao medo que estas causam nos alunos, levando a uma avaliação deturpada daquilo que o estudante realmente sabe; entre outras.” (FANELLI, 2012).

Como refere (KNIGHT, 1995), a aprendizagem está no centro da abordagem integral do processo avaliativo do aluno, portanto, uma está indubitavelmente ligada a outra.

A busca por inovação no ambiente acadêmico desafia mantenendores e educadores a estabelecerem novos conceitos e padrões de propostas pedagógicas. Em decorrência deste cenário, investir em novas metodologias de aprendizagem em conformidade com a estratégia pedagógica da IES - Instituição de Ensino Superior, requer visualizar os benefícios reais e concretos que a IES poderá conceber.

A replicação do projeto PBL na disciplina de Mecânica dos Fluidos dos cursos de engenharias elétrica, mecânica, civil e produção no Centro Universitário Salesiano - Unisal Lorena em 2015 é um embrião afim de formatar todo o curso em uma proposta pedagógica diferenciada e alinhada com o cenário atual. É necessário buscar continuamente a melhoria do processo avaliativo de cada disciplina para se maximizar a cada dia o ciclo de aprendizagem do aluno e vislumbrar os benefícios a serem obtidos por alunos e IES.

O objetivo é propor melhorias no processo de avaliação da disciplina Mecânica dos Fluidos para todos os cursos de engenharia UNISAL Lorena, buscar a padronização e atuar para encontrar novas lacunas e corrigir continuamente este processo avaliativo do aluno, afim de instigá-lo a pensar, solucionar problemas, analisar criticamente o ambiente para que esteja em consonância com o papel exigido pela sociedade no século XXI.

2 Desenvolvimento do Trabalho de Avaliação

O Centro Universitário Salesiano – UNISAL LORENA - SP, criado em 2002, em sua estratégia de negócio, tem como proposta pedagógica trabalhar com duas áreas interligadas no desenvolvimento de novas metodologias e abordagens inovadoras, objetivando melhorias no processo de aprendizado de seus alunos:

- NAP– Núcleo de Apoio Pedagógico foca no papel pedagógico da instituição e tem a responsabilidade formativa do docente em seu papel como educador.
- LMI Laboratório de Metodologias Inovadoras - LMI, foi criado em 2012 e seu foco é buscar novas metodologias ativas, conhecê-las, desenvolvê-las e aplicá-las em nossa realidade com o objetivo de formar docentes nesta perspectiva e proporcionar novas oportunidades aos nossos alunos.

Figuras 1 e 2: Logotipos do Laboratório de Metodologias Inovadoras e do Núcleo de Apoio Pedagógico do Unisal Lorena

Linha do tempo das metodologias implementadas e aplicadas no Unisal Lorena:

- 2012: adoção do Peer Instruction - estudo a partir do modelo aplicado em Harvard, pelo Professor Eric Mazur; Team Based Learning - estudo a partir do modelo aplicado na Universidade Central Missouri, pelo

Professor Larry Michaelsen; Writing Across the Curriculum - estudo a partir do modelo aplicado no MIT, pela Professora Jennifer Craig. (Pinto, A. S. S.; Bueno M. R. P.; et all, 2012)

- 2014: Project Based Learning - PBL, estudo a partir do modelo do professor Jonathan Stolk, aplicado em Olin College, na disciplina Mecânica dos Fluidos, disciplina do ensino básico das engenharias do UNISAL, nos cursos de Engenharia Civil, Elétrica, Eletrônica e Mecânica. (Chagas, 2015)
- 2015: Project Based Learning – PBL, replicação na disciplina Mecânica dos Fluidos, nos cursos de Engenharia Mecânica e Elétrica Civil no Unisal Lorena, que é a proposta deste artigo.

O trabalho realizado em 2014 com PBL em Mecânica dos Fluidos foi pioneiro no Unisal e a sua implementação se deu de maneira integrada, com foco em convencer o aluno de que era possível buscar seu conhecimento e desenvolvimento de forma invertida, sendo ele o protagonista de seu aprendizado.

Uma análise crítica feita pelos professores ao final do ano de 2014 possibilitou encontrar 5 fatores importantes para desenvolvimento em 2015:

- Registro integrado de todas as avaliações na plataforma de gestão e avaliação de notas do aluno, que, no Unisal Lorena é o software Moodle;
- Inclusão de fatores avaliativos de participação ativa e postura do aluno na condução de projetos, apresentações, cumprimento de prazos, com reflexo na qualidade final do trabalho apresentado;
- Estabelecer um processo de feedback do aluno para obter sua percepção referente ao aprendizado;
- Customizar projetos para a dimensão de cada engenharia;
- Padronizar o planejamento da disciplina dentro do projeto pedagógico de cada curso.

2.1 Motivação e Estratégia

Foram realizadas reuniões prévias de planejamento entre os professores afim de buscar um processo padronizado desta dimensão de avaliação formativa mais eficiente do aluno para 2015.

A Avaliação Formativa é toda prática de avaliação contínua que pretenda contribuir para melhorar as aprendizagens em curso, qualquer que seja o quadro e qualquer que seja a extensão concreta da diferenciação do ensino. Levam-se em consideração os propósitos estabelecidos por professores e alunos para garantir – se a regulação das aprendizagens (MENDES, 2005).

Ainda, foram definidos os pesos aplicados às atividades apresentadas: 30% da nota final apontada para a avaliação em grupo e 70% da nota final, para atividades individuais. Desta maneira, foram realizadas diversas atividades de pesquisa, questionários, interpretações que contribuíram para a avaliação individual e, o projeto apresentado, considerado o protótipo, a apresentação, o relatório e a participação individual e em grupo como parte da avaliação em grupo.

Neste contexto foram estabelecidas 4 formas avaliativas: projetos apresentados; auto-avaliação do grupo; auto-avaliação individual; avaliação individual.

Assim, foram incluídos questionários auto-avaliativos com perguntas e discussões em grupo para coleta de dados para acompanhamento do PBL aplicado:

a) Pesquisa de auto-avaliação em grupo dos planejamentos realizados e dos projetos apresentados: o objetivo foi proporcionar a cada grupo auto avaliar-se e repensar o que foi apresentado em cada um dos 3 projetos apresentados. Permitiu estabelecer uma discussão interna e proporcionar sua auto-crítica, elogios e oportunidades de melhorias para os projetos seguintes.

O quadro 1 apresenta a tabela auto-avaliativa aplicada aos alunos após a apresentação de cada projeto.

Quadro 1 - auto-avaliação em grupo sobre os respectivos projetos apresentados.

DISCIPLINA MECÂNICA DOS FLUIDOS - AUTO AVALIAÇÃO DO TIME - 2o.ANO ELÉTRICA-ELETRÔNICA - 2015											
02/10/2015	GRUPO 1	GRUPO 2	GRUPO 3	GRUPO 4	GRUPO 5	GRUPO 6	GRUPO 7	GRUPO 8	GRUPO 9	GRUPO 10	GRUPO 11
COMO ESTÁ A QUALIDADE DO NOSSO PROJETO?	4	3	3	4	4	5	3	5	5	3	4
COMO NOS SENTIMOS ACERCA DO NOSSO ENVOLVIMENTO?	3	4	4	5	4	5	3	4	5	4	3
GOSTEI DO PROTÓTIPO CONSTRUÍDO?	5	3	3	5	5	5	5	4	5	3	5
FOI EFICAZ NOSSA COORDENAÇÃO E PLANEJAMENTO DO PROJETO?	4	3	4	4	4	5	4	4	5	4	4
COMO FOI O RELACIONAMENTO DO NOSSO GRUPO?	4	5	5	5	5	5	5	3	5	5	5
ADQUIRIMOS CONHECIMENTO?	5	5	4	5	5	5	4	5	5	4	3

b) Avaliação de cada um dos 3 projetos apresentados no semestre: o objetivo foi estabelecer parâmetros e critérios de avaliação para cada projeto apresentado. Com a padronização do método de avaliação, os alunos tiveram a oportunidade de conhecer o processo avaliativo previamente e construir seus projetos conforme a proposta de trabalho. A divulgação prévia do processo avaliativo padronizados em todas as disciplinas, proporcionou transparência e um processo democrático de avaliação.

O quadro 2 abaixo ilustra a avaliação de cada projeto e protótipo apresentado na disciplina Mecânica dos Fluidos como parte do processo avaliativo realizado em 2015.

Quadro 2: Avaliação de cada projeto e protótipo apresentados.

DISCIPLINA MECÂNICA DOS FLUIDOS - AVALIAÇÃO DOS PROJETOS – METODOLOGIA PBL – 4o. SEMESTRE/2015				
ENGENHARIA ELÉTRICA E ELETRÔNICA				NOITE
NOMES		**PROJETO 1**	**PROJETO 2**	**PROJETO 3**
GRUPO 1		**GUINDASTE HIDRÁULICO**	**DESLOCAMENTO DE MASSA**	**TANQUE COM ESCOAMENTO**
ALUNO 1		Seringas não mostraram variação de pressão no protótipo. Foram apresentados cálculos do protótipo no relatório apresentado. Faltou o video no youtube	Demonstração do deslocamento de massa mergulhado em água e em função do empuxo,através de diferentes corpos imersos	Demonstrar o tipos de escoamentos em mangueiras transparentes e corante
ALUNO 2				
ALUNO 3				
ALUNO 4				
ALUNO 5				
CRITÉRIOS DE AVALIAÇÃO DOS PROJETOS NOTA		**PROJETO PASCAL**	**PROJETO EMPUXO E ARQUIMEDES**	**PROJETO NÚMERO DE REYNOLDS**
		(0 a 10)	(0 a 10)	(0 a 10)
APRESENTAÇÃO	Comunicação	8,5	5	6
	Postura (x2)	8	4	6
	Participação dos membros	8,5	4	6
PROTÓTIPO	Qualidade e esmero na construção	7,5	4	6
	Criatividade (x2)	7,5	1	5
	Relevância	8,5	6	8
RELATÓRIO	Fundamentação Teórica	9	5	6

	Dados e cálculos do protótipo (x2)	8,5	4	4
	Reflexão e análise crítica	8,5	4	5
	Formatação e organização da estrutura	8	5	6
	Adequação aos objetivos	8	5	7
NOTA FINAL		**8,18**	**4,00**	**5,71**

c) Acompanhamento das avaliações da disciplina ao longo do semestre: ficou definido junto aos alunos que a plataforma Moodle seria o site oficial de postagem dos relatórios e arquivos a serem avaliados e das respectivas notas apontadas a cada atividade. Foram trabalhados 17 tipos de avaliações ao longo do semestre divididas entre planejamento, pesquisa, laboratórios, apresentação e auto-avaliação. Também definido junto aos alunos que as notas e resultados de cada atividade seriam divulgadas com prazo máximo de 1 semana após a entrega da ação, o que permitiu o acompanhamento do aluno da sua evolução ao longo do semestre.

O quadro 3 abaixo resume todo o processo avaliativo aplicado na disciplina Mecânica dos Fluidos.

Quadro 3 – Resumo das avaliações aplicadas na disciplina de Mecânica dos Fluidos no Unisal Lorena em 2015.

	NOTAS																	MÉDIA
	LAB	PESQUISA	PLAN	LAB	PROJ	PLAN	AVALIAÇÃO	PESQUISA	PESQUISA	PROJ	PLAN	PESQUISA	PESQUISA	LAB	LAB			
NOME DO ALUNO	FONTE DE HERON	QUESTIONÁRIO SOBRE PRESSÃO - MOODLE	Planilha 5W2H PROJETO I	LAB LATA DE COCA	PROJETO 1 - PASCAL	PLANILHA 5W2H PROJETO II	DISCUSSÃO DO PROJETO II - 2/10	ANÁLISE EXERCÍCIOS DE EMPUXO - 9/10	ENTENDA O EMPUXO	PROJETO 2 - ARQUIMEDES	PLANILHA 5W2H PROJETO III	PESQUISA: O QUE É PRESSÃO ESTÁTICA, DINÂMICA, VAZÃO	EXERCÍCIO DE VAZÃO - LABORATÓRIO	CÁLCULO DO NÚMERO DE REYNOLDS	EXPERIMENTO DA BOLA DE PING PONG - ESCOAMENTO DE AR	PROJETO 3 - No. DE REYNOLDS	NF	SEMESTRE
Aluno 1	10,0	10,0	10,0	10,0	9,8	7,0	10,0	10,0	10,0	7,1	0,0	10,0	10,0	10,0	0,0	6,1	8,1	8,0
Aluno 2	8,0	0,0	10,0	0,0	8,6	10,0	10,0	10,0	10,0	8,0	0,0	8,0	10,0	10,0	10,0	7,6	7,6	7,5
Aluno 3	10,0	0,0	10,0	10,0	9,6	10,0	10,0	10,0	10,0	8,0	0,0	0,0	10,0	10,0	10,0	9,6	8,1	8,0
Aluno 4	0,0	10,0	7,0	10,0	8,5	10,0	0,0	10,0	10,0	6,2	0,0	0,0	10,0	8,0	10,0	7,4	6,8	7,0
Aluno 5	8,0	0,0	10,0	10,0	8,6	10,0	10,0	10,0	10,0	6,3	0,0	6,0	10,0	10,0	0,0	6,1	7,2	7,0

3 Resultados

Os aspectos diretos que influenciaram este estudo estão diretamente ligados a tornar o aluno protagonista do seu conhecimento e convencê-lo a aceitar a nova concepção de ensino – aprendizagem através da metodologia ativa. Desta maneira, a devolutiva sistemática da nota individual possibilitou catalisar este convencimento, pois permitiu a ele o discernimento de que é totalmente responsável pelos resultados apresentados. Assim, eliminam-se reclamações, e discordâncias dos critérios de avaliação adotados. A seguir são apresentados os resultados das 4 formas avaliativas definidas para 2015.

3.1 Aproveitamento do Aluno

Em 2015, na engenharia elétrica e eletrônica do Unisal Lorena houve um total de 58 alunos matriculados na disciplina Mecânica dos Fluidos. Deste total, 56 alunos foram aprovados, totalizando 96,55% de aproveitamento da turma nesta disciplina.

3.2 Auto-avaliação referente aos projetos apresentados

O objetivo foi observar quanto o aluno esteve satisfeito ao final de cada projeto com o resultado do seu trabalho apresentado.

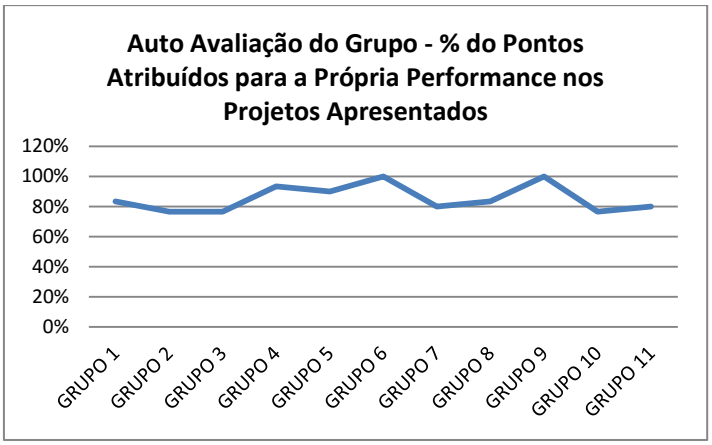


Figura 3: Gráfico de auto-avaliação de cada grupo sobre o respectivo grau de satisfação com os projetos apresentados.

O gráfico abaixo apresenta a resposta de cada grupo sobre sua percepção acerca do conhecimento adquirido no projeto 1, Leis de Pascal, onde 63% dos grupos informaram que estavam 100% de acordo com o conhecimento proposto, nota 4 de uma régua entre 4 e 5, 27% dos grupos apontaram nota 4 e responderam que tiveram um bom aproveitamento do conhecimento proposto e somente 1 grupo atribuiu nota 3 para aquisição satisfatória de conhecimento.

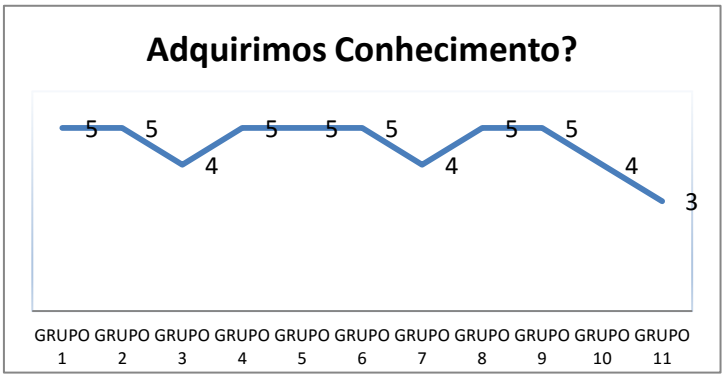


Figura 4: Gráfico de auto-avaliação em grupo com sua visão acerca do conhecimento proposto em cada projeto.

O quadro 4 abaixo representa a auto-avaliação crítica referente à participação ativa do indivíduo dentro do time. Todos apontaram notas individuais à contribuição maior ou menor de cada um para o sucesso do projeto. Foram avaliados critérios como empenho, dedicação, responsabilidade, aprendizado e desenvoltura. Foram apontadas 42% de notas não 10, o que mostra uma oportunidade de exploração destes dados de forma a estratificar informações preciosas para melhoria deste processo. Como observações dos alunos surgiram palavras como "dedicado", "proativo", "cumpriu as tarefas", "pontual", "faltou maior dedicação", entre outras e nos remete a uma condição onde a auto-crítica, se bem explorada, pode ser ainda mais rica em informações a respeito do resultado do projeto concluído.

Quadro 4 – Resumo das notas apontadas pelos integrantes de cada grupo ao demais alunos do grupo

ATRIBUIÇÃO DE NOTAS	No. NOTAS	PONTUAÇÃO	PORCENTUAL
NOTAS 10	102	1.020	58%
NOTAS 9	39	351	22%
NOTAS 8	16	128	9%
NOTAS 7	15	105	8%
NOTAS 6	5	30	3%
TOTAL	177	1.634	100%

4 Conclusões

A replicação do PBL no curso de engenharia do Unisal nos desafia a dar passos importantes e consolidados na direção de perpetuar este modelo para o século XXI. Em consonância, o curso também atende o Standard 11 CDIO (Conceive, Design, Implement, Operate), no qual foi inserido em maio de 2016.

Desta maneira concluimos que o nível de aprovação dos alunos na disciplina é extremamente significativo comparado com os resultado obtidos em 2013 e em 2014 (Chagas, 2015). Segundo a pesquisa, o grau de conhecimento adquirido é satisfatório quando se obtém o feedback do aluno, o que contribui para a consolidação e a multiplicação do modelo dentro da universidade. Os critérios bem definidos de avaliação dos projetos e devidamente divulgados e alinhados entre todos, minimiza a questão da reclamação e da isenção da culpa por parte do aluno. O acompanhamento sistemático de cada nota minimiza e suaviza o impacto reativo e refratário sobre o novo processo de ensino-aprendizagem, sendo o aluno o próprio protagonista de seu aprendizado. O grau de satisfação de cada grupo, segundo o gráfico da figura 3 aponta uma média de 85% de satisfação própria com os resultados dos trabalhos apresentados. Esta satisfação pode ser usada em prol de explorar o modelo PBL para consolidar e perpetuar o modelo no Unisal. E a plataforma Unisal, o portal Moodle de gerenciamento da disciplina junto ao aluno, deve continuar sendo a ferramenta mais importante para manter o aluno informado, atualizado e ciente do seu papel para a sua condução ao longo do curso.

Em contrapartida, remetemos algumas reflexões e passos necessários para a evolução contínua deste processo: replicação do PBL para outras disciplinas técnicas nas engenharias Unisal; revisão do projeto pedagógico de curso (PPC) de cada engenharia, para incluir o conceito de sala de aula invertida e uso das metodologias ativas em diversas outras disciplinas; consolidar a pesquisa de auto-avaliação para todos os cursos e alunos das engenharias Unisal; desenvolver uma ferramenta de auto-avaliação individual e em grupo para estratificar informações importantes sobre o desempenho e a postura do aluno e realimentar o processo avaliativo como melhoria continua; construir e proporcionar espaços dedicados à realização do PBL (espaços makers).

O grande diferencial que esta metodologia proporciona é desenvolver o aluno para solucionar problemas, trabalhar com adversidades e isso o tira de sua zona de conforto. Em contrapartida, mantê-lo informado sistematicamente sobre os resultados, sua evolução e o andamento do seu aproveitamento ao longo da disciplina, força-o a assumir seu papel de protagonista nesta nova abordagem de ensino-aprendizagem. Padronizar este processo em uma disciplina 100% em PBL requer planejamento, engajamento, organização e cumplicidade dos docentes para se obter o pleno aproveitamento do aluno.

5 Referências Bibliográficas

Mendes, O.M. Avaliação Formativa no Ensino Superior: reflexões e alternativas possíveis. In: VEIGA, I.P.A. Currículo e Avaliação na Educação Superior. Araraquara: Junqueira & Marin, 2005, p. 150-175.

Fanelli, Marina A. A avaliação formativa sob o olhar de professores do Ensino Superior. Monografia apresentada ao Curso de Ciências Biológicas da Universidade Presbiteriana Mackenzie, como parte dos requisitos para a obtenção do diploma em Licenciatura Plena em Ciências Biológicas. 2012. Brasil

Knight, P. Assessment for learning in higher education . London: Kogan Page. 1995.

Chagas, Renata L. C. P. The Impact to Implement a Model of Discipline in 100% PBL (Project Based Learning). Paper from PAEE 2015, San Sebastián, Spain.

Inova Engenharia (2006). Propostas para a Modernização da Engenharia no Brasil. Confederação Nacional da Indústria CNI, Serviço Nacional de Aprendizagem Industrial (SENAI) e Instituto Euvaldo Lodi (IEL). Brasília.

Stolk, Jonathan (2014). Student motivations as predictors of high-level cognitions in project-based classrooms.

Vasconcellos, Celso dos S. Avaliação da aprendizagem: práticas de mudança – por uma práxis transformadora. São Paulo: Libertad, 1998.

Pereira, D. A. R. A avaliação das aprendizagens no ensino superior na perspectiva dos estudantes: um estudo exploratório. 2011. Dissertação (Mestrado em Ciências da Educação) – Universidade do Minho, Portugal, 2011.

Pinto, Antonio. S. S.; Bueno,Marcilene R. P.; et all. Inovação Didática – Projeto de Reflexão e Aplicação de Metodologias Ativas de Aprendizagem no Ensino Superior: Uma Experiência com "Peer Instruction". Lorena – SP – Brasil, 2012.

Interdisciplinary Project Applied in the Industrial Engineering – Result of the Proposed *Copaker* Services

Lucio Garcia Veraldo Junior[1,2], Bianca Soares Lucio[1], Danillo Vicente Silva[1], Karine Boirges de Oliveira[1], Jorge Muniz Junior[2], Messias Borges Silva[2,3]

[1] Department of Industrial Engineering, Salesian University Center of Sao Paulo, Lorena, Brazil
[2] Department of Industrial Engineering, State University of Sao Paulo, Guaratinguetá, Brazil
[3] Department of Industrial Engineering, University of Sao Paulo, Lorena, Brazil

Email: lucioveraldo@gmail.com, bianca.soares.lucio@gmail.com, danillovicente@hotmail.com, karineborges.eng@gmail.com, jorgemuniz@feg.unesp.br, messias@dequi.eel.usp.br

Abstract

In front of a demanding market, the qualification of professionals and the practice experienced during the undergraduate course, makes the academic setting should be re-evaluated as the use of methods to establish activities related to day to day professional work. Include interdisciplinary projects in the learning process provides a student development that goes beyond the acquired knowledge; also develop up the skills expected for the profession according to the proposal of each project. This study is a private higher education institution in Brazil forefront in the use of active methodology in teaching applied in the course of production engineering. Thus, it presents Project Led Education (PLE), teaching methodology that through a project integrating disciplines for a specific term. This project, held on the 8th without the course of the outsourcing process of packing of promotional items of a true company and students, is the idealization of an operational and commercial proposal for copaker. The following information was provided: Mounting records of packaging; sales forecast of items; income and current contractor productivity. The aim of the article is the overview of the interdisciplinary project, from proposal characterized by teachers, including how to follow up the results of the students, detailing their best second written report and oral presentation. Another important result is the contribution of each discipline of that relevant half the established project. Finally, it presents the evaluation process of the project, both in skills and in acquired knowledge in order to further research in other interdisciplinary projects of the course.

Keywords: Interdisciplinary Project; Competence; Industrial Engineering; Copaker; Standard 5 CDIO.

Projeto Interdisciplinar Aplicado na Engenharia de Produção – Resultado da Proposta de Serviços *Copaker*

Lucio Garcia Veraldo Junior[1,2], Bianca Soares Lucio[1], Danillo Vicente Silva[1], Karine Boirges de Oliveira[1], Jorge Muniz Junior[2], Messias Borges Silva[2,3]

[1] Department of Industrial Engineering, Salesian University Center of Sao Paulo, Lorena, Brazil
[2] Department of Industrial Engineering, State University of Sao Paulo, Guaratinguetá, Brazil
[3] Department of Industrial Engineering, University of Sao Paulo, Lorena, Brazil

Email: lucioveraldo@gmail.com, bianca.soares.lucio@gmail.com, danillovicente@hotmail.com, karineborges.eng@gmail.com, jorgemuniz@feg.unesp.br, messias@dequi.eel.usp.br

Resumo

Diante de um mercado exigente, a qualificação dos profissionais quanto a pratica vivenciada durante o curso de graduação, faz com que o cenário acadêmico deva ser reavaliado quanto ao emprego de métodos que estabeleçam atividades relacionadas ao dia a dia do trabalho profissional. Incluir projetos interdisciplinares no processo de aprendizagem proporciona um desenvolvimento do aluno que vai além do conhecimento adquirido; desenvolvem-se também as competências esperadas para a profissão segundo a proposta de cada projeto. Este estudo trata de uma instituição de ensino superior privada que está na vanguarda brasileira quanto à utilização de metodologia ativa no ensino aplicado no curso de engenharia de produção. Dessa forma, apresenta o *Project Led Education* (PLE), metodologia de ensino que através de um projeto, integra disciplinas de um período letivo específico. O referido projeto, realizado no 8° sem do curso, parte da terceirização do processo de embalagem de itens promocionais de uma empresa verídica e aos alunos, consiste na idealização de uma proposta operacional e comercial de *copaker*. Foram disponibilizadas as seguintes informações: fichas de montagem das embalagens; previsão de vendas dos itens; rendimento e produtividade atual da contratante. Assim, o objetivo do artigo está na descrição geral do projeto interdisciplinar, desde a proposta caracterizada pelos professores, incluindo forma de acompanhamento, até os resultados dos alunos, detalhando o melhor deles segundo relatório escrito e apresentação oral. Outro resultado importante está na contribuição de cada disciplina do referido semestre pertinente ao projeto estabelecido. Por fim, apresenta o processo de avaliação do projeto, tanto nas competências quanto no conhecimento adquirido, no intuito de futuras pesquisas em outros projetos interdisciplinares do curso.

Palavras Chave: Projeto Interdisciplinar; Competências; Engenharia de Produção; Standard 5 CDIO.

1 Introdução

A educação está em constante evolução para o aprimoramento da aprendizagem. É extremamente importante verificar a melhor forma de aprender, combinando assim, atividades de desafios, lideranças, trabalho em grupo e informações contextualizadas. Segundo Gemignani (2012) estão acontecendo grandes mudanças curriculares nas disciplinas escolares para a interdisciplinaridade, além de apresentar novas estratégias de ensino incluindo às metodologias ativas considerando assim, um novo desafio para a formação de professores do futuro, futuro este cada vez mais presente.

Como forma de utilizar métodos ativos no ensino, os cursos de engenharia do Centro Universitário Salesiano de São Paulo (UNISAL), em sua unidade Lorena (SP - Brasil) estabelecem em sua matriz curricular, projetos interdisciplinares ao longo de todo o curso, envolvendo o máximo de disciplinas do respectivo semestre. Nos quatro primeiros, os projetos são básicos a todos os cursos devido à similaridade das disciplinas. Para os quatro últimos, os projetos são específicos de acordo com a modalidade da Engenharia (Civil, Computação, Elétrica, Eletrônica, Mecânica e Produção).

A aplicação de projetos interdisciplinares na grade curricular dos cursos de Engenharia vem do compromisso da Instituição estudada, em desenvolver a integração das disciplinas mostrando a abrangência e principalmente a conexão entre os conteúdos. Esta responsabilidade é caracterizada pelo Standand 5 da Iniciativa CDIO - Concive (Conceber), Design (Projetar), Implement (Implementar) e Operate (Operar), organização mundial englobando conceituadas instituições de ensino para o desenvolvimento do curso de

engenharia através de projetos, da qual o UNISAL Lorena (campus São Joaquim) passou a ser membro em maio de 2016 sendo pioneira no Brasil.

Segundo Crawley *et al* (2008), as experiências na aplicação dos projetos apresenta uma gama de atividades da engenharia considerada centrais para o processo de desenvolvimento de novos produtos e sistemas trazendo aspectos relevantes do projeto conceitual desde a fase de concepção. Os alunos desenvolvem produtos, processos e habilidades de construção do sistema, bem como a capacidade de aplicar a ciência da engenharia do básico ao avançado em termos de sua abrangência, complexidade e sequência no programa. Oportunidades para conceber, projetar, implementar e operar os produtos, processos e sistemas também podem ser incluídos nas atividade extracurriculares necessárias, por exemplo, projetos de pesquisa de graduação e estágios.

Sendo assim, este artigo tem como objetivo principal mostrar a aplicação de um destes projetos, realizado no 8° semestre no curso de Engenharia de Produção, no qual, os grupos formados por alunos, deveriam idealizar uma proposta operacional e comercial de prestação de serviço de *copacker (serviço de empacotamento dos produtos por contração do filme de embalagem através de processo térmico)* na terceirização do processo de embalagem de itens promocionais para uma empresa multinacional, a partir de dados reais fornecidos pela mesma.

Desta forma, será apresentado no tópico 2, uma breve conceituação de metodologias ativas com o aprofundamento em projetos interdisciplinares, incluindo o PLE (*Project Led Education*). No tópico seguinte será apresentada a proposta aos alunos para realização do projeto informando os detalhes que deveriam ser utilizados. No tópico 4, serão apresentados os resultados que os alunos obtiveram. Por fim, serão destacadas as considerações finais.

2 Metodologias Ativas de Ensino Aprendizagem

Para Morán (2015) é muito importante que as metodologias de ensino aprendizagem sejam acompanhadas por objetivos pretendidos pela instituição e aprendizagem aos alunos. Se a instituição quer que seus alunos sejam pró-ativos, é necessário adotar metodologias em que os mesmos se envolvam em atividades, com cada vez mais interesse, em que tenham que tomar decisões e avaliar os resultados, com apoio de materiais relevantes para autoconhecimento.

Uma metodologia ativa de ensino aprendizagem acaba por ser uma concepção educacional que estimula a aprendizagem em processos de desafios construtivos onde se torna como uma aprender-ação, pois, quanto mais aprendemos o que está mais próximo da vida, melhor nos tornamos e isto acaba sendo o ponto de partida para o avanço em processos, desenvolvimentos, inovação e tecnologia assim criando uma reelaboração de novas práticas.

Segundo Gemignani (2012) o professor tem um papel importante, que é permitir que o estudante aprimore e melhore a visão de forma independente e autônoma, pois requer um esforço para ambos no sentido de verificar modelos e cenários de ensino, assim utilizando também as metodologias baseadas em problemas, conhecida como Aprendizagem Baseado em Problemas (ABP).

Ainda segunda Gemignani (2012), esta metodologia caracteriza-se pela busca de informações sobre o problema escolhido com alguns componentes que são fundamentais para o sucesso de aprendizagem como uma sistematização da metodologia com algumas etapas, como as seguintes: observação da realidade; pontos chaves; teorização; hipóteses de solução; aplicação à realidade. Estas etapas são apenas um caminho no qual é articulado à participação individual e em grupo, sendo assim, uma equipe desenvolve a capacidade de acompanhar, mediar, analisar, verificar as necessidades, resultados e lacunas nos projetos em se que envolvem.

2.1 Projetos Interdisciplinares

O objetivo do projeto interdisciplinar é desafiar os estudantes a desenvolverem soluções criativas para problemas que eles enfrentarão em seu cotidiano no mercado de trabalho. Em conjunto com as metodologias ativas de ensino, os projetos interdisciplinares são cada vez mais utilizados pelas instituições de ensino. O

sucesso do projeto é proporcional ao empenho que os estudantes aplicam no desenvolvimento do mesmo, através da utilização de materiais didáticos, consultas aos professores das disciplinas envolvidas e conversas realizadas entre os integrantes do grupo. Quanto maior o envolvimento de todos, maior o aprendizado e o sucesso na apresentação final do projeto.

A interdisciplinaridade surgiu nos anos 70 como resposta às necessidades de uma abordagem mais integradora da realidade. Ainda que muitas vezes esteja associada a modismo ou à realização de projetos apenas aparentemente ou pseudo-interdisciplinares na área da educação, ela nasce da hipótese de que, por seu intermédio, é possível superar os problemas decorrentes da excessiva especialização, contribuindo para vincular o conhecimento à prática (Dencker, 2002).

Para Tavares (1999) o caminho interdisciplinar é amplo no seu contexto e nos revela um quadro que precisa ser redefinido e ampliado. Tal constatação induz a reflexão sobre a necessidade de professores e alunos trabalharem unidos, se conhecerem e se entrosarem para juntos vivenciarem uma ação educativa mais produtiva. O papel do professor é fundamental no avanço construtivo do aluno. É a partir dele que o professor pode captar as necessidades do aluno e o que a educação lhe proporcionar. A interdisciplinaridade do professor pode envolver e modificar o aluno quando ele assim o permitir.

A interdisciplinaridade corresponde a uma nova consciência da realidade, a um novo modo de pensar, que resulta num ato de troca, reciprocidade e integração entre áreas diferentes de conhecimento, visando tanto a produção de novos conhecimentos, quanto a resolução de problemas, de modo global e abrangente. (Favarão & Araújo, 2004).

Para Lück (2001) interdisciplinaridade é o processo de integração e engajamento de educadores, num trabalho conjunto, de interação das disciplinas do currículo escolar entre si e com a realidade, de modo a superar a fragmentação do ensino, objetivando a formação integral dos alunos, a fim de que exerçam a cidadania, mediante uma visão global de mundo e com capacidade para enfrentar os problemas complexos, amplos e globais da realidade.

2.2 Project Led Education (PLE)

Para Alves *et al*. (2007), o Project Led Education (PLE) é uma metodologia onde as equipes de estudantes devem desenvolver projetos abertos ou propostos pelo curso, contendo como base no conteúdo todos ou quase todas as matérias do semestre.

Segundo Franzen *et al*. (2013), o PLE consiste em uma metodologia de aprendizagem ativa baseada em projetos desenvolvidos a partir de um problema recorrente na área de atuação profissional do engenheiro. Assim, os projetos desenvolvidos no PLE permitem que o estudante já chegue ao campo profissional com algum conhecimento prático e, também, com todas as questões que vão além da atuação profissional, como os domínios da responsabilidade e gestão de tempo e pessoas. Ainda segundo os autores, a metodologia apresentada tem o caráter ativo e colaborativo, tendo assim um novo processo de ensino-aprendizagem, onde numa articulação direta entre a teoria e a pratica, colocando assim um projeto onde tem o profissional/real.

3 Proposta do Projeto

Projeto Interdisciplinar aplicado no curso de Engenharia de Produção, especificamente à turma do 8º Sem letivo no ano de 2015, consiste em idealizar uma proposta operacional e comercial de serviços de *copacker*, para uma conhecida empresa multinacional, a partir de dados reais fornecidos pela mesma. O trabalho deveria desenvolvido em grupos, com formação feita de livre escolha entre os alunos, e com as ações coordenadas pelos professores das disciplinas participantes do projeto com a respectiva contribuição de aprendizado de cada uma delas, que seguem na tabela 1.

A disciplina "Planejamento, Programação e Controle da Produção II", definida como a integradora do projeto, é tida como estruturante na formação do egresso do Curso de Engenharia de Produção. O projeto alinha-se aos objetivos do curso e ao perfil pretendido do egresso quanto às competências: análises qualitativa e quantitativa, comunicação, oportunidade, aprender sempre, trabalho em grupo, contexto, projeto e diagnose.

A adoção do modelo de aprendizagem centrado em projeto consiste numa metodologia que enfatiza o trabalho em equipe, a resolução de problemas interdisciplinares e a articulação teoria e prática, que culmina com a apresentação de uma situação real, relacionada com o futuro contexto profissional. A ênfase é a aprendizagem do aluno e o seu papel ativo neste processo, a fim do desenvolvimento não só de competências técnicas, mas também de competências transversais.

Tabela 1. Contribuição das disciplinas no Projeto Interdisciplinar.

Disciplina	Contribuição
Custos Gerenciais	Custos operacionais e gerenciais. Plano financeiro de negócio.
Ergonomia e Saúde	Layout, ergonomia dos postos de trabalho. Instruções de trabalho
Gestão da Qualidade II	Controle e gestão da qualidade. Plano de inspeção.
Logística e Administração de Materiais	Sistemas de controle de insumos puxado ou empurrado, logística indoor, movimentação e armazenamento de materiais
Planejamento, Programação e Controle da Produção II	Análise da capacidade, dimensionamento e balanceamento de linha, planejamento, produtividade, layout, controle da produção.

O objetivo geral do projeto foi de formular uma proposta de terceirização de serviços de *copacker* nas dimensões operacional e comercial. Para tanto, foram também definidos objetivos específicos, tais como:

- Definir uma proposta de layout da linha de embalagem e respectivo balanceamento;
- Dimensionar o quadro funcional incluindo cargos operacionais e de supervisão;
- Apresentar o custeio dos serviços e precificação;
- Formular uma apresentação comercial da proposta.

De caráter exclusivamente didático-pedagógico, os dados, desenhos, especificações, textos e quaisquer outras informações, em qualquer meio em que estejam registrados, fornecidos durante o trabalho, foram tratados como material reservado e confidencial. Foi absolutamente vedada a sua utilização, reprodução ou divulgação, por qualquer meio, a terceiros.

3.1 Processo de avaliação dos projetos

O projeto foi avaliado de forma continuada, tanto no mérito das competências do engenheiro de produção quanto no conhecimento adquirido, sendo:

- Avaliação inicial individual das competências dos alunos participantes do projeto;
- Avaliação intermediaria da equipe nas competências dos alunos participantes do projeto;
- Avaliação avançada individual (30%) do conhecimento adquirido dos alunos participantes do projeto;
- Avaliação final da equipe (50%) através de apresentação dos projetos para banca examinadora, segundo os seguintes critérios:
    - Diferenciais da proposta;
    - Exequibilidade do projeto;
    - Qualidade das estimativas e uso de ferramentas de simulação e/ou previsão orçamentária;
    - Discussões e conclusões apresentadas.
- Avaliação do Relatório Final (20%), segundo os seguintes critérios:
    - Adequação do trabalho aos objetivos propostos;
    - Estrutura do relatório: coerência, clareza e sistematização;
    - Fundamentação e rigor conceitual: utiliza uma terminologia científica adequada, relevância e contemporaneidade das fontes de informação, clareza na interpretação de conceitos, espírito inovador nas propostas apresentadas e capacidade de síntese;
    - Capacidade de reflexão e análise crítica;
    - Formatação (aderência ao Guia de Elaboração de Trabalhos Acadêmicos UNISAL) e apresentação gráfica;
    - Cumprimento de prazos e condições de entrega;
    - Coleta de dados do protótipo.

Na apresentação final, os projetos foram apresentados a uma banca examinadora composta pelos professores das disciplinas participantes do projeto interdisciplinar. A avaliação foi assim dividida:

- (15%) - Proposta de layout da linha de embalagem e respectivo balanceamento;
- (15%) - Dimensionamento do quadro funcional incluindo cargos operacionais e de supervisão;
- (15%) - Custeio dos serviços e precificação;
- (20%) - Formulação da apresentação comercial da proposta;
- (10%) - Comunicação: postura adequada, clareza na exposição dos conceitos, comunicação eficaz;
- (15%) - Criatividade: ideias inovadoras, demonstra originalidade e revela espírito de iniciativa;
- (10%) - Síntese: Capacidade de síntese, mantendo clareza sem perder o objetivo proposto.

4 Desenvolvimento dos alunos – Aplicação e Resultados

O desenvolvimento do trabalho se deu através da utilização das seguintes informações cedidas pelo cliente, atual responsável pela execução dos serviços:

- Forecast (por questões de confidencialidade, não será divulgado);
- Ficha de embalagem (especificação de montagem de produto) de cada um dos itens a ser embalados;
- Informações relativas ao transporte dos materiais embalados;
- Dados das equipes de trabalho atuantes.

Inicialmente, a equipe buscou aprofundar seus conhecimentos no sistema de embalagem *copacker*, os maquinários utilizados, os recursos humanos necessários para execução dos serviços e as limitações do sistema de trabalho, através de pesquisas realizadas na internet, utilizando inclusive vídeos com exibição de empresas do ramo.

Depois de obtidos tais conhecimentos, os dados do *forecast* e desempenho de produção por tipo de material foram analisados de forma a dimensionar as novas equipes de trabalho, com o objetivo de reduzir custos garantindo ao cliente o atendimento integral às demandas e requisitos apresentados. Para elaboração da proposta, primeiramente foram definidos os escopos de trabalho da contratante e da contratada.

Os valores dos salários foram estabelecidos através do levantamento da média paga pelo mercado no local das instalações da empresa, considerando o perfil de cada funcionário. Os dados foram obtidos através do sistema "salariômetro", que utiliza como base as informações cedidas pelo Ministério do Trabalho. Da mesma forma, foram levantados os valores de tributação municipal, estadual e federal.

4.1 Proposta de Layout

O galpão foi projetado conforme o dimensionamento da linha de montagem e foi elaborado tendo o cuidado de tornar a linha o mais otimizada possível, a fim de evitar desperdício de tempo.

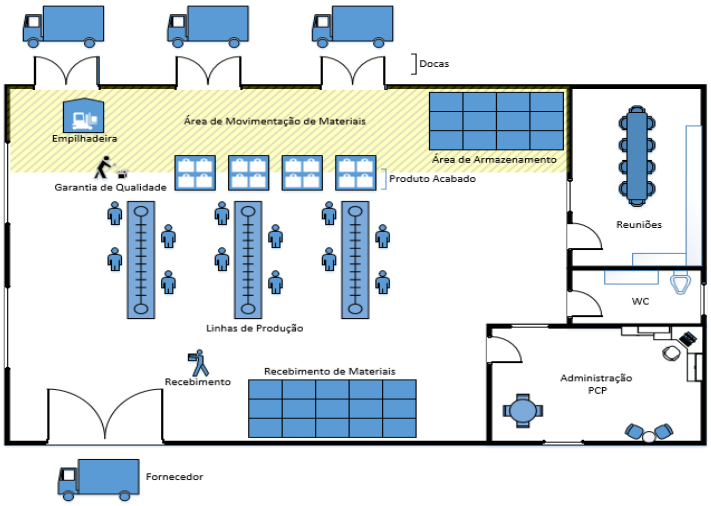


Figura 1. Layout do galpão externo.

No layout foram consideradas as seguintes questões:

- Segurança do operador
- Fluxo produtivo "enxuto"
- Possibilidade de ampliação da linha
- Determinação de área para carga e descarga da matéria-prima e produtos acabados

4.2 Dimensionamento do quadro funcional

O dimensionamento da mão de obra foi feito com base nas horas necessárias para atendimento ao volume de produção informado no *forecast* os dados de produtividade informados pela contratada. O critério de rateio adotado para os custos de mão de obra foi o volume de produção e o rateio dos EPIs (equipamentos de proteção individual) foi feita pela quantidade de funcionários por linha de produção, de acordo com os volumes totais, por produto, e as respectivas horas.

O cálculo da capacidade nominal em horas (CNh) foi desenvolvido com base nos seguintes parâmetros:

$$\text{CNh} = \frac{44 \text{ horas}}{1 \text{ semana}} \text{ x } \frac{52 \text{ semanas}}{1 \text{ ano}} \text{ x n}$$

n = número de funcionários

Capacidade da linha esteira:

$$\text{CNh} = \frac{44 \text{ horas}}{1 \text{ semana}} \text{ x } \frac{52 \text{ semanas}}{1 \text{ ano}} \text{ x } 4$$

$$\boldsymbol{CNh = 9.152\ horas}$$

Capacidade das linhas *shrink*:

$$\text{CNh} = \frac{44 \text{ horas}}{1 \text{ semana}} \text{ x } \frac{52 \text{ semanas}}{1 \text{ ano}} \text{ x } 9$$

$$\boldsymbol{CNh = 20.592\ horas}$$

Tabela 2. Quantidade de funcionários com o respectivo salário

Cargo	Número de funcionários	Salário (R$)	Salário (U$)[1]
Auxiliar de embalador	04	1.210,00	327,03
Embalador	06	1.496,00	404,33
Embalador líder	03	1.804,00	487,57
Técnico eletromecânico	01	2.090,00	564,86
Conferente	01	1.120,00	302,70

[1]Cotação do dólar fixada em R$ 3,70.

4.3 Custeio dos serviços e precificação

Foram considerados dois cenários diferentes sendo:

- Execução dos serviços nas instalações do cliente, utilizando seu espaço e maquinários;
- Execução dos serviços em instalação própria.

Após levantamento de todos os custos envolvidos nos dois cenários, foram executados os cálculos e apresentados os valores por produto, possibilitando ao cliente a escolha do melhor cenário de acordo com sua necessidade.

Para a formação do preço de venda dos serviços, foram considerados os seguintes custos:

- Mão de obra direta e indireta
- Equipamentos de proteção individual

Tendo definido os salários dos profissionais com a respectiva carga tributária para a empregabilidade do mesmo, além de valores provisionados e benefícios foi totalizado para o respectivo contrato um valor mensal de R$ 46.437,09. Toda a contabilidade da empresa, com as atividades de emissão de nota fiscal, pagamento de funcionários, etc., são feitos por uma empresa especializada a ser contratada pelo valor de R$ 4.000,00 mensais.

Para a realização das atividades de embalagem, os funcionários deverão utilizar os equipamentos de proteção individual (EPI). Todos os EPIs utilizados pelos funcionários possuem certificado de aprovação fornecido pelo ministério do trabalho e emprego. Para tal, foi calculado um valor de R$ 10.980,00/ano.

Serviços	Custos (R$)	Custos (U$)
Mão de obra	602.245,08	162.768,94
EPIs	10.980,00	2.967,57
Impostos	132.341,12	35.767,87
Total	745.566,20	201.504,38

Incluindo o lucro proposto para a viabilidade do negocio, o total apresentado a empresa contratante é de R$ 942.758,23 / U$ 254.799,52, sendo o valor de R$ 1,37 / U$ 0,37 por caixa embalada (segundo a totalidade do *forecast*).

5 Conclusão

A proposta de realização do projeto é ter um objetivo geral único. De acordo com Lima et al (2009), todas as equipes devem desenvolver o mesmo tema do projeto a fim de criar condições de avaliação semelhantes. No entanto, os projetos propostos devem ser abertos o suficiente para permitir soluções diferentes, estabelecendo o desenvolvimento da iniciativa do aluno e sua capacidade de tomar decisões com informações incompletas, redundantes ou distorcidas. Para tal segundo os autores, é importante que essas equipes devam ser grandes o suficiente para impor dificuldades tanto no projeto quanto na coordenação das atividades. Esse propósito melhora o desenvolvimento de várias competências transversais, tais como: capacidades de liderança e habilidades de gerenciamento de projetos, entre outros.

Dessa forma, o objetivo geral do artigo foi atingido com a apresentação de um estudo de caso de um projeto interdisciplinar no curso de Engenharia de Produção em uma instituição de ensino superior no Brasil. São mostrados os requisitos que os alunos deveriam apresentar no projeto além do resultado do melhor grupo desenvolvido. Assim, percebe-se a importância do desenvolvimento de atividades de ensino na qual os alunos são submetidos a diversos desafios tendo, como propósito final, o aprimoramento das competências do egresso do curso.

O método de analise do projeto é inovador, pois além avaliar os conhecimentos referentes aos conteúdos das disciplinas envolvidas, as competências analisadas individualmente e também, coletivamente. Fica como trabalhos futuros, a inclusão deste método em outras abordagens de ensino, seja em projetos interdisciplinares, seja em disciplinas específicas.

6 Referências

ALVES, A., MOREIRA, F., SOUSA, RUI M. and LIMA, RUI M.- TEachers' workload in a project-led engineering education approach – 2007

CRAWLEY, EDWARD F.; BRODEUR, DORIS R.; SODERHOLM, DIANE H. The education of future aeronautical engineers: conceiving, designing, implementing and operating. Journal of Science Education and Technology, v. 17, n. 2, p. 138-151, 2008.

DENCKER, A. F. M. Pesquisa e interdisciplinaridade no Ensino Superior: uma experiência no curso de turismo. São Paulo: Aleph, 2002.

FAVARÃO, N. R. L.; ARAÚJO. C. S. A. Importância da Interdisciplinaridadae no Ensino Superior. EDUCERE. Umuarama, 2004.

FRANZEN, A. B., SHLICHTING,S.T., HEINIG, M.O.L.O - engenheiros: uma construção de múltiplas identidades – COMBEGE 2013

GEMIGNANI, Y.M.E; Formação de Professores e Metodologias Ativas de Ensino-Aprendizagem: Ensinar para a Compreensão. Revista Fronteira das Educação [online], Recife,v.1,n.2,2012.ISSN:2237-9703.

LIMA, R M. et al. Management of interdisciplinary project approaches in engineering education: a case study. In: First Ibero-American Symposium on Project Approaches in Engineering Education (PAEE'2009). Universidade Minho. Instituto de Educação. Centro de Investigação em Educação (CIEd), 2009. p. 149-156.

LÜCK, H. Pedagogia interdisciplinar: fundamentos teórico-metodológicos. 9. ed. Petrópolis: Vozes, 2001.

MORÁN, J; Mudando a educação com metodologias ativas. Coleção Mídias contemporâneas.Educação e Cidadania, VolI.EPG-2015. www.uepgfocafoto.wordpress.com/. Acesso: 14/02/2016.

TAVARES, D. E. Práticas interdisciplinares na escola. São Paulo: Cortez, 1999.

Model of an MTS system with reorder point, economic lot and FIFO processing of production orders and requests

José de Souza Rodrigues[1], Mariana de Toledo Marinho[1], Renato de Campos[1], Jorge Muniz Jr.[1], Fernando Bernardi de Souza[1]

[1] Universidade Estadual Paulista "Júlio de Mesquita Filho" – UNESP

Email: jsrod@feb.unesp.br, mariana.tmarinho@gmail.com, rcampos@feb.unesp.br, jorgemuniz@feg.unesp.br, fbernardi@feb.unesp.br

Abstract

This paper presents the model of a productive system which was projected to supply the demand making to stock, operate with reorder point, economic production quantity and process the production orders by the rule first-in, first out. This model it was developed to teach operations in engineering courses and it was motivated by the difficult of present in integrated way the concepts of "make to stock", "reorder point", "economic production quantities" and rules of production orders dispatch. Nowadays, it is very common to find these concepts separated in the text books used in the undergraduate, but it is not common to find them acting together. So, it was created a model of a production system which process four products and operate under these concepts. The purpose of create the model has the intention of provide students with a model that present the dynamic behavior of a system built with these characteristics. The results obtained by simulation of the model showed that the failures of this system will depend of its initial conditions, indicating that the freezing time of the production planning it is a very important variable of planning and controlling production systems.

Keywords: MTS; Models; PROMODEL; Simulation.

Modelo de um Sistema MTS com Ponto de Pedido, Lote Econômico e Processamento FIFO de Ordens e Pedidos

José de Souza Rodrigues[1], Mariana de Toledo Marinho[1], Renato de Campos[1], Jorge Muniz Jr.[1], Fernando Bernardi de Souza[1]

[1].Universidade Estadual Paulista "Júlio de Mesquita Filho" - UNESP

Email: jsrod@feb.unesp.br, mariana.tmarinho@gmail.com, rcampos@feb.unesp.br, jorgemuniz@feg.unesp.br, fbernardi@feb.unesp.br

Resumo

Este artigo trata da construção de modelo de um sistema de produção para facilitar o ensino de gestão de estoques, atendimento da demanda, reposição de estoques por ponto de pedido de reposição em lotes econômicos e processar as ordens de produção pela lógica FIFO (first in, first out). A motivação para construção do modelo foi a necessidade de apresentar estes conteúdos de forma integrada, pois eles geralmente são apresentados de forma isolada nos livros textos. O modelo foi criado em um software comercial e será integrado ao curso de graduação em Engenharia de Produção da Faculdade de Engenharia de Bauru. O modelo foi desenvolvido e simulado, sendo que os resultados mostram a viabilidade de utilizá-lo para fins didáticos, com grande ganho em relação à integração de conteúdos, às possibilidades de desenvolvimento de variantes para gerar debates e discussões em sala, ou mesmo como trabalho direcionado ao aprendizado dos conteúdos e do software de modelagem e simulação.

Palavras Chave: MTS; Modelos; PROMODEL; Simulação.

1 Introdução

Os cursos de graduação em Engenharia de Produção brasileiros são organizados e estruturados com base nas Diretrizes Curriculares Nacionais instituídas pela Resolução CNE/CES 11, de 11 de março de 2002 (MEC, 2002). Esta resolução também faz referência ao Projeto Político Pedagógico dos cursos, que prevê as competências e habilidades dos egressos, a estrutura curricular, as formas de avaliação, as metodologias de ensino/aprendizagem e os recursos disponíveis durante o oferecimento do curso como laboratórios, salas de aulas, recursos audiovisuais, espaços para alunos e professores e o acervo bibliográfico. Os cursos possuem um currículo estruturado e organizado em disciplinas apoiadas em livros textos. Esta demanda por livros textos é suprida pelo mercado editorial que oferece um conjunto diversificado de obras, nos interessando aqui as que abordam o tema gestão das operações de produção.

Na área de engenharia, especificamente na de gestão das operações de produção, os livros textos utilizados nesta pesquisa apresentam este tema na forma de capítulos ou sessões que abordam subtemas especializados como gestão de estoques, qualidade, projeto das operações de produção, produção enxuta, desta da demanda e da capacidade, gestão financeira, entre outros. Apesar da disponibilidade de uma grande quantidade de material na Internet (CAPES, 2016), os livros ainda são considerados importantes porque reúnem, de forma organizada, conteúdos basais da área, sendo que algumas subdisciplinas da gestão de operações, como a gestão de estoque, "estão entre os resultados mais antigos da GO e continuam a ser usados e citados" (HOPP & SPEARMAN, 2013, p. 45).

Apesar dos livros terem incluindo novos recursos didáticos/pedagógicos como demos de softwares, *cases*, sugestões de debates relacionados aos conteúdos, materiais complementares colocados à disposição de professores e estudantes via WEB, entre outras inovações, persistem os desafios de conectar conteúdos apresentados de forma fragmentada e unir teoria com a prática. A apresentação deles como tópicos específicos nos livros textos procura atender a dois propósitos básicos: aprendizado individual e apoio a disciplinas curriculares.

No primeiro caso o livro é para uso próprio, no segundo, está associado à disciplina em que é utilizado. A fragmentação de conteúdo encontrada na estrutura de livro também se repete nos cursos de graduação, uma

vez que são estruturados com base em disciplinas abordando conteúdos específicos e ofertados por professores especialistas na área.

Para minimizar este tipo de dificuldade propôs-se a construção de um modelo em que diversos conteúdos atuam em conjunto. Trata-se da representação do comportamento dinâmico de um sistema produtivo planejado com o Modelo Hierárquico de Planejamento e Controle da Produção, atendendo a demanda a pronta entrega (MTS - *make to stock*), repondo os estoques por ponto de pedido de reposição (PPR) em lotes econômicos de produção (LEP) e processando as ordens de produção segundo a ordem de chegada delas nas estações de trabalho (FIFO – *first in, first out*).

A pesquisa justifica-se por que é uma alternativa aos métodos tradicionais de ensino e condizente com a abordagem em que o aluno tem uma participação ativa em seu aprendizado. Como o livro texto ainda faz parte das exigências formais que as Instituições de Ensino Superior brasileiras devem cumprir, a pesquisa complementa-os, ao tornar-se uma opção interativa de aprendizado sobre como operam em conjunto os temas apresentados de forma isolada. Outro elemento relevante é que a indústria editorial não mostra sinais de declínio e o universo dos livros textos ofertados tem-se ampliado com edições e títulos novos. Conclui-se que apesar da limitação que eles apresentam, continuam a serem largamente utilizados.

A pesquisa é aplicada, exploratória e preenche uma lacuna na literatura consultada, qual seja, o uso de modelagem e simulação no ensino de engenharia. Buscas feitas na base dados "Portal de Periódicos CAPES/MEC" com "operations management teaching" sem as aspas, ou seja, a busca envolvia quaisquer combinações das três palavras com uma, duas e três posições, retornou 2088 documentos, sendo 147 sobre gestão de operações. Para simplificar o processo de leitura e análise dos documentos, refez-se a busca considerando somente documentos em que constava a frase exata em qualquer local do documento (título, resumo ou corpo do documento), cujo retorno foi de 17 documentos, sendo 10 relacionados a gestão de operações e dois deles, Umble & Umble (2013) e Pasin & Giroux (2011), sobre o uso de simulação para ensinar gestão de operações ou temas a ela relacionados.

O modelo foi construído no PROMODEL, um software comercial de modelagem e simulação, e pode ser utilizado para facilitar a aprendizagem de construção de modelos no referido software e/ou no comportamento de um sistema produtivo operando segundo as condições estabelecidas. A escolha do software tomou como base o conhecimento prévio do mesmo e disponibilidade de licença na instituição em que a pesquisa foi realizada. Ele tem uma interface gráfica para visualização do comportamento do modelo durante a simulação, um gerador de relatórios com dados da simulação e funcionalidades que permitem exportar dados da simulação para planilhas eletrônicas. Com estes recursos, o modelo pôde ser adaptado a diversas abordagens dos conteúdos envolvidos, tornando possível elaborar estratégias de ensino-aprendizagem mais atraentes para alunos e professores e mais complexas em termos analíticos.

Como resultado obteve-se um modelo em que as simulações feitas com ele mostraram que parte da capacidade de produção se perde devido ao sequenciamento e às rotas de produção, ou seja, é pouco provável que se consiga, ao mesmo tempo, maximizar utilização, minimizar WIP e *throughput time,* como indicam Wiendahl; Von Cieminski; Wiendahl (2005). Pode-se observar também que um sistema de planejamento e controle da produção deve ser capaz de conciliar a reposição de produtos, a quantidade de material em processo (*Work in process* – WIP) e produtos acabados, uma vez que ambos estão relacionados à demanda, ao nível de serviço e ao volume de capital necessário para suportar as operações de produção.

2 Referencial Teórico

Uma análise preliminar de diversos títulos relacionados à gestão das operações de produção publicados de 1971 a 2013, no Brasil, mostrou que os temas mais recorrentes são conceituação de gestão das operações de produção (os livros mais antigos se referem à administração da produção), competitividade e estratégia de operações, tomada de decisão, análise de investimento, localização de planta industrial, "projeto, capacidade produtiva e layout", projeto e análise de processos, projeto e medida do trabalho, previsão da demanda, "planejamento, programação e controle da produção", administração de estoque e materiais, administração de projetos e qualidade.

Foram analisados Starr (1971), Schaum (1987), Slack et al. (1997), Martins & Laugeni (1999), Stevenson (2001), Davis, Aquilano, Chase (2003), Gaither & Frazier (2005), Peinado & Graeml (2007), Moreira (2008), Krajewski, Ritzman, Malhotra (2009), Heizer & Render (2009), Fernandes & Godinho Filho (2010), Slack, Chambers, Johnston (2010), Corrêa & Corrêa (2012) e Hopp & Spearman (2013). Ela sofreu diversas mudanças ao longo do tempo, sendo que Voss (2007) afirma que o trabalho de Agricola (1556 apud SPRAGUE, 2007) pode ser entendido como um texto de gestão de operação da época.

A gestão das operações de produção envolve diversos temas especializados apresentados em livros textos na forma de capítulos e seções. Como área do conhecimento tem o objetivo de combinar pessoas, materiais, tecnologias e informação em sistemas produtivos para levar as organizações a atingirem seus objetivos de negócio (HORVÁTHOVÁ & DAVIDOVÁ; 2011). Pensando somente em termos de "administração da produção", Slack et al. (1997) atribuem a ela a tarefa de determinar a maneira pela qual os bens e os serviços são produzidos pelas organizações e entregues aos clientes.

Hopp & Spearman (2013) apontam o modelo ocidental de pensar como o responsável pelo desenvolvimento da gestão das operações de produção a partir de modelos aplicados a problemas específicos. Um exemplo é o tratamento cartesiano que Hax & Meal, (1973) dão aos problemas inerentes aos sistemas de produção. Para eles, estes problemas são complexos e devem ser tratados de forma estruturada, de tal forma que as decisões dos níveis superiores (na modelagem e abordagem do problema) produzam soluções que possam ser aplicadas aos níveis seguintes, até que se possa modelar o problema como um todo.

Schneeweiss (1995) sugere o mesmo caminho para lidar com a complexidade, ou seja, desmembrar os problemas em partes mais simples, num lógica que vai do topo (nível de maior complexidade) para a base (nível de menor complexidade). Gfrerer & Zäipfel (1995) afirmam que Hax & Meal (1973) foram os primeiros a abordar o problema do planejamento e controle das operações de produção a partir de uma estrutura hierarquizada de decisões. "We did this because we found that we could not, with available analytic methods and data processing capability, develop an optimization of the entire system" (HAX & MEAL; 1973, p. 3).

A tecnologia disponível e a estrutura verticalizada e funcional das organizações contribuíram para que o estudo das operações de produção, inicialmente, enfatizasse as atividades de manufatura. No final dos anos 60 e durante a década de 70 o planejamento e controle da manufatura eram realizados utilizando-se os conceitos de lotes econômicos de compra e produção e ponto de reposição. De acordo com Jacobs & Weston Jr. (2007), estes conceitos eram suficientes para a época porque as organizações industriais estavam usando estratégias de manufatura focadas em produto e tinham como base competitiva a minimização de custos, alto volume e estabilidade das condições econômicas.

A informática, hoje uma base importante para a melhoria de processos, era cara, limitada e focada em departamentos funcionais nas organizações. Isto é particularmente visível no desenvolvimento do conceito de ERP, cujo embrião é relacionado por Jacobs & Weston Jr. (2007) ao esforço de IBM e J.I. Case para desenvolver um sistema de planejamento e controle da manufatura. O resultado recebeu o nome de PICS (production and inventory control system) e armazenava os dados em fitas magnéticas, recurso de armazenamento de dados de grande escala disponível à época.

Deste esforço inicial surgiram diversos conceitos que foram integrados por um único sistema computacional, o ERP (Enterprise Resource Planning). De forma geral, o modelo abrangente que orienta o ERP, no que refere ao planejamento hierárquico da produção, está ilustrado na Figura 1.

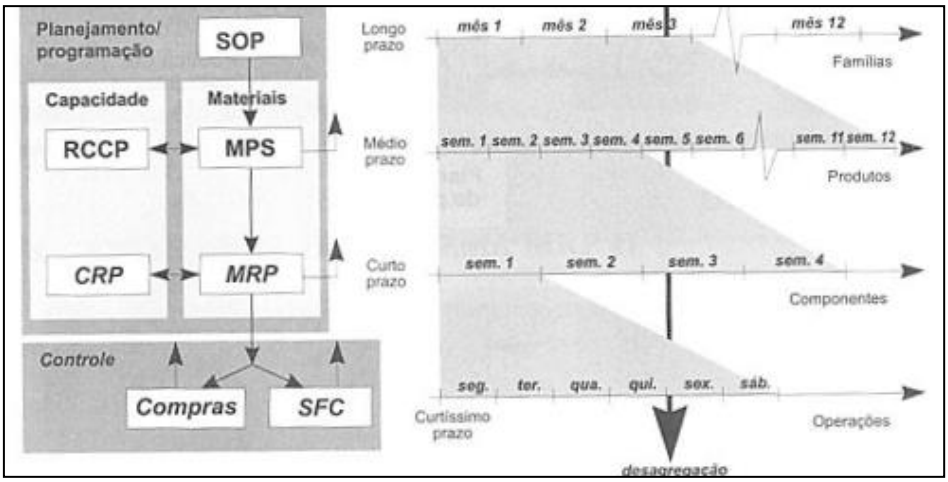


Figura 1. Planejamento Hierárquico da Produção. Fonte: Corrêa, Gianesi e Caon (2007, p.152)

Este modelo diz que o processo é iniciado com a fase de planejamento das vendas futuras, passa por um processo de confrontação da capacidade necessária com a disponível e para fixação do volume de produção, passando-se, então, à execução, quando são feitos ajustes, sempre que necessário, para adequar planejamento e execução.

Deve ser lembrado que o modelo geral deve ser adaptado ao modelo de negócio da empresa, ou seja, como atende os clientes, se a pronta entrega (make to stock –MTS), por encomenda (make to order – MTO), por montagem sob encomenda (assembly to order – ATO) ou projeto e execução sob encomenda (make to order and engineering – MTOE) (SLACK et al., 1997). O MTS depende da combinação esforço de venda, previsão de venda e capacidade produtiva.

O modelo operacional da produção também deve ser definido, ou seja, são definidos os modos de reposição de materiais e produtos acabados, se por ponto de pedido de reposição ou por revisão periódica. No primeiro caso, sempre que o nível de estoque atinge o ponto de pedido de reposição, nova ordem de compra (materiais, componentes, peças e insumos) ou de produção (componentes e bens acabados) é emitida usando lote econômico, enquanto que no sistema de revisão periódica a períodos constantes os estoques são avaliados e as quantidades necessárias são compradas ou produzidas para abastecer o sistema de produção até o período seguinte (SLACK et al., 1997).

De certa forma, este modelo operacional define a política de estoques da empresa, pois ao definir como os estoques serão repostos e em que momento, automaticamente, são definidos os valores médios em estoque e os pontos máximos permitidos. Para complementar o sistema operacional, deve ser definidas as regras de despacho, sendo que uma delas é o FIFO (*first in, first out)*, ou seja, a primeira unidade que chega na estação de trabalho é a primeira a ser processada. Como todos estes elementos atuam em conjunto? É o que se pretende mostrar com o modelo construído.

3 Método da Pesquisa

Esta pesquisa é aplicada e objetivou criar um modelo ilustrativo do comportamento dinâmico de um sistema de produção que atende a demanda à pronta entrega (MTS), usa ponto de pedido de reposição e lotes econômicos para repor produtos acabados e processa as ordens de produção pela lógica FIFO (primeiro a chegar é o primeiro a ser processado). O sistema produtivo é composto de 8 estações de trabalho. As sete primeiras são compostas têm 1 equipamento cada e, a oitava, que é uma estação de montagem, tem 2 unidades de capacidade de trabalho. São fabricados 4 produtos com os tempos de processamento indicados na Tabela 1.

Tabela 1. Tempos (minutos) de processamento dos produtos nas estações de trabalho.

	Maq1	Maq2	Maq3	Maq4	Maq5	Maq6	Maq7	Montagem
P1	0,4	0,55	0,49	0,4	0	0	0	0,71
P2	0,57	0,45	0,55	0,72	0,51	0	0	1,08
P3	0,67	0,55	0,53	0	0,74	1,57	1,65	1,45
P4	0,44	0,64	0,72	0,28	0,91	1,28	1,71	2,28

A jornada média mensal de trabalho considerada foi de 9.675 minutos e o modelo foi simulado durante 116.100 minutos (um ano). Considerou-se que os lotes econômicos de produção de P1, P2, P3 e P4 são 3.676, 4982, 3.370 e 2.191 unidades, respectivamente. Eles foram obtidos por meio da equação (1), extraída de Stevenson (2007).

$$Q=\sqrt{\frac{2*D*A}{h}}\sqrt{\frac{p}{p-d}} \tag{1}$$

Q é lote econômico de produção, D é a demanda anual, A é o custo de set up, h, o custo anual de estocar uma unidade, p é a taxa de reposição da produção e d é a demanda média. O estoque de segurança foi calculado com o auxílio da equação (2).

$$ES=k*\sigma \tag{2}$$

Onde k é fator de segurança e σ o desvio padrão da demanda.

Já o ponto de pedido de reposição foi calculado com base na equação (3).

$$PPR=d*LT+ES \tag{3}$$

Onde d é a demanda média, LT é o lead time de reposição da produção e ES, o estoque de segurança.

O lead time foi calculado considerando o tempo de processamento de todas as etapas somado a um tempo considerado para o processamento do pedido e acompanhamento da produção, estimado em 2.400 minutos (5 dias de trabalho, estabelecido de forma arbitrária), conforme Tabela 2.

Tabela 2. Tempos de processamento, administrativo, total e *lead time*.

Processamento (min)	Administrativo (min)	Total (min)	Lead Time (mês)
9.374	2.400	11.774	1,2
19.330	2.400	21.730	2,2
24.129	2.400	26.529	2,7
18.098	2.400	20.498	2,1

Para minimizar o efeito do transporte entre as estações de trabalho foram colocadas esteiras entre elas. Assim, evita-se a necessidade de dimensionar o sistema de transporte para que o desempenho do modelo não seja prejudicado. Para melhorar o visual foram acrescentados um depósito e quatro áreas de expedição, sendo cada uma delas dedicada a um produto, e uma área inicial que contabiliza as OPs (ordens de produção) que chegam no sistema, colocada antes da estação de trabalho 1. Estes acréscimos tiveram a finalidade de facilitar o uso didático do modelo. Também foram utilizadas cores para melhorar o aspecto visual do modelo. Cinza para o produto 1, vermelho para o 2, verde para o 3 e azul para o 4. Considerou-se que o material necessário para produzir os produtos está sempre disponível. Diversas variáveis foram utilizadas para coletar dados do sistema e torná-los visíveis no modelo. Além disso, os dados de demanda (quando foi gerada e quando foi atendida) e das OPs (quando foi gerada e quando foi concluída) foram coletados em planilhas MS Excel com dados exportados pelo PROMODEL. Com estas condições de contorno foi construído um modelo no PROMODEL e simulado.

4 Dados e Resultados

Para a elaboração do modelo criou-se um histórico de demanda de um ano, de janeiro a dezembro. Com estes dados foram calculados a média, o desvio-padrão, o estoque de segurança e o PPR (ponto de pedido de reposição). Com o valor de PPR ajustou-se o número de lotes de produção para tornar o trabalho de programação adequado aos meses do ano. Depois de ajustados os número de lotes de produção, ajustou-se o tamanho dos lotes para que as quantidades a produzir ficassem próximas da demanda estimada, conforme Tabela 3.

Tabela 3. Média, desvio-padrão, PPR, estoque de segurança, n. lotes e tamanho lote.

Produto	P1	P2	P3	P4
Média	7.350	4.982	1.685	1.095
Desv.Padr	362	328	187	174
ES	753	683	390	362
PPR	9.698	11.873	5.010	2.683
LEP	3.892	3.979	2.573	2.085
n.Lot	23	15	8	6
Lote Aj	24	12	6	6
LEPa	3.676	4.982	3.370	2.191
LT	1,2	2,2	2,7	2,1
Dem.Tot	88.224	59.784	20.220	13.146

ES=estoque de segurança; PPR=ponto de pedido de reposição; LEP=Lote econômico de produção; n.Lote=quantidade de lotes; Ajuste=número de lotes ajustado; LEPa=Lote econômico de produção ajustado; LT=Lead time; Dem.Tot.=Demanda total no ano simulado.

Com os dados contidos na Tabela 1 foi feita uma análise para averiguar se existe capacidade para processar as quantidades previstas e indicadas na Tabela 3. Foram calculadas as necessidades de equipamentos, conforme equação (4).

$$N.Eq_i = \frac{\sum_{j=1}^{N} \left(Q_{P_{j,i}}\right) * \left(T_{P_{j,i}}\right)}{TDE_i} \tag{4}$$

Onde: $Q_{P_{j,i}}$ é a quantidade a processar do Produto j no equipamento i.

$T_{P_{j,i}}$ é o tempo necessário para processar uma unidade do produto j no equipamento i.

TDE_i é o tempo disponível para alocação de trabalho no equipamento i.

Os cálculos feitos com o auxílio da equação(4), sendo $N.Eq_i$ arredondado para cima, estão apresentados na Tabela 4.

Tabela 4. Necessidade de equipamentos para processar a demanda estimada.

	Maq1	Maq2	Maq3	Maq4	Maq5	Maq6	Maq7	Mont
P1	35.290	48.523	43.230	35.290	0	0	0	62.639
P2	34.077	26.903	32.881	43.044	30.490	0	0	64.567
P3	13.547	11.121	10.717	0	14.963	31.745	33.363	29.319
P4	5.784	8.413	9.465	3.681	11.963	16.827	22.480	29.973
Total	88.698	94.960	96.293	82.015	57.416	48.572	55.843	186.498
N.Eq.Nc.	1	1	1	1	1	1	1	2

A Tabela 4 mostra que a capacidade instalada é suficiente para processar a demanda esperada. Com os dados foi feita a simulação do modelo para o tempo equivalente a 1 ano (1935 horas ou 116.100 minutos), gerando os resultados apresentados na Tabela 5.

Tabela 5. Entidades principais do modelo e resultados obtidos.

Entidade	Saídas	Estoque Final	TEMPO MÉDIO (min)	
			No sistema	Em Operação
OP1	22	3	13.057,91	9.376,97
OP2	10	2	20.865,08	19.334,59
OP3	5	1	29.937,05	24.294,39
OP4	5	2	23.157,10	18.507,36
P1	88.491,00	2.581,00	3.252,19	66,71
P2	59.795,00	3.025,00	8.578,68	129,23
P3	20.091,00	2.259,00	10.755,17	323,52
P4	13.293,00	562	11.309,28	402,63
PD1	241	1	584,3	480
PD2	241	1	484,11	480
PD3	241	1	557,46	480
PD4	241	1	1.005,17	480

OPi=ordem de produção do produto i, Pi, produto i, PDi, pedidos do produto i

Pode-se observar que os *lead times* obtidos na simulação para as ordens de produção OP1, OP2, OP3 e OP4 são superiores aos presumidos quando da construção do modelo, mesmo considerando 5 dias (2.400) para o processamento administrativo das OPs. Os valores obtidos foram 1,3 para OP1, contra estimativa de 1,2, 2,2 para OP2, contra estimativa de 2,2, 3,1 para OP3 contra 2,7 e 2,1 para OP4 contra 2,4. Somente o produto 2 teve desempenho compatível em termos de *lead time* real e calculado. Estes resultados demonstram um aspecto importante do planejamento e controle da produção. A forma como os recursos produtivos são utilizados determina o tempo total de atravessamento das ordens de produção pelo sistema de produção. Portanto, não envolve somente os tempos presumidos em termos de efetiva ocupação dos recursos de produção. Este aspecto, geralmente, não é explicitado nos livros textos.

A simulação também mostrou outro elemento importante para os engenheiros de produção, o sistema falha. Quando se usa o estoque de segurança há uma melhoria no nível de serviço, mas ela não é suficiente para evitar falta de produto no sistema. Não é possível demonstrar com os dados obtidos aqui, mas é possível supor que mesmo com os sistemas de programação avançada as falhas decorrentes de falta de produto possam ocorrer, ou seja, haverá situações em que a empresa não conseguirá atender os seus clientes nos prazos combinados, especialmente se a comercialização for feita considerando prazos pré-fixados de entrega sem a devida conexão com os estoques reais da empresa. Nestes casos, as vendas poderão ser realizadas sem que haja condições factíveis de produzir e entregar os produtos dentro dos prazos combinados com o cliente. A Figura 2 ilustra 517h 47min da simulação, sendo que é possível observar falta de produtos para entrega e que o sistema tende a ajustar o estoque físico total entre 4.000 e 12.000 unidades. Embora a figura não ilustre uma

simulação completa, diversas simulações do modelo demonstraram este comportamento, o que leva à conclusão de que a operação do sistema com estas regras tende a manter este tipo de comportamento, pois parte do estoque está na forma de material em processo.

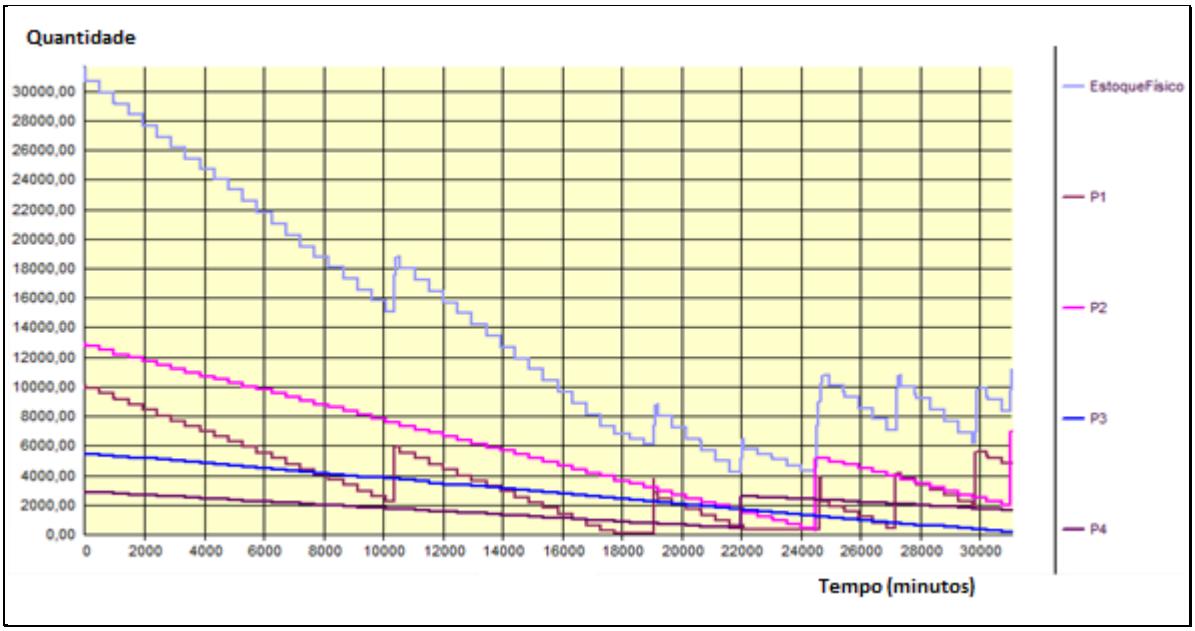


Figura 2. Estoques totais e dos produtos P1,P2,P3 e P4

A validação do uso do modelo com alunos está sendo conduzida no semestre letivo corrente. Os alunos da disciplina Administração da Produção II estão utilizando o modelo. Primeiramente foram apresentados os conceitos utilizados no modelo, ou seja, foi apresentado um histórico de demanda de um ano, com o qual foram projetadas as vendas do período seguinte. Com estes dados foram calculados os lotes econômicos de produção, as médias, os desvios-padrão e os pontos de pedido de reposição para os quatro produtos, bem como o número de lotes que deveriam ser produzidos ao longo do ano. Depois os alunos foram para o laboratório e simularam o modelo com estes parâmetros e comparam com o esperado. Numa fase mais avançada, os alunos reduziram, separadamente, o tamanho dos lotes e os tempos de *set up* e refizeram a simulação. Assim, puderam verificar como o sistema produtivo se comporta, sendo os resultados utilizados para discussão em sala de aula e análise do sistema produtivo, permitindo analisar os efeitos das duas ações sobre o sistema produtivo o que na prática, implica em preparar os alunos para a disciplina seguinte, que irá abordar sistema de produção segundo as filosofias *Lean Manufacturing* e teoria das restrições. Ainda não foi concluído este trabalho porque está em processo a fase de mudança do código do modelo computacional (aprendizado da construção do modelo e do PROMODEL) e, por isso, não está sendo apresentada aqui uma avaliação do modelo pelos alunos.

5 Conclusão

O modelo construído foi capaz de ilustrar o sistema produtivo estabelecido em operação, permitindo fazer analogias com os sistemas reais. Neste sentido, o uso didático do modelo melhora um aspecto importante que tem sido motivo de debate, a integração de conhecimento. Também deve ser ressaltado que o ambiente em que o modelo foi construído permite que se façam modificações para analisar o efeito de algum parâmetro em particular, por exemplo, o que ocorreria se os custos de *set up* fossem reduzidos? Obviamente que o primeiro impacto é a redução dos tamanhos do estoque, mas como isto impactaria o desempenho do sistema? Mesmo sendo um modelo construído com a teoria tradicional, ainda utilizada, é possível discutir questões associadas às teorias mais recentes que geralmente levam à redução dos estoques.

Os resultados apresentados obtidos com o modelo indicam que o sistema administrativo é de grande importância para o desempenho do conjunto de teorias empregadas na construção do modelo. Isto quer dizer que os mecanismos de controle de estoque devem ser capazes de indicar a posição de estoque a cada instante, o número de ordens de produção em execução, além de calcular as necessidades de materiais e fazer a reposição conforme o necessário.

Pode-se concluir que a pesquisa cumpriu seus objetivos de construir um modelo que fosse capaz de ilustrar um conjunto de conteúdos da área gestão de operações atuando em conjunto de tal forma a facilitar a aprendizagem, fazendo com que os livros textos da área possam ser utilizados para aprofundamento dos conceitos, ou seja, é possível, inclusive, inverter a ordem de abordagem dos conteúdos, partindo-se do estudo do modelo e sua operação para em seguida iniciar o estudo dos conteúdos como forma de síntese. Outra possível abordagem seria o uso concomitante do modelo e livro texto.

6 Referências

ANDRADE, J. H. CHINET,F.S., RIBEIRO, M. H. U., GODINHO FILHO, M., Quick response manufacturing: aplicação de conceitos e ferramentas para a redução do lead time na manufatura de bens de capital sob encomenda. XXXI Encontro Nacional de Engenharia de Produção, **Anais...,** Belo Horizonte, MG, Brasil, 04 a 07 de outubro de 2011, Disponível em: http://www.abepro.org.br/biblioteca/enegep2011_TN_STO_135_856_17695.pdf. Acesso em: 09 dez. 2015.

CAPES - Comissão de Aperfeiçoamento de Pessoal do Nível Superior. **Portal de periódicos** CAPES, disponível em: http://www.periodicos.capes.gov.br/. Acesso em: 12 mar. 2016.

COOLIER, D.A., EVANS, J.R., **Operations Management:** goods, services and value chains. Mason (OH):Thomson, 2007.

CORREA, C.A.; CORREA, H.L.; **Administração de Produção e Operações:** Manufatura e Serviços - Uma Abordagem Estratégica. 3ª. Ed. São Paulo: Atlas, 2012.

DAVIS, M.M., AQUILANO, N.J., CHASE, R.B. **Fundamentos da administração da produção.** Porto Alegre: Bookman, 2003, 598p.

FERNANDES, F. C. F.; GODINHO FILHO. **Planejamento e Controle da Produção.** São Paulo: Atlas, 2010.

GAITHER, N. FRAZIER, G. **Administração da Produção e Operações.** São Paulo: Thomson Learning, 2001, 598p.

GFRERER, A., ZÄPFEL, G., Hierarchical model for production planning in the case of uncertain demand, **European Journal of Operational Research**, 86, pp. 42-161, 1995.

HAX, A.C., MEAL, H.C. **Hierarchical integration of production planning and scheduling.** Massachusetts Institute of Technology, Sloan School of Management, Arthur D. Little, Inc., 1973, pp. 656-673.

HOPP, W.J., SPEARMAN, M.L., **A ciência da fábrica**. 3a. ed., Bookman:Porto Alegre, 2013.

HOPP, W.J., SPEARMAN, M.L., To Pull or Not to Pull: What Is the Question?. **Manufacturing & Service Operations Management** 6(2):133-148, 2004 http://dx.doi.org/10.1287/msom.1030.0028

HORVÁTHOVÁ, P. DAVIDOVÁ, M., Operations Management as Practice of Organizations' Strategic Management in Relation to the Environment. International Conference on Financial Management and Economics IPEDR, vol.11 (2011), **Proceedings...,** IACSIT Press, Singapore.

JACOBS, F. R.; WESTON JR., F.C. Enterprise resource planning (ERP)—A brief history. **Journal of Operations Management**, Vol. 25 (2007), pp. 357–363.

LIMA, A. D., BACHEGA, S., J., Manufacturing critical-path time (MCT) e system dynamics (SD): um estudo de caso no processo de orçamentação. XXX Encontro Nacional de Engenharia de Produção, **Anais...,** São Carlos, SP, Brasil, 12 a15 de outubro de 2010. Disponível em: http://www.abepro.org.br/biblioteca/enegep2010_TN_STO_113_739_15752.pdf. Acesso em: 09 dez. 2015.

MACINTYRE, A. C. **The end of education The fragmentation of the American University.** UnivForum. Disponível em: http://www.univforum.org/sites/default/files/668_MacIntyre_End_education_1111_ENG.pdf. Acesso em 08/01/2016.

MEC Ministério da Educação do Brasil. **Perguntas frequentes sobre educação superior.** Disponível em http://portal.mec.gov.br/sesu-secretaria-de-educacao-superior/perguntas-frequentes#condicoes_de_oferta_do_curso. Acesso em: 06 nov. 2015.

MEC Ministério da Educação do Brasil. **Portaria normativa nº 40, de 12 de dezembro de 2007**. Disponível em: http://www2.mec.gov.br/sapiens/portarias/port40.pdf. Acesso em: 06 nov. 2015.

MEC Ministério da Educação do Brasil. Resolução CNE/CES 11, de 11 de março de 2002 institui As Diretrizes Curriculares Nacionais.

MEYER, R.R., **Administração da produção,** 1st ed**.** São Paulo:Atlas, 1980.

MONKS, J.G. **Administração da Produção.** São Paulo. McGraw-Hill, 1987.

MOREIRA, D. **Administração da produção e operações.** 2ª. Ed. São Paulo: CENGAGE, 2008.

PASIN,F., GIROUX, H. The impact of a simulation game on operations management education. **Computers & Education**, 57 (2011), pp. 1240–1254.

RITZMAN, L.P. KRAJEWSKI, L.J. **Administração da Produção e Operações.** São Paulo: Prentice Hall, 2004, 431p.

SCHNEEWEISS Christoph Hierarchical structures in organisations: A conceptual framework. **European Journal of Operational Research, Vol.** 86 (1995), pp. 4-31.

SEVERINO, M.R., LAGE JUNIOR, M., CAMPANINI, L., GUIMARÃES, A.A., GODINHO FILHO, M., AGUILERA, M., Proposta de utilização do sistema Period Batch Control para redução de lead time em uma empresa de bens de capital. **Produção**, v. 20, n. 4, out./dez. 2010, p. 612-625.

SLACK, N. et al. **Administração da Produção.** 3ª. Ed. São Paulo: Atlas, 2009.

SLACK, N., CHAMBERS, S., JOHNSTON, R., **Operations Management,** 6th Ed. Harlow (England):Prentice Hall, 2010.

SPRAGUE, L.G**.** Evolution of the field of operations management. **Journal of Operations Management,** 25 (2007), pp. 219–238

STARR, M.K., **Administração da produção: sistemas e sínteses.** São Paulo:EdUSP/Edgard Blücher, 1964.

STARR, M.K., **Foundations of production and operations mangement.** Mason(OH):Thomson, 2007.

STEVENSON, W.J. **Administração das operações de produção.** Rio de Janeiro: LTC, 2001, 701p.

TUBINO, D.F. **Manual de Planejamento e Controle da Produção.** 2ª. Ed. São Paulo: Atlas, 2009, 208p.

UMBLE, E., UMBLE, M., Utilizing a Simulation Exercise to Illustrate Critical Inventory Management Concepts. **Decision Sciences Journal of Innovative Education**, Volume 11 Number 1, January 2013, pp-13-20.

WIENDAHL, H.H., VON CIEMINSKI, G., and WIENDAHL,H. P., Stumbling blocks of PPC: Towards the holistic configuration of PPC systems. **Production Planning & Control**, Vol. 16, No. 7, October 2005, 634–651.

Knowledge repository in active learning methodology - project pilot in the engineering

Lucio Garcia Veraldo Junior[1,2], Benedito Manoel de Almeida[1], Jorge Muniz Junior[2], Messias Borges Silva[2,3]

[1] Department of Industrial Engineering, Salesian University Center of Sao Paulo, Lorena, Brazil
[2] Department of Industrial Engineering, State University of Sao Paulo, Guaratinguetá, Brazil
[3] Department of Industrial Engineering, University of Sao Paulo, Lorena, Brazil

Email: lucioveraldo@gmail.com, salomaoalmeida@uol.com.br, jorgemuniz@feg.unesp.br, messias@dequi.eel.usp.br

Abstract

Higher education institutions should be appropriate to the needs of society and especially of the labor market and the education process. Thus, employing methods where students actively learn the concepts has shown positive results in the content assimilation process. Thus, the UNISAL (Salesian University Center of São Paulo), which is the Brazilian vanguard for the use of active learning methodology, preparing teachers and promotes to use increasingly different forms of education compared to the traditional model established. Thus, different subjects in different courses have the use of innovative learning methods, but not always shared among the teachers of the institution, even outside. Thus, the creation of a digital repository with the practices applied it is necessary in order to disseminate, evaluate and criticize, for that are the proposed improvements to the established method. Therefore, the purpose of this article is through bibliographical studies, demonstrate the process of creating a repository of knowledge and apply it as a pilot project in engineering courses of the institution. To this end, a digital database will be set and can use the existing virtual platform, establishing a standard model for teachers to include information relevant to the method applied: driving process; role of the student; the evaluation process; student performance, among others. Also, it is included resources for stakeholders to interact solving doubts or proposing suggestions. With that, among the volunteer teachers will be tested and evaluated the model, according to the pedagogical information described. Once approved the tests, it is the official repository of the virtual platform.

Keywords: Knowledge Management, Active Learning Methodology, Engineering, Repository, Standard 8 CDIO.

Repositório de conhecimento em metodologia ativa de aprendizagem – projeto piloto na engenharia

Lucio Garcia Veraldo Junior[1,2], Benedito Manoel de Almeida[1], Jorge Muniz Junior[2], Messias Borges Silva[2,3]

[1] Department of Industrial Engineering, Salesian University Center of Sao Paulo, Lorena, Brazil
[2] Department of Industrial Engineering, State University of Sao Paulo, Guaratinguetá, Brazil
[3] Department of Industrial Engineering, University of Sao Paulo, Lorena, Brazil

Email: lucioveraldo@gmail.com, salomaoalmeida@uol.com.br, jorgemuniz@feg.unesp.br, messias@dequi.eel.usp.br

Resumo

As instituições de ensino superior devem estar adequadas às necessidades da sociedade e principalmente, do mercado de trabalho quanto ao processo de ensino. Assim, empregar métodos onde os alunos aprendem ativamente os conceitos tem mostrado resultados positivos no processo de assimilação de conteúdo. Diante disso, o UNISAL (Centro Salesiano de São Paulo), que está na vanguarda brasileira quanto ao uso de metodologia ativa de aprendizagem, prepara os professores e os promove para que utilizem cada vez mais formas diferentes de ensino ante ao modelo tradicional estabelecido. Com isso, diversas disciplinas nos diferentes cursos têm o uso de métodos inovadores de aprendizagem, porém nem sempre compartilhada entre os professores da instituição, até mesmo fora dela. Dessa forma, a criação de um repositório digital com as praticas aplicadas faz-se necessário no intuito de divulgar, avaliar e criticar, pra que sejam propostas melhorias ao método estabelecido. Portanto, o objetivo deste artigo é através de estudos bibliográficos, demonstrar o processo criação de um repositório de conhecimento e aplica-lo como projeto piloto nos cursos de engenharia da instituição. Para tal, será definido um banco de dados digital, podendo utilizar a plataforma virtual já existente, estabelecendo um modelo padronizado para que os professores possam incluir as informações pertinentes ao método aplicado: processo de condução; protagonismo do aluno; processo de avaliação; desempenho dos alunos, entre outras. Além disso, poderão ser incluídos recursos para que os interessados possam interagir sanando dúvidas ou propondo sugestões. Tendo isso, entre os professores voluntários será testado e avaliado o modelo, de acordo com as informações pedagógicas descritas. Uma vez aprovado os testes, faz-se a oficialização do repositório na plataforma virtual.

Palavras Chave: Projeto Interdisciplinar, Competências, Engenharia de Produção, Standard 8 CDIO.

1 Introducão

O processo de aprendizagem evolui de acordo com as necessidades do comportamento do ser humano e, principalmente quanto ao desenvolvimento do mercado exigindo profissionais cada vez mais qualificados, preparados para atuar nas respectivas funções. Dessa forma, os cursos devem criar novas formas diferenciadas de ensino. Longe dos modelos tradicionais, as metodologias ativas de ensino estabelecem a conexão entre os conceitos teóricos da formação dos alunos com a pratica necessária exigida pelo mercado atual.

Os repositórios institucionais, com a implementação mais comum de sistemas de arquivos abertos (*open access*), segundo Rennen (2006), têm sido discutido na literatura sob vários aspectos, tanto como uma ferramenta quanto como uma estratégia para maximizar a visibilidade da pesquisa de uma universidade ou instituição. Sob o aspecto de ferramenta de gestão do conhecimento, eles podem potencializar o compartilhamento de informações nas comunidades cientificas, em seus diferentes níveis de agregação. Segundo Drake (2004), os repositórios estão sendo criados para controlar, preservar e manter os recursos digitais, permitindo uma recuperação eficaz do conhecimento disponibilizado.

Este artigo tem como objetivo principal apresentar o projeto de criação de um repositório para organização das práticas desenvolvidas quanto às metodologias ativas de ensino. No intuito de estabelecer um protótipo para o repositório, será desenvolvido um projeto piloto com os métodos aplicados nos cursos de Engenharia da instituição. Criados em 2011, englobando Produção, Civil, Computação, Elétrica, Eletrônica e Mecânica, os cursos foram sempre balizados no desenvolvimento prático utilizando métodos na qual os alunos são os protagonistas dos conhecimentos.

Para tal, o compartilhamento das práticas entre os professores se faz necessário para o desenvolvimento de todos, gerando algo mais que simplesmente informação. A diferença entre informação e conhecimento é sutil, mas muito importante. Conhecimento é o significado que se extrai da informação e envolve sua interpretação. Segundo Nonaka & Takeuchi (1997), conhecimento é a informação com propósito, com significado. Para desenvolver o conhecimento, é necessário um ambiente de aprendizagem mais rico e diversificado do que aquele utilizado para a transmissão de informação.

Dessa forma, será apresentada uma breve conceituação quanto aos conceitos de gestão do conhecimento com o foco principal em criação de repositórios e as metodologias ativas das quais são utilizadas na instituição principalmente quando aplicadas nos cursos de Engenharia. Objeto principal . No tópico seguinte serão apresentados os conceitos gestão do conhecimento com o foco principal em criação de repositórios. No tópico 4, será mostrado a proposta do repositório a ser desenvolvido na instituição. Por fim, serão destacadas as considerações finais.

2 Método de pesquisa

A pesquisa de caráter bibliográfico relacionando os conceitos de metodologia ativa na aprendizagem de cursos da Engenharia aplicados na instituição. Este estudo é propor um modelo de repositório para armazenar e compartilhar de maneira padronizada através de um sistema *on line* de modo a organizar o processo de consulta. Como projeto piloto será criado o repositório apenas para as aplicações relacionadas a Engenharia, apesar do uso de metodologia ser amplamente praticado na instituição também nos cursos de humanas incluindo as licenciaturas.

Dessa forma, para o cumprimento do objetivo deste artigo, onde a utilização será monitorada entre os educadores que utilizaram o modelo, compartilhando suas práticas os resultados esperados

3 Repositórios institucionais

Segundo Leite e Costa (2006), as universidades têm sido reconhecidas como espaços de produção e transferência de conhecimento científico por excelência. Embora seja possível encontrar na literatura especializada estudos sobre Gestão do Conhecimento (GC) no âmbito de universidades ou no contexto acadêmico, esses estudos, na maioria das vezes, lidam com o conhecimento científico sob o ponto de vista do desenvolvimento de tecnologias de informação ou então na mesma perspectiva do conhecimento organizacional. Ainda segundo os autores, as funções das universidades (principalmente as públicas em se tratando de Brasil), giram em torno da produção de conhecimento científico, sendo a sua comunicação processo fundamental para o ensino e a pesquisa. Por outro lado, as aplicações de ferramentas e mecanismos de gestão do conhecimento contemplam geralmente a criação, armazenamento, compartilhamento e aplicação de conhecimento, atividades essas que se tornam viáveis a partir do processo de comunicação. Além disso, concluem que os repositórios institucionais são sistemas de informação que servem para armazenar, preservar e difundir os resultados de pesquisa e desenvolvimento de uma determinada instituição ou determinado grupo de instituições, mantidos de forma individualizada ou por grupos que trabalham em forma cooperativa.

Basicamente, de acordo com Camargo & Vidotti , os repositórios institucionais são coleções digitais que armazenam, preservam, divulgam e dão acesso à produção intelectual de comunidades universitárias. Ao fazê-lo, os repositórios pretendem intervir e dar resposta a duas questões estratégicas que as universidades enfrentam:

- Contribuir para o aumento da visibilidade, estatuto, imagem e "valor" público da instituição, servindo como indicador tangível da qualidade dessa universidade e demonstrando a relevância científica, econômica e social das suas atividades de investigação e ensino;
- Contribuir para a reforma do sistema de comunicação científica, expandindo o acesso aos resultados da investigação, reassumindo o controle académico sobre a publicação científica, aumentando a

competição e reduzindo o monopólio das revistas científicas, o que se pode traduzir também em economias para as universidades e as bibliotecas que as servem.

De acordo com a Declaração de Budapeste, a partir de pesquisa no site (descrito nas referências) da iniciativa, que impulsionou este movimento vulgarmente conhecido por *Open Access Initiative* (BOAI) e que aqui designaremos por Acesso Livre, o encontro entre uma velha prática (a disponibilidade dos investigadores para publicarem os resultados do seu trabalho – em revistas científicas ou atas de congressos – sem esperarem qualquer pagamento) e novas tecnologias (a Internet e as ferramentas e protocolos a ela associados) pode promover um inestimável bem: o acesso livre e irrestrito à literatura científica por parte dos cientistas e académicos, professores, estudantes e público em geral. São geralmente consideradas duas vias (paralelas e não antagónicas) para o acesso livre ao conhecimento:

- Revistas com acesso livre, onde os artigos ficam disponíveis sem restrições desde a sua publicação;
- O próprio arquivo pelos autores dos seus trabalhos em repositórios institucionais livremente acessíveis;

Crow (2002) afirma que enquanto os repositórios institucionais centralizam, preservam, tornam acessíveis e disseminam o capital intelectual de uma instituição, ao mesmo tempo eles constituem um sistema global de repositórios distribuídos e interoperáveis que fundamentam um novo modelo de publicação científica. Em outras palavras, ao mesmo tempo em que os repositórios institucionais permitem reunir, preservar, dar acesso e disseminar boa parte do conhecimento da instituição, eles aumentam a visibilidade da sua produção científica.

4 Metodologias Ativas de Ensino Aprendizagem

Para Morán (2015) é muito importante que as metodologias de ensino aprendizagem sejam acompanhadas por objetivos pretendidos pela instituição e aprendizagem aos alunos. Se a instituição quer que seus alunos sejam proativos, é necessário adotar metodologias em que os mesmos se envolvam em atividades, com cada vez mais interesse, em que tenham que tomar decisões e avaliar os resultados, com apoio de materiais relevantes para autoconhecimento.

A conquista de melhores níveis de qualidade, em qualquer estágio e área de ensino, vem desafiando educadores a buscarem alternativas para suas propostas pedagógicas. Há uma pressão cada vez maior para que as instituições de ensino superior passem por uma transformação pedagógica, de maneira a alterar as necessidades conceituais dos tempos atuais (FRANCISCHETTI, 2014).

A pedagogia tradicional, onde o professor atua como repositório e transmissor do conhecimento estão sendo substituído por uma pedagogia que tem como Metodologia de ensino uma proposta Ativa, onde o aluno interage com outro aluno e busca acesso flexível á informação do assunto, a ser estudado, antes de vir para a sala de aula. As instituições de ensino superior (IES) estão adaptando seus cursos para dotar os egressos do curso com habilidades, conhecimento e atitudes que são necessárias para maximizar o impacto de grande envergadura imposta pela sociedade (XIE, 2014).

Durante uma aula expositiva tradicional, ás dúvidas e as perguntas são difíceis de serem geradas, pois os alunos não têm chances de se envolverem em uma efetiva discussão, diferentemente de uma aula expositiva dialogada (SCHLINGENSIEPEN, 2013). Aqueles educadores que sempre estiveram engajados com o compromisso de construir uma escola onde a premissa básica é a aprendizagem significativa e o aluno é o centro do processo de ensino, certamente já usaram de estratégias e técnicas de ensino que hoje são apresentadas sobre o enfoque metodológico ativo. Para que a aprendizagem significativa ocorra, o aluno deve ter conhecimento prévio relevante do novo conhecimento a ser apresentado, permitindo relacionar o novo conhecimento com o prévio (XIE, 2014).

O uso de uma metodologia sem a participação ativa do aluno tais como metodologias tradicionais, pode representar risco de fracasso, pois nessas metodologias os alunos não tem oportunidade de pesquisar, descobrir ou aplicar o conhecimento em um contexto autêntico que permite entender que o conhecimento fornecido foi importante e será útil (SOMYUREK, 2014).

Com o uso de metodologia ativa, a participação do aluno se dá no exercício de aprender fazendo, ao professor, cabe induzir o processo metodologicamente, estimular as atividades dos alunos, apoiar e valorizar as iniciativas na direção do foco maior que á a solução do problema em estudo. A metodologia ativa enfatiza o aprendizado experimental, o que torna o conhecimento mais aplicável a diferentes situações-problemas do mundo real, do que mera memorização de fatos (SOMYUREK, 2014). A metodologia ativa permite que todas as dúvidas e dificuldades sejam gerenciadas pelo professor e posta a serem resolvidas por cooperação e ajuda mútua. Na esfera cognitiva, a metodologia ativa permite que o aluno estude situações suficientes para si mesmo, quando depara com situações-problema ou, caso-prático.

4.1 Métodos ativos aplicados no ensino da Engenharia

A evolução tecnológica tem tomado um papel fundamental no desenvolvimento do cenário global, vários setores da produção estão exigindo, cada vez mais, profissionais aptos a enfrentarem os mais variados problemas de gestão. Para Ribeiro (2005) o ritmo acelerado dessas mudanças tecnológicas afetam principalmente os cursos de Engenharia. O autor destaca ainda que este fenômeno afeta a engenharia, a prática do engenheiro e, consequentemente, o ensino de engenharia, o que pode ser atestado pela grande expansão da base de conhecimento em ciência e tecnologia e pela rápida obsolescência de muito daquilo que é ensinado durante o período de formação profissional.

As escolas de Engenharia devem levar em conta que, no futuro, os alunos irão aprender de uma forma completamente diferente. Até os dias de hoje a maioria desenvolvem currículos, prevendo os problemas que esperamos enfrentar. Ao fazer isso, o foco é mais no conhecimento, em vez das habilidades. Os currículos baseados em conhecimento específico são construídos de baixo para cima. (HASSAN *et. al*., 2012).

Exemplificando a ideia de currículos baseados em conhecimentos específicos construídos de baixo para cima, Vallim *et. al*. (2006) destacam que muitos conceitos estruturados nas matrizes curriculares dos cursos de Engenharia, trazem nos anos iniciais disciplinas de cunho científico como Matemática e Física, deixando cadeiras mais específicas para os últimos períodos. Isto porque, a teoria vem antes da prática e deve ser apresentado primeiramente e os alunos devem ser mais maduros para compreender as abordagens de engenharia relacionadas ao mundo real.

Os futuros currículos de Engenharia devem ser construídos em torno do desenvolvimento de competências, e não em torno do ensino de conhecimentos específicos. O foco deve estar na formação de habilidades analíticas, habilidades de design e na capacidade de resolver problemas (HASSAN *et. al*., 2012).

A construção do conhecimento por parte dos alunos é uma das principais características da corrente teórica denominada de Construtivismo, nela a inteligência humana não é considerada unicamente como um processo inato ao indivíduo, é também consequência de um processo de interação entre o sujeito e o meio em que vive, o indivíduo age em resposta à estímulos externos construindo e organizando o seu próprio conhecimento, segundo Erdogan & Senemoglu (2013).

Os empregadores também exigem habilidades de comunicação, liderança, gestão de projetos, uso de planilhas, banco de dados e trabalho em equipe. Eles recomendam que os educadores devam estar cientes das competências que os empregadores do setor estão buscando, por duas razões: (i) estas habilidades específicas são fundamentais porque estão entre os seis primeiros requisitos para graduados na área, independente do setor, função ou grau; (ii) os empregadores podem achar que os graduados em Pesquisa Operacional não atendem os requisitos e habilidades, então eles acabarão por contratar graduados em Ciência da Computação, Estatística ou negócio. (SODHI & SON, 2010).

5 Caso UNISAL (Brasil)

O UNISAL (Centro Universitário Salesiano de São Paulo) é instituição privada localizada na cidade de Lorena, São Paulo, Brasil. Tem carácter filantrópico, que integra um conjunto de Instituições Universitárias Salesianas existentes em países do mundo todo. É uma instituição de porte médio para os padrões brasileiros, com cerca de 13.000 alunos em 4 campi universitários. O carisma salesiano, através da educação de jovens, tem origem no fundador da congregação, São João Bosco, e inspirador de todas as suas ações.

Segundo Lourenço Jr & Veraldo Jr (2015), o atual modelo de formação de engenheiros oferece ao aluno uma representação "bidimensional", narrativa de uma realidade que é tridimensional e complexa. Desvinculada dessa realidade, a teoria acaba perdendo o papel de importante ferramenta para sua compreensão. A consequência é que os novos cursos, desde a concepção, foram definidos a partir de outros paradigmas.

Em função disto, no campus São Joaquim localizado na cidade de Lorena (SP), no ano de 2010 foram criados os cursos na área das engenharias com o proposito de aprendizado diferenciado envolvendo teoria e pratica num processo *"hands on"*. Iniciou pelo curso de Engenharia de Produção em 2011 e, em seguida, com os cursos de Engenharia Civil, Elétrica, Eletrônica e de Computação em 2012 para, por último, em 2013, incluir curso de Engenharia Mecânica em seu portfólio.

Desde o início, houve a convicção da necessidade de introdução de conteúdos práticos e contextualizados desde o início do curso como fator essencial para a assimilação dos conteúdos teóricos dentro da perspectiva de sua aplicação prática criativa. Além disso, dever-se-ia ser um importante fator de motivação para o aluno, ajudando a reduzir os índices de evasão. A conjugação entre as chamadas atividades teóricas e práticas habilita o futuro profissional para intervir na realidade, dominando suas nuanças por meio de atividades simuladas, como exercícios, trabalhos, estudos de caso, práticas raramente associadas aos conteúdos teóricos dos cursos.

Aplicação de métodos ativos no ambiente educacional no intuito de aprimorar o processo de aprendizagem se faz necessário no compromisso da Instituição estudada, principalmente os cursos de Engenharia, na contínua melhoria quanto ao desenvolvimento de seus espaços de ensino. Esta responsabilidade é caracterizada pelo Standand 8 da Iniciativa CDIO (Conceber, Desenhar, Implementar e Operar), organização mundial englobando conceituadas instituições de ensino para o desenvolvimento do curso de engenharia através de projetos.

Crawley *et. al.* (2008), apresenta que os métodos de aprendizagem ativos busca envolver os alunos diretamente no pensamento e atividades de resolução de problemas. Há menos ênfase na transmissão passiva de informações (de maneira expositiva), porém está em envolver os alunos na manipulação, aplicação, analisar e avaliar ideias. Ao envolver os alunos no pensamento sobre conceitos, particularmente novas ideias e exigindo algum tipo de resposta aberta. Descrevem também que os estudantes não só aprender mais, eles reconhecem por si mesmos o que e como eles aprendem.

5.1 Metodologias aplicadas

Nos últimos anos, a abordagem de ensino-aprendizagem construtivista tem sido amplamente utilizada em contextos educacionais, nela os alunos assumem a responsabilidade de sua própria aprendizagem ao construir suas próprias versões de conhecimento.

Vallim *et. al*. (2006), Rotgans & Schmidt (2011) e Keyser (2000), além dos estudos de Hsieh & Knight (2008), Alwi *et. al*. (2012), Erdogan & Senemoglu (2013), Hassan et. al. (2012) e Mitchell & Delaney (2004), sugerem a utilização de recursos pedagógicos baseados em Metodologias Ativas, tais como PBL (*Problem-based Learning* - Aprendizagem baseada em problemas), PBLa (*Project-based Learning* - Aprendizagem baseada em projetos), FC (*Flipped Classroom* - Sala de aula invertida), entre outras, frente a utilização LBL (*Lecture-based Learning* - Aprendizagem baseada em exposições orais, palestras). A seguir, breve descrição dos métodos aplicados na instituição:

- PBL – Schmidt (1983) define o PBL como um "método de ensino, que fornece aos alunos conhecimentos adequado para a resolução de problemas". No PBL o problema é utilizado para iniciar o processo de ensino aprendizagem e integrar o ensino com os eventos da vida real. Hmelo-Silver (2004) afirma que os currículos baseados em problemas proporcionam aos alunos experiências dirigidas pelas resoluções de problemas complexos extraídos do mundo real. O aluno é o foco do processo de ensino aprendizagem e o mesmo é favorecido pela reciprocidade social em que os conhecimentos adquiridos são interpretações do mundo em que vivemos. Em outras palavras, Hansen (2006) afirma que o PBL é um método de ensino em que os alunos participam ativamente e são

aprendizes independentes, além de promover a cooperação de todos os membros do grupo para efetivamente resolverem o problema;

- PBLa – segundo Bell (2010), é uma abordagem inovadora para a aprendizagem que ensina uma infinidade de estratégias críticas para o sucesso no século XXI. Estudantes poderem direcionar sua própria aprendizagem através da investigação, bem como o trabalho de forma colaborativa para pesquisar e criar projetos que refletem o seu conhecimento. Além disso, consegue desenvolver novas habilidades tecnológicas viáveis, para se tornar proficientes comunicadores e solucionadores de problemas avançados, os alunos beneficiar dessa abordagem à instrução;
- FC – Refere-se a uma sala de aula que troca o arranjo de conhecimento no processo de transmissão e internalização do conhecimento comparando a sala de aula tradicional. Na sala de aula invertida, os papéis de professores e alunos foram alterados e o tempo de classe deve ter um novo plano. A inclusão da tecnologia da informação nas atividades de aprendizagem auxilia na construção do ambiente de aprendizagem de maneira individual e coletiva criando uma cultura no processo de ensino (ZINLEI *et al*, 2012);
- PI – Segundo Porter et al (2013), Peer Instruction é um método de ensino que pode ser aplicado a uma gama de disciplinas e conteúdos. PI suporta um ambiente de aprendizagem centrado no aluno, na qual a instrução da atividade é centrada no aluno. Dessa forma, a explicação do instrutor é aumentada e a inclusão de perguntas cuidadosamente elaboradas concebidas para envolver a aprendizagem dos alunos. O núcleo da metodologia PI é ter estudantes no processo de discussão e análise dasr questões em pequenos grupos. O uso de clickers para motivar a participação plena e para permitir de maneira rápida e revisão de pontos de vista de toda a classe principalmente daquilo que não foi compreendido totalmente. A combinação de responsabilidade pessoal (talvez através da atribuição de pontos para clicar), a discussão dos pares e *feedback* dos alunos (incluindo a forma como os seus colegas estão fazendo) estão na base da experiência PI;
- PLE – Powell & Weenk (2003), o PLE trata-se de uma metodologia de caráter ativo e colaborativo, capaz de melhorar o processo de ensino-aprendizagem, numa articulação direta entre a teoria e a pratica, através de um projeto que culmina com a apresentação de uma solução para um problema relacionado com uma situação real/profissional. A proposta de realização do projeto é ter um objetivo geral único. De acordo com Rui *et al* (2009), todas as equipes devem desenvolver o mesmo tema do projeto a fim de criar condições de avaliação semelhantes. No entanto, os projetos propostos devem ser abertos o suficiente para permitir soluções diferentes, estabelecendo o desenvolvimento da iniciativa do aluno e sua capacidade de tomar decisões com informações incompletas, redundantes ou distorcidas. Para tal segundo os autores, é importante que essas equipes devam ser grandes o suficiente para impor dificuldades tanto no projeto quanto na coordenação das atividades. Esse propósito melhora o desenvolvimento de várias competências transversais, tais como: capacidades de liderança e habilidades de gerenciamento de projetos, entre outros.
- C^3 – O método C^3 (Cumbuca do Compartilhamento do Conhecimento) está em processo de aplicação e pesquisa dentro da instituição em algumas disciplinas. Refere-se a disponibilizar um texto antecipadamente para nortear o aluno no processo de pesquisa do assunto abordado. Na data previamente definida, os alunos são consultados no início da aula quanto à preparação ou não de material para apresentação. Esta preparação consiste em comunicação e domínio do assunto. Identificados os alunos preparados, é feito um sorteio de 3 deles para que possam compartilhar aquilo que entenderam e estudaram do assunto. A média das 3 apresentações é a nota para todos aqueles que indicaram estar preparados. Após as apresentações é feito um debate entre todos os presentes que, conforme a participação e interação dos alunos, define o valor desta seção. Os ausentes não são avaliados.

Essas metodologias evidenciam uma abordagem de ensino-aprendizagem centrada no aluno, em que o professor deixa de ser o agente principal do processo, detentor que transmite o conhecimento e o aluno um mero receptor passivo das informações. Os alunos são estimulados a trabalharem em pequenos grupos com problemas do mundo real e o professor passa a ter um papel fundamental de facilitador do processo de ensino-aprendizagem.

5.2 Projeto Repositório: Compartilhando Conhecimento Ativo

No intuito de desenvolver um sistema de informação digital (biblioteca virtual) dedicado ao conteúdo de descrever as metodologias aplicadas nos cursos de engenharia do UNISAL (campus São Joaquim), foi definido o repositório de acesso livre (*open access*) de modo a divulgar internamente na instituição e principalmente, para a comunidade científica e acadêmica.

Com o compromisso da instituição quanto ao cumprimento das normas da Iniciativa CDIO para aprendizado na Engenharia através de projeto, estruturou-se a criação do repositório seguindo as etapas provenientes da sigla da organização, ou seja, Conceber, Desenhar, Implantar e Operar. Neste projeto, intitulado *Repositório: Compartilhando Conhecimento Ativo*, as atividades ficarão assim definidas:

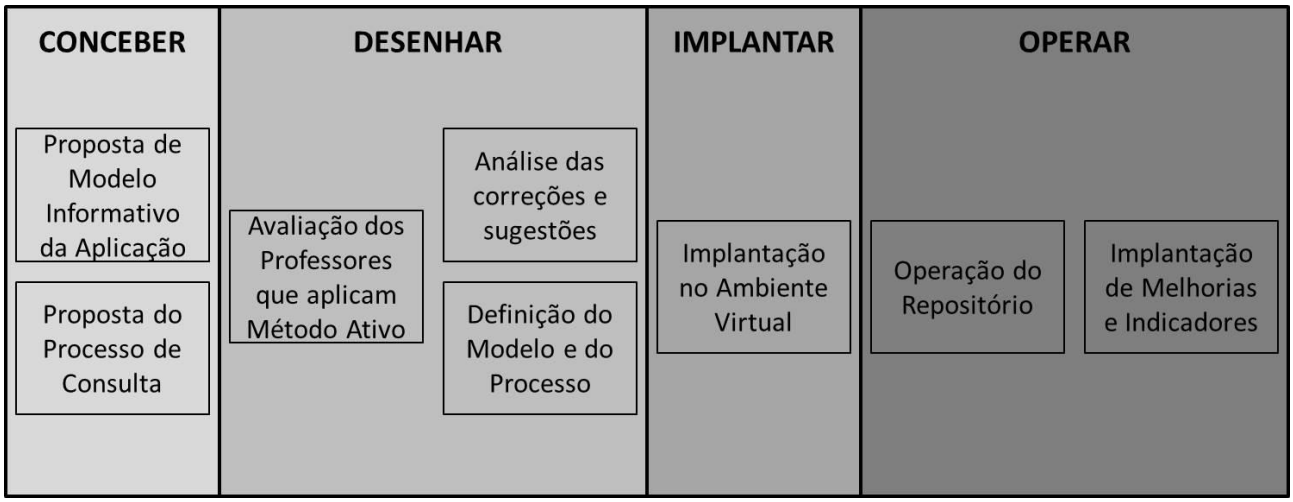


Figura 1. Atividades – Projeto Repositório

Dessa forma, na etapa de conceber, será elaborada uma proposta padrão de documento para apresentação das informações do método aplicado, intitulado *Modelo Informativo de Aplicação* (MIA). Além disso, será estabelecido o processo inicial quanto à forma de consulta.

O desenvolvimento do MIA deverá incluir as informações pertinentes àquilo que é aplicado em determinada disciplina, dentro e fora da sala de aula. Para tal, seguirá um modelo de artigo acadêmico que no futuro poderá ser submetido a uma publicação segundo sua contribuição científica. Este documento padronizado incluirá os seguintes itens:

- Autor
- Curso na qual foi aplicado
- Ano/Sem
- Disciplina ministrada
- Método utilizado
- Competências desenvolvidas
- Instrumento de avaliação
- Bibliografia

A forma de consulta seguirá os seguintes parâmetros:

- Palavras-chaves (aberto)
- Curso (fechado)
- Método (fechado)
- Competências (fechado)

Quanto a parametrização fechada, seguem as opções. A figura 1 apresenta em qual curso determinado método ativo foi aplicado:

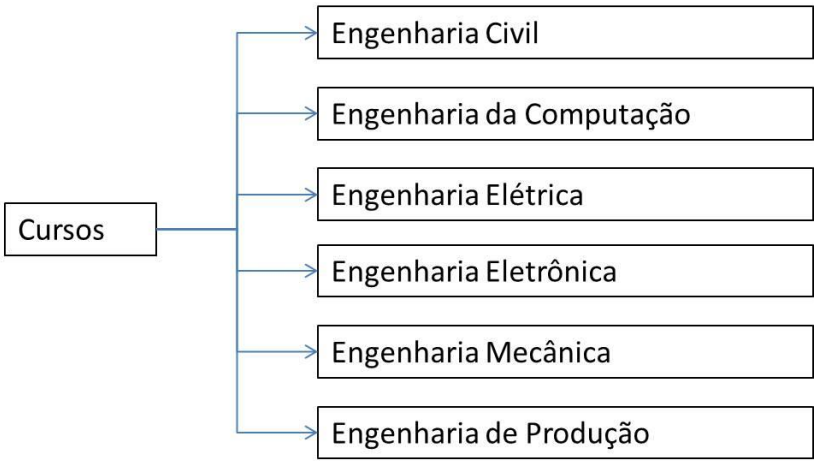


Figura 2. Cursos disponíveis para consulta

Já na figura 3 é mostrado qual o método que foi aplicado em determinada apresenta em qual curso determinado método ativo foi aplicado:

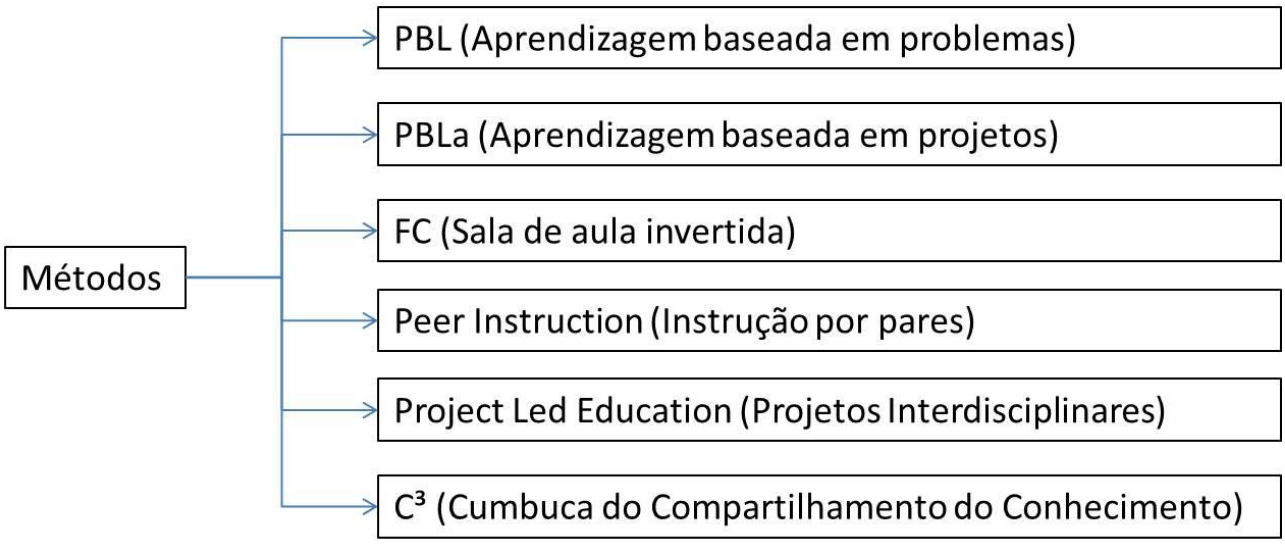


Figura 3. Métodos ativos aplicados na instituição

A formação do egresso em Engenharia exige muito mais que apenas os conhecimentos. Sendo assim, A figura 4 apresenta as competências relacionadas ao engenheiro:

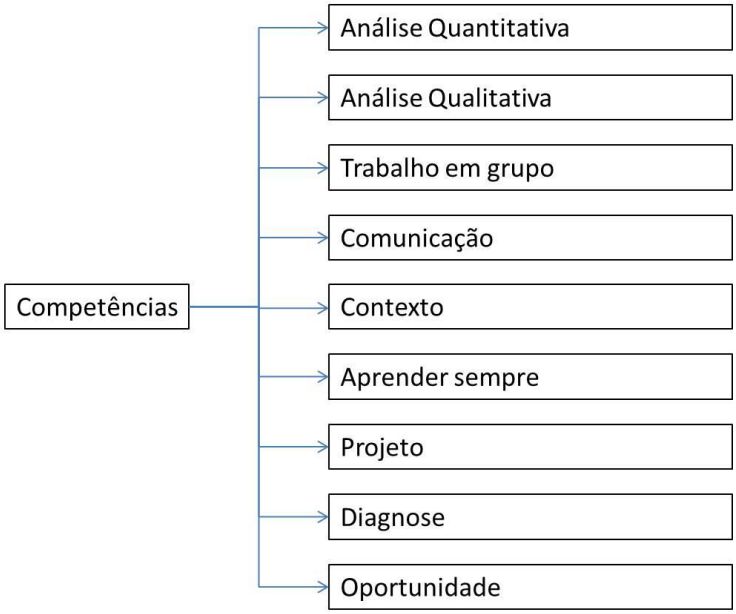


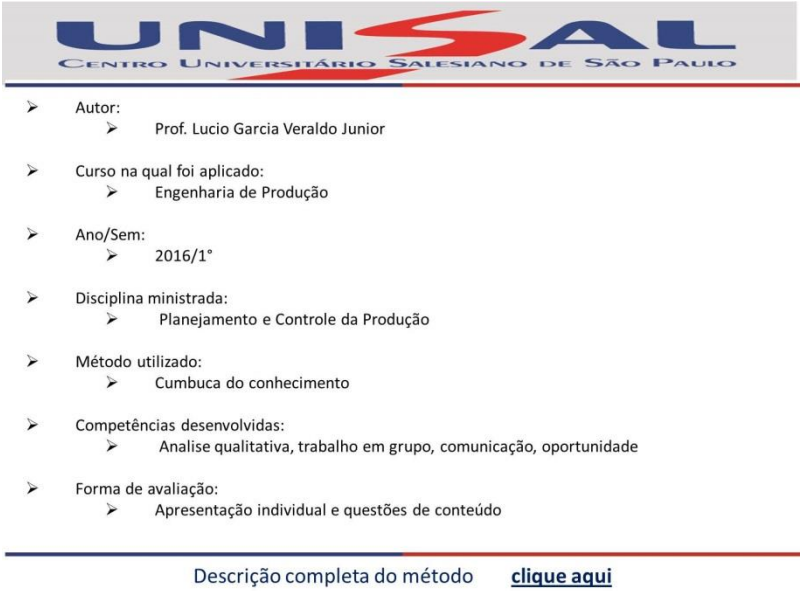
Figura 4. Competências desenvolvidas no método

5.3 Sistema de Consulta

Disponível de maneira *on line* o repositório está sendo criado no portal da instituição. A tela inicial do sistema terá o seguinte layout, conforme mostrado na figura 5.

Figura 5. Tela inicial de consulta

Uma vez incluídas as palavras-chaves ou mesmo nas opções pré-definidas (curso, competência e métodos) serão apresentados os resultados da consulta, ao escolher um deles, será mostrada a seguinte tela com características conforme a figura 5:



UNISAL
CENTRO UNIVERSITÁRIO SALESIANO DE SÃO PAULO

- Autor:
  - Prof. Lucio Garcia Veraldo Junior
- Curso na qual foi aplicado:
  - Engenharia de Produção
- Ano/Sem:
  - 2016/1°
- Disciplina ministrada:
  - Planejamento e Controle da Produção
- Método utilizado:
  - Cumbuca do conhecimento
- Competências desenvolvidas:
  - Analise qualitativa, trabalho em grupo, comunicação, oportunidade
- Forma de avaliação:
  - Apresentação individual e questões de conteúdo

Descrição completa do método clique aqui

Figura 6. Exemplo de resultado em consulta no repositório

5.4 Próximos passos

Até a submissão deste artigo as etapas na fase de concepção já haviam sido cumpridas. O envio do modelo para análise dos professores que aplicam método ativo foi feito ainda sem o retorno de todos. Espera-se encerrar esta fase incluindo aa definição do modelo informativo da aplicação até o mês de junho igualmente com o processo de consulta.

Estima-se que há pelo menos 30 aplicações diferenciadas dos métodos ativos descritos neste artigo em diversas disciplinas dos cursos de engenharia do UNISAL. Assim, espera-se que nos próximos meses, a base de dados contemple grande parte desta forma inovadora na qual o protagonismo do aluno é evidente no processo de aprendizagem.

A garantia da padronização e veracidade das informações necessárias para uma consulta científica, fez com que ações pesquisadas só possam ser implantadas durante a operação para que não tenha postergação da disponibilidade do repositório. Enriquecer os conteúdos é parte da melhoria contínua do processo. Diante disso, é expectativa implantar os metadados que são dados sobre dados, e, portanto, fornecem informações básicas como o autor de uma obra, a data de criação, referências a outros trabalhos relacionados, etc.

6 Conclusão

A proposta de construção do repositório se faz necessária numa instituição que é a vanguarda no cenário brasileiro no uso de metodologia ativa no processo de aprendizagem. O surgimento desta biblioteca digital propõe reunir as aplicações dos métodos ativos aplicados pelos professores da instituição que comumente são divulgadas na comunidade cientifica individualmente (isto, quando são) através de artigo ou reuniões técnicas. Diante deste cenário, fazer a gestão do conhecimento através de uma ferramenta digital, facilita a disseminação do conteúdo proposto de maneira padronizada e organizada, seja interna ou externamente.

Esta organização parte tanto da forma de consultar quanto do resultado que é apresentado. O modelo é baseado em portais pesquisados com grande aceitação da comunidade cientifica o que leva a crer que o portal proposto poderá a se tornar referencia quanto a consultas para o tema de metodologias ativas de ensino.

Dessa forma, o objetivo geral do artigo foi atingido com a apresentação de um projeto piloto para criação de um repositório digital com informações de aplicações de métodos ativos de ensino da Engenharia em uma instituição brasileira. Definido o modelo da qual os educadores irão incluir as informações de maneira padronizada fez-se também a proposta de consulta por interessados no assunto

Uma vez avaliado o processo de implantação do repositório nas aplicações dos cursos de Engenharia, no índice de participação dos professores (incluindo consulta quanto às possibilidades de melhoria através de questionário de satisfação) além da quantidade de acessos a determinado documento. De posse da analise dessas informações será apresentado à direção operacional a viabilidade de expandir o repositório a toda a instituição. Isto vem de encontro ao consórcio STHEM Brasil (site disponível nas referencias), grupo de mais de 40 universidades brasileiras, lideradas pelo UNISAL, dedicado à prática e disseminação do uso de métodos ativos de aprendizagem. Como trabalhos futuros avaliar a inclusão de outras áreas da instituição onde os métodos ativos são aplicados. Além disso, integrar as aplicações em um único projeto relatado através de um livro pode ser de grande contribuição para outros pesquisadores e instituições.

7 Referências

ALWI, SHARIFAH RAFIDAH WAN, YUSOF, KHAIRIYAH MOHD, HASHIM, HASLENDA, ZAINON, Zainura. Sustainability Education for First Year Engineering Students using Cooperative Problem Based Learning. Procedia - Social and Behavioral Sciences, 56, 52-58, 2012.

BELL, STEPHANIE. Project-based learning for the 21st century: Skills for the future. The Clearing House, v. 83, n. 2, p. 39-43, 2010.

CRAHERTY, IEDAETAL. ACTIVE Learning Methodologies: Na Experience for Falculty Training at Medical Education. Creative Education, v5, n 21, p 1881, 2014.

CROW, R. The Case for Institutional Repositories: A SPARC Position Paper. Washington, DC: Scholarly Publishing & Academic Resources Coalition, 2002. Disponível em http://www.arl.org/sparc/IR/ir.html Acesso em fev. 2016.

ERDOGAN, TOLGA, SENEMOGLUB, NURAY. Problem-Based Learning in Teacher Education: Its Promises and Challenges. Procedia - Social and Behavioral Sciences, 116, 459-463, 2014

HASSAN,SYED AHMAD HELMI SYED, YUSOF, KHARIYAH MOHD, MOHAMMAD, SHAHRIN, ABU, MOHD SALLEH , TASIR, ZAIDATUN. Methods to Study Enhancement of Problem Solving Skills in Engineering Students through Cooperative Problem-Based Learning. Procedia - Social and Behavioral Sciences, 56, 737-746, 2012.

HANSEN, J. D. Using problem-based learning in accounting, Journal of Education for Business, 81(4), 221-224, 2006.

HMELO-SILVER, C. E. Problem-based learning: what and how do students learn? Education Psychology Review, 16(3), 235-266, 2004

HSIEH, CYNTHIA, KNIGHT, LORRIE. Problem-Based Learning for Engineering Students: An Evidence-Based Comparative Study. Journal of Academic Librarianship, Vol. 34 (1), pp.25-30, 2008.

http://www.budapestopenaccessinitiative.org/read. Acesso em Mar.2016

JINLEI, ZHANG; YING, WANG; BAOHUI, ZHANG. Introducing a New Teaching Model: Flipped Classroom [J]. Journal of Distance Education, v. 4, p. 46-51, 2012.

KEYSER, MARCIA. Active Learning and Cooperative Learning: Understanding the Difference and Using Both Styles Effectively. Research Strategies, Vol.17 (1), p.35-44, 2000.

LIMA, R M. et al. Management of interdisciplinary project approaches in engineering education: a case study. In: First Ibero-American Symposium on Project Approaches in Engineering Education (PAEE'2009). Universidade Minho. Instituto de Educação. Centro de Investigação em Educação (CIEd), 2009. p. 149-156.

LOURENÇO Jr, J., VERALDO Jr, L. G. CDIO approach: description of the experience in a brazilian HEI. Proceedings of the 11th International CDIO Conference, Chengdu University of Information Technology, Chengdu, Sichuan, P.R. China, 2015

MITCHELL, GEORGE, DELANEY, JAMES DECLAN. An Assessment Strategy to Determine Learning Outcomes in a Software Engineering Problem-based Learning Course. Int. Journal Engineering Ed. Vol.20, No.3, pp. 494-502, 2004.

PORTER, LEO; BAILEY LEE, CYNTHIA; SIMON, BETH. Halving fail rates using peer instruction: a study of four computer science courses. In: Proceeding of the 44th ACM technical symposium on Computer science education. ACM, 2013. p. 177-182.

POWELL, P.; WEENK, W. Project-led engineering education. Utrecht: Lemma, 2003.

RIBEIRO, LUIS ROBERTO CAMARGO. A aprendizagem baseada em problemas (PBL): Uma implementação na educação em Engenharia na voz dos atores. Tese de Doutorado. São Carlos: UFSCar, 2005

ROTGANS, JEROME, SCHMIDT, HENK. Situational interest and academic achievement in the active-learning classroom. Learning and Instruction, Vol.21 (1), pp.58-67, 2011.

SCHMIDT, H. G. Problem-based learning: rationale and descriptions. Medical Education, 17, 11-16, 1983.

SCHLINGENSIEPEN, JARN, Innovation in sistance, E-and Blendel Learning in Education mass production Using Inverted classroom model. Procedia-social and behavioral-Sciences, v141, p393-398, 2014.

SODHI, M. S.; SON, BYUNG-GAK. Content analysis of OR job advertisements to infer required skills. Journal of the Operational Research Society, v. 61, n. 9, p. 1315-1327, 2010.

SOMYUREK, SIBEL. Na effective education-toool; construction kits for fun and meaningful learning International jornal of technology and Design Education, v25, n.1, p.2541, 2015.

VALLIM, MARCOS BANHETI RABELLO, FARINES, JEAN MARINE, CURY, JOSÉ EDUARDO RIBEIRO. Practicing engineering in a freshman introductory course. Ieee Transactions On Education, Vol.49 (1), 2006, pp 74-79.

The Reference Matrix as Support for Skills Assessment in Differential and Integral Calculus

Mauro L. Rabelo[1], Celius A. Magalhães[1], Marcelo Furtado[1], Claisy M. Marinho-Araújo[2]

[1] Department of Mathematics, University of Brasilia, Brasilia, Distrito Federal, Brazil
[2] Faculty of Psychology, University of Brasilia, Brasilia, Distrito Federal, Brazil

Email: rabelo@unb.br, celiusm@gmail.com, mfurtado@unb.br, claisy@unb.br

Abstract

The learning in Differential and Integral Calculus is the subject of frequent research in higher education, in particular for exact science courses. As a rule, the tests usually practiced by teachers consist of a list of exercises that seek to check whether students can repeat routine procedures for solving math problems without proposing an in-depth reflection about the students' learning, disregarding the fundamental role that feedback plays in the evaluation process. To better understand the mathematical learning of first year students of the undergraduate courses, mathematics teachers at the University of Brasilia decided to reorganize the Calculus discipline and proposed the creation of a proficiency exam, built from a reference matrix based in the development of competences and from the construction of a calibrated item bank. This matrix articulates the characteristics of the expected professional profile of formation with the cognitive skills that contribute to the achievement of this profile and the objects of knowledge of calculus, by means of which the skills can be evaluated. The test items are analysed from the point of view of the classical test theory and item response theory, methodology that allows the interpretation of the proficiency (latent trait) scale of students and fosters the establishment of feedback, a critical step of the evaluation process. The process has proved to be of great learning for teachers, especially as regards the development of assessment tools that provide feedback on the development of fundamental skills for the learning of mathematics, redirecting old practices and opening future prospects of change of posture of teachers to face the traditional trinomial: teaching-learning-evaluation. The initial findings of this study reveal its potential as a contribution to the evaluation of the students in a formative perspective.

Keywords: Differential and Integral Calculus; Reference Matrix; Evaluation of Learning; Item Response Theory.

A Matriz de Referência como Suporte para Avaliação de Competências em Cálculo Diferencial e Integral

Mauro L. Rabelo[1,3], Celius A. Magalhães[1], Marcelo Furtado[1], Claisy M. Marinho-Araújo[2]

[1] Department of Mathematics, University of Brasilia, Brasilia, Distrito Federal, Brazil
[2] Faculty of Psychology, University of Brasilia, Brasilia, Distrito Federal, Brazil
[3] Supported by Fundação de Apoio a Pesquisa do Distrito Federal (FAPDF)

Email: rabelo@unb.br, celiusm@gmail.com, mfurtado@unb.br, claisy@unb.br

Resumo

O aprendizado de Cálculo Diferencial e Integral é tema de investigação frequente na educação superior, em especial para os cursos da área de ciências exatas. As avaliações usualmente praticadas pelos docentes que ministram essa disciplina são, via de regra, constituídas de listas de exercícios que buscam verificar se os estudantes conseguem repetir procedimentos rotineiros de resolução de problemas de matemática, sem contudo propor uma reflexão acerca do aprendizado dos estudantes, desconsiderando o papel fundamental que o feedback desempenha no processo avaliativo. Com o intuito de compreender melhor as dificuldades em termos de aprendizado de matemática dos alunos ingressantes nos cursos de graduação, professores de matemática da Universidade de Brasília decidiram reorganizar a disciplina de Cálculo e propuseram a criação de um exame de proficiência, construído a partir de uma matriz de referência, fundamentada no desenvolvimento de competências, e da construção de um banco de itens calibrado. Essa matriz articula as características do perfil profissional de formação esperado com as habilidades cognitivas que contribuem para o alcance desse perfil e os objetos de conhecimento de Cálculo, por meio dos quais as habilidades podem ser avaliadas. Os itens dos testes elaborados a partir da matriz são analisados do ponto de vista psicométrico, utilizando-se a Teoria Clássica dos Testes e a Teoria de Resposta ao Item, metodologia que permite a interpretação da escala de proficiência (traço latente) dos estudantes. O processo tem-se revelado de grande aprendizado para os professores, principalmente no que se refere à elaboração de instrumentos de avaliação que possibilitam feedback acerca do desenvolvimento de habilidades fundamentais para o aprendizado da matemática, redirecionando práticas cristalizadas e abrindo perspectivas futuras de mudança de postura de docentes frente ao tradicional trinômio: ensino-aprendizagem-avaliação. As primeiras conclusões deste estudo revelam seu potencial como uma contribuição para a avaliação dos alunos na perspectiva formativa.

Palavras-chave: Cálculo Diferencial e Integral; Matriz de Referência; Avaliação da Aprendizagem; Teoria de Resposta ao Item.

1 Introdução

A educação superior brasileira vem passando por profundas transformações na última década, decorrentes, principalmente, da implantação das políticas de expansão de vagas, criação de novas instituições públicas e inserção de estudantes pertencentes a grupos sociais historicamente excluídos do ensino superior. Naturalmente, esse quadro vem trazendo para o cenário acadêmico um novo perfil de aluno, levando as instituições de ensino superior (IES) a repensar estratégias de acolhimento e avaliação dos estudantes do primeiro ano, no intuito de reduzir as taxas de abandono e repetência. Nesse cenário, insere-se a Universidade de Brasília, uma IES pública federal, situada na capital brasileira, que conta atualmente com cerca de 37 mil estudantes de graduação. Nessa instituição, encontra-se o Departamento de Matemática (MAT), que oferta, semestralmente, mais de 6 mil matrículas em disciplinas de graduação para estudantes de diversos cursos da instituição.

A disciplina Cálculo Diferencial e Integral desempenha papel fundamental no ensino superior por causa da grande quantidade de cursos que a inserem como obrigatória no primeiro ano do fluxo do curso. Isso acarreta uma elevada quantidade de estudantes matriculados em diversas turmas. No entanto, apesar de sua relevância para a formação dos estudantes, a disciplina é mais conhecida por seus altos índices de reprovação e retenção. (RASMUSSEN, MARRONGELLE & BORBA, 2014)

Com o intuito de compreender melhor o aprendizado em matemática dos estudantes nas disciplinas do primeiro ano dos cursos de graduação, professores do MAT decidiram aprofundar estudos sobre as metodologias de elaboração de itens e propor um exame de proficiência em Cálculo, a partir da criação de uma matriz de referência embasada no desenvolvimento de competências e da construção de um banco de itens calibrado, utilizando, para isso, a Teoria de Resposta ao Item (TRI) e a Teoria Clássica dos Testes (TCT).

Segundo Deluiz (2001), a função das matrizes de competências evoluiu atrelada a movimentos teórico-conceituais predominantes em determinados momentos históricos, originando diversas concepções: behaviorista, funcionalista, construtivista e crítico-emancipatória. Devido às críticas frequentes às matrizes behaviorista e funcionalista, por se limitarem à descrição de funções e tarefas e à transposição linear das competências investigadas, concebidas como intermináveis listas de atividades e comportamentos, optou-se pela matriz construtivista, por revelar a dimensão processual e contextual na investigação das competências, expressas, no presente estudo, pelas características do perfil de formação desejado.(MARINHO-ARAÚJO & RABELO, 2015)

Neste trabalho, apresentam-se os achados iniciais da experiência desenvolvida na UnB, revelando suas potencialidades para que a avaliação dos estudantes assuma uma perspectiva mais formativa, oferecendo *feedback* não somente para os alunos, mas também para os docentes.

2 Método

2.1 Participantes

O trabalho envolveu 10 professores e 1173 estudantes matriculados em 24 turmas do primeiro semestre letivo de 2015. Os estudantes pertencem a diferentes cursos presenciais de graduação da instituição, que incluem: engenharias, matemática, física, química, biologia, geociências, geofísica, administração, economia, ciências contábeis, estatística e computação.

2.2 Instrumentos e procedimento

Durante o primeiro semestre de 2014, os professores criaram a matriz de referência que serviria de suporte para a criação dos itens dos testes. A matriz teve concepção tridimensional, correlacionando as características do perfil profissional de formação desejado com as habilidades imprescindíveis para o alcance do perfil e os conhecimentos de matemática necessários para seu desenvolvimento. Inicialmente, a matriz contemplava 12 habilidades e 5 características do perfil. Após o processo de validação semântica e de conteúdo, duas habilidades foram fundidas, restando apenas 11. A escolha dos objetos de conhecimento foi realizada após a matriz ser estruturada em termos de características do perfil e habilidades. Os objetos de conhecimento foram selecionados dos conteúdos curriculares das disciplinas em que serão aplicados os testes e explicitados em quais cruzamentos ou células da matriz eles se inserem, conforme figura 1. Desse modo, a matriz poderá ser utilizada em outras disciplinas, já que as dimensões referentes ao perfil e às habilidades são transversais à formação.

O grupo de professores elencou, após validação semântica e de conteúdo, as seguintes habilidades a serem avaliadas nos itens que compõem os testes:

- H1. Identificar linguagens e traduzir sua plurissignificação;
- H2. Interpretar diferentes representações de um mesmo conceito, transitando por representações simbólicas, gráficas e numéricas, entre outras;
- H3. Inter-relacionar objetos de conhecimento em diferentes áreas;
- H4. Organizar estratégias de ação e selecionar métodos;
- H5. Ler e interpretar dados e informações e expressar-se com clareza e precisão;
- H6. Aplicar métodos adequados para análise e resolução de problemas;
- H7. Formular e articular argumentos adequadamente;
- H8. Fazer inferências indutivas, dedutivas e analógicas;
- H9. Formular hipóteses e conjecturas, prever resultados e fazer generalizações;

H10. Analisar criticamente a solução encontrada para uma situação-problema;
H11. Confrontar possíveis soluções para uma situação-problema.

Para o perfil de formação desejado, tomando-se como base as diretrizes curriculares nacionais para os cursos de graduação, foram destacadas as seguintes características:

P1. Concebe a matemática como um corpo de conhecimentos rigoroso, formal e dedutivo, produto da atividade humana, historicamente construído;
P2. Domina os conhecimentos matemáticos e compreende o seu uso em diferentes contextos interdisciplinares;
P3. Identifica, formula e soluciona problemas;
P4. Valoriza a criatividade e a diversidade na elaboração de hipóteses, de proposições e na solução de problemas;
P5. Analisa criticamente a contribuição do conhecimento matemático para a sua formação.

Os objetos de conhecimento contemplam os seguintes tópicos: limites, derivadas, máximos e mínimos, integrais e aplicações.

A figura 1 a seguir ilustra a estrutura básica da Matriz de Referência. A partir dessa composição, se estabelecem as relações plausíveis entre as características do perfil e as habilidades, materializadas pelos objetos de conhecimento, que são inseridos nas células marcadas com um "X". A síntese desse complexo cruzamento é que dará origem ao item da prova, que precisará dar conta da articulação proposta em cada célula da Matriz.

Características do perfil	Habilidades										
	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	H11
P1	X	X	X				X				X
P2	X	X	X		X	X	X		X	X	X
P3	X	X	X	X	X	X	X	X	X	X	X
P4		X	X	X		X	X	X	X		X
P5			X			X	X	X	X		

Figura 1. Relações entre as habilidades (Hi) e as características do perfil (Pi).

Para a elaboração dos itens, utilizou-se a metodologia proposta por Rabelo (2013). Para possibilitar que sejam feitas inferências acerca dos erros cometidos pelos estudantes, as opções incorretas (distratores) dos itens de múltipla escolha foram elaboradas segundo o critério da plausibilidade. Isso significa que cada distrator deve ser cuidadosamente construído e analisado, fazer parte do contexto do item e ser uma resposta possível de um estudante que não sabe o conteúdo ou que não desenvolveu a habilidade avaliada. Deve-se elaborar um distrator que tenha aparência de resposta correta, mas que seja inquestionavelmente incorreto. Se o contrário ocorrer, poderá ocorrer desvios no poder de discriminação do item, o que acarretará a necessidade de sua reformulação ou até mesmo sua retirada da avaliação. (RABELO, 2013)

A figura 2 ilustra e sintetiza os procedimentos que precisam ser adotados quando a Matriz de Referência é escolhida como cerne da elaboração dos itens de avaliação: inicia-se com a descrição do perfil e sua decomposição em características; faz-se, em seguida, a escolha das habilidades a serem avaliadas e elencam-se os objetos do conhecimento que darão suporte aos itens de avaliação; finaliza-se com a elaboração das situações-problema ou dos cenários que serão utilizados para a criação dos itens. Nessa concepção, os itens constituem desafios a serem enfrentados pelos estudantes e que permitem a mobilização dos conhecimentos e das habilidades em busca da solução para a situação proposta. Essa perspectiva coaduna-se com a avaliação de competências e de perfil profissional proposta por Marinho-Araújo & Rabelo (2015), que tem como base a ampliação conceitual de competências segundo Le Boterf (2000), Tardif (1996), Wittorski (1997) e Zarifian (2003). Extrapolando a visão meramente tecnicista e considerando o contexto multifacetado e orgânico das práticas avaliativas no âmbito educacional, a experiência mostra que a Matriz traz organicidade ao processo e faz com que os professores elaborem cada item – ou mesmo cada opção, no caso da múltipla escolha –, com intencionalidade, um dos pressupostos fundamentais da avaliação. Além disso, os testes ficam mais

equilibrados em termos de abrangência e de nível de complexidade, já que devem contemplar o máximo possível de habilidades e características de perfil elencadas na Matriz.

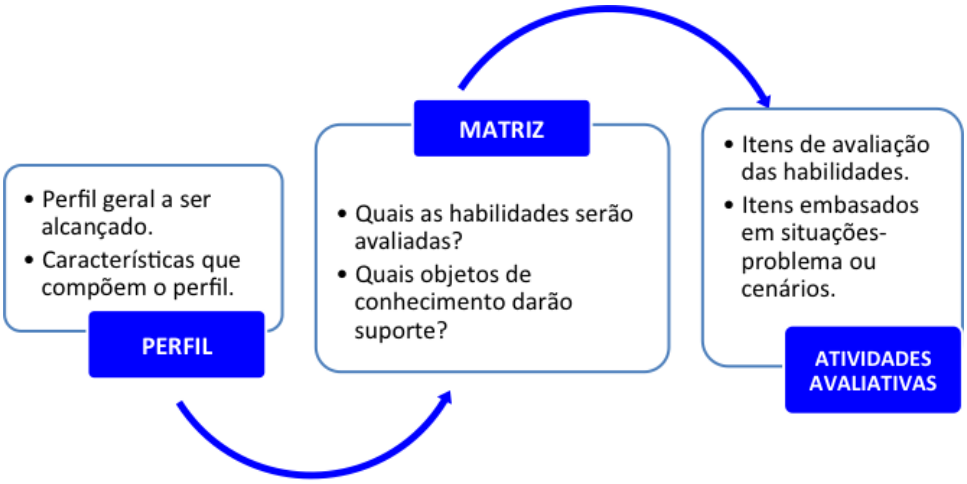


Figura 2. Representação esquemática simplificada do processo de elaboração embasado em matrizes de referência.

Durante o primeiro semestre letivo de 2015, foram aplicados 78 itens de múltipla escolha, com 5 opções de resposta cada um, em 3 testes da disciplina Cálculo I. Cada caderno de teste era composto de 10 itens de múltipla escolha e de duas questões discursivas. Em cada etapa, foram montados 3 cadernos diferentes, com dois itens de múltipla escolha comuns entre os três, totalizando, assim, 26 itens diferentes. Os itens comuns permitiram a equalização das proficiências dos estudantes e dos parâmetros da TRI a eles associados. A análise dos resultados será feita a seguir.

3 Resultados e discussão

Os resultados de desempenho foram analisados considerando-se parâmetros oriundos da TRI e da TCT. Mais especificamente, foram calculados os parâmetros de discriminação (a), dificuldade (b) e de acerto ao acaso (c), fornecidos pela TRI, e o coeficiente bisserial (Bis) e a dificuldade (D), a qual corresponde simplesmente à proporção de acertos, dados pela teoria clássica.

O modelo da TRI adotado foi o logístico de três parâmetros, que representa a probabilidade de um indivíduo dar uma resposta a um item como função de seu traço latente (proficiência) e dos parâmetros a, b e c do item. (ANDRADE, TAVARES & VALLE, 2000)

Para cada item, foram também geradas a Curva Característica do Item (CCI) e a Análise Gráfica do Item (AGI). A primeira representa a probabilidade de acerto em função da proficiência, enquanto a segunda ilustra os percentuais de marcação por opção de resposta em cada faixa de escore bruto no teste. Ambas constituem excelentes ferramentas de análise do comportamento de cada item, que subsidiam a tomada de decisão do cumprimento ou não de seus objetivos. Via de regra, elabora-se um item pressupondo-se que ele vá cumprir determinada finalidade, mas, somente após análise dos parâmetros, descobrem-se desvios nas alternativas, problemas nos enunciados, falta de capacidade de discriminação, dificuldade superior à esperada, entre outros.

Com essa metodologia, são fortalecidos os processos de ação-reflexão-ação no espaço educativo, possibilitando ao professor a transformação não apenas de seu fazer docente mas também de si, em um exercício permanente para a melhoria da qualidade das atividades desenvolvidas durante a ação pedagógica. Para exemplificar o tipo de análise feita, apresenta-se na tabela 1 os parâmetros dos itens encontrados após a aplicação de uma das provas de 2015.

A tabela 1 ilustra alguns dados encontrados na primeira avaliação, aplicada em abril de 2015 para 1173 estudantes de Cálculo I.

Tabela 1. Parâmetros dos itens da primeira avaliação segundo a TRI e a TCT.

	TRI			TCT	
Questão	a	b	c	Bis	D
01	1.475	0.562	0.245	0.694	0.497
02	0.719	-1.816	0.212	0.585	0.886
03	0.714	-0.897	0.189	0.616	0.760
04	0.904	-0.897	0.182	0.691	0.776
05	1.697	1.018	0.123	0.740	0.291
06	0.629	0.925	0.197	0.571	0.450
07	1.148	-0.183	0.164	0.765	0.634
08	0.869	-0.757	0.194	0.663	0.758
09	0.955	0.170	0.240	0.667	0.593
10	2.076	0.970	0.109	0.760	0.280
11	0.901	-1.313	0.209	0.717	0.851
12	0.819	-1.191	0.225	0.670	0.829
13	0.865	-0.375	0.176	0.720	0.669
14	0.611	-1.254	0.224	0.518	0.806
15	1.629	0.671	0.143	0.750	0.413
16	0.516	0.428	0.241	0.526	0.564
17	1.619	0.885	0.081	0.787	0.287
18	0.869	-0.419	0.193	0.700	0.686
19	1.150	-1.439	0.207	0.728	0.883
20	0.692	-1.994	0.207	0.615	0.894
21	0.884	0.549	0.224	0.647	0.494
22	0.525	-0.686	0.223	0.540	0.711
23	1.235	0.914	0.128	0.696	0.325
24	0.827	1.869	0.182	0.493	0.275
25	0.764	0.621	0.174	0.666	0.455
26	1.140	0.422	0.209	0.674	0.497
Média	1.009	-0.128	0.1885	0.664	0.599

Os dados sugerem que o conjunto de itens comportou-se bem do ponto de vista psicométrico, com parâmetros de discriminação e dificuldade médias respectivamente iguais a 1.009 e -0.128, segundo a TRI, e 0.664 e 0.599, segundo a TCT. Apenas 4 itens apresentaram parâmetro de discriminação abaixo de 0.65, segundo a TRI, merecendo um olhar mais acurado no sentido de verificar sua adequabilidade. Somente um item revelou-se muito difícil para os estudantes, segundo o parâmetro b.

De acordo com Pasquali (2003), recomenda-se, em avaliação educacional, uma distribuição de níveis de dificuldade de itens no teste dentro de uma curva normal: 10% dos itens em cada uma das duas faixas extremas, 20% em cada uma das faixas seguintes e 40% na faixa média". A tabela 2 mostra que a distribuição encontrada na primeira avaliação de Cálculo I não difere muito dessa recomendação, indicando que, pelo menos no que se refere à dificuldade, o conjunto de itens mostrou-se adequado.

Tabela 2. Distribuição dos itens segundo o parâmetro de dificuldade b.

Classificação	**Valores de b**	**Itens na faixa**	**%**
Muito fáceis	até -1.28	2, 11, 19, 20	15.4
Fáceis	de -1.27 a -0.52	3, 4, 8, 12, 14, 22	23.1
Medianos	de -0.51 a 0.51	7, 9, 13, 16, 18, 26	23.1
Difíceis	de 0.52 a 1.27	1, 5, 6, 10, 15, 17, 21, 23, 25	34.6
Muito difíceis	1.28 ou mais	24	3.8

Os índices de aprovação das turmas dos cursos diurnos em 2014 e no primeiro de 2015 constam da tabela 3. Nela, AP significa aprovados, RP representa os reprovados e TR são os trancamentos feitos voluntariamente pelos estudantes.

Tabela 3. Percentuais de aprovação nas turmas dos cursos diurnos: semestres 1 e 2/2014 e 2/2015.

	Semestre											
	2015/1				2014/2				2014/1			
Turma	AP	RP	TR	%AP	AP	RP	TR	%AP	AP	RP	TR	%AP
A	51	9	2	82,26	49	7	3	83,05	49	9	0	84,48
B	18	40	1	30,51	23	36	0	38,98	31	36	1	45,59
C	40	14	7	65,57	22	30	8	36,67	36	25	4	55,38
D	32	26	4	51,61	33	28	3	51,56	21	44	4	30,43
E	25	13	1	64,10	18	13	0	58,06	18	28	3	36,73
F	32	13	1	69,57	39	12	0	76,47	44	16	0	73,33
H	31	28	1	51,67	14	27	2	32,56	43	17	1	70,49
J	41	16	4	67,21	40	11	0	78,43	38	20	1	64,41
M	38	23	0	62,30	21	21	0	50,00	38	26	2	57,58
N	26	19	0	57,78	11	22	5	28,95	36	16	2	66,67
O	23	29	3	41,82	32	31	0	50,79	18	26	15	30,51
Y	38	15	3	67,86	30	34	1	46,15	28	30	7	43,08
Z	35	15	2	67,31	29	23	9	47,54	40	25	0	61,54
TOTAL	430	260	29	59,81	361	295	31	52,55	440	318	40	55,14

Verifica-se uma melhora em termos de desempenho médio dos estudantes do ano de 2014 para 2015. Naturalmente, ainda é cedo para se fazer inferências acerca desse resultado, mas isso já representa um alento, principalmente se for observado que o quantitativo de estudantes ingressantes que cursaram integralmente o ensino médio em escolas públicas aumentou em cerca de 12.5% de 2014 para 2015, a partir da denominada Lei das Cotas Sociais. Esses estudantes ingressam com escores inferiores nos exames de acesso e, em tese, teriam mais dificuldades de acompanhar as disciplinas do primeiro ano dos cursos.

4 Conclusão

Os resultados encontrados revelam a potencialidade da avaliação proposta como instrumento que auxilia na compreensão acerca do aprendizado em matemática dos estudantes ingressantes da educação superior. Observou-se, também, uma sensível melhora do desempenho médio dos estudantes no período investigado. À medida que o banco de itens de Cálculo aumentar, a teoria de resposta ao item poderá ser usada para se fazer a descrição dos níveis da escala de proficiência, o que constituirá ferramenta fundamental de *feedback* para estudantes, propiciando um movimento constante de ação-reflexão-ação dos docentes.

No âmbito educacional, avaliar é refletir sobre determinada realidade e julgar a necessidade de ajustes nas estratégias que contribuam para a melhoria das aprendizagens. Neste estudo, ficou evidenciado que a Matriz de Referência é excelente ferramenta orientadora do processo de avaliação, especialmente porque constitui uma oportunidade para os professores fazerem inferências sobre o atingimento do perfil de formação esperado e do aprendizado em matemática dos estudantes. A reflexão dos docentes sobre o desempenho contribui sobremaneira para a melhoria da qualidade dos instrumentos de avaliação atualmente praticados e possibilita também que se façam inferências sobre o aprendizado dos alunos quando se consideram as análises dos erros cometidos, já que os distratores de cada item têm sido elaborados respeitando-se o critério de plausibilidade. Desse modo, a prática reflexiva proporcionará ao professor fundamentação para a sua práxis no espaço-tempo em que constrói seu fazer pedagógico.

O trabalho aqui descrito pode também ser considerado um pré-teste para calibração do banco de itens que será futuramente utilizado para o estabelecimento do Exame de Proficiência em Cálculo, a ser utilizado como

critério de dispensa da disciplina ou de nova oportunidade para aqueles que não forem bem-sucedidos quando cursarem o Cálculo pela primeira vez. Nesse sentido, os resultados da calibração, mesmo que preliminares, demonstram que o processo está caminhando na direção correta.

5 Referências

Andrade, D. F., Tavares, H. R., Valle, R. C. (2000). *Teoria da resposta ao item: conceitos e aplicações*. São Paulo: ABE.

Deluiz, N. (2001). O modelo das competências profissionais no mundo do trabalho e na educação: implicações para o currículo. *Boletim Técnico do SENAC*, Rio de Janeiro, v. 27, n. 3, set./dez.

Le Boterf, G. (2000). *Construire les compétences individuelles et collectives*. Paris: Ed. d'Organisation.

Marinho-Araújo, C. M., Rabelo, M. L. (2015). Avaliação educacional: a abordagem por competências. *Avaliação*, 20(2), 443-466.

Pasquali, L. (2003). *Psicometria: teoria dos testes na Psicologia e na Educação*. Rio de Janeiro: Vozes.

Rabelo, M. (2013). *Avaliação Educacional: fundamentos, metodologia e aplicações no contexto brasileiro*. Coleção PROFMAT. Rio de Janeiro: SBM.

Rasmussen, C., Marrongelle, K., & Borba, M. C. (2014). Research on cauculus: what do we know and where do we need to go? *ZDM Mathematics Education*, 46, 507-515.

Tardif, J. (1996) Le transfer de compètences analysé à travers la formation de professionnels. *In*: Meireieu, P. H. (Orgs.). *Le concept de transfert de connaissance em formation initiale et continue*. Lyon: CRDP.

Wittorski, R. (1997). La compétence au travail. *Revue Education Permanente*, 135, 57-69.

Zarifian, P. (2003). *O modelo da competência: trajetória histórica, desafios atuais e propostas*. São Paulo: Editora Senac.

Influence of Problem-Based Learning via Projects in INEP/MEC Student Performance Evaluation: Case of the Production Engineering Undergraduate Program at UnB

João Carlos Félix Souza[1]; João Mello da Silva[1], Carlos Henrique Rocha[1]; Simone Borges Simão Monteiro[1], Andréa Cristina Santos[1]

[1] Department of Production Engineering, Faculty of Technology, University of Brasília, Campus Darcy Ribeiro, Brasília-DF, Brazil

Email: jocafs@unb.br, joaomello@unb.br, chrocha@unb.br, andreasantos@unb.br, simoneborges@unb.br

Abstract

As disclosure, by the Inep (Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira), sorting the results list of the Enade (National Examination performance of students) and CPC (Calculation of Preliminary Concept of Course) to College and University in Brazil, the course of the Department of Production Engineering of UnB (EPR) received, in assessing Enade , the second largest evaluation of 329 Production Engineering courses and the best evaluation of all courses at the University of Brasilia. The Enade constitutes important indicator in the evaluation of the general criterion CPC. An estimate of the Inep, the course of UnB would be ranked among the 5 best courses of engineering production of Brazil. The proposed research aims to assess the results of the EPR in relation to other courses in Brazil, mainly to colleges well classified and the main benchmarks (average, median and other measures). Otherwise, the size as the methodology used by the Inep portrayed with reliability the results in comparison to other statistical techniques (Factorial Analysis and Clustering) and DEA (Data Envelopment Analysis), techniques widely used for ranking decision making units. The results show that the Department of production engineering of UnB among the most prominent courses and, by any of the methods and techniques used, the EPR ranked among the best courses in production engineering from Brazil.

Key words: Inep;Enade; CPC; C*luster* and DEA.

A Influência do PjBL na avaliação de desempenho dos estudantes pelo INEP/MEC: o caso do Programa de Graduação de Engenharia de Produção da UnB

João Carlos Félix Souza[1]; João Mello da Silva[1], Carlos Henrique Rocha[1]; Simone Borges Simão Monteiro[1], Andréa Cristina Santos[1]

[1] Department of Production Engineering, Faculty of Technology, University of Brasília, Campus Darcy Ribeiro, Brasília-DF, Brazil

Email: jocafs@unb.br, joaomello@unb.br, chrocha@unb.br, andreasantos@unb.br, simoneborges@unb.br

Resumo

Conforme divulgação, pelo Inep (Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira), de lista de classificação dos resultados do Enade (Exame Nacional de Desempenho de Estudantes) e CPC (Cálculo do Conceito Preliminar do Curso) para as Escolas de nível superior no Brasil, o curso do Departamento de Engenharia de Produção da UnB (EPR) recebeu, na avaliação Enade, a segunda maior avaliação dos 329 cursos de Engenharia de Produção e a maior avaliação de todos os cursos da Universidade de Brasília. O Enade constitui indicador importante na avaliação de curso no critério geral CPC. Numa estimativa do Inep, o curso da UnB estaria classificado entre os 5 melhores cursos de Engenharia de Produção do Brasil. A pesquisa proposta avalia os resultados do EPR em relação aos demais cursos no Brasil, principalmente às escolas bem classificadas e aos principais parâmetros de comparação (média, mediana e demais separatrizes). De outra maneira, procura-se neste artigo, dimensionar o quanto a metodologia utilizada pelo Inep retratou com fidedignidade os resultados em comparação a outras técnicas estatísticas (Análises Fatoriais e *Clusterização*) e DEA (Data Envelopment Analysis), técnicas utilizadas no meio acadêmico para o *rankeamento* de Unidades de Decisão. Os resultados mostram que o Departamento de Engenharia de Produção da UnB entre os cursos de maior destaque e, por qualquer uma das metodologias e técnicas utilizadas, o EPR classificou-se entre os melhores cursos de Engenharia de Produção do Brasil.

Palavras Chave: Inep; Enade; CPC; *clusterização* e DEA.

1 Introdução

O Inep (Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira), além de outras atribuições, avalia, de três em três anos, todas as escolas de ensino superior no Brasil (INEP, 2015). Com isso, as Instituições são auxiliadas no reposicionamento e reavaliação da estrutura acadêmica, bem como auxilia as decisões dos estudantes na escolha dos seus cursos de ingresso. No ano de 2014 houve levantamento e pesquisa com todas as escolas de nível superior no Brasil. Em dezembro de 2015 esses resultados foram divulgados (INEP, 2015)

A lista de classificação dos resultados do Enade (Exame Nacional de Desempenho de Estudantes) e CPC (Cálculo do Conceito Preliminar do Curso) avaliou 329 cursos de Engenharia de Produção. O curso do Departamento de Engenharia de Produção da UnB (EPR) classificou-se como a segunda maior avaliação de Engenharia de Produção e a maior avaliação de todos os cursos da Universidade de Brasília (UnB).

Os modelos tradicionalmente utilizados para segmentação, agrupamento, classificação e *rankeamento* de Instituições são as análises de *clusters* ou modelos de *clusterização* (LARWOOD, 1995 e CHATURVEDI, 2001). As técnicas DEA (Data Envelopment Analysis) propostas por Charnes et. al (1978) são, também, bastante utilizadas em classificação de instituições. Essa técnica é frequentemente utilizada em classificação de agências bancárias (SOUSA e SOUZA, 2014). Ângulo-Meza (1998) utiliza uma aplicação na área de ensino de universidades.

Devido os resultados alcançados no Enade destaca-se a metodologia de ensino do EPR (ZINDEL et. al, 2013), diferenciada e inovadora, aplicada com visão PjBL (Project Basic Learning). Trata-se de condução do curso de Engenharia de Produção com disciplinas e áreas definidas na ABEPRO, associadas, simultaneamente, a disciplinas práticas de desenvolvimento de projetos (LIMA et. al, 2012). Neste caso, com aplicação do PMBOK

(Project Management Body Knowledge). A correlação é verificada, empiricamente, pelo resultado do Enade. Porém, o estabelecimento de causalidade requer pesquisas aprofundadas e testes apropriados com maior espaço de tempo para sua confirmação. Assim, o artigo se limita a avaliação de resultados do Inep com foco no EPR e comparação de metodologias.

As disciplinas teóricas do EPR juntamente com as disciplinas de projetos PjBL/PMBOK (LIMA et. al, 2012), utilizam temas práticos de projetos em produtos e notadamente em serviços públicos, refletindo o mercado de Brasília como capital do Brasil. As aulas tradicionais são acrescidas de horários para trabalhos de equipes de projetos. Estes projetos estão associados a situações reais e com objetivos definidos com as empresas e instituições envolvidas (ZINDEL et. al, 2013) com a denominação de PSP (Projeto de Sistema de Produção). A pesquisa que originou este trabalho está dividida em três fases: 1) validação comparativa da metodologia do Inep; 2) pesquisa sobre a percepção do modelo da UnB com modelos das demais Escolas de Engenharia de Produção no Brasil; 3) Impacto de causalidade do modelo PjBL utilizado pela UnB. Neste artigo trabalha-se a primeira fase e expõe algumas prévias das fases 2 e 3.

Após esta Introdução a próxima seção descreve, em resumo, a Metodologia Inep utilizada para avaliação e classificação das escolas de nível superior. Essa descrição é feita e divulgada no site do Inep através de duas Notas Técnicas de 27/10/2015: nota técnica Enade 57/2015 e nota técnica CPC 58/2015. A terceira seção versa sobre metodologias alternativas comumente usadas para classificação de instituições, tais como Análise de *Clusters* e DEA. A quarta seção apresenta e analisa os resultados. A última seção conclusões e desenvolvimento das demais fases.

2 Metodologia INEP- Cálculo do Enade e CPC

Conforme a Nota Técnica 57/2015 do Conceito Enade do INEP seu cálculo é feito para cada unidade de observação, constituída pelo conjunto de cursos que compõe uma área de avaliação específica de uma mesma Instituição de Educação Superior (IES), em um determinado município com estudantes concluintes em 2014. Todas as medidas originais, referentes ao Conceito Enade, são padronizadas e reescalonadas para assumirem valores de 0 (zero) a 5 (cinco), na forma de variáveis contínuas. O processo de padronização e reescalonamento passa por duas etapas: (a) cálculo do afastamento padronizado de cada unidade de observação, fazendo-se uso das médias e dos desvios-padrão calculados por área de avaliação, (b) transformação dos afastamentos padronizados em notas padronizadas que também podem variar de 0 (zero) a 5 (cinco).

O passo inicial para o cálculo do Conceito Enade de uma unidade de observação é a obtenção do desempenho médio de seus concluintes na Formação Geral (FG) e no Componente Específico (CE) que compõem pesos diferentes para cada curso. Para que todas as unidades de observação tenham suas notas FG e CE numa escala de 0 (zero) a 5 (cinco), efetua-se a interpolação linear, obtendo-se, assim, respectivamente, as Notas Padronizadas de FG e CE para cada unidade *j*, As unidades com afastamento padronizado menor que -3,0 e maior que +3,0 recebem nota padronizada igual a 0 (zero) e 5(cinco), respectivamente.

2.1 Conceito Enade

A *Nota dos Concluintes no Enade* da unidade de observação *j* (*NCj*) é a média ponderada das notas padronizadas da respectiva unidade de observação em FG e CE, sendo 25% o peso da Formação Geral e 75% o peso do Componente Específico da nota final, como mostra a equação abaixo:

$$NC_j = 0{,}25\ NP_{FGj} + 0{,}75\ NP_{CEj} \qquad (1)$$

Onde:
NC_j é a nota dos concluintes no Enade da unidade de observação *j*;
NP_{FGj} é a nota padronizada em FG da unidade de observação *j*;
NP_{CEj} é a nota padronizada em CE da unidade de observação *j*.

O Conceito Enade é uma variável discreta que assume valores de 1 a 5, resultante da conversão da *Nota dos Concluintes no Enade* da unidade de observação *j* (*NCj*), realizada conforme definido na Tabela 1. As unidades

de observação com menos de 2 (dois) concluintes participantes no Exame não obtêm o Conceito Enade, ficam "Sem Conceito (SC)".

TABELA 1 – Parâmetros de conversão do *NCj* em Conceito Enade.

Conceito Enade (faixa)	*NCj*(valor contínuo)
1	$0 \leq NCj \leq 0{,}945$
2	$0{,}945 \leq NCj \leq 1{,}945$
3	$1{,}945 \leq NCj \leq 2{,}945$
4	$2{,}945 \leq NCj \leq 3{,}945$
5	$3{,}945 \leq NCj \leq 5$

Fonte: INEP/Daes

2.2 Metodologia INEP – Cálculo CPC

A metodologia de cálculo do Conceito Preliminar de Curso (CPC) é um indicador de qualidade que combina, em uma única medida, diferentes aspectos relativos aos cursos de graduação. O CPC é calculado para cada unidade de observação, constituída pelo conjunto de cursos que compõe uma área de avaliação específica do Enade, de uma mesma Instituição de Educação Superior (IES) em um determinado município em 2014.

2.2.1 Componentes do Conceito Preliminar de Curso

A composição e o cálculo do CPC abarcam 8 (oito) componentes, agrupadas em três dimensões de avaliação da qualidade dos cursos de graduação: a) *Desempenho dos Estudantes*; b) *Corpo Docente* e c) *Percepção Discente sobre as Condições do Processo Formativo*.

Desempenho dos Estudantes

A dimensão *Desempenho dos Estudantes* é constituída pelos componentes:

Nota dos Concluintes no Enade (*NCj*) é a média das notas do teste Enade de cada unidade de observação *j* padronizadas e com valores de escala de 0 (zero) a 5 (cinco).

Nota do Indicador da Diferença entre os Desempenhos Observado e Esperado (*NIDDj*) é o Indicador da Diferença entre os Desempenhos Observado e Esperado (IDD). Busca aferir o valor agregado pelo curso no desenvolvimento dos estudantes concluintes, considerando seus desempenhos no Enade e suas características de desenvolvimento ao ingressar no curso de graduação avaliado. Os fatores que determinam o desempenho dos concluintes de cursos de graduação podem estar relacionados a: a) características de desenvolvimento do estudante concluinte ao ingressar na Educação Superior; b) qualidade das condições do processo formativo oferecido pelos cursos; e c) outros elementos que afetam o desempenho do estudante concluinte, captados por um termo de erro. Assim sendo, o desempenho de cada estudante concluinte no Enade poderia ser decomposto em função dos três aspectos, como mostra a equação abaixo:

$$C = I + Q + \varepsilon \qquad (2)$$

Onde:

C é o desempenho observado do estudante concluinte;

I é a parte do desempenho do estudante concluinte, decorrente de suas características quando ingressante no curso;

Q é a parte do desempenho do estudante concluinte decorrente da qualidade das condições de oferta do processo formativo do curso; e

ε é o termo de erro, com a hipótese usual de que $E[\varepsilon / I,Q] = 0$.

Partindo-se dos fatores que determinam o desempenho dos concluintes, o *IDD* é:

$$IDD = C - \tilde{I} \qquad (3)$$

Para $\tilde{I}$ a estimativa da parte do desempenho do estudante concluinte, decorrente de suas características quando ingressante no curso. Para obtenção dessa medida, buscou-se localizar na base de dados do Enem (Exame Nacional de Ensino Médio) as notas dos estudantes concluintes. Posteriormente, identificam-se as

unidades de observação que atendam as condições de cálculo do indicador que devem 1) Ter o mínimo de 2 (dois) estudantes concluintes participantes do Enade e do Enem; 2) Ter atingido 20% (vinte por cento) do total de estudantes concluintes participantes do Enade com dados recuperados da base de dados do Enem.

Após essa definição aplica-se o modelo de regressão linear multinível ou hierárquico, do tipo paramétrico para dados agrupados, com o uso de parâmetros de efeitos fixos e efeitos aleatórios. Esse modelo descreve a relação entre uma variável dependente contínua e variáveis independentes ou explicativas (covariáveis).

No cálculo do IDD, o modelo de regressão multinível foi especificado em dois níveis: (1) o estudante, identificado pelo subscrito *i*; e (2) a unidade de observação, identificada pelo subscrito *j*. Para todas as etapas do processo de cálculo do IDD, as regressões e as estimativas de seus parâmetros ocorreram por área de avaliação do Enade.

O primeiro passo no processo de cálculo do IDD foi estimar os parâmetros do modelo de regressão utilizado para cada área de avaliação do Enade. A equação 3 expressa o primeiro nível da regressão relativa ao estudante. O intercepto refere-se ao curso, as demais medidas o desempenho do estudante no Enem.

$$C_{ij} = \beta_{oj} + \beta_1.CN_{ij} + \beta_2.CH_{ij} + \beta_3.LC_{ij} + \beta_4.MT_{ij} + \lambda_{ij} \quad (4)$$

Onde:
Cij é medida de desempenho do estudante concluinte *i* no Enade, ponderada das notas no componente específico (75%) e na formação geral (25%), da unidade de observação *j*;
CNij é a medida de desempenho do estudante concluinte *i* da unidade de observação *j* na prova do Enem de ciências naturais e suas tecnologias;
*CHij*é a medida de desempenho do estudante concluinte *i* da unidade de observação *j* na prova do Enem de ciências humanas e suas tecnologias;
LCij é a medida de desempenho do estudante concluinte *i* da unidade de observação *j* na prova do Enem de linguagens e códigos e suas tecnologias;
MTij é a medida de desempenho do estudante concluinte *i* da unidade de observação *j* na prova do Enem de matemática e suas tecnologias; e
λij é o efeito aleatório associado ao estudante concluinte *i*, da unidade de observação *j*.

Já a equação 8 expressa o segundo nível da regressão, relativo à unidade de observação.

$$\beta_{0j} = \beta_{00} + u_{0j} \quad (5)$$

β_{00} representa a média ou valor do intercepto geral, que é constante entre as unidades de observação e u_{oj} é o efeito aleatório associado à unidade de observação *j*.

O modelo de regressão apresentado nas equações 3 e 4 é estimado duas vezes. Na primeira, estima-se a regressão, computa-se o resíduo e, então, calcula-se o resíduo padronizado. A partir do resíduo padronizado são identificados os estudantes com resíduos considerados discrepantes (*outliers)*, ou seja, aqueles que apresentaram o resíduo padronizado com valor absoluto maior que 3. Na segunda estimativa, desconsiderando-se estudantes *outliers*, são obtidos os parâmetros definitivos que serão utilizados no cálculo de $\tilde{I}_{ij}$, necessário ao cálculo do IDD.

Obtidos os parâmetros da regressão, calcula-se $\tilde{I}_{ij}$ para cada estudante concluinte, como mostra a equação abaixo:

$$\tilde{I}_{ij} = \beta_{oj} + \beta_1.CN_{ij} + \beta_2.CH_{ij} + \beta_3.LC_{ij} + \beta_4.MT_{ij} \quad (6)$$

Portanto, o *IDD* bruto foi calculado para cada estudante *i* da unidade de observação *j* como exposto na equação 10:

$$IDD_{ij} = C_{ij} - \tilde{I}_{ij} \quad (7)$$

Desta forma, o *IDDj* corresponde a média dos estudantes de cada unidade j de observação que obedecem às condições indicadas. A variável *NIDDj* é a variável padronizada conforme definido anteriormente.

Quando a unidade de observação não apresentou os critérios mínimos para obtenção do *IDD*, a Nota Padronizada do *IDD* recebeu o mesmo valor da *NCi* (Nota dos Concluintes no Enade) para o cálculo do CPC.

Corpo docente
A dimensão *Corpo Docente* é constituída pelos componentes: Nota de Proporção de Mestres (*NMj*), Nota de Proporção de Doutores (*NDj*) e Nota de Regime de Trabalho (*NRj*) para a unidade de observação j. Posteriormente, essas medidas são padronizadas conforme o procedimento da equação 1.
Percepção Discente sobre as Condições do Processo Formativo
A dimensão *Percepção Discente sobre as Condições do Processo Formativo* é constituída pelos componentes: Nota referente à organização didático-pedagógica (*NOj*), nota referente à infraestrutura e instalações físicas (*NFj*) e nota referente às oportunidades de ampliação da formação acadêmica e profissional (*NAj*). As formas de cálculo dos componentes seguem metodologias próprias e utilizam os itens do Questionário Socioeconômico do Enade de 2014.
Esses itens são os que tratam da percepção dos estudantes sobre diversos aspectos relativos aos cursos e às instituições. Caracterizam-se como variáveis ordinais e estão em escala *likert*.

2.2.2 Fórmula do Conceito Preliminar de Curso
Finalmente, a composição e a forma de cálculo do CPC de 2014, com os respectivos pesos dos componentes, é dada pela seguinte fórmula:

$$NCPCj = 0{,}2NCj+0{,}35NIDDj+0{,}075NMj+0{,}15NDj+0{,}075NRj+0{,}075NOj+0{,}05NFJ+0{,}025NAj \quad (8)$$

NCPCj índica a *Nota Contínua do Conceito Preliminar do Curso* da unidade de observação *j* calculada com valores de 0 a 5. Estas notas são transformadas em *Conceito Preliminar de Curso (CPC)*. A Tabela 1 indica as mesmas transformações das notas contínuas em conceitos.

3 Resultados e Análises
A nota Enade é o principal resultado do CPC. Além de compor um indicador para avaliação única, contribui com 55% (nota Enade com 20% e mais nota IDD com 35%) no CPC (equação 8).

Este trabalho faz a comparação do curso do Departamento de Engenharia de Produção da Faculdade de Tecnologia da Universidade de Brasília (EPR/FT/UnB) com os 329 cursos de Engenharia de Produção credenciados no Brasil. Portanto, neste item vinte e sete alunos do curso de Engenharia de Produção da UnB (primeira turma) alcançaram um resultado ou nota contínua de 4,835; resultado que, na classificação conceitual (Tabela 1), é nota 5.

3.1 Comparações dos Resultados
Na comparação entre os cinco maiores cursos (notas CPC) o curso de Engenharia de Produção da UnB é a maior nota (Gráfico 1). Portanto, as comparações foram feitas com os cursos da Universidade Federal de Juiz de Fora (UFJF), Universidade Santa Cecília de Santos (UNISANTA). Universidade Federal do ABC de São Paulo (UFABC), Universidade Paulista de Araraquara (UNIP) e a Universidade Federal do Estado do Rio de Janeiro (UNIRIO).

Na nota Enade contínua o EPR perde apenas para o curso da UFRJ (Universidade Federal do Rio de Janeiro) com 4,929 (nota máxima).

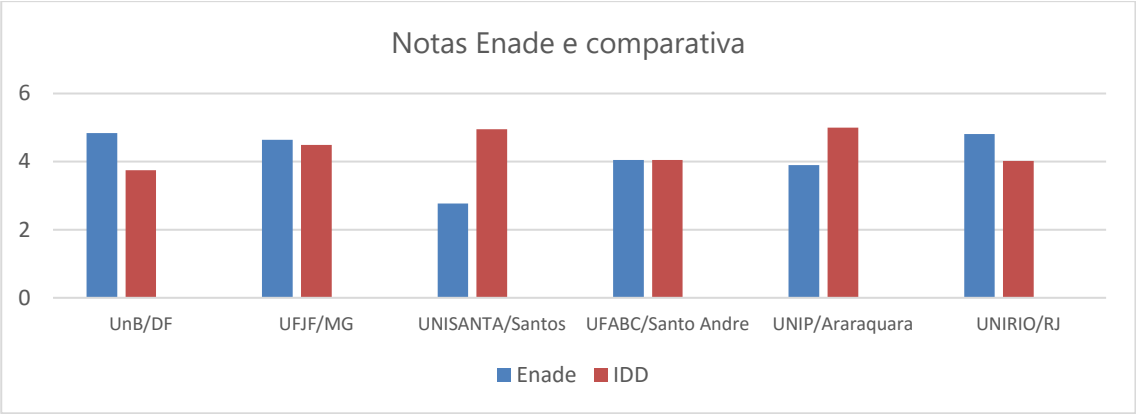


Gráfico 1: Nota Contínua Enade e IDD - 55% nota CPC Fonte: Inep/Dae

A nota IDD (Índice da Diferença entre os Desempenhos Observados e Esperados), tem participação de 35% da pontuação final do CPC. O curso da UnB atingiu o menor resultado em comparação aos cursos avaliados neste trabalho (Gráfico 1). No entanto, o indicador do EPR está acima do nonagésimo percentil e entre as 18 maiores notas IDD. Explica-se esse resultado pelo fato de que a nota IDD, de acordo com a sua própria definição, representa a diferença entre as notas do Enade e do Enem. A avaliação da metodologia, como explicado na seção 2.2.1, indica a evolução do aluno no processo de ensino e aprendizagem da instituição, comparativamente a situação inicial antes do ingresso do aluno no Ensino Superior.

Um dos problemas na avaliação deste indicador é que nem todos os alunos que fizeram o Enade (20% ou menos), à época, se submeteram ao exame do Enem. Nestes casos, a pontuação do Enem é zero, o que contribui para uma avaliação distorcida do índice, comparativamente com as demais instituições, nas quais mais de 20% dos alunos realizaram os dois exames. O que é o caso do EPR. Como o curso de Engenharia de Produção da UnB iniciou suas atividades no segundo semestre da 2009, a maioria dos alunos matriculados realizou o exame do Enem. Nesta ocasião, o exame estava popularizado e muitas Instituições exigiam a sua realização para o ingresso.

Espera-se, com o tempo, que este problema seja solucionado. Visto que todos os alunos e todas as Instituições estão aplicando o Enem como índice de ingresso.

No caso das respostas das pesquisas dos alunos do EPR referentes a, respectivamente, Organização Didático-Pedagógico, Infraestruturas e Instalações e Oportunidades de Ampliação da Formação Acadêmica e Profissional, o curso da UnB está acima da média apenas nas Oportunidades de Ampliação da Formação Acadêmica e Profissional. Esse resultado deve-se, talvez, a nova proposta do curso no conceito PjBL, enquanto os demais resultados expressam a precariedade inicial da estrutura do curso.

3.2 Comparações Metodológicas

Com a intenção de averiguar quais Unidades são semelhantes em função das variáveis que compõem o *NCPC*, *Nota Contínua do Conceito Preliminar do Curso*, de todos os cursos de Engenharia de Produção no Brasil procurou-se *Clusterizar* todas as 329 unidades de observação. Conforme Mulaik (1990) e Velicer and Jackson (1990) usou-se, inicialmente, uma Análise Fatorial com a utilização de todas os indicadores ou variáveis do CPC, que gerou 3 fatores com 84,4% de carga fatorial. Este procedimento é importante para retirar as correlações das variáveis antes da *Clusterização*.. Com este resultado aplicou-se o modelo *k-means* não hierárquico (CHATURVEDI, 2001) inicialmente com 10 grupos e, por semelhança, repetiu-se o procedimento até alcançar 5 grupos de segmentos homogêneos internamente e heterogêneos entre eles (LARWOOD, 1995). O resultado gerou um grupo do qual o curso de Engenharia de Produção da UnB está inserido. Ele é composto por 37 Faculdades e Universidades, sendo 10 privadas, 1 pública estadual e 26 públicas federais. São Instituições com nota 4 ou 5 no Enade e CPC e com resultados Enade contínuo superiores a média nos itens Enade e IDD. Todas as cinco instituições analisadas na seção anterior encontram-se no mesmo grupo da UnB.

O próximo passo foi um procedimento de Análise Envoltória de Dados (DEA – *Data Envelopment Analisys*) com as 329 unidades de observação (DMU – Decision-Making Units). O modelo pressupõe definição de *inputs* e

outputs (CHARNES et. al 1978). As variáveis definidas de *output* foram: a nota contínua Enade e o IDD item 2.2.1 (Desempenho dos Estudantes). Como *input* as demais variáveis definidas nos itens 2.2.2 (Corpo docente) e 2.2.3 (Percepção sobre as condições do processo formativo). O grupo (*cluster)* da UnB, com 37 Instituições, foram classificadas com 100% de eficiência. O resultado apresentou 124 unidades na fronteira de eficiência entre as 329 unidades comparadas. Esta aplicação (CHARNES et. al, 1978), segundo as características diferenciadas da metodologia para avaliação de eficiência em comparação com a metodologia do Inep, fortalece o conceito de melhor produto (*output*) na utilização de recursos (*inputs*) limitados ou suficientes (SOUSA e SOUZA, 2014). Muito embora a metodologia DEA é contestatória ao modelo usado pelo Inep/Daes, os resultados foram semelhantes.

4 Conclusões e Sugestões

Alguns aspectos devem ser considerados em relação aos resultados desta pesquisa: 1) Confirma-se o posicionamento do curso do Departamento de Engenharia de Produção da UnB entre os melhores do país, tanto na metodologia do Inep como na metodologia DEA. As análises identificaram que o que mais contribuiu para o sucesso do EPR foram os indicadores do conceito contínuo Enade e IDD, ambos com valores superiores e significativos na comparação com os demais. Estes indicadores reforçam o desempenho dos alunos como resultado de um processo de ensino/aprendizagem. 2) O fraco desempenho nos subitens que compõe o item Percepção Sobre as Condições do Processo Formativo, particularmente nos subitens Organização Didático-Pedagógica e Nota de Infraestrutura e Instalações Físicas, indicam a percepção dos alunos na relação dos (poucos) recursos oferecidos com os resultados alcançados. O modelo DEA acentua esta situação no conceito aplicado *input/output*. A respeito de resultados melhores do subitem Notas Referentes às Oportunidades de Ampliação da Formação Acadêmica e Profissional, comparativamente aos subitens anteriores, a percepção dos alunos corrobora com a expectativa de sucesso do modelo de ensino do EPR. 3) As metodologias utilizadas de classificação: Inep, *Cluster* e DEA; confirmam os resultados empíricos e, principalmente, indicam que não haveria diferença significativa na opção metodológica utilizada para avaliação das Instituições. Apenas é necessário que, no uso da metodologia Inep, sejam feitos testes regulares e com amostras significativas para as avaliações Enem e Enade para todas as instituições.

Numa pesquisa preliminar a percepção de resultado positivo dos PSPs do EPR está com 95,8% dos alunos entrevistados (69 de uma amostra de 72 alunos). Os alunos responderam ao questionário cuja pergunta indaga sobre o impacto na absorção do conhecimento das disciplinas de PSP no aprendizado das matérias tradicionais vinculadas. No entanto, além de se tratar de percepção, a pesquisa ainda está sendo desenvolvida.

Como sugestão deve-se avaliar as grades curriculares dos cursos de melhor desempenho para eventual *benchmarking.* Da mesma forma, com o objetivo de efetuar melhorias, explorar os resultados dos questionários respondidos pelos alunos no item Percepção Sobre as Condições do Processo Formativo. Particularmente, com relação ao curso de Engenharia de Produção da Universidade de Brasília, faz-se mister pesquisar o grau de correlação e possível causalidade decorrente do impacto do modelo de ensino PjBL no sucesso de seus resultados (fases 2 e 3 da pesquisa de maior abrangência citada na Introdução).

5 Referências

Ângulo-Meza, L. (1998). Data Envelopment Analisys na Determinação da Eficiência do Programas de Pós-Graduação da COPPE/UFRJ. Tese de Mestrado, COPPE/UFRJ. Rio de Janeiro, RJ, Brasil, 1998.

Charnes, A.; Cooper, W. W.; Rhodes, E. Measuring the Eficiency of Decision-Making Units. European Journal of Operational Research, vol. 2, pp. 429-444, 1978.

Chaturvedi, A.; Green, P. E.; Carroll, J. D.K-Modes Clustering. Journal of Classification, vol. 18, pp. 35-56, 2001.

Cook, W. D.; Kress, M.; Seiford, L. Onethe use of ordinal data in Data Envelopment Analysis. Journal of the Operational Research Society, vol. 44, pp. 133-140,1993.

INEP. Portal: Inep/Daes. Consultado dia 20 de dezembro de 2015 às 15:32hs horário de Brasília (DF) – Brasil. (//https: www.portal.inep.gov.br).

Larwood, L. C. M. F.; Kriger, P. M.; Miesing, P. Structure and Meaning of Organizacional Vision. Academy of Management Journal, vol. 38 (3), pp. 740-769, 1995.

Lima, R. M.; Silva, J. M.; Natasha, H.; Monteiro, S. B. S.; Souza, J. C. F. Project-based Learning Course Design – A servisse Design Approach. International Journal of Operations & Production Management, vol. 11, pp. 292-313, 2012.

Mulaik, S. A. Blurring the Distiction between Component Analysis and Common Factor. Multivariate Behavioral Research, vol. 25, pp. 53-59, 1990.

Sousa, M.C.S; Souza, J.C.F. Robust Effciency Evaluations of Bank Branch in Brazil. Revista Pesquisa e Planejamento Econômico IPEA, vol.44 (1), pp. 37-79, 2014.

Velicer, W. F.; Jackson, D. N. Component Analysis versus Common Factor Analysis: Some Issues in Selecting na Appropriate Procedure. Multivariate Behavioral Research, vol. 25, pp. 1-28, 1990.

Zindel, M. L.; Silva, J. M.; Souza, J. C. F.; Monteiro, S. B. S.; Oliveira, E. C. A New Approach in Engineering Education the Design-Centric Curriculum at th University of Brasilia – Brazil. Journal of Basicand Applied, vol. 12 (05), 12 7105-8585, 2013.

Cases for Teaching, Problem-Based Learning and Consulting: Perception of Students Implementation of a Pilot Project in the Course of Management of UFRN - Brazil

Maria Valéria P. Araujo[1], Afranio Galdino de Araújo[1], Maria Isabel de Medeiros Brito[2]

[1] Department of Management, Federal University of Rio Grande do Norte, Natal, Brazil
[2] Management, Administration Regional Council, Natal, Brazil

Email: valeriaaraujoufrn@gmail.com, afranioga@gmail.com, belmedeiros@gmail.com

Abstract

The changes that affect society and human activities in the workplace has generated a rethinking regarding the adoption of new educational models that strengthen the development of skills and full training of the subject. This article aims to evaluate the perception of students of management of the Federal University of Rio Grande do Norte - UFRN regarding the implementation of the pilot cases for Teaching, Problem-based learning - PBL and Consultancies in companies in discipline marketing, in partnership with the Euvaldo Lodi - RN IEL. The teaching cases comprise an active teaching methods that allow the transfer of a dilemma and a real problem involving an organizational decision, which was built for educational purposes and student learning to be applied in the classroom. While the PBL learning environment, students receive an open problem, which does not have a single correct solution, causing the group to search theory, deepening the diagnosis of the issue to the development of actions for their solution. Specifically in the discipline, students spent the first cases experience for teaching, to adapt and understand the logic and the evolution of the next phase of the discipline that has been the development of a consulting business, now adopting the PBL methodology. The data used in this study were collected through the application of an interview script with students enrolled in the course in which they were asked to assess what their opinion on the application of the two teaching methodologies in the discipline: the teaching cases and PBL and its contributions in learning and behavior change. The results indicate that students consider teaching cases and PBL as complementary methodologies and appropriate to the current lineup, still thinking very relevant as they approached the completion of the consultancy.

Keywords: Problem-based learning; Teaching cases; consulting; Management education.

Casos para Ensino, Aprendizagem Baseada em Problemas e Consultoria: Percepção de Alunos da Aplicação de um Projeto Piloto no Curso de Administração da UFRN - Brasil

Maria Valéria P. Araujo[1], Afranio Galdino de Araújo[1], Maria Isabel de Medeiros Brito[2]

[1] Department of Management, Federal University of Rio Grande do Norte, Natal, Brazil
[2] Management, Administration Regional Council, Natal, Brazil

Email: valeriaaraujoufrn@gmail.com, afranioga@gmail.com, belmedeiros@gmail.com

Resumo

As transformações que atingem a sociedade e as atividades humanas no mundo do trabalho geraram um repensar em relação à adoção de novos modelos educacionais que fortalecem o desenvolvimento de competências e a formação profissional integral do sujeito. Este artigo tem como objetivo avaliar a percepção de alunos do curso de administração da Universidade Federal do Rio Grande do Norte - UFRN em relação à implementação do projeto piloto de "Casos para Ensino, Aprendizagem Baseada em Problemas – PBL e Consultorias em empresas", na disciplina de Marketing, em parceria com o Instituto Euvaldo Lodi - IEL do RN. Os casos para ensino compreendem Metodologias de Aprendizagem ativa que permitem a transferência de um dilema e problema real, envolvendo uma tomada de decisão organizacional, que foi construído para fins educacionais e de aprendizado do aluno para ser aplicado em sala de aula. Enquanto que no ambiente de aprendizagem PBL, os alunos recebem um problema aberto, que pode ser real ou simulado, não comportando também uma solução correta única, levando o grupo a pesquisar sobre a questão, aprofundando-se no seu diagnóstico até o desenvolvimento de ações para a sua solução. Especificamente na disciplina, os alunos passaram inicialmente pela experiência dos casos para ensino, para se adaptarem e entenderem a lógica e a evolução da fase seguinte da disciplina que foi a elaboração de uma consultoria empresarial, adotando agora o método do PBL. Os dados utilizados neste trabalho foram coletados por meio da aplicação de um roteiro de entrevista com alunos matriculados na disciplina, no qual lhes foi pedido que avaliassem qual a opinião deles em relação à aplicação das duas metodologias de ensino na disciplina: os casos para ensino e o PBL e suas contribuições no aprendizado e na mudança de comportamento. Os resultados indicam que os alunos consideram os casos para ensino e o PBL, como metodologias complementares e adequadas para a formação atual, julgando ainda muito relevante quando se aproximaram da realização da consultoria.

Palavras-Chave: Aprendizagem Baseada em Problemas; Casos para ensino; Consultoria; Ensino de Administração.

1 Introdução

As constantes mudanças no mercado, no contexto econômico-social e político, aliadas a um elevado padrão de competitividade, produtividade e redução de custos nas organizações, afetam no desenvolvimento das competências profissionais, exigindo cada vez mais aproximação entre essas novas demandas da sociedade e o processo educacional.

Nesse contexto, surgem as Metodologias de Aprendizagem Ativas, que estão alicerçadas em um princípio teórico significativo: a autonomia, onde os discentes são capazes de autogerenciar seu processo de formação, algo explícito na invocação de Freire (1996) que destaca que ensinar não é transferir conhecimento, mas criar as possibilidades para a sua produção (...), onde os educandos vão se transformando em reais sujeitos da construção e da reconstrução do saber ensinado, ao lado do educador igualmente sujeito do processo.

As diversas abordagens de metodologias de aprendizagem ativas auxiliam, assim, no desenvolvimento de competências educacionais e profissionais, fazendo com que a realidade esteja presente, cada vez mais, dentro das instituições de ensino, proporcionando assim um aprendizado real e constante.

A relação ensino-aprendizagem se constitui num processo dinâmico e ativo, requer a participação ativa do professor e do aluno. Ambos podem interagir de modo a concretizar os objetivos educacionais através de aulas estruturadas, interativas e dinâmicas que propiciem uma verdadeira viagem de descoberta do mundo real.

O desafio docente surge assim, com essa nova concepção do processo de ensino aprendizagem, onde o conhecimento leva em consideração uma perspectiva histórico-social. Onde haja um favorecimento à produção de conhecimento e que esse conhecimento possa ser construído e reconstruído conforme a sua necessidade de utilização, suas experiências e seu desenvolvimento profissional (Nunes, 2001).
Quando o docente depara-se com essa situação, precisa identificar, dentre outras coisas, quais as metodologias de ensino mais adequadas levando em consideração aspectos como: a estrutura da organização de ensino, o perfil do discente, o seu próprio perfil como conhecedor de metodologias e, o mais importante, se está apto a utilizá-las, dentro de um contexto que possibilite a orientação e o desenvolvimento de competências, habilidades e autonomia dos discentes do curso.
Diante desse contexto, o presente estudo tem o intuito de responder à seguinte questão de pesquisa: Qual a percepção de discentes em relação à adoção do projeto piloto "Casos para Ensino, Aprendizagem Baseada em Problemas – PBL e Consultorias em empresas" na disciplina de Marketing I, da Universidade Federal do Rio Grande do Norte?
Portanto, o trabalho tem como objetivo avaliar a percepção de alunos de administração da Universidade Federal do Rio Grande do Norte - UFRN em relação à implementação do projeto piloto de Casos para ensino, PBL e consultoria, em uma disciplina do curso.
O desenvolvimento do presente trabalho se apoiou na compreensão da experiência de aprendizagem (processo e resultados) na percepção dos estudantes que participaram dessa primeira disciplina do curso de administração da UFRN, nesse formato de combinação das três metodologias de aprendizagem ativas: casos para ensino, PBL e consultoria.
O caso de ensino é a descrição de uma situação real, que comumente envolve uma decisão, uma mudança, um problema ou ideia enfrentada por uma pessoa numa organização (ERSKINE; LEENDERS, 1997), é a reconstrução para fins didáticos de uma situação problemática gerencial ou organizacional.
Sob esta mesma ótica, o PBL pode ser definido como um método de ensino-aprendizagem que propicia o aluno adquirir conhecimento no contexto de problemas. Esse método de aprendizagem ativa de ensino tem sua fundamentação no pressuposto de que a aprendizagem não é um simples processo de recepção de informações, mas de construção de significados.
Enquanto os processos de consultoria, como afirmam Grocco e Guttmann (2005), compreendem a construção de uma relação de ajuda, interativa, executada por uma ou mais pessoas, independente se externas ao problema em análise, com o objetivo de fornecer aos executivos da empresa-cliente um ou mais conjuntos de opções de mudanças que proporcionem a tomada de decisão mais adequada ao atendimento das necessidades da organização. Os autores dividem ainda o processo de consultoria em três partes: a definição do problema; o desenvolvimento de possíveis soluções e a proposta para uma recomendação final.
O trabalho torna-se relevante, considerando que a bibliografia em português relacionando a combinação dos três assuntos ainda é escassa, permitindo o desenvolvimento de estudos metodológicos voltados para subsidiar reflexões acerca de reflexões e escolhas metodológicas para o curso de administração da UFRN. Ressalta-se ainda a vinculação da proposta de trabalho às linhas de pesquisa estabelecidas no projeto intitulado "Learning from the Case Method" dos professores Burgoyne e Mumford (2001), sendo inclusive recomendado no estudo supra-citado como uma sugestão para futuras pesquisas: a concentração de estudos voltados para a experiência no processo de aprendizagem envolvendo os estudantes.

2 Casos para ensino

O caso para ensino é uma metodologia de aprendizagem ativa que descreve um problema real enfrentado por uma pessoa e ou mais pessoas na organização, geralmente apresentado sob o ponto de vista do tomador de decisões, com intuito de levar essa situação para um contexto de aprendizagem, convidando pessoas e alunos a refletirem e a se posicionarem diante do contexto apresentado.

Na visão de Garvin (1991) casos são documentos de ensino que atendem dois objetivos: aplicação em uma aula e uma eficaz pedagogia. Percebe-se assim que o primeiro conceito valoriza e enfatiza como deve ser feita a elaboração e a construção dos casos, enquanto que a visão do segundo conceito reflete os impactos da utilização dos casos no alcance dos objetivos educacionais e nos processos de aprendizagem.

Autores como Barnes, Christensen e Hansen (1994), consideram o caso para ensino como uma descrição de episódios práticos, selecionados da realidade, uma fatia da vida, uma estória designada e apresentada como material de estudo, um exercício, um quebra-cabeça ou um problema.

Um grupo é ensinado pelo método de caso quando os participantes estudam uma situação anterior para discutirem como se posicionariam caso estivessem diante desse contexto de decisão. (Reynolds, 1998) Desta forma, o professor que usa o método do caso em aula é visto mais como um facilitador e encorajador da discussão e participação ao invés de um repositório da resposta correta.

Burgoyne e Mumford (2001) possuem uma visão ainda mais completa sobre os casos para ensino, uma vez que descrevem as características, a importância da sua utilização e as formas de adotá-lo. Para os autores o caso para ensino compreende uma descrição (em palavras ou em vídeo) de um contexto com o propósito do desenvolvimento, que aconteceu ou acontece em uma organização, onde estudantes leem ou assistem um vídeo/filme e refletem sobre a situação. Em seguida, eles apresentam, debatem, defendem, discutem e criticam a análise, com tutores e outros alunos, em uma variedade de maneiras, como interação em pares, grupos ou sessões plenárias.

3 Aprendizado baseado em Problema

Outra metodologia de ensino, que valoriza a filosofia de ensino por meio de problema é o PBL – *Problem Based Learning* - ou o Aprendizado Baseado em Problema (ABP). O método PBL tem como foco a aprendizagem ativa, centrada no estudante, através do estudo autônomo e discussão de problemas atuais, relacionados à disciplina ou a outros contextos sociais e econômicos (Frezatti e Silva, 2012). Assim, o método também está associado às teorias construtivistas, em que o conhecimento não é absoluto, e sim construído pelo estudante por meio de seu conhecimento pregresso, relacionando-se com as futuras práticas profissionais e sua percepção global, dimensionando a necessidade de aprofundar, amplificar e integrar o conhecimento, ocorrendo por ação motivada, não decorrendo de imposição, mas do nível crítico de conhecimento do estudante, ao qual se chega pelo processo de compreensão, reflexão e crítica (Vila; Vila, 2007 apud Decker & Bouhuus, 2009).

O processo de aprendizagem, na metodologia do PBL, vai ainda além da vontade de aprender e se incorpora à maneira de viver do sujeito, modifica suas relações com o mundo. Quando falamos em aprendizagem colocamos o sujeito que aprende como figura central do processo, e isso implica também na consideração de seus desejos e na modificação de seus modos de interpretar a realidade e se relacionar com o mundo. Por isso, não se pode reduzir a aprendizagem à mera apreensão de conteúdos (Klein, 2013).

Para Lopes et. al. (2011), diferentemente dos casos para ensino, que devem ser construídos a partir de uma situação real, os problemas do PBL, sempre que possível, devem tomar exemplos da vida real, sendo construídos com objetivos previamente determinados.

Para Araujo et. al. (2010), no processo de aplicação do PBL existem alguns passos sistematizados que ajudam na tarefa do estudante de como fazer para aprender por meio do PBL, e promove a sugestão de um caminho para a aplicação do ensino, pelo professor/tutor, por meio do método baseado em problemas. O professor/tutor ensina o estudante a aprender a aprender.

De acordo com Park (2006), esses sete passos são: i) esclarecer os termos difíceis ou desconhecidos, ii) listar os problemas, iii) discussão dos problemas (brainstorming), iv) resumir, v) formulação dos objetivos de aprendizado, vi) busca de informações, e vii) retorno, integração das informações e resolução do caso.

Pode-se encontrar no método PBL algumas vantagens e desvantagens. Para Ribeiro & Mizukami (2005) a principal vantagem salientada pelos estudantes foi atribuída ao fato de que foi motivador, fez a classe mais viva e estimulou o desenvolvimento de habilidades interpessoais e de investigação.

4 Consultoria

Existe ainda outra metodologia de aprendizagem que apóia a mudança e criação de um olhar novo sobre a organização, nesse contexto de complexidade e velocidade dos cenários contemporâneos, assumindo, além disso, um papel educativo na formação e no desenvolvimento das competências das pessoas: a atividade de consultoria nas organizações. Trata-se de um novo recurso que contribui para a formação de profissionais voltados essencialmente para o saber-ser e saber-fazer nas organizações, proporcionando aos alunos a experiência teórica e vivencial desta importante ferramenta de gestão, de modo que estes possam implantá-la efetivamente quando da sua inserção no mercado profissional.

O processo de consultoria ocorre quando surge um agente de mudanças, externo à empresa, que assume a responsabilidade de auxiliar seus executivos e profissionais na tomada de decisão, não tendo o controle direto da situação (Oliveira, 2003).

Mesmo sendo utilizada de muitas formas e em diferentes áreas, a atividade de consultoria, na visão do autor, consiste em pesquisar e prover informações para entender, subsidiar e apoiar as pessoas que atuam diretamente na coordenação de equipes ou lideranças dos diversos segmentos organizacionais, dar a solução de um problema; fornecer diagnóstico capaz de redefinir a problemática; recomendar ou prescrever ou acompanhar a implementação. Em linhas gerais, pode-se afirmar que o objetivo do consultor é efetuar um trabalho de qualidade, ajudando a empresa-cliente na solução dos problemas enfrentados.

Partindo destas definições, identificamos que o processo tem pelo menos dois agentes, o consultor que irá ajudar e a organização cliente que receberá ajuda. Definindo a consultoria como "o ato de um cliente fornecer, dar e solicitar, pedir pareceres, opiniões, estudos, a um especialista contratado para que este auxílio apóie, oriente o trabalho administrativo", propõe uma categorização na qual evidencia alguns aspectos da consultoria: é uma troca; é um serviço especializado; é um serviço ético; é conduzir, não filosofar; é um serviço de orientação.

5 Metodologia

A pesquisa se caracteriza como estudo de caso de natureza exploratória com abordagem qualitativa de análise, sendo realizada uma pesquisa de campo, que apresenta uma experiência prática, com a adoção de metodologias de aprendizagem ativas na disciplina de Marketing 1, com a participação de dois docentes, com a aplicação dos casos para ensino, combinados com o método PBL e de consultoria, no curso de Administração da Universidade Federal do Rio Grande do Norte.

A técnica de coleta de dados adotada foi à entrevista semi-estruturada, com uma amostra intencional de 19 estudantes do curso de administração, realizadas no segundo semestre de 2015. O tratamento de dados foi realizado através da análise de conteúdo, tendo como base, as três categorias de análise: comparações das metodologias de aprendizagem; avaliação das fases da disciplina e contribuições na aprendizagem.

Baseado no referencial de categorizações, identificado a partir da sustentação teórica, foi efetuado uma leitura dos comentários transcritos na entrevista, visando codificar e agrupar as unidades de texto – para se realizar assim a análise dos comentários dos alunos.

6 Adoção e Percepção dos alunos em relação a aplicação das Metodologias de Casos, PBL e Consultoria na disciplina de Marketing

Nesta seção, apresenta-se a estrutura do funcionamento da disciplina, além da análise dos dados obtidos nas entrevistas realizadas ao final da disciplina, em novembro de 2015, com os alunos e professores, da disciplina Marketing I.

A ideia inicial da disciplina surgiu de uma conversa informal realizada com dois professores, do Departamento de Administração, que participaram de uma oficina de capacitação em PBL, oferecida pela UFRN em 2013, com professores da Universidade do Minho. No segundo semestre de 2015, os professores capacitados resolveram adotar a metodologia do PBL na disciplina de Marketing I, apresentando um projeto piloto pioneiro, uma

proposta de integração universidade-empresa, para o curso de Administração, da Universidade Federal do Rio Grande do Norte.
Para viabilizar o desenvolvimento da proposta, os professores decidiram procurar a chefia do Departamento de Administração, para fortalecer a sua implantação, solicitando uma infraestrutura de sala de aula mais adequada para esse modelo educacional. Além disso, os professores solicitaram o apoio institucional na aproximação com o mundo do trabalho, especificamente com a unidade do Instituto Euvaldo Lodi (IEL), órgão vinculado a Federação das Indústrias do Rio Grande do Norte, que tem como objetivo: fortalecer a indústria, atuando na representação e defesa de seus interesses, na promoção da educação profissional e qualidade de vida do trabalhador e no desenvolvimento tecnológico e empresarial, propiciando a melhoria da competitividade das empresas industriais do Rio Grande do Norte, de forma sustentável.
Enquanto isso, em sala de aula, os alunos da disciplina já haviam sido apresentados, ao funcionamento da metodologia PBL, apresentando-a como uma experiência piloto do curso, com normas próprias e sistema de avaliação específico. Além disso, como os dois professores possuíam experiência com elaboração de casos para ensino e desenvolvimento de consultoria, decidiram ampliar a proposta inicial do projeto, aplicando ainda, essas duas outras metodologias de aprendizagem ativas, juntamente com o PBL.

Na primeira reunião, realizada no IEL, a chefia juntamente com os professores do departamento apresentaram o projeto para a entidade, solicitando o apoio do órgão e definindo responsabilidades e atribuições, dos professores, alunos e empresas vinculadas à parceria. Por sua vez, o IEL identificou um sindicato patronal muito ativo na instituição, o Sindicato da Indústria da Panificação e Confeitaria do RN – SINDIPAN, para indicação de empresas para a realização do projeto.

Depois de algumas reuniões realizadas, entre os professores da disciplina, representantes do IEL e dirigentes do SINDIPAN, foram definidas as atribuições e responsabilidades entre as entidades, além da discussão em relação à cordialidade e confidencialidade no uso das informações coletadas.

Em seguida o IEL, marcou uma nova reunião com os professores da disciplina, agora no Sindicato Patronal de Panificação - SINDIPAN, com intuito dos professores comunicarem a proposta do projeto a esse grupo de empresários, em uma tentativa de sensibilizar empresas do segmento para a realização da consultoria que seria realizada pelos alunos, com o apoio dos tutores.

Na ocasião, das onze organizações presentes nessa reunião, empresas varejistas e industriais no segmento de panificação, além do próprio IEL, todos os representantes dessas entidades comunicaram seu grau de interesse em ingressarem do projeto. Porém, em virtude de limitações da quantidade dos grupos de trabalho e dos custos decorrentes com o deslocamento e da coleta de dados em campo, foram estabelecidos critérios para a seleção da participação dessas organizações no projeto de consultoria do PBL: custo do deslocamento e distância entre a organização e a universidade, sendo escolhidas então seis dessas organizações.

Para o planejamento da disciplina piloto de marketing, adotando a metodologia de aprendizagem do PBL, os professores consideraram os seguintes parâmetros, para ajustar a proposta da disciplina piloto: publicações e experiências de PBL; produção e aplicação de casos para ensino; experiências anteriores de aplicações metodológicas de outras aprendizagens ativas; experiências de consultorias; os conteúdos da unidade curricular; as competências da formação; a infraestrutura existente no curso; os direitos e deveres dos docentes e discentes e as resoluções pedagógicas institucionais.

Uma condição que impactou, na decisão da definição do planejamento e distribuição das aulas e atividades curriculares da disciplina foi uma norma da UFRN que determina a necessidade de se manter, em cada disciplina oferecida no curso de Administração, pelo menos uma unidade, no sistema de avaliação, no formato tradicional de aplicação de prova.

Assim, diante dessa diretriz institucional, os professores, ao planejaram a disciplina, optaram por ministrar 12 encontros de 2 horas cada, que representa 24 horas de uma disciplina, que possui uma carga horária total de 60 horas, mesclando-se aulas expositivas-dialogadas, voltadas para a teoria do marketing, além de atividades de pesquisa e seminários em grupo.

Em seguida, na segunda unidade da disciplina, que durou o mesmo período da unidade anterior, os docentes, que já passaram a agir como tutores, orientaram os alunos para escolherem os componentes dos grupos de

trabalho, além de definirem o líder e relator. Alertando que esse grupo permaneceria até o final da disciplina, salvo em situações específicas definidas nas regras da disciplina, onde foram formados seis grupos, de até oito alunos.

Na ocasião, os professores apresentaram o primeiro caso para ensino, na área de marketing, pediram para os grupos lerem o texto e depois perguntaram aos grupos: esse problema do caso pode ser respondido a partir de qual (is) teoria(s)?

Os docentes orientaram os alunos a adotarem o papel de gestor da organização/empresa, que estava diante de uma situação de decisão. A partir dessas orientações, os alunos realizaram a pesquisa teórica e, simultaneamente, elaboraram um diagnóstico consistente e definiram um plano de ação para a resolução dos problemas apresentados no caso para ensino, já adotando o modelo do relatório do PBL.

Assim, nesse processo, o aluno começou a se aproximar de situações problemas reais em marketing, no formato do modelo da Universidade Harvard, onde foram adotados dois casos problemas, com uma média de cinco aulas para cada caso, contemplando teoria, diagnóstico e plano de ação. Essa fase, assim, serviu de preparação e simulação para a próxima etapa da disciplina, a realização da atividade da consultoria de marketing a uma organização/empresa real.

Durante a realização do processo de consultoria, além de participarem da reunião inicial com as empresas, juntamente com os professores e proprietários dos negócios/responsáveis pela organização, os alunos ainda realizaram entrevistas com os funcionários, pesquisas com clientes, análises dos ambientes e até realizaram observações como clientes ocultos, onde os alunos se passaram por clientes para identificarem detalhes dos processos de atendimento e organização dos ambientes.

Na pesquisa realizada no final da disciplina, com os alunos participantes do processo, quando se comparou a adoção das metodologias tradicionais e as metodologias de aprendizagem ativas, especificamente o PBL. Todos os alunos demonstraram satisfação com a adoção de metodologias mais inovadoras, ressaltando que a metodologia aplicada à disciplina se sobressai em relação à metodologia tradicional, diante da necessidade que as disciplinas têm em aproximar-se da prática e aplicar conhecimentos de forma interdisciplinar, atendendo a necessidade do aluno em conhecer o mercado, comentando ainda que a metodologia estimula a busca do conhecimento, uma postura mais ativa, deles, no processo educacional, melhorando o aprendizado. Esse resultado está em conformidade com os dados da pesquisa de Ribeiro & Mizukami (2005), que destacam o PBL como uma metodologia atrativa e que se apóia no desenvolvimento de habilidades requeridas pelo mercado, conforme demonstrado nos depoimentos:

> "A metodologia PBL contribui muito mais para o aprendizado, visto ser prático".
>
> "Acredito que a metodologia tradicional teve seu tempo de colaboração no processo de ensino, entretanto, já não atende as necessidades do mercado, fato que o PBL apresenta como proposta e resultado".
>
> "Acho muito boa, pois foi possível ter a noção do que o mercado de trabalho espera de nós e o que podemos oferecer".
>
> "esse formato de disciplina deve ser ampliado para melhoria da formação do administrador. Nosso grupo pesquisou as teorias antes de ir a campo, depois fizemos observação e aprendemos na prática sempre com a supervisão dos professores. Acho que deveria ser aplicada no curso todo para integrar as disciplinas, o curso e a profissão".
>
> "Em minha opinião é mais interessante o modelo PBL, porque força o aluno a se envolver mais com a matéria".
>
> "A metodologia (...) potencializa a capacidade do aluno de aprender".
>
> "Me vi mais interessado no assunto, consegui me envolver mais".

"Me ajudou a ir a procura de conhecimento e a participar mais".

"A corrida pelo conhecimento se tornou necessária, bem mais que em metodologias tradicionais".

"A disciplina consolidou conceitos que eu já conhecia, mas percebi que não entendia".

"A disciplina contribuiu para o estímulo da pesquisa e na elaboração de resoluções, aplicando as teorias na prática".

"Nós conseguimos viver a realidade, mas com interdisciplinaridade entre marketing e informática, gestão de pessoas, dentre outras, em um campo muito maior de alternativas para resolver problemas. O maior desafio é unir as melhores metodologias para dar o melhor resultado possível para o cliente".

"Há uma saída da zona de conforto onde houve aprendizado que é importante ficar inquieto..."

Apesar de apontarem alguns pontos fortes da sua aplicação, os alunos também destacaram alguns obstáculos que impactaram no desenvolvimento da proposta pedagógica, conforme depoimentos apresentados a seguir. A questão da indisponibilidade de tempo deles, para o desenvolvimento dos trabalhos, além das dificuldades decorrentes da gestão do trabalho em equipe, surgiram como os principais problemas identificados ao longo do desenvolvimento da disciplina.

"(...) a noite muita gente possui pouco tempo para realizar tantas atividades fora do horário de aula".

"(...) é complicado para quem trabalha por falta de tempo".

"O tempo, enquanto alguns do grupo possuíam mais tempo para as atividades, eu tinha pouco. Outra questão foi na divisão das tarefas no grupo".

"Acho que as maiores dificuldades foram trabalhar em grupo, pois era difícil nos reunirmos e acabava fragmentando o desenvolvimento do trabalho".

Ressalta-se aqui que os alunos, que fizeram parte da amostra da pesquisa, são do turno noturno, e que, todos eles atualmente atuam no mercado de trabalho. Assim, talvez o fato de exercerem, simultaneamente, atividades profissionais e acadêmicas, esteja gerando uma sobrecarga de trabalho para o aluno. E, como o PBL, conforme já mencionado nos depoimentos, exige do aluno mais participação e comprometimento, isso pode gerar uma relativa frustração, caso não exista tempo suficiente para cumprir todas as exigências profissionais e acadêmicas, embora que, em nenhum momento, foi apontado nenhum tipo de insatisfação em relação à escolha metodológica adotada na disciplina, conforme demonstrado na análise das respostas anteriores.
Existia ainda, uma questão que procurava analisar a percepção dos alunos em relação a adoção simultânea das propostas metodológicas de aprendizagem ativas, considerando os casos para ensino, o PBL e a consultoria.
Nos depoimentos dos alunos, apontados a seguir, pode-se identificar a satisfação em relação a cada uma das metodologias de aprendizagem adotadas na disciplina, comentando inclusive as suas contribuições: como a aproximação do campo de trabalho do administrador; a ordenação e a combinação delas apoiando no desenvolvimento paulatino do processo aprendizagem, considerando principalmente o grau de dificuldade de cada uma, e a sua respectiva ordenação, combinação e complementaridade, proporcionando as condições de um processo de formação e aprendizagem gradual.

"Com certeza, a metodologia de estudo de caso serviu para abrir a mente de como a PBL funciona, servindo de base/treino para o caso real".

"Acredito que na ordem que foram apresentados na disciplina se tornaram complementares na construção do conhecimento".

"As fases se complementam. Os casos em sala de aula foram importantes, como uma preparação para a fase de diagnóstico nas empresas".

"Gostei de todas as fases, porém, ir a campo foi dinâmico. Se deparar com as diversas situações é desafiador. Gosto disso!"

"É muito legal termos a visão da empresa a partir da entrevista, a gente consegue traçar o perfil dela construindo o diagnóstico e o plano de ação. A experiência é muito enriquecedora".

"Lidar com problemas reais traz outra perspectiva na prática administrativa. O tempo para dar a resposta ao cliente, a responsabilidade de contribuir para o desenvolvimento do negócio".

"Os casos desafiam a imaginação. Já as consultorias as empresas aprimoram e valorizam o conhecimento prático".

"Com os casos para ensino aprendemos a aplicar algumas teorias no diagnóstico e na resolução dos problemas. É onde devemos errar, corrigir e aprender com eles. Já nos casos reais temos a responsabilidade de solucionar os problemas das empresas e principalmente eles contam com a gente".

Os dados apresentados demonstram que, com a adoção da combinação das metodologias de aprendizagem ativas o aluno adquire as condições de autonomia para relacionar, criticar, amadurecer, transformar e desenvolver a construção de um conhecimento, ou seja, confirmando o que destacava Freire (1996), transformando o sujeito, com autonomia para pensar, em real sujeito do processo de construção e da reconstrução do saber, através da aproximação de uma situação real, considerando as discussões geradas com o grupo e com as reflexões apresentadas pelo tutor, contribuindo assim para a formação de um sujeito com competências técnicas, habilidades e atitudes, condizentes com as demandas da sociedade.

7 Conclusão

A experiência pioneira apresentada na disciplina de Marketing I, do curso de Administração da UFRN, utilizando uma proposta de integração universidade-empresa, com esse desenho inovador, combinando as metodologias de casos para ensino, do PBL e o desenvolvimento de um projeto de consultoria, além de proporcionar a aproximação com o campo de trabalho do administrador, gerando um ambiente de sala de aula mais condizente com o dia a dia das organizações, apoiou e potencializou a capacidade de aprendizagem gradativa do aluno, considerando a respectiva ordenação, combinação e complementaridade, das metodologias de aprendizagem adotadas na disciplina.

Os resultados da pesquisa demonstraram ainda que, os alunos pesquisados se sentiram satisfeitos em relação a adoção do PBL na disciplina de marketing, na comparação com a adoção de metodologias tradicionais, onde os motivos alegados foram: a necessidade das disciplinas de aproximar-se da prática e aplicar conhecimentos de forma interdisciplinar, atendendo as exigências de formação do mercado, estimulando a busca do conhecimento, o processo educacional e melhorando o aprendizado.

Apesar disso, os alunos também destacaram alguns obstáculos identificados ao longo do desenvolvimento da disciplina: a indisponibilidade de tempo deles, para o desenvolvimento dos trabalhos, além das dificuldades decorrentes da gestão do trabalho em equipe. Esses problemas, talvez, estejam relacionados ao fato de todos

atualmente trabalharam, além de serem alunos da turma da noite, exercendo, simultaneamente, atividades profissionais e acadêmicas, gerando uma sobrecarga de trabalho para o aluno.
O estudo não se propõe a fazer generalizações, nem pretende servir como caminho único a ser trilhado por docentes e instituições. Busca assim, servir como fonte de comparação e inspiração, gerando possibilidades de pesquisas, reflexões e discussões de novos modelos pedagógicos mais voltados para a realidade do dia a dia dos gestores, nesse ambiente de complexidade e inovação.

8 Referências

Araujo, A. M. P. de; Fregonesi, M. S. F. A; Soares, M. A., Slomski. V. G. (2010). Aplicação do Método Problem-based Learning (PBL) no curso de Especialização em Controladoria e Finanças. PBL 2010 Congresso Internacional, Brasil.

Barnes, l. B.; Christensen, C. R.; Hansen, A. J. (1994).Teaching and the case Method: Text, Cases and Readings. 3.ed. Boston: Harvard Business School Press.

Burgoyne, J.; Mumford, A. (2001). Learning from the Case Method. Lancaster, Lancaster University.

Decker, I. R. & Bouhuus, P. A. J. (2009) Aprendizagem Baseada em Problemas e metodologia da problematização: identificando e analisando continuidades e descontinuidades nos processos de ensino e aprendizagem. In: Araújo, U. F. & Sastre, G. (Org.). Aprendizagem Baseada em Problemas no ensino superior. São Paulo: Summus.

Erskine, J. A., Leenders, M. R. (1997). Learning with cases. London: University of Western Ontario.

Freire, Paulo. (1996). Pedagogia da Autonomia: saberes necessários à prática educativa**.** São Paulo: Paz e Terra.

Frezatti, F. & Da Silva, Sidnei Celerino. (2012). Prática versus incerteza: como gerenciar o aluno nessa tensão na implementação de disciplina sob o prisma do método PBL? Anais do 12º. Congresso USP de Controladoria e Contabilidade. São Paulo.

Garvin, D. A. (1991). Operations strategy: text and cases. Englewood Cliffs: Prentice Hall.

Grocco, L.; Guttmann, E. (2005). Consultoria Empresarial. Editora Saraiva.

Klein, A. M. (2013). O uso da aprendizagem baseada em problemas e a atuação docente. Brazilian Geographical Journal: Geosciences and Humanities research medium, Ituiutaba.

Lopes, R. M.; Silva Filho, M. V.; Marsden, M.; Alves, Neila G. (2011). Aprendizagem baseada em problemas: uma experiência no ensino de química toxicológica. Química Nova. São Paulo.

Nunes, C.M.F. (2001). Saberes docentes e formação de professores: um breve panorama da pesquisa brasileira. Educação & Sociedade, Campinas.

Oliveira, D. P. R. (2003). Manual de Consultoria Empresarial. Editora Atlas.

Park, S. H. (2006) "Impact of Problem-Based Learning (PBL) on teachers‟ beliefs regarding technology use. Thesis (Doctoral in Philosophy) - Faculty of Purdue University, West Lafayette, f171.

Reynolds, J. I. (1998). Case method in management development: guide for effective use. Management Development series, Geneva.

Ribeiro, L. R. de C. & Mizukami, M. da G. N. (2005) "Problem-based learning: a student evaluation of implementation in postgraduate engineering education". European Journal of Engineering Education, Taylor & Francis Ltd, v. 30, n.1 mar p. 137-149.

The Project-Based Learning Experience of a new Engineering Campus from the Perspective of the Students

Waydja C. Correia[1], Marcos G. Ghislandi[1], Rui M. Lima[2], Diana Mesquita[2,3], Maria Conceição Amorim[1]

[1] Campus UACSA, Universidade Federal Rural de Pernambuco, Cabo de Santo Agostinho, Pernambuco, Brazil
[2] Department of Production and Systems, School of Engineering, University of Minho, Campus of Azurém, Guimarães, Portugal
[3] Institute of Education, University of Minho, Campus of Gualtar, Braga, Portugal

Email: waydja.correia@yahoo.com.br, ghislandi@gmail.com, rml@dps.uminho.pt, diana@dps.uminho.pt, ceca1977@gmail.com

Abstract

This work aims to describe the experience of Project Based Learning (PBL) in the course of Mechanical Engineering (Engineering Campus - UACSA) of the Federal Rural University of Pernambuco (UFRPE), Brazil. To this end, it were considered both the perceptions of the students and also the data analysis, collected from 20 students, about the experience. The questionnaire answered by the students was organized around six topics: theme of the project, developed competences and learning skills, teamwork, role of teachers, the project assessment and project as a teaching-learning methodology. Also they wrote on the positive and less positive aspects and pointed suggestions for the implementation of PBL. Concisely, the survey results revealed that teamwork, the need for interpersonal relationships and the development of soft skills (autonomy, initiative and creativity in creating the prototype, research capacity, decision, organization, problem solving, time management) are prominent positive aspects, added to the fact that PBL brings the chance for the students to put into practice the theoretical knowledge acquired during the course. Problems for the project's implementation were identified as: lack of instruments and conditions given to students for the development of the prototype, the dense load of disciplines of the semester, the non-suitability of some disciplines involved in the project, plus the bad interaction between them. Besides the fact that there was the need for greater dialogue between the disciplines of the semester and/or a more substantial adjustment of the Pedagogical Course Project (PPC), the PBL as a teaching-learning methodology in the course of Mechanical Engineering met the main expectations, and also collaborated for integration, socialization and learning of students. Therefore it is defended its permanence and expansion (over all semesters of the course) at UACSA / UFRPE.

Keywords: Project-Based Learning; Engineering Education; PBL process evaluation.

A Experiência de Aprendizagem Baseada em Projetos Interdisciplinares em um Novo Campus de Engenharia sob a Perspectiva dos Discentes

Waydja C. Correia[1], Marcos G. Ghislandi[1], Rui M. Lima[2], Diana Mesquita[2,3], Maria Conceição Amorim[1]

[1] Campus UACSA, Universidade Federal Rural de Pernambuco, Cabo de Santo Agostinho, Pernambuco, Brasil
[2] Departamento de Produção e Sistemas, Escola de Engenharia, Universidade do Minho, Campus de Azurém, Guimarães, Portugal
[3] Instituto de Educação, Universidade do Minho, Campus de Gualtar, Braga, Portugal

Email: waydja.correia@yahoo.com.br, ghislandi@gmail.com, rml@dps.uminho.pt, diana@dps.uminho.pt, ceca1977@gmail.com

Resumo

O presente artigo aborda a primeira experiência da Unidade Acadêmica do Cabo de Santo Agostinho campus das engenharias da UFRPE com o trabalho interdisciplinar através da metodologia de Aprendizagem Baseada em Projetos Interdisciplinares - PBL. Para tal, foi utilizado ao final do semestre letivo um questionário voltado aos discentes, com o objetivo de avaliar a experiência em suas várias dimensões. Os resultados da pesquisa presente neste artigo baseiam-se, sobretudo, nas percepções dos estudantes sobre o processo de implementação e avaliação desta experiência. O questionário respondido pelos estudantes foi organizado em torno de seis tópicos: tema do projeto, aprendizagens e competências desenvolvidas, trabalho em equipe, papel dos docentes, avaliação no projeto e projeto como metodologia de ensino-aprendizagem. Também responderam de forma dissertativa sobre os aspetos positivos e negativos e apontaram sugestões para a implementação do PBL. A investigação realizada através do questionário revela que o trabalho em equipe, o exercício do relacionamento interpessoal e o desenvolvimento de competências transversais são aspectos positivos de destaque, somados ao fato do PBL trazer possibilidade para que os discentes coloquem em prática os conhecimentos teóricos adquiridos durante o curso, promovendo o interesse dos discentes pelo próprio aprendizado ao terem contato com a aplicabilidade dos conceitos aprendidos no curso, além de desenvolver nos mesmos um senso crítico. Somando-se a isto, também foram apontadas algumas dificuldades, principalmente no que diz respeito à articulação entre as disciplinas e a carência de instrumentos para o desenvolvimento dos protótipos. No entanto, embora esses aspectos tenham sido verificados, percebe-se que o uso do PBL como metodologia de ensino cumpre o seu papel de atender aos objetivos propostos para uma aprendizagem ativa e o desenvolvimento de sujeitos críticos e reflexivos.

Palavras-Chave: Aprendizagem Baseada em Projetos Interdisciplinares; Educação em Engenharia; Avaliação de experiência PBL; PBL.

1 Introdução

As universidades e as empresas têm percebido que profissionais cada vez mais qualificados são necessários para a utilização de métodos e técnicas eficazes e adequadas às suas necessidades. Em consonância com as tendências contemporâneas de formação, marcadas pela revolução tecnológica, pela competência técnica aliada à formação geral, pela necessidade de formação de profissionais criativos e resolutivos, competentes para o trabalho em equipe, o ensino não pode reduzir-se à produção de profissionais especialistas, mas sim, estender-se à formação de profissionais que além dos conhecimentos técnicos possuam também competências transversais (Lima, Mesquita, & Rocha, 2013) para lidar com as situações problemas existentes nos ambientes organizacionais (UNESCO, 2010). O desenvolvimento de competências e habilidades para a formação do perfil profissional pressupõe uma base sólida, que no Brasil deve estar fundamentada nas Diretrizes Curriculares Nacionais, com ênfase na formação interdisciplinar, integrando as dimensões humanísticas, ambiental, cidadã e empreendedora ao processo formativo e na utilização de metodologias ativas de ensino-aprendizagem.

A metodologia ativa é uma concepção educativa que estimula a crítica e reflexão no processo de ensino e aprendizagem. O educador, neste caso, participa ativamente do processo, em situações que promovam aproximação crítica do discente com a realidade. Uma das principais metodologias ativas utilizadas atualmente é a Aprendizagem Baseada em Projetos, que se apresenta como um modelo educacional centrado no discente

com o propósito de ajudá-lo a desenvolver competências essenciais para a prática profissional. Para tal, são desafiados a trabalharem em equipes para resolução de um problema aberto através do processo de articulação entre a teoria e prática (Fernandes, Flores e Lima, 2010), o que contribui para sua autonomia (Mesquita, Lima e Flores, 2013).

Neste artigo apresentamos os resultados de uma experiência de Aprendizagem Baseada em Projetos Interdisciplinares no curso de Engenharia Mecânica pertencente ao campus das engenharias da Universidade Federal Rural de Pernambuco (UFRPE). Neste sentido, foi utilizado um questionário como principal instrumento de coleta de dados e os resultados aqui apresentados abordam sobretudo, as percepções dos estudantes em relação a um conjunto de aspectos essenciais para o desenvolvimento do PBL no curso de Engenharia Mecânica e da compreensão do processo de implementação da experiência e do seu impacto, além de apontar sugestões para a implantação do modelo PBL nos demais períodos do semestre letivo.

2 Contexto do Estudo

A Unidade Acadêmica no Cabo de Santo Agostinho (UACSA) surgiu através do processo de interiorização da Universidade Federal Rural de Pernambuco (UFRPE), que inova para atender as demandas de cursos nas áreas das Engenharias e "a construção e disseminação do conhecimento e inovação, através de atividades de ensino, pesquisa e extensão atenta aos anseios da sociedade" (PDI/UFRPE, 2013, p. 29), iniciou suas atividades com cinco cursos de Engenharias: Civil, Elétrica, Eletrônica, Mecânica e de Materiais no segundo semestre de 2014. A UACSA propõe o desenvolvimento de uma abordagem interdisciplinar com a metodologia de Aprendizagem Baseada em Projetos (Project Based Learning – PBL) e uma matriz curricular que objetiva oportunizar aos discentes egressos o acesso ao mundo do trabalho e uma formação humanística. O desafiador dessa proposta é, entre outros aspectos, a quebra de paradigmas históricos no que diz respeito às estratégias didáticas e às opções pedagógicas adotadas, uma vez que trás características marcadas pela preocupação com a interdisciplinaridade como fundamento para as práticas pedagógicas e com a formação integral dos sujeitos. A experiência com a Project Based Learning (PBL) tem sido vivenciada em cursos de engenharias de diversas universidades no Brasil e em outros países por proporcionar um ambiente interativo de trabalho em equipe voltado para a resolução de problemas, colaborando para o desenvolvimento de saberes essenciais para a prática profissional e do discente. No caso da UACSA os cursos de engenharia de materiais e engenharia mecânica deram início aos seus projetos interdisciplinares em 2015 com estudantes do terceiro período, como resultado da parceria da UFRPE com a Universidade do Minho (UMINHO).

3 Aprendizagem Baseada em Projetos

A Aprendizagem Baseada em Problemas tem sua gênese no final dos anos 60, quando um grupo de inovadores da Universidade de McMaster em Hamilton, Canadá, insatisfeito com o ensino tradicional, resolve realizar uma reforma na educação médica e propõe um currículo baseado no estudo de problemas. Nascia, dessa forma, o Problem-Based Learning (PBL), ou Aprendizagem Baseada em Problemas. No entanto, a ideia de utilizar problemas da vida real como parte da aprendizagem já havia sido usada nos anos 30 na Harvard Business School, porém com uma abordagem diferente da utilizada em McMaster. Assim, a história do PBL começou com uma experiência rudimentar na Harvard Business School, foi reformulada na escola médica de McMaster e disseminou-se para outras Universidades, como a Universidade de Maastricht na Holanda, onde a prática do PBL adquiriu o alicerce que sustenta sua doutrina (Penaforte, 2001, p. 52:53).

Os princípios que formam a base do PBL possuem muita semelhança com as teorias de Ausubel, Piaget, Bruner, Dewey, entre outros (Ribeiro, 2008, p. 16), no entanto a contribuição de John Dewey para a renovação do pensamento educacional pode ser reconhecida como uma das principais bases da matriz conceitual na qual está fundamentado o PBL. A teoria de Dewey, considerada como uma filosofia da experiência, ressalta como extremamente relevante a experiência para o processo de aprender (Penaforte, 2001, p. 59). Ela quebra com a ideia tradicional da aprendizagem passiva, na qual a mente é uma tábula vazia esperando ser preenchida por informações. Dewey rompe com a ideia de que os conhecimentos prévios nada significam para o que se

pretende aprender, ele descarta a aprendizagem que ocorre fora do contexto das experiências, bem como o armazenamento na memória de dados sem significado e experiências que terminam em si mesmas. Propõe-se uma filosofia de educação centrada na experiência, para Dewey, a educação é a contínua reorganização e reconstrução da experiência. Nesse contexto, a aprendizagem parte de problemas que abarcam inquietação e dúvida para, através de um esforço ativo, trazer clareza, coerência e harmonia.

São nessas bases teóricas que o PBL está ancorado, através de sua metodologia podemos verificar a preocupação com a aprendizagem ativa e com a busca pela desfragmentação do conhecimento a partir do diálogo entre as disciplinas, surge como uma proposta de articulação entre os saberes, apontando para uma cooperação entre as disciplinas ao focalizarem um objeto, propondo uma maior aproximação com a realidade. Infere-se que essas correlações interdisciplinares desempenham o papel de eixo integrador entre as disciplinas do currículo, o que propicia ao discente ver um mesmo objeto sob diferentes ângulos, prática que o levará, certamente, a responder os problemas cotidianos que a vida lhe impõe, com maior equilíbrio e competência.

Somando-se a isto, podemos verificar que o PBL enfatiza o trabalho em equipe, a resolução de problemas e a articulação teoria/prática através da realização de um projeto que culmina com a apresentação de uma solução/produto a partir de uma situação real, articulada com o futuro contexto profissional (Powell & Weenk, 2003). São seus objetivos principais: centrar a aprendizagem no discente, fomentar o trabalho em equipe, desenvolver o espírito de iniciativa e a criatividade, desenvolver competências de comunicação, desenvolver o pensamento crítico e relacionar conteúdos interdisciplinares de forma integrada. O PBL tem mostrado resultados de aprofundamento do conhecimento (Fernandes et al. 2014) e reconhecimento pela UNESCO (2010) como metodologia relevante para o desenvolvimento de competências transversais, com destaque para gestão e liderança de equipes, organização do trabalho, gestão do tempo, pensamento crítico, criatividade, comunicação em público e interpessoal, dentre outras. Segundo Ribeiro (2005, p. 32), o PBL é "um método de instrução caracterizado pelo uso de problemas da vida real para estimular o desenvolvimento de pensamento crítico e habilidades de solução de problemas e a aprendizagem de conceitos fundamentais na área de conhecimento em questão".

4 A primeira experiência de PBL na Engenharia Mecânica na UACSA

Foram realizados dois workshops com públicos distintos: docentes e discentes. O workshop destinado aos docentes da UACSA totalizou 20h cujo objetivo foi dar apoio à criação de planos para implementação de projetos de aprendizagem em PBL. Estiveram presentes 24 docentes dos cursos das Engenharias citados anteriormente, incluindo seus Coordenadores. O workshop foi organizado com base num processo de ensino-aprendizagem ativo, cooperativo, participativo e centrado nos participantes facilitando a aquisição de competências para projetar, planejar e controlar o desenvolvimento de projetos dos discentes. Para que os docentes desenvolvessem estas competências era necessário o aprendizado dos conceitos essenciais da Aprendizagem Baseada em Projetos e reflexão sobre as vantagens e restrições para que, em equipe, conseguissem construir um plano para implementação de um projeto que considerasse: o perfil do discente, as especificidades da instituição, a motivação dos docentes, entre outros aspetos que se encontram inerentes ao contexto e que torna cada modelo PBL único.

Os docentes foram organizados em grupos de acordo com os cursos de atuação, dessa maneira dialogaram e elaboraram as propostas de PBL, apresentadas ao final do workshop. Ao longo do processo cada grupo recebeu acompanhamento e feedback sobre o trabalho desenvolvido, sendo continuamente desafiados para a importância do seu papel como docentes, agentes principais de mudança na forma de ensinar e de aprender. Esta abordagem ativa na formação docente proporcionou espaços e oportunidades para que analisassem criticamente suas práticas, a natureza das disciplinas que lecionam e a forma como podem ser integradas para a resolução de problemas de engenharia. Assim, ao longo das sessões, foram colocados a refletir sobre as dificuldades e as potencialidades do PBL, a comunicarem e a interagirem uns com os outros, a aplicarem os conhecimentos desenvolvidos nas suas propostas inclusive sobre a avaliação do processo de ensino-aprendizagem.

O workshop realizado com os discentes totalizou 4h e também foi coordenado pelo Professor Rui M. Lima e Diana Mesquita. Foram matriculados estudantes dos cinco cursos da UACSA e consistiu na apresentação do PBL e sua importância para o processo de aprendizagem. Também foram abordados: a importância do trabalho em equipe como facilitador para o planejamento e realização do projeto, o desenvolvimento das competências específicas das unidades curriculares de apoio direto ao projeto e as competências transversais ambas relevantes para a realização cooperativa das tarefas, o monitoramento do desenvolvimento do projeto, pesquisa e seleção de informação, a negociação de conflitos e a comunicação interpessoal.

Na sequência de processos de formação em PBL, por parte de professores da Universidade do Minho, os docentes e discentes de Engenharia Mecânica e Engenharia de Materiais da UACSA/UFRPE acordaram que iniciariam essa metodologia no terceiro período de seus cursos. Como relato dessa experiência, abordaremos apenas o que foi vivenciado no curso de Engenharia Mecânica. Os docentes do terceiro semestre, um professor-tutor convidado a auxiliar os discentes durante o processo e mais um participante externo responsável pelo apoio pedagógico elaboraram uma proposta do projeto que seria realizado pelos estudantes.

O referido projeto tinha como objetivo a construção de um protótipo veicular movido à energia elétrica construído com materiais reciclados. Tal proposta mostrava-se estar inserida em um tema amplo e atual, uma vez que a sustentabilidade tem se mostrado como uma grande preocupação dos atuais engenheiros juntamente com o uso de fontes de energia limpas e o reaproveitamento de materiais. O coordenador geral do projeto era o professor da disciplina de Tópicos para a Engenharia Mecânica III, disciplina destinada às vivências de projetos interdisciplinares no curso e pela organização dos grupos. Dada a complexidade do objeto de estudo as disciplinas de Tópicos para Engenharia Mecânica III, Cálculo III, Física III e Português III estariam em diálogo ao longo do semestre para alcance do objetivo proposto bem como o desenvolvimento das competências tratadas no workshop e aquelas relacionadas às disciplinas diretamente envolvidas no projeto.

Para que a metodologia fosse iniciada a coordenação do projeto elaborou um "Guia" que descrevia alguns dos aspectos associados à forma como se daria o projeto, seus objetivos e o material que seria disponibilizado antecipadamente. As equipes de discentes receberam nesse documento a definição dos pontos de monitoramento do projeto que incluía os seguintes requisitos:

1. Sessão Inicial do projeto com os discentes (brainstorming de soluções e ideias);
2. Project Charter / Plano do Projeto – Proposta inicial de construção do protótipo (que atenda aos objetivos do projeto);
3. Primeira apresentação formal do andamento do projeto (Modelagem, Caracterização, identificação de problemas e testes iniciais);
4. Segundo Relatório de andamento do projeto (relatório parcial de desenvolvimento do projeto e teste (I) preliminar do protótipo veicular elétrico- deve incluir resultados que têm avaliação nas disciplinas);
5. Segunda apresentação formal do andamento do projeto (apresentação formal do projeto e teste (II) do protótipo veicular - deve incluir resultados que têm avaliação nas disciplinas);
6. Entrega: Artigo final (6000 palavras) e blog construído ao longo do semestre + Protótipo;
7. Apresentação, Feedback e Discussão.

Do ponto de vista dos materiais disponibilizados antecipadamente, os discentes receberam um motor elétrico DC (corrente contínua) com alimentação nominal de 12 V. De forma resumida o protótipo veicular construído com esse motor teria que ser capaz de realizar duas tarefas: A primeira seria transportar um peso determinado (disco metálico de 100 g) por uma distância (em linha reta) de 100 metros no menor tempo possível; como segundo objetivo, o protótipo teria que transportar o maior peso possível (discos metálicos com peso inicial a 100 g) por uma distância (em linha reta) de 100m sem tempo determinado.

No Guia do projeto, os discentes também podiam observar que existiam algumas restrições e critérios a serem seguidos na elaboração do produto final - o protótipo veicular, esclarecimentos sobre a estrutura do relatório que deveria ser escrito na forma de um artigo mostrando a prospecção e planejamentos iniciais, detalhamento da construção do veículo e análise dos resultados obtidos, de acordo com os conteúdos de todas as disciplinas.

Somando-se a isto, os discentes também teriam que construir um blog que apresentasse as etapas realizadas pelo grupo.

Os espaços destinados especificamente para a construção do protótipo e elaboração do artigo eram as aulas semanais da disciplina de Tópicos para Engenharia Mecânica III, realizadas numa sala organizada com mesas circulares para o desenvolvimento do trabalho em equipe. Nessas aulas os discentes contavam com a presença do coordenador do projeto e do tutor das equipes como forma de mediar o processo, tirar dúvidas e dar alguns encaminhamentos que julgassem necessários.

Em relação ao processo avaliativo, os discentes foram avaliados de maneira contínua durante todo o semestre, considerando aspectos individuais (20% nota) e do trabalho em grupo, neste ultimo caso considerando o projeto (60% nota) e o protótipo (20% nota). As atividades avaliativas foram diversificadas compondo a nota do grupo no projeto: plano inicial do projeto, a primeira apresentação, relatório parcial, a segunda apresentação e o artigo. A nota individual contou com avaliação pelos pares no início e no meio do semestre e, por fim, a nota do grupo pelo protótipo encerra a composição da avaliação, sendo realizada por testes no meio e no fim do período.

As demais disciplinas que compõe o projeto realizaram seus processos avaliativos de acordo com as competências que foram trabalhadas durante o processo e que estavam presentes no Guia. Por se tratar de um projeto interdisciplinar, foi oportunizados aos discentes o desenvolvimento de um conjunto de competências transversais na gestão de projetos, de trabalho em equipe, desenvolvimento pessoal e comunicação. O desenvolvimento dessas competências transversais também foi avaliado.

5 Metodologia

Com o interesse de compreender as ações que ocorrem em um ambiente no qual o PBL é a estratégia de ensino, especificamente para essa experiência de implantação do modelo e a verificação dos seus resultados, realizou-se uma investigação de abordagem qualitativa. Segundo (Tikunoff, Ward, 1980), a pesquisa qualitativa proporciona a possibilidade de vislumbrar o objeto de pesquisa, de vários modos e o que permite que isso aconteça são as técnicas de coleta propostas.

Como principal instrumento de coleta de dados, foi utilizado o inquérito por questionário, que consiste em formular perguntas diretamente aos sujeitos, utilizando como instrumento, entrevistas ou questionários. Utiliza-se geralmente esta técnica quando a investigação procura estudar opiniões, atitudes e pensamentos de uma dada população (Sousa, 2009).

A coleta de dados ocorreu no final do semestre letivo através de um questionário junto a 20 discentes do terceiro período do curso de Engenharia Mecânica. Nele, os estudantes respondiam as seguintes variáreis: tema do projeto, aprendizagens e competências desenvolvidas, trabalho em equipe, papel dos docentes, avaliação no projeto e projeto como metodologia de ensino-aprendizagem. Os discentes puderam responder a apenas uma das seguintes opções: 1 – discordo totalmente; 2 – discordo; 3 – Não tenho certeza; 4 – concordo; 5 – concordo totalmente em cada item temático, composto por diversos enunciados.

Em seguida, também responderam de forma dissertativa sobre os aspectos positivos e menos positivos na aplicação do PBL, além de contribuírem com sugestões na implementação dessa metodologia. Tais temas favorecem a análise crítica sobre aspectos que compõe o PBL e oportunizam uma reflexão sobre a experiência vivenciada especificamente com os discentes do curso de engenharia da UACSA. A seguir vamos proceder à apresentação e reflexão sobre os dados coletados através do questionário.

6 Análise de Dados

De acordo com a análise e com a sistematização dos dados recolhidos, é possível destacar um conjunto de dimensões relacionadas à organização do processo de implementação da metodologia, observar seus pontos positivos e menos positivos apontados pelos estudantes e suas implicações no processo de ensino e aprendizagem. A abordagem seguida para a análise dos dados baseou-se sobretudo numa perspectiva

indutiva (Miles, Huberman, 1994), tentando identificar os temas emergentes nos discursos dos estudantes, a partir das dimensões consideradas estruturantes na metodologia PBL.

Acerca do ***tema do projeto*** a maioria dos respondentes o considerou como interessante, motivador e relevante para sua atuação como profissional (Figura 1). Também concordaram significativamente com o caráter desafiador do projeto aberto a várias soluções e expressaram orgulho pelos projetos construídos nos grupos. Consideremos então a necessidade de maior articulação entre os conteúdos das disciplinas do período ou, adequações mais substanciais no Projeto Pedagógico do Curso (PPC).

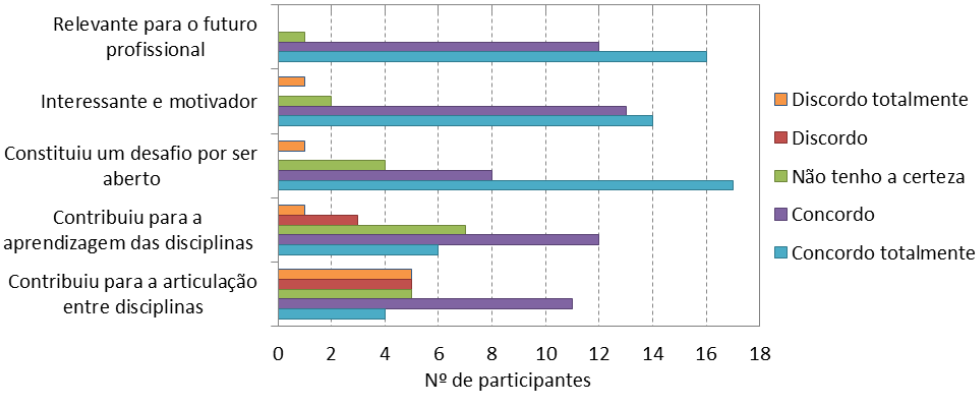


Figura 1. Tema do projeto.

Sobre as ***aprendizagens e competências desenvolvidas*** no PBL, houve a predominância das respostas 4 (concordo) e 5 (concordo totalmente) sobre o desenvolvimento da autonomia, das competências oral e escrita e no estímulo à capacidade de iniciativa e criatividade na criação do protótipo (Figura 2). Porém, nesta última questão, houve um baixo índice de respostas. Também no caso da competência de gestão de projetos (capacidade de investigação, decisão, organização, resolução de problemas, gestão do tempo) houve destaque para a opção 5 seguida pela 4, e respostas distribuídas nas outras três opções, em menor grau.

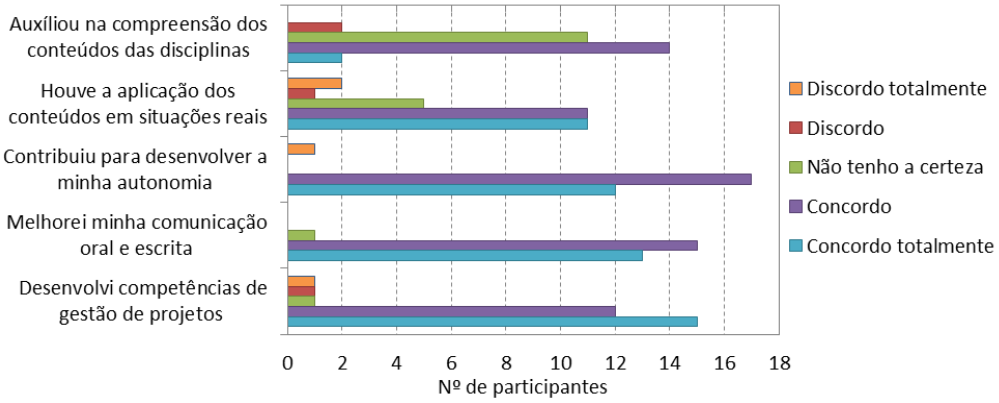


Figura 2. Aprendizagens e competências desenvolvidas.

A compreensão dos conteúdos das disciplinas e sua aplicação em situações reais foram objetivos definidos para a experiência com o PBL, contribuindo na aprendizagem. Acerca da melhor compreensão dos conteúdos os discentes apresentaram 3 (não tenho certeza) e 4 (concordo), com maior adesão a esta ultima. E no caso da aplicação dos conteúdos em situações reais foram as opções 4 e 5 (concordo) as mais frequentes e em níveis bem próximos. No geral, houve baixa frequência nas opções 1 (discordo totalmente) e 2 (discordo). O desenvolvimento de diferentes competências pelos discentes contou com o apoio de estratégias metodológicas viabilizadas pelo PBL que necessitam ser vivenciadas no contínuo da formação dos estudantes, fortalecendo sua experiência com os conteúdos em situações reais.

Algumas das competências mencionadas no item anterior estão relacionadas com o ***trabalho em equipe***, terceiro item do questionário (Figura 3). Os discentes afirmaram, em sua maioria, que o trabalho em grupo

contribuiu para o aumento da motivação pela aprendizagem e que a existência de diferentes papéis no grupo é fundamental para o bom desempenho do mesmo. As competências de relacionamento interpessoal também são importantes para a formação profissional e contou com a maioria das respostas. A partilha dos conhecimentos no grupo e a resolução de conflitos foi, segundo os discentes, prática frequente para a maioria dos participantes. No entanto, houve poucas respostas sobre o desempenho de um papel ativo no grupo e sua maioria também optou pelos campos 4 e 5. Sobre a preferência do trabalho em grupo em detrimento ao individual houve marcações nas cinco opções, com maioria na nº 4 (concordo). No geral, houve baixa frequência nas opções de discordo totalmente e discordo, e a recorrência de respostas positivas. Sendo assim, verificamos que os discentes reconhecem a importância do trabalho em equipe para a construção das competências de relacionamento interpessoal necessárias para a realização de projetos interdisciplinares.

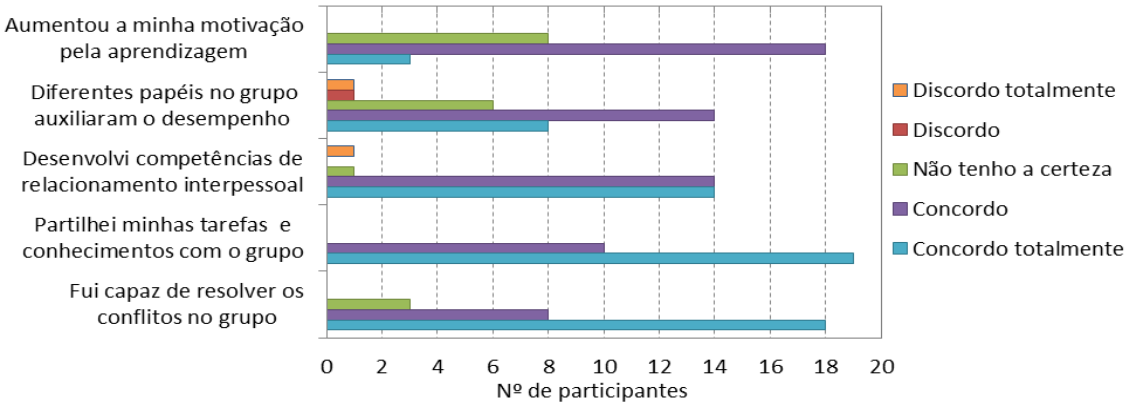


Figura 3. Trabalho em equipe.

O quarto item do questionário nomeado de ***papel dos docentes*** contempla a avaliação da atuação dos docentes responsáveis pelas disciplinas do semestre e do tutor (Figura 4). Houve uma avaliação positiva sobre a disponibilidade e apoio técnico dos docentes envolvidos e que ministraram as disciplinas no semestre. Contudo, sobre o desempenho deles houve marcação nas cinco opções dadas pelo questionário, sendo as opções 4 e 5 as maiores. O desempenho do tutor correspondeu às expectativas dos estudantes sendo considerado indispensável no trabalho do grupo.

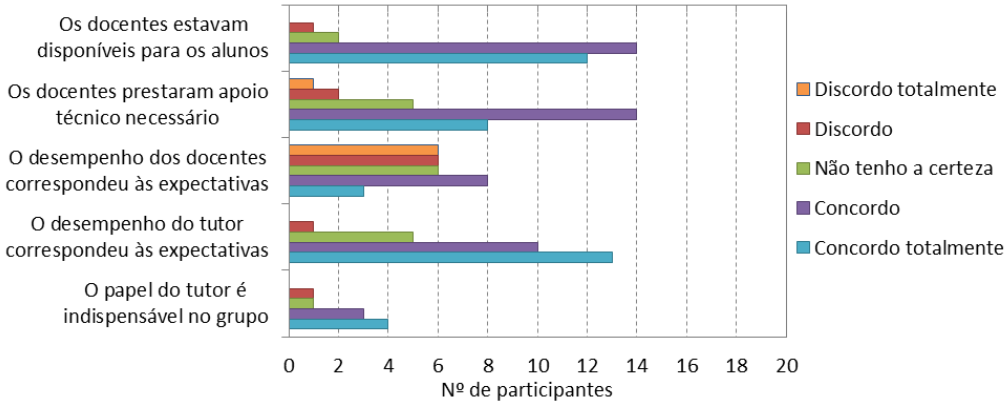


Figura 4. Papel dos docentes.

A avaliação é um elemento importante de análise e envolve uma diversidade de elementos: critérios definidos e compartilhados, clareza sobre os objetivos esperados e instrumentos, entre outros aspectos. Sobre a ***avaliação no projeto*** os discentes destacaram a clareza dos feedbacks dos docentes sobre os relatórios e apresentações e confirmaram a leitura e compreensão dos critérios avaliativos disponíveis no Guia do projeto (Figura 5). A maioria não concorda que o número de avaliações durante o projeto devesse ser menor. As respostas sobre a avaliação em pares foram distribuídas nas cinco opções de resposta, mas a maioria concordou que é um instrumento adequado para esse tipo de trabalho em grupo, embora não seja consenso que reflita o desempenho de cada elemento. Sobre estar satisfeito com os resultados obtidos no projeto,

houve marcação nas opções discordo, concordo e concordo totalmente. A resposta sobre a ajuda do teste final no preparo e apresentação final do projeto variaram entre 1, 2, 3 e 4.

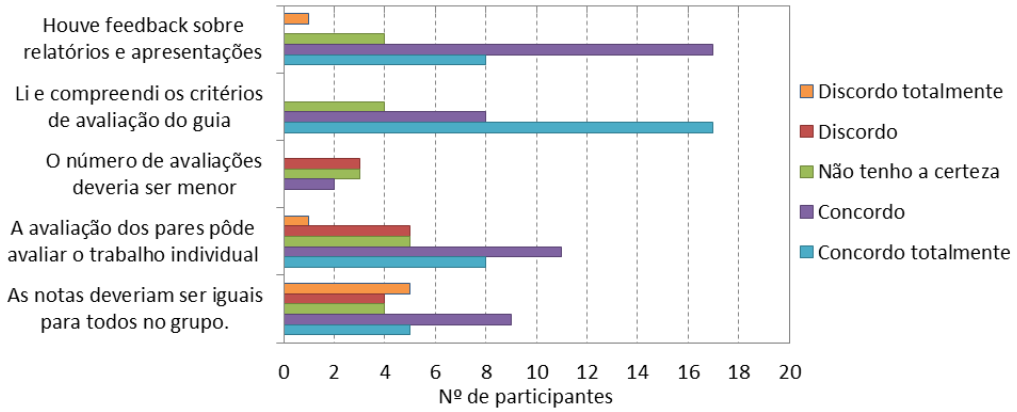


Figura 5. Avaliação do projeto.

No último tópico do questionário intitulado ***projeto como metodologia de ensino-aprendizagem*** os discentes responderam, em sua maioria, na opção 4 (concordo) à questão do PBL enquanto metodologia de ensino-aprendizagem no curso de engenharia mecânica, colaborando para a integração, socialização e permanência na UACSA/UFRPE. Também concordaram que a referida metodologia demandou o trabalho em equipe por parte dos docentes. Sobre a aplicação do PBL no curso de engenharia mecânica a maioria concorda com seu início no 1º período e que, de forma geral o projeto estava bem organizado, incluindo o guia do aluno/projeto. A maioria das respostas sobre o acompanhamento do projeto pelo coordenador e a realização da pesquisa durante o PBL ocorreram nos itens 4(concordo) 5 (concordo totalmente).

Concisamente, os resultados do questionário revelam que o trabalho em equipe, o exercício do relacionamento interpessoal e o desenvolvimento de competências transversais (autonomia, iniciativa e criatividade na criação do protótipo, capacidade de investigação, decisão, organização, resolução de problemas, gestão do tempo) são aspectos positivos de destaque, somados ao fato do PBL trazer possibilidade para que os discentes coloquem em prática os conhecimentos teóricos adquiridos durante o curso.

Foram apontadas como dificuldades para a ótima realização do projeto, a falta de instrumentos e condições dadas aos estudantes para o desenvolvimento do protótipo, a densa carga horária semestral e a má-adequação de algumas disciplinas envolvidas no projeto, bem como a falta de articulação entre elas.

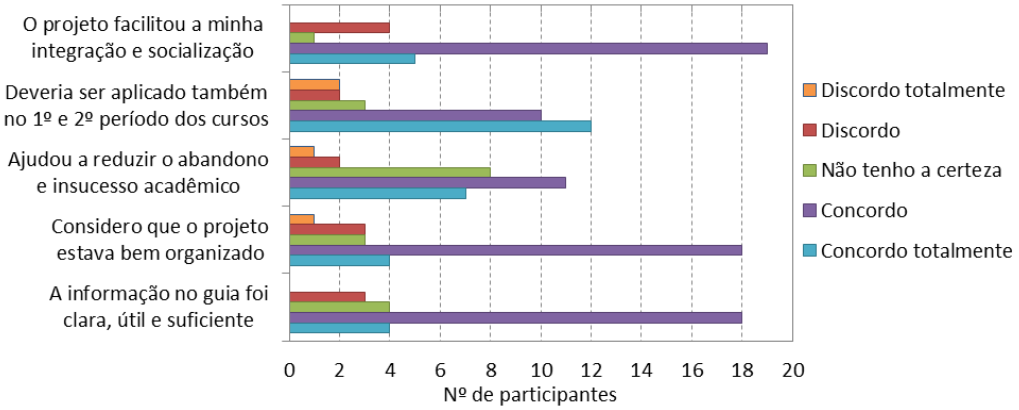


Figura 6. Projeto como metodologia de ensino-aprendizagem.

Nas ***questões dissertativas*** o trabalho em equipe foi apresentado pelos discentes no rol dos aspectos positivos, somando-se ao desenvolvimento das competências transversais e o fato do PBL trazer a possibilidades dos discentes colocarem em prática os conhecimentos adquiridos durante o curso. Conforme podemos observar nos relatos abaixo:

Trabalho em equipe, muitos alunos puderam se conhecer melhor e aprender mais principalmente no que se refere à organização e preparação do projeto de uma maneira mais acadêmica (apresentação, relatório e artigo).
Acredito que em termos de aspectos positivos, posso considerar o desenvolvimento de características que todo profissional deveria ter, como por exemplo, paciência, entrega em prazo, etc...
Por em prática o conhecimento na área da engenharia mecânica.

(Questionário de Avaliação Final)

Em relação aos aspectos menos positivos foram mencionados: a falta de instrumentos e condições dadas aos discentes para o desenvolvimento do protótipo, a divisão dos grupos realizada pela coordenação e a vivencia de situações difíceis com algum participante da equipe. Além disso: a dificuldade em administrar o tempo considerando a matriz curricular com muitas disciplinas e a necessidade de um tempo maior que a aprendizagem por projeto exige. Encontramos alguns exemplos desses aspectos avaliados como menos positivos nos relatos abaixo:

Falta de instrumentos e laboratórios levando os alunos a trabalhar fora da universidade, ir buscar outros locais.
Apesar de trabalhar em grupo ser algo positivo, para mim em partes foi algo negativo em muitos momentos pelo fato de termos sido colocados em grupos específicos escolhidos pelos docentes. A irresponsabilidade de alguns foi carga demasiada para mim em um período tão exaustivo quanto este último que tivemos.

(Questionário de Avaliação Final)

Como sugestões para as melhorias apresentadas pelos discentes, verificamos: melhor divisão dos grupos, revisão dos termos das restrições e o tempo que o projeto demanda. Uma hipótese no primeiro caso é a permanência dos grupos que já existem na realização do projeto considerando a afinidade existente como fator colaborador para a realização das atividades. Além disso, sugeriram que os docentes dessem um maior suporte durante o projeto, a realização do projeto nos períodos anteriores ao III período do curso e a possibilidade de haver oficinas de formações durante o processo. Conforme podemos verificar através das respostas apresentadas a seguir:

Na minha opinião, a ideia do PBL é muito boa. Com certeza será de grande incentivo e ajuda no desenvolvimento crítico e profissional. No entanto, se tratando de melhorias, acredito que os critérios para a construção dos protótipos estejam ainda mais claros. Outra sugestão que gostaria de dar é que as divisões dos grupos fossem deixadas em aberto para que nós mesmos escolhêssemos, tendo em vista que o não interesse de alguns traz desânimo ao restante do grupo. Entendo os objetivos da divisão, mas o fato de termos a obrigatoriedade de estarmos com todas as pessoas do grupo do começo ao final, mesmo que elas não estejam trabalhando, faz com que a proposta não seja tão animadora.

(Questionário de Avaliação Final)

De fato, podemos observar que o trabalho de colaboração é uma das características fundamentais inerentes ao PBL, apresenta-se como uma das competências que a metodologia desenvolve nos discentes e a construção de um resultado partilhado é de estrema importância, uma vez que ao final a responsabilidade é de todos os envolvidos.

7 Conclusões

A experiência do PBL no curso de Engenharia Mecânica da UACSA representa uma contribuição significativa no alcance dos objetivos idealizados através do seu perfil inovador e interdisciplinar, nomeadamente no que se refere aos processos de ensino e aprendizagem centrados na aprendizagem do estudante e ainda às mudanças desejáveis ao nível do trabalho dos docentes. Os resultados deste estudo alertam para uma reflexão acerca da importância do trabalho com a aprendizagem ativa e colaborativa, envolvendo todas as partes que constituem a comunidade acadêmica, professores, estudantes e gestores.

Para vencer todos os desafios que aparecem com a implementação de uma nova metodologia de ensino/aprendizagem, é essencial o desenvolvimento de um modelo de gestão de ensino e do corpo docente envolvido, além de uma revisão na matriz curricular. Além disso, uma maior interação entre os docentes, discentes e gestores contribui para o trabalho num ambiente agradável, dinâmico e produtivo para a formação

do profissional em engenharia. A função da coordenação do curso, dos gestores institucionais e dos docentes deverá estar continuamente em discussão e análise crítica visando atingir os objetivos propostos. A expectativa é que a metodologia empregada possa se tornar uma nova ferramenta no ensino superior de engenharia, através de seus métodos ativos, os discentes aprendem maior volume de conteúdo de forma significativa e aproveitam as aulas com mais satisfação e prazer.

Esta atividade tem promovido o interesse dos discentes pelo próprio aprendizado ao terem contato com a aplicabilidade dos conceitos aprendidos no curso, além de desenvolver nos mesmos um senso crítico e empreendedor, possibilita exercitar suas capacidades de trabalhar em grupo, analisar e solucionar problemas e de planejar experimentos, simulando as situações encontradas no dia-a-dia pelos engenheiros. A solução desenvolvida pelos discentes foi construída através da interação com os colegas para a troca de conhecimentos e experiência, com a orientação e supervisão da equipe de coordenação e também do tutor responsável pela monitora.

Do ponto de vista de quem conduziu a atividade, foi possível perceber maior motivação, comprometimento e entusiasmo por parte dos discentes para estudar o assunto abordado, se comparado ao comportamento observado em aulas exclusivamente expositivas. Também se observou a atitude mais ativa para a pesquisa de soluções para o problema proposto. A aplicação de um questionário no final da atividade possibilitou observar a percepção dos discentes quanto ao método utilizado.

Embora se tenha verificado a necessidade de maior diálogo entre os conteúdos das disciplinas do período e adequações mais substanciais no Projeto Pedagógico do Curso (PPC), o PBL, enquanto metodologia de ensino-aprendizagem no curso de Engenharia Mecânica, atendeu às principais expectativas e colaborou para a integração, socialização e aprendizagem dos discentes.

Entende-se que as principais dificuldades apresentadas pelos discentes para o desenvolvimento da metodologia encontra-se relacionada ao fato muito particular da UACSA, uma vez que a Unidade ainda está em fase inicial de suas atividades acadêmicas e com suas instalações provisórias em um ambiente não favorável a esse tipo de método de ensino, a falta de espaços mais específicos como um laboratório com ferramentas e outros tipos de materiais necessários para a construção dos protótipos dificultou o processo de produção e um melhor aproveitamento acadêmico.

Portanto, percebe-se que a utilização de problemas e atividades didáticas para o ensino no curso de engenharia pode proporcionar um ambiente mais dinâmico e motivador para o discente, que quando desafiado passa a superar as suas dificuldades. Quanto aos benefícios para o professor, percebe-se a ampliação de seu campo de atuação conduzindo o discente na pesquisa e no processo lógico de tomada de decisão. Dessa forma, a partir do estudo proposto, observa-se a possibilidade e demanda para o desenvolvimento e aplicação do PBL desde os períodos iniciais e nos demais cursos de Engenharia da UACSA.

8 References

Fernandes, S., Flores, M. A., & Lima, R. M. (2010). A aprendizagem baseada em projectos interdisciplinares: avaliação do impacto de uma experiência no ensino de engenharia. *Avaliação, 15*(3), 59-86.

Fernandes, S., Mesquita, D., Flores, M. A., & Lima, R. M. (2014). Engaging students in learning: findings from a study of project-led education. *European Journal of Engineering Education, 39*(1), 55-67. doi: 10.1080/03043797.2013.833170

Lima, R. M., Mesquita, D., & Rocha, C. (2013, 2013-07-31). *Professionals' Demands for Production Engineering: Analysing Areas of Professional Practice and Transversal Competences.* Paper presented at the International Conference on Production Research (ICPR 22), Foz do Iguassu, Brazil, [1-7]352a.

Mesquita, D., Lima, R. M., & Flores, M. A. (2013, 8-9 July 2013). *Developing professional competencies through projects in interaction with companies: A study in Industrial Engineering and Management Master Degree.* Paper presented at the Project Approaches in Engineering Education (PAEE'2013): Closing the Gap between University and Industry, Eindhoven, The Netherlands

Miles, Matthew B.; Huberman, Michael. (1994). Qualitative data analysis**.** An expanded source book. Thousand Oaks: Sage.

Penaforte, J. C. (2001). John Dewey e as raízes filosóficas da aprendizagem baseada em problemas. In Mamede, Silvia; Penaforte, J. C. (Orgs.). Aprendizagem baseada em problemas: anatomia de uma nova abordagem educacional. São Paulo: Hucitec/ESP-CE.

PDI/UFRPE (2013,). Plano de Desenvolvimento UFRPE 2013-2020. Universidade Federal Rural de Pernambuco. Retrieved from:
http://ww4.ufrpe.br/download.php?endArquivo=noticias/4616_PDI-2013-2020-CONSU.pdf.txt.pdf.

Powell, P. C.; Weenk, W. (2003). Project-led engineering education. Utrecht: Lemma Publishers.

Ribeiro, L. C. (2008). Aprendizagem baseada em problemas (PBL): uma experiência no ensino superior. São Carlos: EdUFSCar.

Sousa, A. (2009). Investigação em educação. 2ª Ed. Lisboa: Livros Horizonte.

Tikunoff, W., Ward, B. (1980*). Interactive Research and Development on Teaching*. San Francisco: Far West Laboratory for Educational Research and Development.

UNESCO. (2010). Engineering: Issues, Challenges and Opportunities for Development. Retrieved from http://unesdoc.unesco.org/images/0018/001897/189753e.pdf

PjBL Evolution in the Course of Production Engineering at the University of Brasilia

Simone Borges Simão Monteiro[1], João Mello da Silva[1], João Carlos Félix Souza[1], Ana Carla Bittencourt Reis[1]

[1]Department of Production Engineering , Faculty of Technology, University of Brasilia, Campus Darcy Ribeiro, Brasilia - CEP 70910-900 Brasilia, Brazil

Email: simoneborges@unb.br, joaomello@unb.br, jocafs@unb.br, anacarlabr@unb.br

Abstract

The Industrial Engineering undergraduate program offered by the University of Brasília was structured based on the Project Based Learning methodology (PjBL). This innovative educational proposal allows the students to deploy their technical competencies through real problem solving situations. In addition to that, the methodology also stimulates the development of the students' soft skills, by exposing them to such a challenging environment. The undergraduate program has 7 disciplines of Production System Projects (PSP), which are offered from the 4th to the 10th semesters. The first PSP1 discipline was offered in the first semester of 2011 and, until the end of 2015, the students had already developed 243 projects with different external agents ("OIT", "INSS", "HUB", "Ministério do Planejamento", "Ministério da Defesa", "SERPRO", "Gravia", among others). At the end of each project, the results obtained are presented to the respective external agent and some of them get to be implemented in the organization. To sum up, the main objective of this paper is to present the evolution of the PSP courses, which mainly adopt the PMBOK as their project management guide, in addition to a technical discipline related to the project subject. Another relevant aspect of the PSP disciplines is that the students get to play different roles in each project, such as project manager, teaching assistant, among others. Also, it involves students from both undergraduate and graduate schools from different areas of engineering, such as Industrial, Mechanical and Civil, which contributes with developing a holistic and integrated problem solving skill.

Keywords: Project Based Learning (PjBL); Industrial Engineering; University of Brasilia; Production System Project (PSP); PjBL progress.

Evolução do PjBL no curso de Engenharia de Produção da Universidade de Brasília

Simone Borges Simão Monteiro[1], João Mello da Silva[1], João Carlos Félix Souza[1], Ana Carla Bittencourt Reis[1]

[1]Departamento de Engenharia de Produção da Faculdade de Tecnologia da Universidade de Brasília, Campus Universitário Darcy Ribeiro, Brasília - CEP 70910-900, Brasília, Brasil

Email: simoneborges@unb.br, joaomello@unb.br, jocafs@unb.br, anacarlabr@unb.br

Resumo

O curso de Engenharia de Produção da Universidade de Brasília (UnB) está pautado em práticas de aprendizagem baseada em projetos (Project-Based Learning – PjBL). Esta nova proposta educacional permite ao aluno colocar em prática suas competências técnicas, além de desenvolver também suas competências transversais. O curso apresenta sete disciplinas de Projetos de Sistemas de Produção (PSPs), que ocorrem do 4º ao 10º semestre. A primeira disciplina (PSP1) foi ofertada no primeiro semestre de 2011. Até o final do primeiro semestre de 2015 foram desenvolvidos 443 projetos com diferentes agentes externos (OIT, INSS, HUB, Ministério do Planejamento, Ministério da Defesa, Serpro, Gravia). Os resultados dos projetos são apresentados aos agentes externos e alguns deles são de fato implantados nas organizações. O objetivo deste artigo é apresentar a evolução das disciplinas de PSPs, que adotam o PMBOK como metodologia de gerenciamento de projetos, além da âncora técnica, que é utilizada como subsídio para o desenvolvimento do projeto. As disciplinas de PSPs envolvem alunos de mestrado, alunos de outros cursos de engenharia, além da monitoria dos próprios alunos do curso de graduação em Engenharia de Produção.

Palavras-chave: Aprendizagem baseada em projetos (PjBL); Engenharia de Produção; Universidade de Brasilia; Projetos de Sistemas de Produção; Evolução do PjBL

1 Introdução

O curso de Engenharia de Produção da Universidade de Brasília (UnB) apresenta um currículo inovador, pautado na metodologia Project Based Learning (PjBL). Ele teve início no segundo semestre de 2009, e as disciplinas perfazem ao todo 12 semestres. A primeira turma se formou no segundo semestre de 2014. O curso apresenta sete disciplinas de projetos denominadas Sistemas de Projeto de Produção (PSP) e ocorrem do 4º ao 10º período.

De acordo com Monteiro et al (2011) as disciplinas de projetos estão baseadas em quatro âncoras principais: disciplinas de metodologia de projetos sustentáveis; disciplinas de conteúdo técnico; agentes externos vinculado a problemas reais; e outras disciplinas com interesses em tópicos específicos do projeto. A Figura 1 ilustra as disciplinas de PSP com as âncoras.

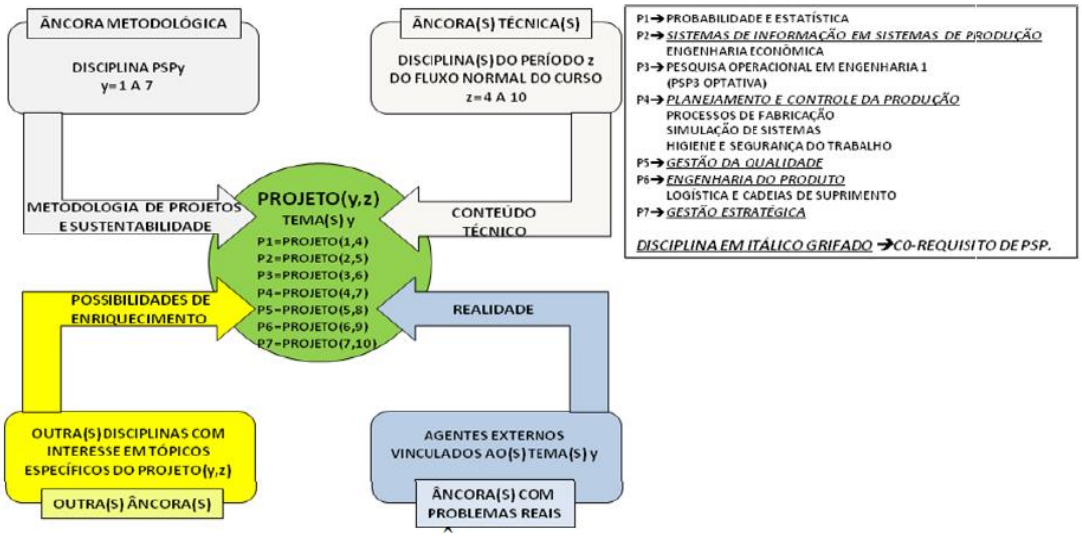


Figura 1: Esquema Geral de Âncoras para Projetos (y,z) de Sistema de Produção Fonte: Monteiro et al (2011).

O Projeto (y,z) pode ter um único ou vários temas y, no qual y representa o correspondente PSP (y=1 a 7) e z identifica o semestre do fluxo normal do curso (z=4 a 10) e se inicia a partir do quarto semestre do fluxo normal. Os problemas oriundos dos temas do Projeto (y,z) são designados a cada equipe de projeto, que normalmente é composta por 5 a 6 membros, e tem a tarefa de identificar problemas detectados pelos *stakeholders* e elaborar respostas e soluções ao longo do semestre letivo. A solução do problema proposta pela equipe de projeto exige um contato direto com o cliente, além da busca de fontes de pesquisa e a integração de conhecimentos multidisciplinares, bem como habilidades de trabalho em equipe. O Projeto (1,4), ponto inicial da série de sete projetos, teve a sua primeira oferta no primeiro semestre de 2011. Até o final de 2015 já foram desenvolvidos 243 projetos envolvendo vários agentes externos, como por exemplo, os órgãos Organização Internacional do Trabalho (OIT), Instituto Nacional do Seguro Social (INSS), Hospital Universitário de Brasília (HUB), Ministério do Planejamento, Ministério da Defesa, Serviço Federal de Processamento de Dados (SERPRO), Gravia, Instituto Brasileiro de Museus (IBRAM), Receita Federal, Centro de Seleção e de Promoção de Eventos (CESPE) dentre outros.

A aprendizagem baseada em projetos (PjBL) utiliza a problematização como estratégia de ensino-aprendizagem. Esta estratégia de ensino utilizada pela UnB em seu curso de Engenharia de Produção estimula o aluno a buscar o conhecimento, uma vez que ele propõe soluções para os problemas reais provenientes dos agentes externos. O estudante passa a ser o sujeito do processo de aprendizagem, pois a sua aprendizagem depende da busca constante pelo conhecimento acerca das novas tecnologias, métodos, técnicas e ferramentas que podem ser utilizadas na condução das atividades para a entrega das possíveis soluções.

A abordagem PjBL propicia a compreensão mais aprofundada dos conteúdos pelo aluno porque de fato ele utiliza os conceitos teóricos na resolução do problema, além do desenvolvimento de competências transversais como aquisição de habilidades em comunicação, liderança, capacidade de gerenciamento, desenvolvimento de estratégias de solução de problemas, desenvolvimento de um pensamento crítico fundamentado. Segundo Barell (2007), em função da maior retenção de informações disponíveis aos alunos e da motivação e do interesse dos estudantes na resolução de casos reais, há um aumento efetivo do seu desempenho.

As próximas seções apresentam os resultados obtidos com as disciplinas de PSP que utilizam a abordagem PjBL.

2 Evolução do PjBL nas disciplinas de PSP no curso de Engenharia de Produção da UnB

A proposta inicial das disciplinas de PSP foi baseada no desenvolvimento de um projeto que contemplava inicialmente temas correlacionados a projetos sustentáveis; que estivessem vinculados ao conteúdo técnico da

disciplina âncora; que tivessem o envolvimento dos agentes externos vinculado a problemas reais; e outras disciplinas com interesses em tópicos específicos do projeto, conforme foi apresentado na Figura 1. Com o passar do tempo novos quesitos foram sendo incorporados na dinâmica dos PSP na Engenharia de Produção da UnB. Estes quesitos serão relatados a seguir.

A fim de atender a demanda de todos os PSP no fluxo normal do curso, do PSP1 ao PSP7, são formadas em média 60 equipes por semestre, que trabalham com temas diferentes, e os projetos desenvolvidos são de várias áreas do conhecimento e envolvem diversos *stakeholders*. Isso requer uma quantidade grande de agentes externos que devem estar disponíveis para levar seu problema real a fim de que os alunos proponham uma solução. Este fato requer uma dedicação muito grande por parte dos docentes do curso, pois além de se preocuparem com as atividades de ensino, pesquisa e extensão, ainda se preocupam com os agentes externos que devem fomentar os projetos de sua respectiva disciplina no semestre subsequente. Além disso, um único professor chega a orientar de 10 a 12 equipes no semestre. O projeto PjBL desenvolvido pelo curso com relação aos PSP é visto como uma excelente forma de aprendizagem, mas a vazão do fluxo das disciplinas no curso de Engenharia de Produção está acima da capacidade dos docentes, assim foram propostas novas formas de trabalho. Uma nova forma de trabalho proposta foi estabelecida com os alunos de PSP8 ao se tornarem monitores de outras turmas, auxiliando o docente no atendimento às equipes, e colocando em prática o que aprendeu nas disciplinas de PSP, e a outra forma está relacionada aos alunos do mestrado profissional apresentar seu "problema de pesquisa real" para as disciplinas de projeto, aliviando a carga do docente em identificar os *stakeholders* para o próximo semestre.

Em todo semestre são ofertadas no mínimo sete disciplinas de PSP. A disciplina de PSP3, vinculada à âncora técnica Pesquisa Operacional é uma disciplina optativa. No segundo semestre de 2015 criou-se uma disciplina que também é optativa, a disciplina de PSP8, vinculada à âncora técnica Controle Estatístico de Processo (CEP). A iniciativa da criação da disciplina de PSP8 veio com o intuito de estabelecer um canal de retroalimentação da experiência adquirida pelos alunos que já passaram pelos sete PSP, aos outros alunos do curso que desenvolvem projetos nas disciplinas de PSP. Os estudantes que cursam PSP8 já desenvolveram projetos nas áreas de Estatística, Sistemas de Informação, Pesquisa Operacional, Planejamento e Controle da Produção, Gestão da Qualidade, Engenharia do Produto e Gestão Estratégica. O propósito é que os alunos que cursam a disciplina de PSP8 sejam monitores das equipes das disciplinas de PSP1 e PSP5, com relação ao desenvolvimento de projetos que contemplem ferramentas de CEP para resolução de problemas no PSP1 e PSP5, relacionado à Probabilidade Estatística e Qualidade. Vale ressaltar que o método de avaliação da disciplina de PSP8 tem uma parte de sua nota vinculada às atividades desenvolvidas pelos alunos nos projetos de PSP1 e PSP5, dessa forma a avaliação contempla a nota de outras disciplinas do Departamento de Engenharia de Produção.

O curso de Engenharia de Produção desenvolveu uma parceria com o Programa de Pós-Graduação do Departamento de Ciências da Computação, especificamente com o Mestrado Profissional de Computação Aplicada (MPCA), que apresenta três linhas de pesquisa (Infraestrutura de TI, Engenharia de *Software* e Gestão de Risco). A Engenharia de Produção assumiu a coordenação da linha de pesquisa de Gestão de Risco, e vários professores do Departamento iniciaram no Programa desenvolvendo pesquisas nesta área. Surgiu a ideia de transformar os problemas de pesquisa dos alunos de mestrado do MPCA em problemas reais que pudessem ser ofertados aos PSPs, uma vez que é um mestrado profissional e o aluno é liberado por sua instituição para resolver um problema vinculado a ela. Dessa forma, um dos agentes externos das disciplinas de PSP1, PSP2, e PSP5 são os alunos do mestrado do MPCA. Para o aluno do mestrado é bem interessante levar seu problema de pesquisa para ser tratado pelos alunos de graduação das disciplinas de PSPs, pois parte daquilo que é proposto como planejamento da pesquisa em comum acordo com o orientador é realizado nos projetos de PSPs. Dessa forma, têm-se duas formas de aprendizado e troca de experiências, o aluno de graduação que conhece diferentes problemas oriundos da área de Gestão de Riscos em Tecnologia da Informação e apresentam soluções pertinentes, e o próprio aluno de mestrado que ensina aos alunos de graduação atuando como um tutor e aprende com as soluções propostas por eles.

A Figura 2 representa as duas situações que são adequadas à realidade do curso.

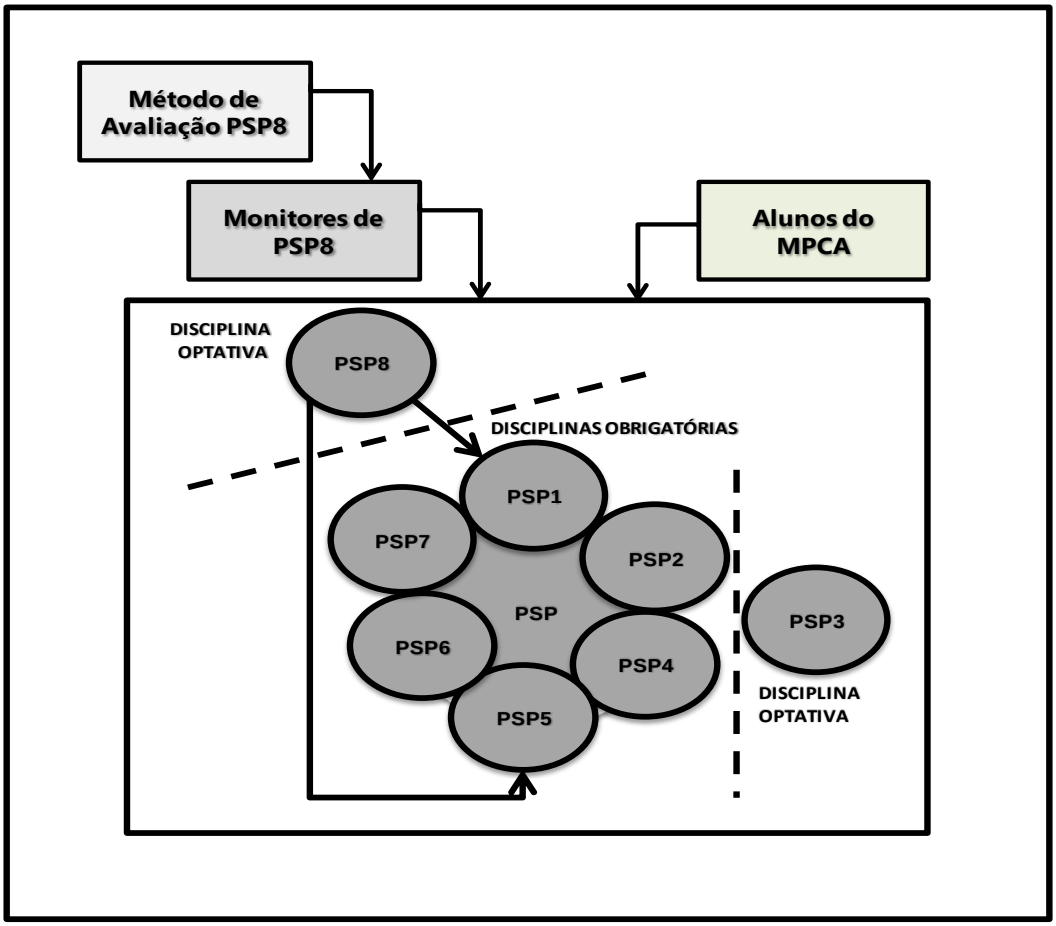


Figura 2: Nova forma de trabalho para as disciplinas de Projetos (PSP).

Com as novas iniciativas para as disciplinas de projetos, os alunos que estão no final do curso (cursando a disciplina de PSP8) tem a oportunidade de repassar seu conhecimento aos outros alunos que cursam as disciplinas de projetos, mais no início ou no meio da trajetória dos PSP, e isso funciona como fator motivador aos demais alunos que sabem que um dia ocuparão o papel de monitor. Além disso, a presença dos alunos do mestrado do MPCA nas disciplinas de projetos fomenta a realização de pesquisas pelos alunos de graduação.

2.1 Estruturação das Disciplinas de PSP

As disciplinas de PSP apresentam um encontro semanal de 100 minutos. A dinâmica das aulas segue uma programação. No primeiro dia de aula é apresentado ao aluno o plano de ensino da disciplina e a forma de condução das atividades. No segundo dia são apresentados os temas que estão disponíveis naquele semestre pelos agentes externos, que podem ser decorrentes de alunos do mestrado do MPCA, de PSP realizado no semestre anterior, ou temas oriundos dos próprios alunos. Os temas devem ser colocados em ordem de prioridade pelos alunos e as equipes são alocadas em função das prioridades estabelecidas.

A disciplina de PSP5 que tem como âncora técnica a disciplina de Gestão da Qualidade na Produção apresenta aos alunos uma nova forma de gerenciamento de projetos com base na metodologia ágil. Dessa forma, no terceiro dia é apresentado aos alunos o conceito do Método Ágil e sua forma de aplicação na disciplina. Na próxima semana as equipes já se reúnem para realização do planejamento do projeto, utilizando como ferramenta o *Project Model Canvas*. A equipe deve deixar claro qual será forma de planejamento e controle de qualidade do produto/serviço entregue. No decorrer das aulas ministradas ao longo do semestre, existem três pontos de controle que são as apresentações do projeto preliminar, projeto intermediário e projeto final, conforme pode ser visto pela figura 3.

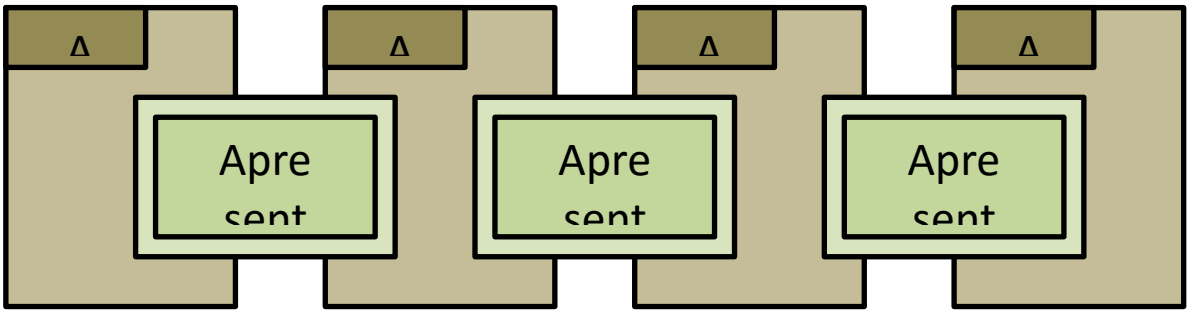


Figura 3: Estruturação das entregas das disciplinas de Projetos (PSP).

Na apresentação do Projeto Preliminar é cobrado apenas o Power Point com o *Project Model Canvas*. Para o Projeto intermediário, os alunos devem entregar uma súmula escrita (que se subdivide em relatório técnico e documento de acompanhamento do projeto, mesmo utilizando a metodologia ágil, a equipe deve detalhar sua forma de trabalho, atingimento ou não das metas estabelecidas, etc.) e, além disso, deve ser feita uma apresentação oral. Na entrega final, além do que é entregue no Projeto Intermediário, as equipes entregam um artigo final que contempla as soluções propostas na resolução do problema. Este foi o critério estabelecido na primeira oferta da disciplina de PSP1 em 2011, e é o que prevalece até hoje nas demais disciplinas de PSP. Além das entregas formais, é importante destacar que existe um critério de avaliação que compõe a nota final, que é a avaliação dos pares. O intuito dessa avaliação é que a nota do aluno seja corrigida em função da análise de seu desempenho pelos pares. Outro ponto interessante é que a avaliação dos pares também é utilizada para comparar a nota estabelecida pelos pares e a nota estabelecida pelo próprio aluno. Isso permite identificar lacunas entre o desempenho do aluno avaliado pelos pares e sua auto-avaliação, com o intuito de apontar os critérios que necessitam de aperfeiçoamento.

3 Relato sobre as principais Evoluções

Após 6 anos da existência do curso, e 5 anos da implantação do PjBL na Engenharia de Produção da UnB, é fácil identificar que os resultados com a aplicação da metodologia PjBL tem sido muito positivos. Isso foi o que os resultados da avaliação do INEP demonstraram.

Segundo o site do INEP, existem indicadores que compõem um sistema de informações e subsidiam tanto o processo de regulamentação, exercido pelo MEC, como garante a transparência dos dados sobre a qualidade da educação superior a toda a sociedade.

Um dos indicadores que avalia a qualidade dos cursos é o Exame Nacional de Desempenho de estudantes (ENADE). São avaliados os alunos ingressantes e concluintes, por meio de prova que contem questões gerais e específicas. Os auditores realizam visitas *in loco* a fim de avaliar a infra-estrutura, condições de ensino, perfil do corpo docente, instalações físicas, e a organização didático-pedagógica.

A avaliação periódica dos cursos é uma necessidade requerida pelo Sistema Nacional da Educação da Escola Superior (SINAES). As avaliações previstas estão relacionadas com as atividades de autorização, reconhecimento e renovação de reconhecimento.

O resultado da avaliação para o reconhecimento do curso de Engenharia de Produção da UnB no segundo semestre de 2014 foi extremamente positivo, obtendo nota 4,33 em uma escala de 0 a 5 (nota máxima).

Já a avaliação com relação à nota do ENADE, segundo o site do curso de Engenharia de Produção, o curso de Engenharia de Produção da UnB obteve a segunda maior nota de Engenharia de Produção no Brasil. A primeira melhor nota foi da UFRJ com 4,929 e a nota do curso de EP da UnB foi de 4,835. Apenas 29 alunos se inscreveram para fazer a prova, e destes, somente 27 alunos realizaram a prova (dois alunos apresentaram atestados médicos).

4 Considerações Finais

O currículo inovador do curso de Engenharia de Produção da Universidade de Brasília forma engenheiros com habilidade para gerenciar projetos, que se baseia tanto na metodologia de gerenciamento tradicional de projetos, com base no PMBOk quanto nas metodologias ágeis. As disciplinas de Projetos de Sistemas de Produção (PSP) são o carro-chefe do curso. Elas permitem aos alunos, por meio da metodologia de aprendizagem baseada em projetos (PjBL), capacitá-los a enfrentar desafios, resolver problemas, tomar decisões com base nos dados provenientes do monitoramento do projeto, exercer liderança, trabalhar em equipe e gerar resultados, dentre outros. Os problemas são advindos de organizações públicas ou privadas, e para fomentar a diversidade de temas que subsidiam o desenvolvimento dos projetos das sete disciplinas de PSP a cada semestre, o curso de Engenharia de Produção adota a prática de envolver os temas de pesquisa dos alunos do Mestrado Profissional em Computação Aplicada (MPCA) como problema real a ser solucionado pelos alunos de graduação. Além disso, os próprios alunos de graduação que estão no final do curso passam a ser monitores dos alunos de graduação que se encontram nas disciplinas de PSP iniciais. Com a adoção dessas práticas, o curso aumenta a quantidade de temas ofertados aos alunos e utiliza os próprios alunos de graduação para auxiliar os professores, em face do aumento da quantidade de equipes a serem gerenciadas por semestre.

Existe uma expectativa de lançar uma revista do curso que irá contemplar publicações dos melhores projetos de PSP desenvolvidos a cada semestre. Além disso, tem um trabalho de um aluno de mestrado que está sendo desenvolvido que irá propiciar a criação de um banco de dados dos projetos de PSP, onde o professor poderá lançar a nota dos projetos via sistema, o aluno pode consultar sua nota, depositar materiais, e o coordenador juntamente com os professores orientadores poderão ter acesso a evolução de cada aluno no sistema ao longo das disciplinas cursadas.

Os resultados tanto do reconhecimento quanto do ENADE foram excelentes, e muito disso se deve ao fato do curso ser inovador e adotar metodologias de aprendizagem ativa (PjBL) que propulsiona o desenvolvimento do aluno, tornando-o destaque, e que de acordo com o resultado, foi considerado o 2º melhor curso de Engenharia de Produção do Brasil.

5 Referências

Barell, J. Problem-based learning: an inquiry approach. 2. Ed. Thousand Oaks: Corwin, 2007.

Monteiro, S. B. S.; Quirino, M. G.; Zindel, M. L; Oliveira, E. C.; Rodrigues, E. C. C. Uma nova abordagem de ensino de Engenharia: Aprendizagem baseada em Projetos (PjBL) na disciplina PSP1 do curso de Engenharia de Produção da UnB. XXXIX Congresso Brasileiro de Educação em Engenharia, COBENGE. Blumenau/SC. Outubro/2011.

Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira. INEP. Disponível em <http://portal.inep.gov.br>. Acesso em 20 de mar. 2016.

Departamento de Engenharia de Produção (EPR/UnB). Universidade de Brasília. Disponível em <http://www.epr.unb.br>. Acesso em 21 mar. 2016.

Engineering Teachers can Learn to be Effective in their Teaching Practice

Valquíria Villas-Boas[1], Ivete Ana Schmitz Booth[2], Diana Mesquita[3]; Rui M. Lima[3]

[1] Centro de Ciências Exatas e da Tecnologia, Universidade de Caxias do Sul, Brasil
[2] Instituto de Educação, Universidade do Minho, Braga, Portugal
[3] Departamento de Produção e Sistemas, Escola de Engenharia, Universidade do Minho, Guimarães, Portugal

Email: vvillasboas@yahoo.com, iasbooth@ucs.br; diana@dps.uminho.pt; rml@dps.uminho.pt

Abstract

Teachers in Higher Education need to deal with different types of challenges, such as dealing with students' profiles and motivation, selecting the adequate learning strategies and assessment methods, selecting and delivering content that is relevant for the professional practice, using new technologies, amongst other. Much has been written about effectiveness of teaching but there is a lack of studies with experiences dedicated to teachers' professional development (e.g. workshops and courses), particularly in Engineering Education context. This paper aims to discuss the importance of effectiveness of teaching taking into account preparing teachers to active learning contexts. This is an exploratory study based on a training program carried out in 2015 at University of Caxias do Sul, Brazil, which focuses on different active learning strategies (e.g. Peer Instruction, In-Class Exercise Teams, Problem and Project Based Learning, etc.). In this training program, teachers had the opportunity to reflect about their practice and to improve teaching and learning process by implementing innovative approaches. Eighteen teachers participated in this program, from different areas of knowledge, including Engineering, Law, Management and Informatics. Teachers' perceptions where collected at the end of the program using a questionnaire which included the motivations and expectations about the program, potential contribution for teaching practice, meaning of "active learning" and also identified the active learning strategies that teachers intended to fulfill in their own contexts. The findings show the relevance of the training program experience for effectiveness of teaching. Most of the teachers will apply active learning in their classroom in the following semester and a few already started implementing this change during the training process. This work allowed to discuss the implications for teachers professional development in engineering education.

Keywords: Active Learning; Effectiveness of Teaching; Teachers Professional Development

Professores de Engenharia Podem Aprender a Tornar a sua Prática Docente Eficaz

Valquíria Villas-Boas[1], Ivete Ana Schmitz Booth[2], Diana Mesquita[3]; Rui M. Lima[3]

[1] Centro de Ciências Exatas e da Tecnologia, Universidade de Caxias do Sul, Brasil
[2] Instituto de Educação, Universidade do Minho, Braga, Portugal
[3] Departamento de Produção e Sistemas, Escola de Engenharia, Universidade do Minho, Guimarães, Portugal

Email: vvillasboas@yahoo.com, iasbooth@ucs.br; diana@dps.uminho.pt; rml@dps.uminho.pt

Resumo

Professores do ensino superior lidam com diferentes tipos de desafios, tais como lidar com perfis e motivação dos estudantes, selecionar as estratégias de aprendizagem e de avaliação adequados, selecionar conteúdos que são relevantes para a prática profissional, utilizando novas tecnologias, entre outros. Muito tem sido escrito sobre a eficácia do ensino, mas há uma falta de estudos com experiências dedicadas ao desenvolvimento profissional dos professores (por exemplo, workshops e cursos), particularmente no contexto da Educação em Engenharia. Este trabalho tem como objetivo discutir a importância da eficácia do ensino tendo em conta a preparação de professores para contextos de aprendizagem ativa. Este é um estudo exploratório com base em um curso de capacitação realizado em 2015 na Universidade de Caxias do Sul, Brasil, que se concentra em diferentes estratégias e métodos de aprendizagem ativa (por exemplo, Instrução pelos colegas, Instrução na hora certa, Aula Invertida, Aprendizagem baseada em Problemas, Aprendizagem baseada em Projetos, etc.). Neste curso de capacitação, os professores tiveram a oportunidade de refletir sobre a sua prática e de melhorar o processo de ensino e aprendizagem através da implementação de abordagens inovadoras. Dezoito professores participaram neste curso, a partir de diferentes áreas do conhecimento, incluindo Engenharia, Direito, Gestão e Informática. Percepções dos professores foram recolhidas no final do curso através de um questionário que incluía as motivações e expectativas sobre o curso, a contribuição potencial para a prática de ensino, o significado de "aprendizagem ativa" e também identificando as estratégias de aprendizagem ativa que os professores pensam em implementar em suas disciplinas. Os resultados mostram a relevância da experiência do curso de capacitação para a eficácia do ensino. A maioria dos professores declarou que irá aplicar as estratégias e os métodos de aprendizagem ativa em sua sala de aula no semestre seguinte e alguns já começaram a implementar esta mudança durante o processo de formação. Neste trabalho discutem-se as implicações no desenvolvimento profissional de professores de Engenharia.

Palavras-Chave: Aprendizagem Ativa; Eficácia do Ensino; Desenvolvimento Profissional de Professores.

1 Introdução

Nas últimas décadas, muitas instituições de ensino superior encontram-se enfrentando o desafio pedagógico de capacitar seus professores, a fim de modificar sua concepção de ensinar centrada na pedagogia diretiva, a qual enfatiza a transmissão de conteúdos, para um processo de ensinar voltado para o desenvolvimento de habilidades e competências, onde o professor é mediador desse processo e os estudantes são os principais atores do mesmo (Flores, Veiga Simão & Carrasco, 2012; Rettl et al., 2011; Stes, Coertjens & Van Petegem, 2010; Cowan, 2006; Fink, Ambrose & Wheeler, 2005; Gibbs & Coffey, 2004; Font & Pozo, 2003; Masetto, 2003; Trigwell, Prosser, & Waterhouse, 1999; Merseth, 1991). Enfrentar tal desafio é importante, considerando que a formação em Engenharia se desenvolve em um cenário cujos protagonistas, os estudantes e seus professores, devem, juntos, construir espaços para o desenvolvimento de competências que distinguirão o engenheiro como um profissional criativo e inovador, que aplica conhecimentos básicos e específicos para lidar com a realidade do meio onde está inserido, buscando aprimorar as condições tecnológicas (Mesquita, Lima, Flores, Marinho-Araújo & Rabelo, 2015; Lima, Mesquita, & Rocha, 2013; Passow, 2012; INOVA, 2006; NAE, 2005).

A prática docente envolve um conjunto de comportamentos complexos e multi-referenciais, cuja dinâmica só pode ser compreendida nas relações que são estabelecidas entre estudantes, professor, o conhecimento e as aprendizagens a desenvolver. Melhorar o ensino de engenharia por meio de alteração de currículos, ampliação de salas informatizadas e condições físicas de laboratórios não garante um ensino eficaz, voltado para as

aprendizagens dos estudantes. É importante nesse cenário fundamentar estudos e ações voltadas para a capacitação epistemológica e pedagógica do professor de engenharia.

Instituições de ensino e de fomento desenvolvem poucas ações para implementar a formação de engenheiros-professores em serviço. Bazzo, Pereira e Linsingen (2000) identificaram a existência de distorções na cultura científica, humanística, na formação e na prática pedagógica, de parcela significativa dos docentes que atuam nesta área. Que comportamentos o professor precisa apresentar para criar condições adequadas à aprendizagem dos estudantes? Para responder a essas questões, parece fundamental a produção de conhecimento sobre variáveis que interferem nos comportamentos de ensinar para que o profissional professor de engenharia possa rever conceitos e desenvolver comportamentos novos capazes de tornar eficaz o ensino de nível superior. Que referenciais epistemológicos os engenheiros-professores levam em conta para decidir o que vão ensinar? Onde buscam informações para planejarem sua atuação no trabalho com o ensino? Que estratégias e métodos utilizam em suas aulas para que o estudante seja um agente ativo no processo de ensino e aprendizagem?

Este trabalho tem como objetivo refletir sobre a importância da eficácia do ensino levando em conta a capacitação de professores para contextos de aprendizagem ativa, capacitação essa desenvolvida na Universidade de Caxias do Sul, Brasil. Por outras palavras, procura-se, neste artigo, explorar três dimensões: a formação docente, a aprendizagem ativa e a eficácia do ensino. A seguir é apresentada uma discussão sobre a formação do professor de engenharia, a descrição de um curso de capacitação em estratégias e métodos de aprendizagem ativa, alguns resultados e, finalmente, algumas considerações sobre o assunto deste trabalho.

2 Formando o professor de engenharia

Refletir sobre a formação do professor de engenharia demanda, antes de qualquer coisa, uma compreensão da docência no ensino superior de uma forma mais geral e dos aspectos e contextos atuais em que se desenvolve a atividade do professor universitário. O padrão francês de universidade, modelo implantado no Brasil em 1808, quando da chegada da família real portuguesa ao Brasil, contribuiu para a manutenção de um perfil de professor que fosse competente no exercício da sua profissão, pois, a atividade de ensinar consistia em ministrar aulas expositivas ou palestras sobre um determinado assunto (Masetto, 1998). Assim, ainda hoje, os professores universitários brasileiros, em sua maioria, são mestres e doutores altamente qualificados em suas áreas de conhecimento, mas são professores por circunstância. No caso particular da educação em engenharia, temos, na maioria dos casos, o engenheiro-professor e não o professor de engenharia.

A discussão em torno da formação do professor de engenharia, colocada no atual cenário científico-tecnológico cambiante, requisita a consideração de diversos aspectos. Ao focar o elemento vital dessa preocupação sobressai a necessidade de preparar gerações de profissionais-engenheiros capazes de lidar com mudanças potenciais, de dimensões ainda não caracterizadas, e seus desdobramentos na fabricação de produtos e na idealização de processos inovadores, em um mundo com precariedades ecológicas e econômicas globalizadas. São evidentes o requisito de uma capacidade crítica apurada, a aptidão na lida com campos novos de conhecimento, com pessoas de áreas distintas e, em especial, a capacidade de empreender e constituir conhecimento novo.

O educador catalão, Antoni Zabala (1998) afirma que, na formação docente, é preciso introduzir ações adaptadas às novas necessidades formativas, que surgem a cada momento. Segundo ele: "O objetivo não pode ser a busca da 'fórmula magistral', mas a melhora da prática. Mas isso não será possível sem o conhecimento e uso de alguns marcos teóricos que nos permitam levar a cabo uma verdadeira reflexão sobre essa prática, que faça com que a intervenção seja a menos rotineira possível, que atuemos segundo um pensamento estratégico que faça com que nossa intervenção pedagógica seja coerente com nossas intenções e nosso saber profissional". Ainda segundo Zabala, o crescimento pessoal dos estudantes implica como objetivo último serem autônomos para atuar de maneira competente nos diversos contextos em que haverão de se desenvolver. Para tanto, é necessário que o professor assuma a postura de investigador, pesquisador, orientador e coordenador, propondo que o estudante desenvolva seu trabalho de forma mais independente. Cabe ao estudante ser essencialmente ativo (a atividade é uma forma de funcionamento do sujeito) e suas

atividades básicas, entre outras, deverão consistir em: observar, experimentar, comparar, relacionar, analisar, compor, encaixar, levantar hipóteses, argumentar, entre outras.

E aqui podemos colocar a seguinte pergunta: o que os professores de engenharia fazem em suas aulas que permite aos estudantes serem ativos, ou seja, serem os sujeitos principais do processo de ensino e aprendizagem? Uma resposta para esta pergunta é que alguns os professores de engenharia estão implementando práticas pedagógicas associadas à aprendizagem ativa. Essas práticas mudam o entendimento sobre o processo de ensinar. As estratégias e os métodos de aprendizagem ativa levam em conta o planejamento e a execução de ambientes de aprendizagem que permitem ao estudante "aprender a aprender" juntamente com o desenvolvimento de competências transversais.

A introdução de conteúdos práticos e contextualizados e de situações-problema, desde o início do curso, é essencial para a construção dos conteúdos teóricos dentro da perspectiva de sua aplicação prática criativa. Além disso, pode ser um importante fator de motivação para o estudante, ajudando a reduzir os índices de evasão. A conjugação entre as chamadas atividades teóricas e práticas habilita o futuro profissional para intervir na realidade, dominando suas nuanças por meio de atividades simuladas, como exercícios, trabalhos, estudos de caso, práticas raramente associadas aos conteúdos teóricos dos cursos. O atual modelo de formação de engenheiros oferece ao estudante uma representação "bidimensional", narrativa de uma realidade que é tridimensional e complexa. Desvinculada dessa realidade, a teoria acaba perdendo o papel de importante ferramenta para sua compreensão.

Promover situações de ensino que levem os estudantes a desenvolver habilidades de resolver problemas e de trabalhar com o desconhecido parece ser um caminho que potencializa a aprendizagem significativa (Ausubel, 2003). O desenvolvimento de aprendizagens estruturadoras não envolve apenas conceitos, mas habilidades complexas, praticamente inexistentes no meio educacional, bem como um tipo de conhecimento ainda não familiar à maior parte de professores e estudantes (Booth, Villas-Boas & Catelli, 2008). É importante, nesse cenário, fundamentar estudos e ações voltadas para a capacitação epistemológica e pedagógica do professor.

Nesse sentido, para que o engenheiro possa lidar com as situações que se apresentam em seu ambiente de trabalho, gerando resultados relevantes, levando em conta as expectativas atuais em relação ao seu trabalho, é necessário que ele seja capaz, não apenas de executar regras e instruções, mas de criar e de aperfeiçoar novas regras, de derivar novas e melhores possibilidades de interagir em seu meio, produzindo resultados de interesse.

É preciso, então, mudar a concepção do que seja ensinar e aprender e dos papéis do professor e do estudante, nesse processo. Com base em estratégias e métodos de aprendizagem ativa, que concebem o aprender como um processo relacionado à construção e ao estabelecimento de relações entre o novo e o que já se conhece, entende-se que, para ensinar, mais que expor e informar, é necessário incentivar o estudante a pensar, a fazer conjecturas, a ler e interpretar informações e, por meio delas, deduzir formas de resolver problemas, interagindo com colegas, refletindo sobre as ações desenvolvidas e tomando decisões. Dessa forma aumentam as possibilidades de que construa relações, aprendendo de forma ativa e significativa.

Quando o professor concebe ambientes de aprendizagem utilizando estratégias e métodos de aprendizagem ativa, estes são estruturados de forma a desencadear a curiosidade, a motivação e o planejamento de ações por parte dos estudantes. Nesse contexto, o professor planeja ações que visem repartir com o estudante a responsabilidade junto ao processo de ensino e aprendizagem. Com a característica da flexibilidade os problemas permitem a inserção, em seu enunciado, de questões com dimensões diferenciadas: objetivos de ensino, objetivos de curso, atividades experimentais, contextualização sociocultural dentre outros. Este, pois, parece ser um dos mecanismos para superar equívocos, impropriedades e perspectivas no trabalho com a educação em Engenharia.

Por exemplo, ao utilizar um problema como iniciador do processo de aprendizagem, o método de Problem based Learning (PBL*)* facilita a vivência de relações entre as ciências, bem como, é um potencial para a aplicação da interdisciplinaridade na sala de aula. Essa característica metodológica é necessária porque, em geral, o problema é um fenômeno de várias áreas do conhecimento e contém informações insuficientes para propor

soluções, permitindo assim um caminho no qual o estudante possa construir seu próprio aprendizado ao tentar resolvê-lo.

Na base das estratégias e dos métodos de aprendizagem ativa, pode-se identificar as teorias de Piaget sobre a aprendizagem que envolve a assimilação e acomodação como formas de apropriação do conhecimento e uma abordagem sócio-construtivista (Leite, 1991), com base em autores que acreditam que "*a interação com a vida real e a meta-cognição favorecem a motivação epistêmica e a aprendizagem*" (Ribeiro & Escrivão Filho, 2007). Piaget (1978) destaca como princípio básico, que o conhecimento é construído na interação do sujeito com o objeto. Interagindo, o sujeito produz sua capacidade de conhecer, ao mesmo tempo em que produz o próprio conhecimento. A aprendizagem, portanto, envolve, em algum grau, um componente ativo, mesmo quando fica na dependência de pessoas que ensinam. Mas distingue-se dentre as teorias, aquelas que consideram a aprendizagem como decorrente da ação própria de quem aprende, operando através de estudo, pesquisa e interações: convivendo em ambientes de aprendizagem onde a troca de ideias, as discussões e as críticas argumentadas constituem um componente de ênfase na aquisição de novos conhecimentos. É dessa forma que se pode entender a aprendizagem ativa: aprender por meio da ação própria de quem aprende, interagindo com o meio, com recursos e com pessoas.

Quando se observa o desenvolvimento das estratégias e métodos de aprendizagem ativa ao longo das últimas décadas, nota-se que invariavelmente contemplam situações nas quais os problemas são elementos centrais. Uma dúvida que surge então é por que as instituições de ensino básico e superior seguiram um caminho inverso, promovendo uma base conceitual antes de promover uma visão "problematizadora" do conhecimento que veiculam (Recena, 2008).

Além do referencial do sócio-construtivismo, podem-se identificar nas estratégias que fazem uso de problemas no ensino as ideias de Thomas Khun (apud de Mello Arruda & Villani, 1994) sobre o desenvolvimento da ciência, que consideram a intercalação de períodos de *ciência normal* e *períodos de revolução*, traduzidos como os momentos de mudança conceitual do indivíduo que aprende. Ainda que o artigo citado faça referência à aprendizagem da ciência, faz-se aqui a opção provocativa de estendê-la como pertinente ao conhecimento de engenharia.

Para Ausubel (2003), a aprendizagem é entendida como significativa quando o indivíduo assimila um novo conhecimento por meio de relacionamentos com a estrutura dos conhecimentos já incorporados. Nesse sentido, entende-se como aprendizagem aquela resultante de processos mentais decorrentes da modificação, relacionamento e complementação de conhecimentos pré-existentes. A função de conhecimentos pré-existentes é a de dar significado e âncoras para novos conhecimentos e assim sucessivamente.

Ainda para Ausubel (2003) e Moreira & Masini (2006), a aprendizagem significativa resulta de um processo de ensino no qual o professor cria condições para o estudante interagir utilizando objetos de aprendizagem, materiais diversos, desafios, problemas, experimentos e mecanismos de ensino potencializadores de aprendizagem significativa buscando um maior envolvimento do estudante no processo. Os autores citados indicam problemas como um material potencializador, e atividades de ensino baseadas na resolução desses problemas como um importante caminho na busca da construção de uma aprendizagem significativa.

Capacitar o professor para conceber ambientes de aprendizagem ativa requer antes de tudo convencê-los a se desapegar de certas "verdades" da docência. Os professores precisam compreender que mais importante do que cobrir a ementa é saber escolher quais conhecimentos são estruturadores e não podem deixar de ser construídos pelos estudantes. Os professores precisam se convencer de que se os estudantes ficarem ativamente envolvidos em sala de aula não significa que ele irá perder o controle da classe. O professor também precisa compreender que se o ambiente de aprendizagem for bem planejado, os objetivos de aprendizagem forem explicitados para os estudantes e a mediação por parte do professor for eficiente, os estudantes não se recusarão a participar e tampouco irão reclamar de que o professor não os está ensinando.

O papel do professor nos ambientes de aprendizagem ativa será, entre outros:

- Engajar os estudantes de forma interativa;
- Encorajar os estudantes a "trabalhar" ativamente em sala de aula e for a dela;
- Incentivar a reflexão, a discussão e o pensamento crítico;

- Promover o trabalho em equipe.

Esta mudança no papel do professor demanda um conjunto de competências que devem ser consideradas no desenvolvimento profissional docente (por exemplo: trabalhar com outros docentes), de modo a ser capaz de conceber e conduzir ambientes de aprendizagem ativa que estarão contribuindo para a formação de profissionais mais criativos e mais competitivos.

3 Programa de Capacitação

Tendo como objetivo capacitar professores de engenharia para uma prática pedagógica mais adequada a formar os engenheiros do século XXI, um curso de capacitação foi planejado e oferecido dentro da programação do programa de Formação para Professores da Universidade de Caxias do Sul (http://www.ucs.br/site/programa-de-formacao-de-professores/). Havia 20 vagas para o curso e 8 foi o número de participantes das áreas das Engenharias, Ciências e Tecnologias. A participação dos professores no curso foi voluntária. Neste curso, foram desenvolvidos alguns fundamentos de Aprendizagem Ativa e também foram compartilhados com os participantes algumas estratégias e alguns métodos que têm sido usados na educação em engenharia (e na educação superior de forma geral). O curso de capacitação teve carga horária de 64 horas, sendo que 40 horas foram destinadas a encontros presenciais e 24 horas a encontros à distância. Os encontros à distância foram planejados para que os professores pudessem ler as referências bibliográficas e para que pudessem se reunir em equipe e preparar as tarefas. Os encontros foram planejados de tal forma que os professores participantes pudessem compreender o potencial das estratégias e dos métodos de aprendizagem ativa. Justifica-se que essas estratégias e esses métodos são naturais para a educação em engenharia, tecnologia e ciências exatas, uma vez que se enquadram muito bem na prática da Ciência e da Tecnologia (Graaff e Christensen, 2004). Na Tabela 1, são apresentados os assuntos desenvolvidos em cada encontro presencial.

Tabela 1. Assuntos desenvolvidos nos encontros presenciais

Encontro Presencial	Assuntos desenvolvidos
1	Apresentação do seminário. Organização de grupos de estudo. Os Processos de Ensinar e Aprender na Universidade. Uma pequena introdução à Teoria da Aprendizagem Significativa
2	Aprendizagem Ativa versus Aprendizagem Tradicional
3	Estratégias de Aprendizagem Ativa para grandes grupos: "Peer Instruction", "Think-Pair-Share", "Cooperative Note-Taking Pairs", "Thinking-Aloud Pair Problem Solving"
4	Estratégias de Aprendizagem Ativa para grandes grupos: "In-Class Exercise Teams", "Guided Reciprocal Peer Questioning", “Just-in-Time Teaching”, “One-Minute Paper”
5	Estratégias de Aprendizagem Ativa para grandes grupos: ““Flipped Classroom", “Jigsaw", “Co-op Co-op", “Constructive Controversy”
6	O método de Aprendizagem por Questionamento ("Inquiry based Learning")
7	O método de Aprendizagem baseada na Resolução de Problemas ("Problem based Learning - PBL")
8	O método de Aprendizagem baseada em Projetos ("Project-organized Learning - POL" ou "Project-based Learning - PjBL")
9 & 10	Apresentação dos Ambientes de Aprendizagem Ativa concebidos pelos participantes

Nos dois primeiros encontros presenciais foram apresentados os fundamentos da Aprendizagem Ativa, bem como os pressupostos pedagógicos e epistemológicos que dão base à mesma. Também no primeiro encontro uma sondagem sobre o que os professores entendiam sobre Aprendizagem Ativa foi realizada.

Ao longo dos oito encontros restantes foram abordados estratégias e métodos de aprendizagem ativa que têm sido muito utilizadas em disciplinas básicas e técnicas dos cursos de engenharia e ciências exatas de algumas universidades brasileiras e de outros países, tais como: "Problem & Project based Learning" (Aprendizagem baseada em problemas e em projetos), "Peer Instruction" (Instrução pelos colegas), "Think-Pair-Share" (Pense-Forme um Par-Compartilhe), "In-Class Exercise Teams" (Grupos resolvendo exercícios em sala de aula), "Cooperative Note-Taking Pairs" (Tomando Notas Cooperativamente em Pares), "Guided Reciprocal Peer Questioning" (Questionamento guiado entre pares), "Thinking-Aloud Pair Problem Solving" (Resolução em voz alta de problemas em pares), dentre outras (Villas-Boas, 2011). Para tanto os participantes foram divididos em equipes. A cada equipe, por sorteio, foi atribuído um grupo de estratégias ou um método a ser estudado e apresentado ao grande grupo. Em equipes, os participantes estudaram as principais referências bibliográficas das estratégias e dos métodos de aprendizagem ativa. Cada equipe apresentou as principais características das estratégias ou dos métodos que lhes foram atribuídos. Finalizando, uma atividade mãos na massa foi proposta aos participantes para reforçar o potencial das estratégias e dos métodos de Aprendizagem Ativa na construção de conhecimento e no desenvolvimento de competências profissionais necessárias a um engenheiro, a um tecnólogo, e a um profissional e professor das ciências exatas.

Como última tarefa do curso, cada participante teve de planejar e apresentar, no contexto de suas disciplinas, um ambiente de aprendizagem que levasse em conta a utilização de uma estratégia ou método de aprendizagem ativa. Além da apresentação, um texto com a descrição do planejamento do ambiente de aprendizagem foi solicitado a cada participante.

No último encontro, um questionário foi aplicado para colher as percepções dos professores, sobre as motivações e expectativas em relação ao programa, a contribuição potencial que o programa proporcionou para a prática de ensino dos mesmos, qual o significado de "aprendizagem ativa" após a vivência no programa e também um levantamento de quais estratégias e/ou métodos de aprendizagem ativa esses professores pretendem utilizar em suas disciplinas.

Neste artigo foram analisadas as respostas de 8 participantes, especificamente das áreas das Engenharias, Ciências e Tecnologias. A análise destes dados foi elaborada através da técnica de análise de conteúdo (Bardin, 1979), considerando categorias emergentes que se justifica pela natureza exploratória em que este estudo assenta. Assim, as categorias que foram possíveis de identificar a partir dos dados empíricos foram essencialmente quatro: motivação dos participantes para participarem no programa; mudança da prática docente decorrente da participação no programa; expectativas em relação ao desenvolvimento e resultado do programa, sugestões de melhoria do programa. Estas categorias serão apresentadas e discutidas na secção seguinte.

4 Resultados

Através dos dados recolhidos, pretende-se analisar a importância da formação docente na eficácia do ensino em contextos de aprendizagem ativa, considerando a perspectiva dos participantes no curso de capacitação aqui avaliado (ou apresentado?)..

Este estudo, em particular, refere-se a oito professores das áreas da Engenharia, Ciência e Tecnologia, com idades compreendidas entre os 30 e 50 anos (ou mais), sendo a sua maioria do sexo feminino (n=7). A experiência como docentes do Ensino Superior varia entre 4 e 28 anos, embora todos já tivessem, previamente, frequentado cursos de capacitação pedagógica como, por exemplo, ensino à distância, processos cognitivos, supervisão de estágios e interações didáticas.

Assim, a motivação dos participantes em frequentar o programa de capacitação em Fundamentos de Aprendizagem Ativa reside, essencialmente, na urgência de mudar a prática docente em uma lógica que contribua para tornar as aulas mais atrativas para o estudante. Daí que tenham manifestado a necessidade de

adquirir e desenvolver conhecimento pedagógico ao nível da aprendizagem ativa que, como estudos internacionais sugerem, em muito contribuem para o engajamento dos estudantes no processo de ensino e aprendizagem (Fernandes, Mesquita, Flores & Lima, 2014), bem como permitem que os estudantes desenvolvam um conjunto de competências fundamentais na sua prática profissional (Mesquita et al., 2015). Desta forma, e tal como mencionado por um dos participantes, o professor tem a responsabilidade de contribuir para o perfil de egresso. A questão que se poderá colocar (e que certamente muitos docentes a colocam) é como? Como é que posso fazê-lo? A formação pedagógica docente, quando contextualizada, pode contribuir para uma mudança nas práticas pedagógicas (Flores, Lima, Mesquita & Fernandes, 2015). O programa de capacitação que se refere neste artigo teve como pressuposto considerar os contextos dos docentes para que as estratégias e métodos de aprendizagem ativa abordados fossem passíveis de serem aplicados na prática. Daí que um dos resultados mais significativos da análise dos resultados realizada resida na mudança ao nível da prática docente, ou seja, impulsionados pelo conhecimento e competências adquiridas no programa de capacitação, alguns professores (n=3) implementaram estratégias e métodos de aprendizagem ativa nas suas disciplinas, nomeadamente One Minute Paper, Think Paire Share, In Class Exercise e Problem Based Learning. Outros professores (n=3) têm intenção de implementar no próximo semestre, nomeadamente Problem Based Learning, Peer Instruction e Project Based Learning.

Não é, portanto, surpreendente que, para a maioria dos participantes, o programa de capacitação que frequentaram tenha superado as expectativas iniciais. Por um lado, porque permitiu conhecer novas estratégias e novos métodos de aprendizagem e ter a oportunidade de aplicar na sala de aula. Por outro lado, porque o ambiente de capacitação permitiu a troca de ideias, a discussão entre pares, que se revelou muito significativa, particularmente para repensar como determinada estratégia e/ou determinado método de aprendizagem pode ser adaptado à realidade da universidade, do perfil do aluno e às condições dos cursos em questão. Neste sentido, a valorização da experiência do processo de capacitação reflete-se nas sugestões de melhoria propostas pelos participantes. A maioria dos participantes considera que o programa de capacitação merecia ser desenvolvido com mais tempo, com vista a aprofundar as temáticas abordadas. Sendo mais prolongado no tempo, os participantes também teriam a oportunidade de partilhar e discutir mais as suas experiências em sala de aula e, adicionalmente, poderiam ser realizadas simulações com o grupo para uma aprendizagem mais efetiva sobre as dificuldades, vantagens e limitações de cada estratégia e método.

5 Considerações Finais

Existe uma multiplicidade de variáveis que os professores de engenharia enfrentam ao trabalharem com o ensino de engenharia. Dentre essas, podem ser destacadas: a natureza de sua formação, a concepção de ensinar, associada à percepção de que para ser um bom professor é suficiente ser um bom engenheiro; a noção de que a titulação acadêmica do professor substitui a necessidade de uma profissionalização ao se tornar professor e, ainda o fato dos professores não perceberem com clareza que esses são problemas ou dificuldades que precisam ser identificadas como condição para superação da prática transmissiva do ensino. Essa concepção, afeta o trabalho do professor e obscurece sua percepção sobre seu papel enquanto formador de profissionais.

No cenário atual da educação é possível perceber que há falta de indicações de variáveis contextuais, como políticas mais amplas institucionais e governamentais, incentivos à formação do professor de engenharia no mesmo nível que os incentivos à pesquisa, programas de atualização permanente e outros para melhoria da qualidade da educação em engenharia. Nesse sentido vale questionar: qual a função das organizações de ensino superior? Quais são os objetivos dessas instituições? Qual a função de seus professores? Se as respostas para essas perguntas revelarem que objetivos de ensino são ações que se pretende alcançar por meio dos processos de ensinar e aprender e que a função de uma instituição de ensino superior é capacitar pessoas para atuarem na e para a sociedade, com diferentes finalidades e de modo coerente com os conhecimentos produzidos, o "caminho" está traçado (Botomé & Kubo, 2002). É preciso afirmar também que decidir o que ensinar e como ensinar necessita estar relacionado aos comportamentos que um profissional apresentará em seu exercício profissional para atender às demandas da sociedade. Booth, Villas-Boas & Catelli (2008) asseveram que uma tarefa para os professores parece ser a redefinição de seus objetivos e executar as

mudanças que se fazem necessárias para alcançar um ensino eficaz. Essas mudanças dependem de vários contextos. Diante desse contexto, é possível afirmar que decidir o que ensinar e como ensinar exige, no mínimo, um processo relacionado aos comportamentos que um profissional deverá apresentar no seu exercício profissional. Nesse sentido, um aspecto que precisa ser considerado no planejamento e na realização do ensino é o compromisso do professor com o novo ponto de partida do ensino, centrado na situação concreta do aluno, na compreensão da realidade, a fim de fundamentar uma formação mais ampla dos futuros engenheiros por meio do ensinar.

Antoni Zabala (Zabala, 1998) afirma que, antes do compromisso com a disciplina, o compromisso do docente é com seus estudantes, motivo pelo qual ele precisa organizar e dirigir situações de aprendizagem para envolver o estudante no processo de construção do conhecimento. Por isso fala-se em "dupla competência" dos bons professores universitários: a competência científica e a competência pedagógica. Nesse sentido, relatar experiências de intervenção na formação pedagógica de professores engenheiros, propondo alternativas para mediar dificuldades, minimizar equívocos conceituais parece ser uma forma viável para administrar a progressão de novas aprendizagens; para esses profissionais da engenharia (Booth *et al*., 2008).

Este estudo não constitui uma análise completa do fenômeno analisado, mas apresenta uma contribuição para promover, nas instituições de ensino superior, estudos sobre planejamento de ensino eficaz. Inclusive, a análise dos dados revela a importância da formação docente para a criação de espaços de desenvolvimento profissional, através da reflexão sobre a prática, discussão entre pares, desenvolvimento de competências para a implementação de estratégias de aprendizagem ativa, que permitem uma mudança do que acontece na sala de aula. Novas questões podem ser derivadas tais como: que tipos de programas as instituições de ensino e de fomento precisam desenvolver para apoiar a formação do professor de engenharia em serviço para melhorar sua atuação? Quais condutas, estratégias e métodos relevantes os professores de engenharia responsáveis pela formação de engenheiros precisam aprender para qualificar futuros profissionais para serem capazes de intervir de maneira adequada no seu campo de atuação profissional?

6 References

Ausubel, D. P. (2003) Aquisição e retenção de conhecimentos: uma perspectiva cognitiva. Lisboa: Editora Plátano.

Bardin, L. (1979). *Análise de Conteúdo*. Lisboa: Edições 70.

Bazzo, W. A., Pereira, L. T. V., & Linsingen, I. V. (2000) Educação Tecnológica: enfoques para o ensino de engenharia. Florianópolis: Ed. da UFSC.

Booth, I. A. S., Villas-Boas, V. & Catelli, F. (2008) Mudança paradigmática dos professores de engenharia: ponto de partida para o planejamento do processo de ensinar. In: Rocha, A. A. *et al.* (org.). Educação, Mercado e Desenvolvimento: Mais e Melhores Engenheiros. São Paulo: ABENGE, 11-20.

Botomé, S. P., & Kubo, O. M. (2002) Responsabilidade Social dos programas de pós-graduação e formação de novos cientistas e professores de nível superior. *Interação em Psicologia*, 6(1), 31-110.

Cowan, J. (2006). On Becoming an Innovative University Teacher: Reflection in Action (2nd ed.). Maidenhead: The Society for Research into Higher Education

Fernandes, S., Mesquita, D., Flores, M. A., & Lima, R. M. (2014). Engaging students in learning: findings from a study of project-led education. European Journal of Engineering Education, 39(1), 55-67.

Fink, L. D., Ambrose, S., & Wheeler, D. (2005). Becoming a professional engineering educator: A new role for a new era. Journal of Engineering Education, 94(1), 185.

Flores, M. A., Veiga Simão, A. M., & Carrasco, V. (2012) Tutoring in Higher Education in Portugal and Spain: Lessons learned from six initiatives in place. In J. O' Meara e M. Spitlle (Eds) Internationalising Education: Global perspectives on collaboration and change (pp. 107-124) New York: Nova Science Publishers Inc. ISBN: 978-1-61324-287-2

Flores, M. A., Lima, R. M., Mesquita, D. & Fernandes, S. (2015). Construção e Validação de Toolbox para o Desenvolvimento Curricular no Ensino Superior. In *Experiências de Inovação Didática no Ensino Superior*, Eds. Ministério da Educação e Ciência. ISBN: 978-972-729-087-1, pp.37-49.

Font, C. M., & Pozo, J. I. (2003). La universidad ante la nueva cultura educativa: enseñar y aprender para la autonomía.

Gibbs, G., & Coffey, M. (2004). The impact of training of university teachers on their teaching skills, their approach to teaching and the approach to learning of their students. *Active learning in higher education*,*5*(1), 87-100.

Graaff, E. de, Christensen, H. P. (2004) Editorial: Theme issue on active learning in engineering education, European Journal of Engineering Education, 29 (4).

Lima, R. M., Mesquita, D., & Rocha, C. (2013, 2013-07-31). *Professionals' Demands for Production Engineering: Analysing Areas of Professional Practice and Transversal Competences.* Paper presented at the International Conference on Production Research (ICPR 22), Foz do Iguassu, Brazil.

de Mello Arruda, S., & Villani, A. (1994). Mudança conceitual no ensino de ciências. *Caderno Brasileiro de Ensino de Física*, *11*(2), 88-99.

Masetto, M. T. (1998) Professor universitário: um profissional da educação na atividade docente. In: Masetto, M. (org.). Docência na Universidade. Campinas, SP: Papirus, p.9-26.

Masetto, M. T. (2003) Competência pedagógica do professor universitário. São Paulo: Summus.

Merseth, K. K. (1991). *The Case for Cases in Teacher Education*. AACTE Publications, One Dupont Circle, Suite 610, Washington, DC 20036-2412.

Mesquita, D., Lima, R. M., Flores, M. A., Marinho-Araújo, C., & Rabelo, M. (2015). Industrial Engineering and Management Curriculum Profile: Developing a Framework of Competences. *International Journal of Industrial Engineering and Management*, 6(3), 121-131.

Moreira, M. A.; Masini, E. F. S. (2006) Aprendizagem significativa: a teoria de David Ausubel. São Paulo: Centauro.

National Academy of Engineering. (2005). *Educating the Engineer of 2020: Adapting Engineering Education to the New Century.* Acesso em http://www.nap.edu/openbook.php?record_id=11338

Passow, H. J. (2012). Which ABET Competencies Do Engineering Graduates Find Most Important in their Work? *Journal of Engineering Education, 101*(1), 95–118.

Stes, A., Coertjens, L., & Van Petegem, P. (2010). Instructional development for teachers in higher education: impact on teaching approach. *Higher education*, *60*(2), 187-204.

Recena, M. C. P. (2008). Reflexões sobre a abordagem da Química nas Séries Iniciais do Ensino Fundamental. PAVÃO, A. C.; FREITAS, D. *Quanta Ciência há no Ensino de Ciências. São Carlos: EdUFSCar*, 169-172.

Rettl, A. M. M., Serra, S. M. B., Arruda, A. C. S., Giostri, E. C., Booth, I. A. S., Camargo Junior, J. B., Almeida Junior, J. R., Mendes, K. B., Tozzi, M. J., Matai, P. H. L. S., Cugnasca, P. S., Matai, S., Villas-Boas, V. & Mossmann, V. L. F. (2011) Educação por Competências e Formação do Professor de Engenharia. In: Vanderlí Fava de Oliveira; Zacarias Chamberlain. (Org.). Engenharia sem Fronteiras. Passo Fundo: UPF Editora, p. 189-246.

Ribeiro, L. R. C., & Escrivão Filho, E. (2007). Um sistema de avaliação no ensino de engenharia: a visão dos alunos em uma experiência com o PBL. In *XXXV Congresso Brasileiro de Educação em Engenharia, Curitiba: PR*.

Trigwell, K., Prosser, M., & Waterhouse, F. (1999). Relations between teachers' approaches to teaching and students' approaches to learning. *Higher education*, *37*(1), 57-70.

Zabala, A. (1998). A prática educativa: como ensinar. Porto Alegre: ARTMED

Active learning for the development of collaborative systems

Crediné S. Menezes[1,2], Rosane Aragón[1,3]

[1] Departamento de Estudos Básicos, Faculdade de Educação, Universidade Federal do Rio Grande do Sul, Brasil
[2] Programa de Pós-graduação em Informática, Universidade Federal do Espírito Santo, Brasil
[3] Programa de Pós-graduação em Educação, Universidade Federal do Rio Grande do Sul, Brasil

Email: credine@gmail.com, rosane.aragon@ufrgs.br

Abstract

We observe today the need for the provision of collaborative systems that fit cooperative practices of each working team. Thus, it is necessary to increase investment in training developers with experience in cooperative practices that enable them to interact more easily with teams and are able to model and develop tuned environments with this demand. In the context of a research project to support the establishment of learning networks, we have invested in training professionals to build collaborative systems, based on immersion in cooperative practices, accredited by them to think more informed way in the interaction needs teams, whether in the business context, the context of learning, leisure context or in the context of research. We report and analyze the performance of a course offered in a focused graduate program for forming professionals interested in the development of collaborative systems. The proposed work is to support the concept of teaching architecture which is supported in interactionist theories of learning. At the end of the semester, students performed a self-assessment and an evaluation of the pedagogical approach that experienced. The analysis of these data allows us to say that the strategies used have the potential to contribute significantly to achieving the objectives of this type of training.

Keywords: Active leaning; Pedagogical Architectures; Collaborative Systems; Cooperation.

Aprendizagem Ativa no Desenvolvimento de Sistemas Colaborativos

Crediné S. Menezes[1,2], Rosane Aragón[1,3]

[1] Departamento de Estudos Básicos, Faculdade de Educação, Universidade Federal do Rio Grande do Sul, Brasil
[2] Programa de Pós-graduação em Informática, Universidade Federal do Espírito Santo, Brasil
[3] Programa de Pós-graduação em Educação, Universidade Federal do Rio Grande do Sul, Brasil

Email: credine@gmail.com, rosane.aragon@ufrgs.br

Resumo

Observa-se hoje a necessidade da oferta de sistemas colaborativos que se ajustem às práticas cooperativas de cada equipe de trabalho. Desta forma, é necessário ampliar o investimento na formação profissional de desenvolvedores com experiência em práticas cooperativas que lhes permitam interagir mais facilmente com equipes e que sejam capazes de modelar e desenvolver ambientes sintonizados com esta demanda. No contexto de um projeto de pesquisa para apoio à constituição de redes de aprendizagem, temos investido na formação de profissionais para construção de sistemas colaborativos, tendo por base a imersão em práticas cooperativas, que lhes credenciem a pensar de forma mais embasada nas necessidades de interação das equipes, sejam elas do contexto dos negócios, do contexto da aprendizagem, do contexto lazer ou no contexto da pesquisa. Neste artigo relatamos e analisamos a realização de uma disciplina oferecida em um programa de pós-graduação voltada para formação de profissionais interessados no desenvolvimento de sistemas colaborativos. A proposta de trabalho tem por sustentação o conceito de arquiteturas pedagógicas, que encontra suporte nas teorias interacionistas da aprendizagem. No final do semestre letivo, os alunos realizaram uma auto avaliação e uma avaliação da abordagem pedagógica que vivenciaram. A análise desses dados permite-nos dizer que as estratégias utilizadas apresentam potencial para contribuir de forma significativa para atingir os objetivos desse tipo de formação.

Palavras-chave: Aprendizagem ativa; Arquiteturas Pedagógicas; Sistemas Colaborativos; Cooperação.

1 Introdução

Os avanços das tecnologias digitais estão ampliando a realização de atividades colaborativas em uma escala até então não imaginadas. Hoje, em todos os ramos de atuação do ser humano observa-se um crescente número de pessoas desenvolvendo atividades coletivas, com participantes geograficamente distribuídos, utilizando os recursos das redes de informação e comunicação tendo a internet como meio. Várias dessas atividades, pela sua natureza, já se beneficiam de ambientes generalistas que oferecem ferramentas e recursos que podem ser selecionados e configurados a partir de um dado repertório.

Entretanto, em atividades colaborativas complexas, as necessidades de recursos e ferramentas de apoio não podem ser previamente determinadas. Com isso, produzir ou selecionar um ambiente computacional para esta finalidade não é uma tarefa trivial, requerendo um investimento na formação de profissionais da computação com uma formação apropriada para a concepção e implementação de ambientes colaborativos especializados.

Formar um desenvolvedor para esta classe de software requer oferecer a estes futuros profissionais, além do conhecimento sobre computação, o desenvolvimento da "familiaridade" necessária para percepção da natureza "imprevisível" das atividades a serem realizadas nestes ambientes. Nossa hipótese é que a experiência com a realização de atividades colaborativas, em paralelo com a reflexão sobre o ferramental requerido, pode contribuir para os objetivos desta capacitação.

Neste artigo relatamos e analisamos uma experiência com o aprendizado de engenharia de groupware, em uma disciplina oferecida em um programa de pós-graduação em computação, frequentada por alunos de mestrado e doutorado.

Na seção 2 apresentamos uma descrição da experiência. No seguimento (seção 3) apresentamos os fundamentos teóricos, discutindo a cooperação, o conceito de arquiteturas pedagógicas que dá suporte à nossa pesquisa com o uso de tecnologias aplicada à educação e sobre a mediação pedagógica. Na seção 4

apresentamos a proposta pedagógica da oferta da disciplina. A seção 5 é dedicada à discussão dos resultados da experiência e finalmente na seção 6 apresentamos nossas considerações finais, destacando o potencial da abordagem pedagógica e sobre trabalhos futuros.

2 Descrição da Experiência

No contexto de um projeto de pesquisa para apoio à constituição de redes de aprendizagem, temos investido na formação de profissionais para construção de sistemas colaborativos, tendo por base a imersão em práticas cooperativas, que lhes credenciem a pensar de forma mais embasada nas necessidades de interação das equipes, sejam elas do contexto dos negócios, do contexto da aprendizagem, do contexto lazer ou no contexto da pesquisa.

Como parte de nossas pesquisas concebemos e oferecemos, no segundo semestre de 2015, uma disciplina, no contexto de um programa do Programa de Pós-graduação em Informática (mestrado e doutorado) da Universidade Federal do Espírito Santo, no Brasil. A disciplina, na modalidade de Tópicos Especiais em Informática, recebeu o nome de "Ambientes e Ferramenta Computacionais para Apoio à Realização de Atividades Colaborativas".

A turma foi formada por nove estudantes, todos do sexo masculino, sendo cinco deles alunos de mestrado, e quatro candidatos ao doutoramento. A faixa etária teve a seguinte distribuição: 25 < idade <=30 anos (4 alunos), 30 < idade <= 35 (4 alunos) e idade > 35 (1 aluno). Todos os alunos participaram da disciplina até o final e obtiveram aprovação.

A disciplina foi realizada no período 4 de agosto a 15 de dezembro de 2015. As atividades síncronas e assíncronas foram viabilizadas pelo uso de diferentes ambientes computacionais dos quais destacamos: uma plataforma do tipo wiki (pbworks.com), um ambiente de blog (blogger.com), um ambiente de web conferência (hangout da google), dados nas nuvens (google drive) e um editor de gráfico (Sweet Home 3D).

Nos encontros presencias foram realizados debates e desenvolvidos artefatos em pequenos grupos. A concepção dessas atividades teve como suporte teórico o conceito de arquiteturas pedagógicas apresentado na seção 3 deste artigo.

A avaliação das aprendizagens se deu através de:

1. Auto-avaliação dos alunos, tendo por base a construção de um portfólio das aprendizagens e a produção de uma síntese reflexiva das aprendizagens;
2. Acompanhamento e análise das produções individuais e de grupo, pelo professor;
3. Apresentações individuais entremeadas com arguições.

A avaliação da proposta de trabalho foi realizada através dos depoimentos registrados nos portfólios e um relatório final de avaliação da disciplina.

3 Fundamentos Teóricos

A realização de atividades em grupo, conhecida por colaboração em vários contextos, é denominada de Cooperação no contexto da epistemologia genética (Piaget, 1973). Na seção 2.1 fazemos uma breve apresentação deste conceito, tendo em vista a sua importância tanto para o estudo de sistemas colaborativos quanto para a fundamentação de nossa abordagem para o trabalho com tecnologias aplicada à educação, denominada de Arquiteturas Pedagógicas, apresentada na seção 2.2.

3.1 Cooperação

Partindo do pressuposto que o desenvolvimento do pensamento implica em um elemento social de cooperação, também conhecido como abordagem construtivista (Piaget, 1973), abandonamos a perspectiva do isolamento intelectual, resultante da recepção passiva dos alunos em situações de ensino e passamos a buscar novas formas de trabalho que acarretem maior atividade, incluindo interações entre os participantes.

Em situações de interação com os outros, o sujeito é levado a introduzir coerência às suas ações para que elas sejam eficazes, ou seja, a cooperação é necessária para que o sujeito possa ultrapassar a sua perspectiva particular. Mediante as trocas de ideias, os sujeitos poderão ultrapassar o egocentrismo do pensamento, já que descobrimos a nós mesmos (tomamos consciência) na medida em que aprendemos a conhecer os outros. Dessa forma, a consciência de si próprio constitui uma conquista cognitiva e social. É pelos confrontos de ideias e oposições de opiniões, que aprendemos a construir argumentos e tomar consciência do nosso próprio pensamento. As trocas interindividuais promovem um efeito duplo e complementar: a tomada de consciência de si e o esforço para situar-se no conjunto das outras perspectivas de pensamento, coordenando-as.

Na abordagem construtivista, a cooperação assume um significado de co-operação. Cooperar não é apenas interagir com o outro, mas compreender e valorizar o seu pensamento, buscando coordenar as diferentes perspectivas (pontos de vista diferentes dos diversos sujeitos), pela reciprocidade e pela construção de regras de condutas oriundas do respeito e controle mútuo. Ou seja, para que haja cooperação são necessárias três condições: 1) Uma escala comum de valores, expressas por símbolos comuns, 2) Uma igualdade geral dos valores em jogo (valores reais, virtuais e conservação de validades anteriormente reconhecidas) e 3) a possibilidade de retorno contínuo às validades reconhecidas anteriormente (reversibilidade), o que acarreta a reciprocidade.

A presença dessas três condições expressa trocas equilibradas enquanto valores e satisfação, em oposição aos desequilíbrios gerados quando as interações são coercivas. Consideramos, nessa perspectiva, que a cooperação difere da colaboração, considerando que essas são definidas por interações nas quais há trocas de ideias ou ações conjuntas, porém sem que sejam satisfeitas, a um mesmo tempo, as três condições que caracterizam a cooperação. Nesse sentido, consideramos que a colaboração representa uma etapa das trocas sociais anterior à cooperação.

Nessa perspectiva, podemos dizer que as interações em rede enriquecem o pensamento individual e geram inovações.

3.2 As Arquiteturas Pedagógicas para a aprendizagem em rede

Ultrapassar as concepções convencionais com foco tão somente nos conteúdos e orientar práticas que privilegiem o protagonismo do aluno e a produção coletiva do conhecimento, implica em buscar "boas traduções" dessas ideias pedagógicas em práticas, criando situações de aprendizagem que tensionem as certezas e ofereçam condições "estruturantes" para as reconstruções.

Nessa perspectiva, assumimos a ideia de arquiteturas pedagógicas. Conforme Carvalho, Nevado e Menezes (2007) as arquiteturas são "suportes estruturantes" para a aprendizagem (e, principalmente, para a aprendizagem em rede), dentro de uma visão ecossistêmica (Lévy, 2010), na qual os elementos estão fundamentalmente interconectados e são interdependentes. Mais recentemente, Aragón (2016) caracteriza as arquiteturas como "microecossistemas cognitivos" que englobam ideias epistemológicas relacionais, pedagogias abertas, tecnologias digitais, além de novos referenciais de tempo e espaço como condições estruturantes para as aprendizagens individuais e construções coletivas.

A aprendizagem, no contexto das arquiteturas, é compreendida como um processo contínuo, mas não linear, construído na interação interindividual e na metarreflexão do sujeito sobre os fatos, os objetos e o meio ambiente socioecológico (Kerckhove, 2009). Alteram-se não apenas as perspectivas de tempo e espaço para a aprendizagem, mas também mudam os referenciais de proximidade e de presença. A ideia de presença e de proximidade ultrapassa o sentido físico para significar as trocas e as construções conjuntas que se estabelecem nas redes.

3.3 A mediação no contexto das Arquiteturas Pedagógicas

O desenvolvimento das arquiteturas pedagógicas depende de uma construção coletiva que, na maior parte dos processos educativos, requer algum grau de mediação, já que uma cultura de trabalho interativo e digital ainda está por se estabelecer.

Na perspectiva das arquiteturas pedagógicas, a mediação não pode ser confundida com as ações de transmissão de conteúdos Cabe à função de mediação articular, acolher e problematizar, provocando o diálogo e a pesquisa a partir da criação de situações que movimentem o campo de conhecimento atual dos participantes para que esse possa ser reconstruído.

O papel do professor desloca-se de "transmissor de informações" para o de "provocador do desejo de aprender"; a tecnologia não é definidora das ações, tampouco um simples apoio, ela é um componente que altera os contextos e as formas de interação. As ações dos alunos deslocam-se das atividades repetitivas para as experimentações, as resoluções de problema, os debates em rede, a autoria coletiva e a metacognição. O sentido da avaliação é deslocado de uma ênfase única nas performances e produtos para as construções de novos instrumentos cognitivos.

Em uma rede de aprendizagem é preciso ainda considerar a função de mediação não apenas como ação de um professor e sim como uma função que pode ser distribuída entre os próprios pares.

A prática de mediação distribuída não significa apenas uma facilidade para o professor, que poderia ficar sem ter como atender a todas as demandas dos participantes (leitura de postagens, problematizações, oferecimento de repertórios para apoio às reconstruções, etc.), mas tem como principal finalidade a consolidação de relações mais horizontais e cooperativas. Nesse sentido, a mediação distribuída pressupõe que os participantes/aprendizes encontrem oportunidades para exercer protagonismos e responsabilidades para com os seus pares.

Considerando a nossa cultura de centralização dos processos educativos na figura do professor, o papel de mediação se coloca como uma novidade para os aprendizes, que precisarão aprender a realizá-la. Como há necessidade de um ponto de partida, as arquiteturas pedagógicas propõem uma organização de trabalho que desloca os aprendizes para uma posição mais ativa, na qual eles exercerão as mediações e estas, por sua vez, serão aprimoradas durante o seu exercício.

Nas arquiteturas são criadas estruturas para a aprendizagem em rede que estimulem o deslocamento desses papéis, possibilitando protagonismos e decisões por parte dos alunos. (Aragón, 2016) Para que as interações ocorram de forma a atingir a ideia de compartilhamento, protagonismo e cooperação, é preciso que o grupo construa algumas condições, facilitadas pelas características das arquiteturas que solicitam as ações de construção compartilhadas e pelas formas de mediação distribuídas.

4 Proposta Pedagógica

A linha mestra de nossa abordagem pedagógica consiste em:

- Vivenciar uma atividade colaborativa, em pequenos grupos, usando uma combinação de diferentes ferramentas computacionais disponíveis tais como: wikis, editores, planilhas etc;
- Discutir entre grupos os resultados dos projetos produzidos pelas equipes;
- Especificar os requisitos para elaboração de um ambiente integrado que seja mais adequado para a realização da atividade;
- Elaborar e avaliar protótipos de ferramentas propostas;
- Ler e fichar os artigos selecionados, seguidos de revisão por pares sobre as leituras e possíveis releituras, além de respostas às questões colocadas pelos revisores.
- Elaborar relatórios avaliando os aspectos positivos e negativos das ferramentas que utilizaram;
- Produzir recomendações sobre o projeto de ambientes integrados.

Em cada uma dessas etapas os participantes da disciplina eram organizados em pequenos grupos e ao final de cada um dos passos, os resultados eram compartilhados e debatidos no grande grupo em sessões síncronas.

Ao final do semestre, realizamos uma avaliação cooperativa do curso incluindo, as aprendizagens individuais e as estratégias pedagógicas utilizadas.

Entre as atividades das disciplinas estavam previstas: a) Projeto de uma residência; b) Elaboração cooperativa de histórias; c) Debate de Teses; d) Aprendizagem baseada produção cooperativa de mapas conceituais; e) aprendizagem cooperativa baseada na Leitura de textos, fichamento e revisão por pares.

4.1 Atividades Cooperativas Desenvolvidas

Apresentamos a seguir o detalhamento de três das atividades desenvolvidas, buscando trazer os principais elementos que evidenciem o potencial da proposta pedagógica.

Projeto de uma residência: A partir de uma descrição dos perfis dos habitantes, dos diferentes aspectos do cotidiano a serem contemplados (lazer, repouso, trabalho etc.) e das restrições de recursos, cada equipe de trabalho deveria produzir uma planta baixa.

Dinâmica da Atividade

a) Reunião síncrona para definição de responsáveis para analisar as implicações e necessidades para contemplar os diferentes aspectos;
b) Trabalho individual a ser compartilhado com os membros de cada equipe;
c) Reunião síncrona para conhecimentos das propostas individuais e negociação para definição dos espaços físicos para contemplar os diferentes aspectos;
d) Produção individual de uma planta baixa, contemplando todos os aspectos.
e) Reunião síncrona para apresentação das contribuições individuais, negociação e produção coletiva de uma síntese buscando contemplar o melhor de cada proposta.

Construção cooperativa de histórias: Cada equipe desenvolve, de forma assíncrona, uma história, de acordo com escolhas estabelecidas antecipadamente. A ênfase é que cada participante escreva individualmente partes da história, tendo por base as definições iniciais e o andamento da escrita.

Dinâmica da Atividade

a) Reunião síncrona para definição do gênero (Terror, comédia, drama, ficção científica etc.), do título e escrita coletiva do primeiro parágrafo da história;
b) Ciclos de produção sequenciada dos parágrafos da história. Cada indivíduo, em seu turno, apresenta a sua contribuição, em sequencia às contribuições anteriores.
c) A história deve ser concluída em uma quantidade pré-estabelecida de ciclos, passível de renegociação.

Debate de Teses: A partir de um elenco de afirmações, passiveis de serem corroboradas ou refutadas, sobre um determinado domínio de conhecimento, um grupo de indivíduos compartilha conhecimentos e realiza debates, buscando construir conhecimento mais aprofundado e fundamentado sobre o domínio em questão.

Dinâmica da Atividade

a) Reunião síncrona para definição do gênero (Terror, comédia, drama, ficção científica etc), do título e escrita coletiva do primeiro parágrafo da história;
b) Ciclos de produção sequenciada dos parágrafos da história. Cada indivíduo, em seu turno, apresenta a sua contribuição, em sequencia às contribuições anteriores.
c) A história deve ser concluída em uma quantidade pré-estabelecida de ciclos, passível de renegociação.

4.2 Avaliação das Aprendizagens

A avaliação das aprendizagens individuais foi baseada na produção individual de portfólios de aprendizagem. Cada participante, no decorrer do semestre letivo, foi produzindo o registro de suas aprendizagens percebidas, de uma forma multi e interdisciplinar. Cada registro contemplava uma ou mais aprendizagens correlatas, ou seja, uma nova forma de agir ou pensar sobre as temáticas associadas com a disciplina consistindo de argumentos e evidências. Essas postagens ficavam a disposição do professor e dos demais colegas que eram incentivados a visitar os portfólios e nestes comentar e questionar as postagens dos colegas. Ao final do semestre, cada individuo produziu uma Síntese Reflexiva Individual das Aprendizagens (SRIA) e uma Avalição Aberta sobre a abordagem pedagógica e sobre o desenvolvimento da disciplina.

Além disso, uma das atividades propostas foi escolhida para ser prototipada e o último evento coletivo consistiu de uma Mostra Virtual de Projetos, onde cada grupo apresentou seu protótipo para o Ambiente para Gerenciamento e Produção Cooperativa de Histórias.

5 Análise da experiência

No início da disciplina, a maior parte dos alunos concebia o trabalho colaborativo como trabalhar em uma mesma atividade (construção de um recurso digital ou resolução de um problema) fazendo uma divisão de tarefas.

A ideia de cooperação/colaboração foi alvo de discussão do grupo, mas a sua compreensão foi facilitada pela proposta de usar o trabalho cooperativo como método e não apenas como conteúdo, conforme evidenciam os depoimentos a seguir:

> *A metodologia usada na disciplina proporciona uma construção de conhecimentos individuais e cooperativos, com uso das tecnologias disponíveis para auxiliar esta aprendizagem, de forma muito didática (mesmo que não convencional) e construtiva. (aluno 1)*
>
> *Acredito que não há forma melhor de ser executar uma disciplina sobre sistemas de apoio a atividades cooperativas que não utilizando um sistema de mesmo fim. Nossa turma teve a oportunidade de vivência essa disciplina seguindo esse modelo, o que acredito que engrandeceu nossas experiências. (aluno 2)*

Usar a cooperação enquanto método pressupõe quebrar os paradigmas tradicionais que trabalham com a ideia de transmissão e implementam a construção de conhecimento mediante a interação interindividual (aluno/aluno, aluno/professor). Essa mudança de perspectiva exige uma adaptação ativa por parte dos alunos já que esses, em geral, não passaram por uma escolarização que estimulou a problematização (Freire, 1999) e a valorização/compreensão do ponto de vista do outro.

No contexto de uma sessão da Arquitetura Pedagógica Debate de Teses (Nevado, Menezes & Vieira Júnior, 2011) os alunos registraram em suas avaliações:

> *Mas não é qualquer discussão, os envolvidos devem entender que qualquer tipo de agressão não é válido. Deve-se sempre manter o respeito pelas pessoas e pelas "regras sociais", que muitas vezes estão implícitas. Entra o afirmar e contra argumentar ocorre o desenvolvimento do aprendizado. O grande desafio foi lidar com ideias diferentes e pessoas desconhecidas até o momento. (aluno 3)*
>
> *Percebi que construir consenso em torno um assunto estranho ao grupo por meio de chats virtuais é um desafio muito maior do que parece. Cada membro pode compreender um tema simples de várias formas diferentes. (aluno 2)*

Na construção desse processo a mediação do professor é importante para que os estudantes mantenham o foco e busquem coordenar os diferentes posicionamentos.

> *Nos processos síncronos, ou que trabalham sobre um mesmo objeto, é natural que apareçam conflitos e divergências sobre diversos aspectos, e neste cenário o papel de moderação tem uma grande importância, pois quem assume este papel precisa interagir com os participantes, conduzir o trabalho e ao mesmo tempo garantir que o resultado está convergindo para o que se deseja. (aluno 4)*

As propostas de atividades, ainda que diversificadas, apresentaram como pontos em comum o confronto de pontos de vista e a problematização. As atividades que envolveram a revisão por pares (mediação distribuída) foram avaliadas pelos alunos como um ponto importante no processo de reconstrução das suas ideias e conceitos relacionados a ambientes computacionais colaborativos, já que solicitaram a articulação e aperfeiçoamento dos argumentos e mesmo a sua "desconstrução".

> *Em vários momentos da disciplina, exercitamos o processo de refletir e problematizar as reflexões dos colegas. Essa mecânica permite o aprimoramento da construção de argumentação de forma a deixar mais claro a exposição da posição e da sua fundamentação.*

Para que possamos rever os problemas, precisamos esvaziar nossas xícaras para poder absorver novamente as experiências. O grande segredo está na capacidade de desaprender o que já se sabe, assim dando espaço para o novo.

A problematização me ajudou bastante a desenvolver meu senso crítico sobre a forma que eu estava organizando e expondo minhas ideias. Foi um método bastante exercitado e que acredito que tinha uma finalidade muito importante, que era o desenvolvimento do senso crítico. (...) O processo de revisão por pares apoiado na problematização tem grande potencial para construir argumentos mais sólidos e definidos. A revisão permite que não somente o revisado tenha a oportunidade de receber um retorno sobre suas visões como também permite ao revisar conhecer outros pontos de vista sobre um determinado assunto. O conhecimento então se aprofunda e se consolida pelas interações e colaborações. (aluno 2)

Além disso, as arquiteturas apresentaram a característica de "criar uma interdependência", ou seja, a ação de um sujeito depende da ação do outro para que o trabalho possa se efetivar.

Essa mecânica nos ajudou a trabalhar exercitar a argumentação e a revisão. Além disso, é possível constatar bem as características de atividade cooperativa nessa arquitetura (aqui refere-se ao Debate de teses) : (1) a definição dos papeis de cada um foi distribuída e a não realização de uma parte da atividade comprometia o desenvolvimento de todo o grupo; (2) a atividade só evoluía se todos tivessem feito a parte que lhe cabia; (3)a existência de sinergia entre o grupo para realização da atividade.(aluno 4)

No decorrer das atividades, os estudantes apresentaram evidências de superação dos obstáculos iniciais, principalmente quanto à aceitação das críticas e busca de reestruturação das aprendizagens no diálogo com os seus pares.

As reflexões realizadas a partir do contato com diferentes pontos de vista ajudam a enxergar que os problemas podem ser vistos de maneira diferente, e que não é sempre que conseguimos ter uma visão global do tema. (aluno 6)

Fazendo uma autorreflexão posso ver claramente que evoluí em relação ao trabalho colaborativo, que agora sou capaz de aproveitar as criticas de forma mais produtiva, assim como problematizar e argumentar de forma mais objetiva, imparcial e construtiva. (aluno 4)

A realização de um trabalho no qual os alunos operem em conjunto pressupõe propostas de trabalho estruturantes que oportunizem, além da discussão e realização conjunta, um espaço para a criação de novidades. As arquiteturas pedagógicas eleitas para a realização da disciplina (ou da experiência) permitiram que os grupos de estudantes definissem suas trajetórias, criassem suas soluções para os problemas apresentados ou mesmo novas ideias e concepções acerca de como conceber, nos seus aspectos técnicos e pedagógicos, ambientes colaborativos.

Os relatórios desenvolvidos pelos estudantes mostram que essa intenção foi concretizada e percebida pelos alunos como um fator que desencadeou uma postura mais criativa, além de ter proporcionado aprendizagens a partir das experiências cooperativas.

A experiência de criar uma história cooperativamente é fantástica porque o próximo parágrafo pode trazer algo inusitado, deixando assim todos bem envolvidos com o processo de criação. (aluno 4)

Tive várias ideias de projetos para apoio à aprendizagem cooperativa e sobre outros assuntos durante o curso da disciplina. (aluno 2)

Os resultados foram muito bons porque, além de conhecermos melhor as teorias e fundamentos que embasam o tema, também pudemos experimentar as dinâmicas colaborativas para aprender fazendo. (aluno 5)

Com respeito à aprendizagem sobre a construção de ferramentas para apoio atividades colaborativas, observamos que os alunos compreenderam a proposta de relacionar a ação (vivência) em uma atividade com a reflexão sobre os requisitos necessários para um ambiente de suporte a esta atividade. O depoimento a seguir mostra a percepção de um dos alunos no contexto da a escrita cooperativa de histórias.

De fato a Arquitetura Pedagógica (AP) de Escrita Cooperativa de Histórias pode ser utilizada para potencializar o ensino/aprendizagem, além é claro de promover a socialização entre os participantes. Um desafio ainda maior é a implementação de um ambiente computacional que contemple todas as regras desta AP. Somente colocando a mão na massa pude perceber a riqueza de detalhes que precisam ser configurados no ambientes para que possa ser

utilizado para os fins pretendidos. Um ambiente para apoiar esta AP precisa ter mecanismos que alertem seus participantes quanto a trocas de editores, estas trocas tanto podem ser realizadas de três formas: quando editor conclui sua contribuição, ou seja, introduz uma parte do texto, quando o tempo para sua contribuição termina, ou quando o editor passa sua vez para outro editor.

Outra importante funcionalidade para um ambiente é ter mecanismos que inibam a edição de um texto depois que o mesmo é lançado para o sistema, os acertos devem ser realizados pelo usuário seguinte. Sendo assim o desenvolvimento para este tipo de ambiente envolvem muitos desafios que precisam ser superados para que assim os aprendizes possam ter uma melhor experiência. (aluno 7)

6 Considerações Finais

A formação de profissionais para o desenvolvimento de software é privilegiada com respeito à possibilidade da elaboração de artefatos reais, que podem ser usados, expandidos e reaproveitados em outras situações. Esta é uma característica marcante do produto software. A matéria prima são elaborações mentais que se materializam em linhas de código.

Apesar disso, o conhecimento sobre o que se deseja especificar e posteriormente construir, requer a disponibilidade de usuários dispostos a participar de extensas sessões de elicitação de requisitos. No caso de sistemas colaborativos, esta dificuldade é mais acentuada, pois requer um conhecimento especializado que envolve a elicitação da dinâmica do trabalho de equipes.

No projeto que apresentamos neste artigo, buscando contribuir para a superação dos obstáculos inerentes à especificação e produção de software, juntamos três estratégias complementares: a experimentação com a aprendizagem ativa, a imersão na aprendizagem cooperativa e o uso de arquiteturas pedagógicas.

A análise dos dados obtidos em uma avaliação realizada pelos participantes da experiência permitem-nos dizer que as estratégias utilizadas apresentam potencial para contribuir de forma significativa para a formação de profissionais com o perfil adequado às necessidades de desenvolvimento de ambientes capazes de dar suporte às demandas por produtos de software de uma sociedade que a cada dia tem ampliado o seu interesse pelo trabalho em rede.

Esta mesma abordagem está sendo usada em uma nova oferta da mesma disciplina e já vem sendo usadas em outras situações como, por exemplo, nas disciplinas Introdução à Pesquisa em Informática Aplicada à Educação (SPIAE) e Jogos Digitais e Aprendizagem (JDA) e vem se constituindo-se em uma das estratégias para envolver os alunos com pesquisas em ambientes interacionistas para promoção da aprendizagem. Esta abordagem tem apresentado excelentes contribuições para a experimentação com novas Arquiteturas Pedagógicas.

7 Referências Bibliográficas

Aragón, R. Interação e mediação no contexto das arquiteturas pedagógicas para a aprendizagem em rede. Revista de Educação Pública. v. 25, n. 59/1 (2016), p. 261-275.

Carvalho, Marie Jane Soares de; Menezes, Crediné Silva de; Nevado, Rosane Aragón de. Arquiteturas Pedagógicas para Educação a Distância. In: Nevado, R. A.. Carvalho, M. J. e Menezes, C. S.. Aprendizagem em rede na educação a distância: estudos e recursos para formação de professores. Porto Alegre: Ricardo Lenz, 2007, p.15-52.

Freire, P. Pedagogia da Autonomia: saberes necessários à prática educativa. Rio de Janeiro: Paz e Terra, 1999.

Kerckhove, D. A Pele da Cultura: Investigando a nova realidade eletrônica. São Paulo: Annablume, 2009.

Lévy, P. As tecnologias da inteligência: o futuro do pensamento na era da informática. 2. ed. São Paulo: Ed. 34, 2010.

Nevado, R.; Menezes, C.; Vieira Júnior, R. Debate de Teses – Uma Arquitetura Pedagógica. In: SBIE, 22.-WIE, 17, 2011, Aracaju. Anais do Evento. Aracaju: WIE, 2011.p. 820-829.

Piaget, J. Estudos Sociológicos. Rio de Janeiro: Forense, 1973.

Science teaching by competition and experiences

Henrique Cesar Sampaio[1], Benedito Manoel de Almeida[1], Cesar Augusto Botura[1], José Lourenço Junior[1]

[1] Department of Engineering, Salesian University Center, Campus Sao Joaquim, Lorena, Brazil

Email: henrique.sampaio@lo.unisal.br, salomaoalmeida@uol.com.br, cabotura@gmail.com, lourencojr.jose@gmail.com

Abstract

The purpose of this paper is to present the relationships and analysis of the expectations versus perception of high school and university students that, together, developed a research project "junior researchers" sponsored by CNPq (National Development Council science and Technology) and managed by UNISAL (Salesian University Center of São Paulo) through active methodology. The research project that guided the scientific initiation has the question: how to learn physics practical and collective? The used active methodology was TBL (Team Based Learning). The article begins with a review of literature on the TBL active methodology, the quality Tool SERVQUAL and the concepts of quality in education. Following presents a field research aimed to investigate the relationship expectation and perception on the use of active methodology and propose improvements for future work that may contribute to the quality of education. The project development fulfilled the Standard 5 of the CDIO Initiative.

Keywords: Active Learning; Engineering Education; Team Based Learning, Standard 5 CDIO.

Ensino de ciências através de competições e experimentação

Henrique Cesar Sampaio[1], Benedito Manoel de Almeida[1], Cesar Augusto Botura[1], José Lourenço Junior[1]

[1] Departamento de Engenharia, Centro Universitário Salesiano, Campus São Joaquim, Lorena, Brasil

Email: henrique.sampaio@lo.unisal.br, salomaoalmeida@uol.com.br, cabotura@gmail.com, lourencojr.jose@gmail.com

Resumo

O artigo tem como fundamento uma pesquisa motivada pela análise da relação expectativa versus percepção dos alunos de Escolas de segundo grau e universidade que juntos desenvolveram um projeto de iniciação científica, "pesquisadores mirins" patrocinados pelo CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico) e gerenciado pelo UNISAL (Centro Universitário Salesiano de São Paulo) por meio de metodologia ativa. O projeto de pesquisa que norteou a iniciação científica tem como pergunta de pesquisa: Como aprender Física de forma prática e coletiva? A metodologia usada foi o TBL (Team Based Learning). O artigo inicia-se com uma revisão da literatura sobre a Metodologia Ativa TBL, a ferramenta de qualidade SERVQUAL e os conceitos da qualidade na educação. Na sequência, apresenta uma pesquisa de campo com o objetivo de investigar a relação expectativa e percepção no uso de metodologia ativa e propor melhorias para trabalhos futuros que venham contribuir com a qualidade de ensino. O desenvolvimento do projeto cumpriu a Norma 5 (Standard 5) da iniciativa CDIO.

Palavras-chave: Metodologia Ativa; Educação em Engenharia; Aprendizado baseado em Projetos, Standard 5 CDIO

1 Introdução

A conquista de melhores níveis de qualidade nas áreas de ensino, vem desafiando educadores a buscarem alternativas para suas propostas pedagógicas. Há uma pressão cada vez maior para que as instituições de ensino passem por uma transformação pedagógica de maneira a alterar as necessidades conceituais atualmente (FRANCISCHETTI, 2014). Por outro lado, existem questões de orçamentos das instituições de ensino, defasagem na formação cognitiva, dificuldades em gerenciar o tempo com as realidades impostas pela vida moderna e um descaso pela educação. O aumento rápido do uso de tecnologia da informação atrelado às necessidades de tomada de decisões rápidas, exigida pela sociedade, tem levado professores e alunos a buscarem uma nova forma de ensino aprendizagem.

A pedagogia tradicional, na qual o professor atua como transmissor do conhecimento está sendo substituída por uma pedagogia que tem como metodologia de ensino a proposta ativa, na qual o aluno interage com outro aluno e busca acesso as informações do assunto, a ser estudado, antes de vir para a sala de aula (XIE,2014).

Embora imprescindíveis, as informações quando apenas retidas ou memorizadas, tem a tendência em tornar um componente de reprodução, de manutenção do conhecimento já existente, colocando os aprendizes na condição de expectadores. Durante uma aula expositiva tradicional, as dúvidas e as perguntas são mais difíceis de serem geridas, pois os alunos não têm chance de se envolverem em uma efetiva discussão de uma aula dialogada após uma prática (SHILINGENSIEPEN, 2013).

Os educadores que estiveram engajados com o compromisso de construir uma escola onde a premissa básica é a aprendizagem significativa e o aluno o centro do processo de ensino, certamente já usaram de estratégia e técnicas de ensino que atualmente são apresentados sobre o enfoque 'Metodológico Ativo'. Para que a aprendizagem significativa ocorra, o aluno deve ter conhecimento prévio relevante do novo conhecimento a ser apresentado, permitindo relacionar o novo conhecimento com o prévio (KIM, 2014).

Este trabalho tem como principal objetivo avaliar a relação da expectativa e percepção dos alunos que fizeram parte das equipes que desenvolveram o projeto "Voo do Conhecimento". O projeto trata-se de uma iniciação científica fundamentada por uma parceria universidade - escola do ensino médio, por meio do desenvolvimento de um experimento prático, cujos alunos têm a oportunidade de usar os fundamentos teóricos na construção de um equipamento, que consistiu no desenvolvimento de um dirigível radiocontrolado

e suspenso por balões com gás hélio. Por meio do desenvolvimento deste projeto, os pesquisadores mirins foram instados a pensar em inovação, promovendo os cálculos a fim de viabilizar o objetivo do projeto, considerando os fenômenos físicos envolvidos e despertando nos alunos o interesse pelo estudo da engenharia e pesquisa científica. O projeto utilizou a Metodologia Ativa para o ensino de Física, neste caso, o TBL (Team Based Learning), que é um método de instrução e aprendizagem colaborativa, construtivista e contextualizada que usa de um problema da prática (real) ou simulada para iniciar, motivar e focar a construção de conhecimento, além de promover habilidades de soluções de problemas (LIMA, 2015). O desenvolvimento e resultados deste projeto propiciou o cumprimento da Norma 5 (*Standard 5*) da iniciativa CDIO (Brodeur e Crawley, 2005).

2 Aspectos Relacionados à Metodologia Ativa – Aprendizado baseado em Projetos

Para atingir o objetivo de avaliar as expectativas e percepções foi usada uma versão modificada da ferramenta de qualidade SERVQUAL. Trata-se de um método que avalia a satisfação do cliente em função da diferença entre a expectativa e o desempenho. SERVQUAL é universal e pode ser aplicado em qualquer organização de serviços para avaliar a qualidade dos mesmos. A ferramenta SERVQUAL foi escolhida, pois oferece de forma simples e eficiente uma avaliação da satisfação dos alunos em relação ao serviço prestado na sua formação. Desta forma, a avaliação da qualidade de um serviço por um cliente é feita por meio da diferença entre a sua expectativa e o seu julgamento do serviço. A escala SERVQUAL possui duas seções: uma destinada ao mapeamento das expectativas do cliente em relação a um segmento de serviço e a outra destinada ao mapeamento da percepção em relação ao serviço sob estudo (OLIVEIRA, 2014). O modelo original do SERVQUAL trabalha com 22 questões avaliadas pela escala LIKERT. Para o presente estudo foi realizada uma adaptação baseada nas referências bibliográficas e nas necessidades do campo da educação.

O uso de ferramentas da qualidade é de grande importância para uma instituição de ensino, pois permite uma avaliação e tomada de decisão que possibilita identificar as fortalezas e os problemas da instituição, trata-se da adequação de seu trabalho com respeito às demandas sociais, identificação do grau de envolvimento tendo em vista as propriedades institucionais (SAMUELSSON e LINBLAD, 2015).

Com o uso de TBL, a participação do aluno se dá no exercício de aprender fazendo; ao professor, cabe conduzir o processo metodologicamente, estimular as atividades dos alunos, apoiar e valorizar as iniciativas na direção do foco maior, que é a solução do problema em estudo de forma coletiva (BERGAMANN, 2015).

O TBL contou com etapas que se complementaram: na primeira, os alunos das escolas convidadas (Colégio São Joaquim e Unisal), quatro alunos do segundo grau junto com um aluno universitário, elaboraram um projeto de pesquisa que buscava a construção de um dirigível sustentado por gás hélio, avaliou-se as variáveis possíveis de experimentação, tais como: temperatura, pressão, propriedades do vento, características dos materiais e outros fenômenos físicos envolvidos, sempre fundamentada com leituras, prévias e práticas de oficina. As leituras prévias permitem que os alunos tragam para as práticas uma variedade de ideias sobre como eles vão aprender, incluindo suas percepções sobre aprendizagem e habilidades, de que precisam fazer uso para o sucesso (KIM, 2015).

A segunda etapa aconteceu de forma prática, sempre em ambiente de laboratório ou oficinas, os alunos foram postos a construir o protótipo do dirigível, observando e relatando todas as etapas e seus resultados. O método enfatiza o aprendizado experimental, o que torna o conhecimento mais aplicável a diferentes situações – problemas do mundo real, do que mera memorização de fatos (SOMYUREK, 2015). Todas as dúvidas foram gerenciadas pelo professor e postas a serem resolvidas, por cooperação e ajuda mútua.

O uso de Metodologia sem a participação ativa do aluno tais como as tradicionais, pode representar risco de fracasso, pois nessas metodologias os alunos não têm oportunidade de pesquisar, descobrir ou aplicar o conhecimento em contexto autêntico que permite entender que o conhecimento fornecido foi importante e será útil (SOMYUREK, 2015). Por último, o grupo de alunos anfitriões do projeto convidaram alunos de outras

escolas que juntos estabeleceram as metas e trocaram experiências sobre a construção dos dirigíveis que foram instrumentos de uma competição denominada "Voo do Conhecimento".

3 Procedimento Metodológico

Inicialmente fez-se uma revisão da literatura em busca de fundamentos de Metodologia Ativa de ensino, em especial a TBL (*Team Based Learning*), sobre a ferramenta da qualidade SERVQUAL e suas devidas contribuições no ensino. Em seguida, realizou-se uma pesquisa de campo com os alunos participantes do projeto.

O objetivo desta etapa foi confrontar dados de pesquisa relacionados à expectativa no uso da prática em questão e as percepções dos alunos após o término do projeto.A ferramenta usada para a pesquisa exploratória foi uma versão adaptada do SERVQUAL. Na parte operacional da ferramenta utilizada, há uma tabela, na qual foram mapeadas as expectativas e percepções do bom uso do TBL, fundamentada em diversas referências. Usou-se de 20 questões para mensurá-los. Os fundamentos escolhidos foram:

- Requisitos necessários para o uso de TBL;

- Gerenciamento da qualidade no uso de TBL;

- As estratégias de ensino usando TBL;

- Os recursos utilizados na metodologia TBL.

O método avalia as expectativas dos alunos (E) e as percepções (P) no uso da Metodologia Ativa TBL. A diferença entre a percepção do serviço e a expectativa do aluno (P – E), foi à base dos resultados. Uma escala Likert de 1 a 7 foi utilizada, onde os extremos são marcados "concordo totalmente" (excelente) e "discordo totalmente" (medíocre). Um desvio positivo de pontuação demonstrou que as expectativas foram atingidas ou ultrapassadas, sendo a qualidade do serviço percebida com satisfação do aluno. A pontuação negativa demonstrou que as expectativas não foram atingidas e a qualidade percebida foi insatisfatória. A fim de aferir a confiabilidade do questionário determinou-se a análise Do Alfa de Cronbach obtendo-se os valores da Tabela 1. Os valores encontrados sugerem um adequado nível de confiabilidade do questionário.

Tabela 1. Alfa de Cronbach

Expectativas	Percepções
α = 0,899	α = 0,925

Segundo Streiner (2003), o valor mínimo aceitável para o alfa é 0,70; abaixo deste valor a consistência interna da escala utilizada é considerada baixa. De outro lado, sugere que o valor máximo esperado é 0,90. Acima deste valor, pode-se suspeitar que há redundância ou duplicação, isto é, vários itens medindo o mesmo elemento de um constructo. Sem prejuízo a tal consideração, uma análise do questionário, particularmente o de percepções, não evidenciou itens redundantes a serem eliminados.

4 Resultados

As medidas em porcentagem foram obtidas convertendo-se os valores da escala Likert (1 a 7) em porcentagem conforme Tabela 2:

Tabela 2. Valores da escala Likert

Expectativa	Emax = 7	Equivale a 100%
Percepção	Pmax = 7	Equivale a 100%
Gap satisfação	G < 0	7 Equivale a 100%
Gap insatisfação	G < 0	-7 Equivale a 100%
(E, P, G) = valores médios		

Nas avaliações dos itens analisados foi utilizada técnica de análise de conteúdo (VERGARA, 2005) demonstrada na Tabela 3:

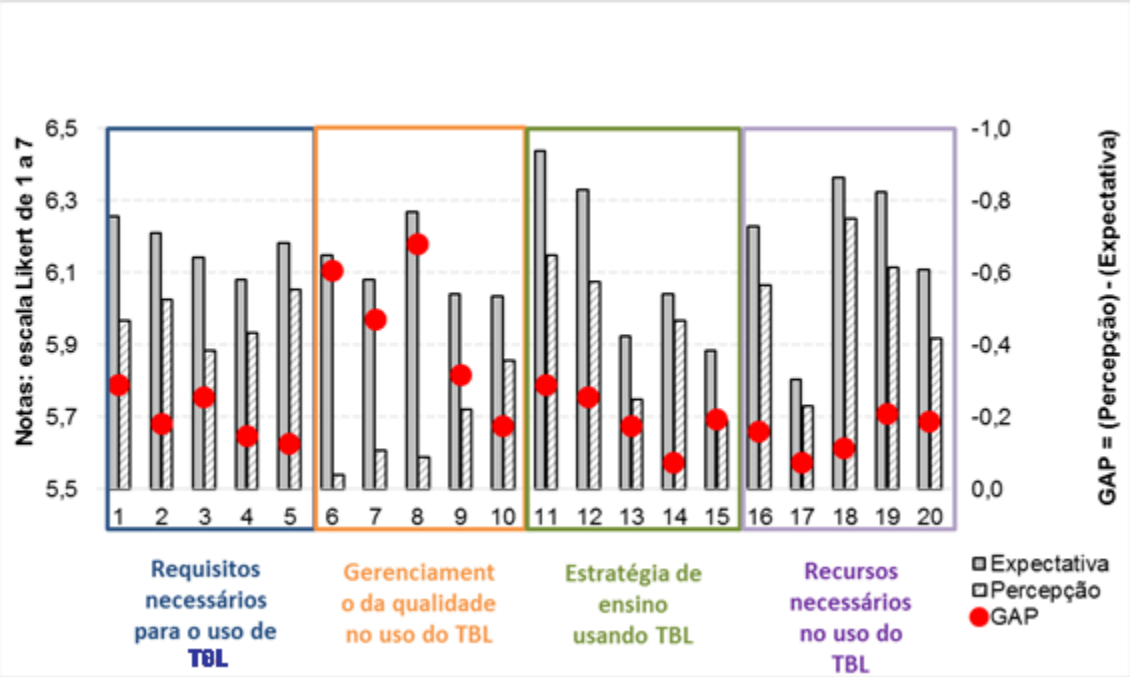
Tabela 3. porcentagem das expectativas, percepções e GAP (valores máximos adquiridos na pesquisa)

Itens	**% Expectativa**	**% Percepções**	**% GAP**
1	85,00	82,80	- 4,28
2	85,70	81,00	- 5,90
3	84.28	81,42	- 2,77
4	89.80	81,00	- 2,30

Fonte: Vergara (2005)

As respostas foram tabuladas e são apresentadas na Tabela 4.

Tabela 4. Resultados: Expectativas, Percepções e GAP's



Item 1 – Requisitos necessários para o uso de TBL: apresentou resultados de expectativa acima de 85% da escala Likert, demonstrando que os alunos valorizam os requisitos estabelecidos para o bom uso do TBL. As percepções estiveram acima de 82,8%, demonstrando que durante a prática do TBL os requisitos necessários para seu uso apareceram de forma significativa.
O GAP máximo foi de -4.28% (insatisfação), mostrando a necessidade de melhoria a serem trabalhadas nos subitens:

- Ambiente adequado para aprender Física;
- Ação do professor como facilitador;
- Exercício em grupo fundamentado em leituras prévias;
- Pensar de maneira lógica;
- Necessidade de motivar os alunos para estudar Física.

Item 2 – Gerenciamento da Qualidade no uso do TBL: apresentou resultado de expectativa acima de 85,7% da escala Likert, demonstrando que os alunos valorizam um gerenciamento da qualidade no uso do TBL. As percepções estiveram acima de 81%, demonstrando que durante a prática do TBL aconteceu um gerenciamento da Qualidade no uso da Metodologia. O GAP máximo foi de -5,9% (insatisfação), mostrando necessidade de melhoria a serem trabalhadas nos subitens:

- Descobrir e atingir as necessidades dos alunos;
- Garantir as necessidades;
- Constantes melhorias;
- Aprofundamento nos temas estudados;
- Conhecimento prévio.

Item 3 – Estratégias de ensino usando o TBL: apresentou resultado de expectativa acima de 84,28% da escala Likert demonstrando que os alunos valorizam a necessidade de estabelecer estratégia de ensino para o uso do TBL. As percepções estiveram acima de 81,42%, demonstrando que foi boa a estratégia de ensino usada. O Gap máximo foi de -2,77% de insatisfação, mostrando a necessidade de melhorias nos itens:

- Participação ativa dos alunos;
- Construção coletiva do conhecimento;
- Conclusão individual do conhecimento;
- Uso do raciocínio;

Item 4 – Recursos necessários no uso do TBL: apresentou resultado de expectativa acima de 82,8% da escala Likert, demonstrando que os alunos valorizam os recursos necessários no uso do TBL. As percepções estiveram acima de 81,5, demonstrando que os recursos usados foram bons. O GAP máximo foi de -2,31% (insatisfação), mostrando a necessidade de melhoria a serem trabalhados nos subitens:

- Recursos adequados ao conteúdo;
- Integração teoria e pratica;
- Criatividade;
  Diferenciação de conceito.

5 Conclusão

O trabalho apresentou com sucesso uma experiência de aplicação de um programa dirigido às escolas públicas e privadas do ensino médio numa cidade brasileira. A abordagem TBL foi aplicada para resolução de problemas, comportamento e prática cooperativa e fomento à aprendizagem de conteúdos das ciências exatas, através de material didático e práticas experimentais lúdicas. O objeto do trabalho despertou o interesse dos alunos das escolas de ensino médio para os estudos nos cursos de engenharia. Uma experiência que teve impacto positivo pela oportunidade de formação do conhecimento de forma interdisciplinar. Conforme observado, a relação entre percepção e expectativa gerou um forte indicador para melhoria da qualidade, expressa quantitativamente nos valores de GAP`s demonstrados na tabela 4. A pesquisa e metodologia realizadas foram contributivas, indicando também possíveis ajustes no processo de uso da ferramenta de Metodologia Ativa TBL de maneira a contribuir com melhoria da qualidade no ensino. Permite orientar professores que queiram fazer uso da metodologia ativa em suas disciplinas ou outros trabalhos voltados à qualidade no ensino de uma forma geral. Possibilitou a ampliação de sua aplicabilidade a outras situações de ensino equivalente.

6 Referências

Bergsmann, E. (2015). Evaluation of competence-based teaching in higher education: From theory to practice. Evaluation and program planning, v. 52, p. 1-9.

Brodeur, D. R., Crawley, E. F. (2005) Program Evaluation Aligned With the CDIO Standards. Proceedings of the 2005 American Society for Engineering Education Annual Conference & Exposition.

Francischetti, I. (2014). Active Learning Methodologies: An Experience for Faculty Training at Medical Education. Creative Education, v. 5, n. 21, p. 1882.

Kim, M. The experience of three flipped classrooms in an urban university: an exploration of design principles. The Internet and Higher Education, v. 22, p. 37-50, 2014.

Kim, M. (2015) Models of learning progress in solving complex problems: Expertise development in teaching and learning. Contemporary Educational Psychology, v. 42, p. 1-16.

Lima, V. (2015). Ativadores de processos de mudança: uma proposta orientada à transformação das práticas educacionais e da formação de profissionais de saúde. Ciência & Saúde Coletiva, v. 20, n. 1, p. 279-288.

OLIVEIRA, Otávio J. Curso básico de gestão da qualidade. São Paulo: Cengage Learning, 2014.

Vergara, Sylvia Constant. Métodos de pesquisa em administração. Atlas, 2005.

Samuelsson, K.; Lindblad, S. (2015). School management, cultures of teaching and student outcomes: Comparing the cases of Finland and Sweden. Teaching and Teacher Education, v. 49, p. 168-177.

Schlingensiepen, J. (2014). Innovation In Distance, E-And Blended Learning In Educational Mass Production Using Inverted Classroom Model (Icm). Procedia-Social And Behavioral Sciences, V. 141, P. 393-398.

Somyürek, S. (2015). An effective educational tool: construction kits for fun and meaningful learning. International Journal of Technology and Design Education, v. 25, n. 1, p. 25-41, 2015.

STREINER, David L. Starting at the beginning: an introduction to coefficient alpha and internal consistency. Journal of personality assessment, v. 80, n. 1, p. 99-103, 2003.

Xie, Z. (2014). An effective hybrid teaching–learning-based optimization algorithm for permutation flow shop scheduling problem. Advances in Engineering Software, v. 77, p. 35-47.

About engineering undergraduate students: the efficiency of Active Learning strategies in engineering courses

Liane L. Loder[1,2]

[1] Department of Electrical Engineer, School of Engineering, Federal University of Rio Grande do Sul, Campus Sede, Porto Alegre, Brazil.
[2] Academic Board, Federal University of Rio Grande do Sul, Câmpus Litoral Norte, Tramandaí, Brazil.

Email: lianeludwig@ufrgs.br

Abstract

From that understanding that the engineering student, along its course, evolve in their cognitive and moral autonomy, in this paper it is considered that the educational interventions should be accompany the different stages of this evolution, as a precondition for the success of these interventions. The student's trajectory over the course provides evidence that, for each step, there is a more appropriate pedagogical action. In the beginning, when students still face the necessary familiarity with the university environment, it seems better a pedagogical action that guide the student action. In more advanced stages, when the students have to overcome the epistemological obstacles represented by the complexity of the field of knowledge, a teaching action to guide and promote, more and more, student autonomy is required. Already in the final stages, characterized by the imminent entry into the labor market, when is expected that the student has already reached an autonomy, the teaching can be less oriented. The use of a pedagogical practice inconsistent with the intellectual, cognitive and affective development of the student can explain why some teachers who work as effectively, in terms of promoting the learning of their students, in some disciplines at the end of course and not so well in the disciplines of the beginning of the course, and vice - versa. In general, the choice of teaching strategies based on the principles of Active Learning seems to contribute positively to these students at all levels of an engineering undergraduate course. However, the effectiveness of these strategies requires permanent monitoring in order to identifying the psychological, sociological and intellectual student level development stage, otherwise the efforts and investments needed to the implementation of active strategies are frustrated in their purposes. In this article, to discuss the efficiency of Active Learning Strategies in engineering courses, it is focused the evolution of students during a traditional Brazilian electrical engineering course, recognized nationally and internationally for the quality of education of its graduates.

Keywords: Engineering Education; Teaching-Learning; Pedagogical strategies based on Active learning.

Sobre ensino-aprendizagem em engenharia: a eficiência de estratégias de Aprendizagem Ativa

Liane L. Loder[1,2]

[1] Docente do Departmento de Engenharia Elétrica, Escola de Engenharia, Universidade Federal do Rio Grande do Sul, Campus Sede, Porto Alegre, Brasil.
[2] Diretora Acadêmica do Câmpus Litoral Norte da Universidade Federal do Rio Grande do Sul, Tramandaí, Brasil.

Email: lianeludwig@ufrgs.br

Resumo

A partir da compreensão de que o estudante de engenharia, ao longo de sua trajetória escolar no curso, apresenta uma evolução não só em termos de ampliação de seus conhecimentos e de construção de competências técnicas, mas também de atitudes que o levam a desenvolver, paulatinamente, a sua autonomia, percebe-se que as estratégias pedagógicas utilizadas no ensino devem estar ajustadas às diferentes fases dessa evolução como pré-condição para o sucesso dessas estratégias. Ao acompanhar a trajetória do estudante ao longo de seu processo formativo, verifica-se que, para o mesmo estudante, as mesmas estratégias surtem efeitos diversos, em diferentes momentos de sua trajetória escolar. Na fase inicial do Curso, em que o estudante está se familiarizando com o ambiente universitário, diverso e muito mais amplo do que o ambiente do ensino médio, pré-universitário, parece ser mais adequada uma estratégia pedagógica que dirija a ação do estudante, estabelecendo metas bem definidas e resultados mais imediatos. Em estágios mais avançados, quando o estudante estiver superado, em boa medida, os obstáculos epistemológicos impostos pela complexidade do campo de conhecimento, uma ação pedagógica que guie e promova, cada vez mais, a autonomia do estudante, parece ser mais eficaz. Já na fase final do ciclo formativo, caracterizado pelo iminente ingresso no mercado de trabalho, quando se espera que o estudante tenha alcançado uma autonomia intelectual e moral plena, o ensino pode se tornar cada vez mais uma orientação de estudos e de pesquisas. A utilização de práticas pedagógicas não condizentes com o estágio de evolução intelectual, moral e afetivo do estudante pode explicar porque algumas ações pedagógicas funcionam bem, em termos de promover a aprendizagem do estudante, no início do curso e nem tão bem ao final do curso e vice-versa. Em geral, a escolha de estratégias de ensino baseadas nos princípios da Aprendizagem Ativa parece contribuir positivamente para a aprendizagem dos estudantes em qualquer nível do curso de engenharia em que se encontrem. Entretanto, garantir a eficácia dessas estratégias requer o monitoramento permanente a fim de identificar o nível de desenvolvimento psicológico, sociológico e intelectual do estudante, caso contrário os esforços e os investimentos necessários para a implementação de estratégias ativas podem ser frustrados em seus objetivos. Esse artigo, para discutir a eficiência de estratégias baseadas em Aprendizagem Ativa, é focalizada a evolução dos estudantes durante um curso de engenharia elétrica tradicional no Brasil, reconhecido, nacional e internacionalmente, pela qualidade de educação de seus graduados.

Palavras - Chave: Educação em Engenharia; Ensino-Aprendizagem; Estratégias Pedagógicas baseadas em Aprendizagem Ativa.

1 Introducão

Na teoria epistemológica de Piaget, o conhecimento é uma construção intelectual cuja gênese é tributária da interação entre sujeito e meio. Assim, o construtivismo piagetiano se contrapõe, simultaneamente, ao empirismo, que nega a ação do sujeito no processo conhecedor, e ao inatismo, que atribui as aprendizagens a qualidades inatas do sujeito. Para PIAGET (1972),

> *"Conhecer não consiste, com efeito, em copiar o real, mas em agir sobre ele e transformá-lo (na aparência ou na realidade), de maneira a compreendê-lo em função dos sistemas de transformação aos quais estão ligadas estas ações."*

A partir dessa compreensão e da constatação de que o estudante de engenharia, ao longo de seu curso, evolui em sua autonomia cognitiva e moral, considera-se que as intervenções pedagógicas devem estar ajustadas às diferentes etapas dessa evolução, como uma pré-condição para o sucesso dessas intervenções.

Esse trabalho objetiva defender essa tese de que as intervenções pedagógicas a serem utilizadas ao longo de um curso devem estar ajustadas às diferentes etapas dessa evolução do estudante como uma pré-condição para promover a aprendizagem do estudante, resultado mais evidente do sucesso dessas intervenções.

Os dados que embasam esse artigo foram obtidos na investigação realizada durante o doutoramento da Autora e estão amplamente detalhados na sua Tese (LODER, 2009).

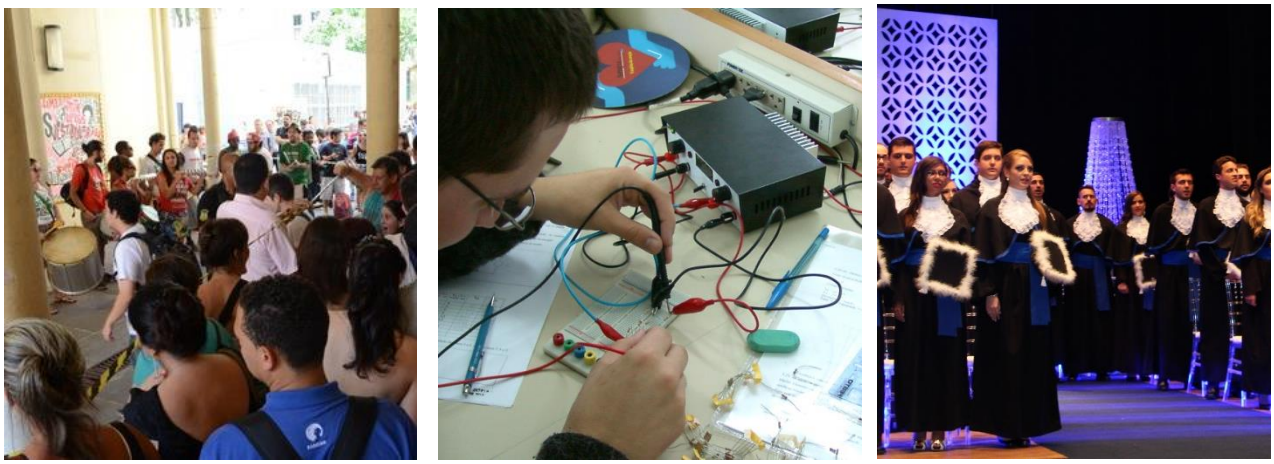


Figura 1. Do ingresso à diplomação, um longo caminho a percorrer

Acima, na Figura 1, registros fotográficos de diferentes momentos de estudantes da Universidade Federal do Rio Grande do Sul. À esquerda, comemoração dos resultados do Vestibular. Ao centro, estudante em uma atividade de laboratório de Eletrônica e à direita, cerimônia de diplomação no Salão de Atos da Universidade.

2 Metodologia utilizada na investigação

A metodologia utilizada na investigação que embasa esse artigo é de caráter, primordialmente, qualitativo. A pesquisa qualitativa caracteriza-se, em geral, por ter o objetivo de ampliar ao máximo o campo de análise para que se possam incorporar as mais diferentes variáveis e ampliar a análise do contexto, propriamente dita. Dessa forma, procura-se fugir do padrão de coleta de dados passíveis de medição, análise matemática e controle experimental, usados com o objetivo de estabelecer generalizações que, na área da educação, não raro, levam a análises superficiais do problema em pauta.

Em particular, a pesquisa apoiou-se na presença prolongada da pesquisadora no contexto investigado, como uma forma de melhor captar as relações, as interações, os significados que ocorrem nesse contexto o que possibilitou, de forma mais qualificada, interpretar as ações e as situações observadas. Em função desses aspectos, e considerando a etnografia como a descrição de um sistema de significados culturais de um determinado grupo, pode-se caracterizar esta pesquisa como, marcadamente, de natureza qualitativa e de caráter etnográfico.

3 Atitudes e competências do estudante de engenharia

O acompanhamento longitudinal da trajetória do estudante ao longo do Curso traz evidências de que, para cada etapa, há uma ação pedagógica mais apropriada.

As etapas iniciais do Curso, quando os estudantes ainda se defrontam com a sua necessária familiarização com o ambiente universitário, requerem ações pedagógicas que, ao mesmo tempo, direcionem e orientem o

trabalho discente, nos estudos e tarefas a cumprir para a consecução dos objetivos de formação estabelecidos pela Instituição de Ensino. Etapas mais avançadas, nas quais a superação dos obstáculos epistemológicos representados pela complexidade do campo de conhecimento, requerem uma ação docente que oriente e promova a autonomia discente, cada vez mais, à medida que o estudante avança no Curso. Já nas etapas finais, que se caracterizam pela iminência da entrada do estudante no mercado de trabalho, é esperado que o estudante já tenha atingido uma autonomia que possibilite a ação pedagógica não diretiva, dessa forma a mesma pode ser posta em prática em toda a sua plenitude.

O uso de uma prática pedagógica não condizente com o nível de maturidade e de desenvolvimento intelectual, cognitivo e afetivo do estudante pode explicar porque se observam professores que atuam com tanta eficácia, em termos de promover a aprendizagem do seu aluno, em algumas disciplinas de final do curso e não tão bem, em disciplinas de início do curso, e vice – versa.

3.1 O estudante ao ingressar no Curso

No Brasil, nas Instituições mais prestigiadas, a maioria dos alunos ingressa ainda adolescente, mas com aptidão lógico-matemática bem desenvolvida o que os capacita a enfrentar os obstáculos epistemológicos do Curso com chances de sucesso.

Os elevados escores desses alunos no Concurso Vestibular ou no Exame Nacional do Ensino Médio - ENEM, no caso das Instituições que selecionam seus estudantes a partir do Sistema de Seleção Unificada – SISU, bem como o excelente aproveitamento em Cálculo e Física observado nas etapas iniciais de seus cursos universitários de engenharia, quando se compara esse contingente de estudantes com os de outros cursos universitários da área de ciência e tecnologia, aliado à observação dos professores quanto à competência desses alunos para o aprendizado são indicadores de suas competências intelectuais.

Quanto às suas atitudes, observa-se entre esses estudantes um entusiasmo e uma auto-estima elevada pelo fato de terem sido selecionados para Cursos cuja seleção de estudantes para ingresso é concorrida e difícil, em função de serem ofertados em Instituições de Ensino prestigiadas pela Sociedade, o que aponta para uma expectativa de sucesso escolar desses estudantes recém ingressos.

3.2 O estudante durante o Curso

Apesar de, na perspectiva das atitudes e competências intelectuais, as condições iniciais serem favoráveis para o sucesso escolar desses estudantes, muitos deles evadem nas primeiras etapas dos Cursos. O baixo percentual de formandos (em muitas Instituições em torno de 50% dos ingressantes), deve-se, em parte, a essa evasão inicial. Alguns depoimentos de estudantes entrevistados (LODER, 2009) demonstram que as dificuldades de aprendizagem e de superação dos obstáculos psicológicos e epistemológicos é um forte fator de influência. O seguinte depoimento de um estudante formado há um ano, por ocasião da entrevista para a Pesquisa, exemplifica essa situação:

Ex- Aluno: *"Acho que esse índice de desistência é muito por causa da desmotivação. Tu começas a bater a cabeça, começa a encontrar muita pedra no caminho e ninguém gosta só de pedra no caminho, do caminho mais difícil, a gente gosta de conciliar...: E tem que ter compensação se não é só sofrimento, aí não dá. O Curso inteiro foi assim, todo o semestre a gente se deparava com aquele questionamento: Será que eu tô no Curso certo? Até no último semestre o lado emocional foi muito complicado, eu tava no último semestre e, às vezes, eu achava que não ia conseguir".*

Em geral, se observa que, à medida que o aluno avança no Curso, ele vai apresentando um comportamento cada vez mais permeado de autonomia cognitiva e moral. Nessa evolução, o trabalho individual inteligente do estudante, muitas vezes de caráter altamente introspectivo, o que costuma ser típico de um fazer científico, vai dando espaço a uma ação colaborativa desse aluno com seus pares. A essa progressiva descentração cognitiva do estudante corresponde uma ação moral de caráter cooperativo com seus colegas. Ao final do Curso, percebe-se um estudante sujeito do seu fazer e do seu aprender, que se caracteriza por apresentar, na sua ação cognitiva, egocentrismo e descentramento, de forma solidária, e, na sua ação moral, a introspecção e a cooperação com um comportamento solidário análogo. Durante esse processo evolutivo, o estudante, calcado

em sua autoconfiança e auto-estima, que sofrem danos e reparos ao longo da trajetória escolar, vai construindo seu conhecimento, desenvolvendo sua capacidade criadora e, assim, se constituindo em sujeito do seu aprender.

Esse processo evolutivo do estudante que se observa no âmbito do contexto escolar se desenvolve entremeado por situações adversas vivenciadas pelo estudante, no âmbito das mais diferentes dimensões desse contexto. Na dimensão pedagógica, as adversidades devem-se à invisibilidade atribuída pelo contexto ao estudante. Na dimensão psicossocial, as dificuldades devem-se às relações interpessoais tensas que se estabelecem entre o estudante e seus colegas e, principalmente, entre o estudante e seus professores. Na dimensão da infraestrutura física, apesar do empenho e da diligência dos professores, a precariedade de algumas instalações e a indisponibilidade de bons equipamentos para as mais variadas atividades práticas, ambas agem de forma a limitar as possibilidades de aprendizagem, principalmente nas Instituições Públicas que dependem, fortemente, de recursos públicos, muitas vezes escassos.

3.3 O estudante ao final do Curso

Ao final de sua trajetória no Curso, o estudante apresenta uma maturidade intelectual e uma maturidade moral que permitem classificá-lo como um sujeito autônomo em seu fazer, com capacidade técnica altamente desenvolvida, e com destacada capacidade inventiva. Há evidências de que esse rol de competências, construído pelo estudante, muito se deve ao seu esforço individual na superação das dificuldades que ele enfrenta ao longo do Curso. O seguinte relato de outro ex-aluno, formado há dois anos por ocasião da Pesquisa (LODER, 2009), é ilustrativo dessa situação:

Ex-Aluno: "*Eu acho que uma das principais coisas que o aluno vai adquirindo durante o Curso é a capacidade de se virar sozinho. Por vários motivos, por deficiência do professor, por deficiência na infra do Curso, o aluno tem que dar um jeito. O professor não quer nem saber, o aluno tem que dar um jeito, tem que se virar*".

Observa-se que a superação dessas adversidades resulta não só no sucesso escolar do estudante como também no seu amadurecimento. Em conseqüência disso, o acesso dos alunos formados aos postos de trabalho se dá com mais facilidade do que em outras áreas do conhecimento, como demonstra o seguinte depoimento:

Ex-Aluno: "*O que eles [a Empresa] mais comentam é a capacidade de resolver problemas, os alunos da engenharia dessa Universidade estão mais acostumados a lidar com as dificuldades*".

A evolução do aluno durante o Curso, em termos de conhecimento, se dá em escala exponencial. O nível de complexidade técnica dos problemas que um formando está apto a resolver retrata as competências intelectuais, morais e éticas desenvolvidas por ele ao longo do Curso. Tipicamente, nas disciplinas iniciais, o estudante opera reagindo às ações do professor. A produção intelectual do calouro e sua capacidade de realizar tarefas de engenharia – da identificação do problema ao projeto e do projeto à execução da solução proposta pelo projeto, se dá de forma bastante precária e abreviada. Já ao final do Curso, o estudante consegue executar essa mesma seqüência de tarefas de forma muito superior, em complexidade, e com amplo domínio da técnica. O estudante prestes a se formar é plenamente capaz de uma ação autônoma e auto-regulada e, assim, age. A qualidade e o impacto social de alguns dos Projetos de Diplomação defendidos por esses estudantes prestes a sair do Curso constituem-se em provas inquestionáveis dessa evolução.

3.4 O engenheiro que a sociedade demanda

No Brasil, a formação dos novos engenheiros é balizada por parâmetros acordados nacionalmente. Esses parâmetros são, fundamentalmente, legais, estabelecidos pelo Ministério da Educação – MEC. Há, também, parâmetros não oficiais, estabelecidos pela Sociedade, que, através de suas demandas, norteia a gestão dos cursos existentes e a criação de novos cursos no âmbito das Instituições de Ensino Superior brasileiras.

As exigências do MEC

A formação em Engenharia no Brasil é regulada pelo Ministério da Educação através da Lei nº. 9.394 (Lei de Diretrizes e Bases), de 1996, cujo Capítulo IV, se dedica à Educação Superior, e da Resolução CNE/CES 11, de

2002, da Câmara de Educação Superior do Conselho Nacional de Educação, que institui as Diretrizes Curriculares Nacionais da Graduação em Engenharia. Segundo esse marco regulatório, o engenheiro deve ser capaz de: projetar e interpretar resultados; planejar e supervisionar serviços de engenharia; comunicar-se nas formas oral, escrita e gráfica; identificar, formular e resolver problemas; atuar em equipes multidisciplinares; avaliar o impacto sócio-ambiental de suas ações; avaliar a viabilidade econômica de seus projetos; buscar, permanentemente, sua atualização.

As demandas do Mercado de Trabalho

A partir da pesquisa intitulada "Mercado de Trabalho para o Engenheiro e Tecnólogo no Brasil" (CONFEA, 2008) da qual participaram 1098 Empresas, pode-se inferir algumas seguintes demandas do mercado empregador de engenheiros no país:

Quanto às formas de acesso dos novos engenheiros no mercado de trabalho, a atividade de Estágio é a porta de entrada mais comum do engenheiro nas Empresas. O Estágio é considerado pelas Empresas uma forma eficiente de o aluno mitigar suas lacunas de formação prática. Para o empresariado, as Escolas de Engenharia não enfatizam o aspecto prático nos seus cursos e os alunos acabam não desenvolvendo um conhecimento prático muito aprofundado em sua formação acadêmica. Os próprios alunos parecem reconhecer a importância do estágio para o seu *curriculum* e, muitas vezes, acabam alongando o seu tempo no curso para poderem estagiar. Outra modalidade de ingresso nas Empresas é via Programas de *Trainee*, às vezes destinados aos alunos, mas na maioria das vezes, aos recém-formados.

Quanto aos critérios utilizados pelas Empresas para balizar a contratação de engenheiros, verifica-se que a Experiência Profissional na área e os Conhecimentos Anteriores são os principais critérios, mencionados por 77% das Empresas entrevistadas, mas as Características Pessoais aparecem logo em segundo lugar, com 69% das menções. Nesse quesito, os seguintes fatores se destacam, em ordem de importância: 1ºLiderança e capacidade de solução de problemas, com habilidades gerenciais; 2º Espírito de equipe a capacidade de trabalhar em grupo; 3º Habilidade no relacionamento humano; 4º Liderança; 5º Iniciativa e disposição para aprender coisas e tarefas novas; 6º Facilidade de comunicação; 7º Facilidade de adaptação a situações novas; 8º Dinamismo e vontade de crescer dentro da empresa.

4 Considerações sobre os resultados encontrados na investigação, base desse Artigo

Apesar de as competências práticas e intelectuais serem consideradas de alto valor no "perfil" do engenheiro desejado pela Sociedade, verifica-se que para algumas outras qualidades desse "perfil" é muito frequente encontrarmos deficiências entre os formandos. Dentre as qualidades desejáveis, e não tão desenvolvidas no âmbito dos Cursos, estão: comunicar-se eficientemente na forma oral; atuar em equipes multidisciplinares e avaliar o impacto das soluções da engenharia no contexto social e ambiental. Coincidentemente, cada uma dessas "deficiências" não são objeto de uma ação pedagógica mais sistemática, na maioria dos Cursos.

A exposição oral de trabalhos para grandes grupos, que poderia funcionar como um exercício para o desenvolvimento da capacidade de se comunicar oralmente de forma eficaz, é uma atividade esporádica. Normalmente, quando há exposição, essa se dá para o professor e um número reduzido de colegas que compõem o seu grupo de trabalho. Um dos alunos entrevistados pela Pesquisa (LODER, 2009) fez parte do seu Curso na França como aluno de dupla diplomação e relata que a prática da "defesa de trabalho" pelo estudante era bem mais comum lá do que é aqui. No seu seguinte relato, ele reconhece o valor dessa prática na formação do aluno de engenharia, como mostra o depoimento transcrito a seguir:

Aluno: [lá na França, às vezes] "*o laboratório era dividido em duas partes, uma de quatro horas onde tu fazias o experimento e outra de duas [horas] onde o teu grupo apresentava as medidas e suas conclusões [...] Lá tinha muito [exposição oral do aluno], nessas aulas de exercícios... [...] era dado um exercício pra próxima aula e um grupo de quatro alunos ficava de resolver e apresentar [...]. Essas apresentações podiam não valer nota, mas era uma obrigação do aluno... se não apresentasse, o professor pulava! [...] Gerava, assim, um desconforto entre a turma e o grupo que deveria ter feito*".

Por outro lado, a atuação em equipes multidisciplinares não é uma prática muito fomentada em cursos de engenharia no Brasil, em geral. A maior parte dos trabalhos em grupo é feita com colegas do Curso, à exceção das atividades extra-classe que se desenvolvem em estágios e em atividades de iniciação científica junto a laboratórios de desenvolvimento e pesquisa existentes nas próprias Universidades.

Quanto à discussão sobre os impactos sócio-ambientais das soluções de engenharia, raramente, é assunto de aula ou de seminários internos. Quando se discute o impacto dessas soluções, é muito comum fazê-lo sob a ótica da relação custo (econômico-financeiro) – benefício. O custo ambiental ou social das soluções não costuma ser pauta das discussões. O seguinte depoimento de outro Aluno, que também fez parte de seu Curso na França, confirma essa sensação que em cursos brasileiros o ensino está focado mais nas questões puramente técnicas e, nesse campo, é que o estudante adquire na sua formação grau de excelência. O seu depoimento encontra-se transcrito a seguir:

Aluno: "*Eu acho que a modificação dos alunos ao longo do Curso se limita às questões de engenharia, mas a visão social, por exemplo, aqui é nula. Não tem ninguém que toque nesse assunto. Da mesma forma, a política. Não tô dizendo que o aluno deva sair daqui politizado, defendendo alguma causa, mas... É importante pra vida dele. [...] Os alunos aqui não reclamam de nada. Reclamam pelas costas. Ninguém acredita na força que tem, realmente. É, basicamente aquela visão que, primeiro, nada vai mudar, segundo, que o Curso é um castigo e que o aluno quer se ver livre duma vez, aqui é uma penitência e é difícil mobilizar as pessoas para alguma coisa*".

Em que medida as pedagogias vigentes têm parcela de responsabilidade nas deficiências de formação do engenheiro, considerando que o perfil ideal do engenheiro deva contemplar os seguintes atributos: excelência técnica, capacidade de empreender, criatividade, autonomia, capacidade de se comunicar eficazmente e comportamento ético e socialmente responsável?

Os resultados da Pesquisa (LODER, 2009) permitem afirmar que as dificuldades a serem superadas têm sua origem no contexto de ensino-aprendizagem vigente que não privilegia a aprendizagem e tende a enfatizar o ensino. Enquanto os alunos tentam dar conta de seu aprendizado, os professores tentam dar conta de seu ensino, praticamente sem nenhum apoio pedagógico da Instituição. Já há algum tempo, as Universidades brasileiras, principalmente as Públicas, contratam docentes já Doutores, com excelente inserção na pesquisa, mas sem qualquer preparo prévio para a docência. Esses professores acabam se qualificando "em serviço", o que não é o melhor nem para os seus estudantes, nem para os próprios professores. A falta de apoio pedagógico institucional continuado dificulta a capacitação docente desse professor e não favorece o estabelecimento de um ambiente de aprendizagem no contexto escolar. Ainda, a pouca valorização atribuída à docência em nível de graduação, quer seja pela Instituição de Ensino, quer seja pelos órgãos de fomento de pesquisa externos à Instituição, também desestimula o professor. O seguinte depoimento de um "Professor Engenheiro Eletricista" por ocasião da Pesquisa (LODER, 2009) é ilustrativo dessa situação:

Professor Engenheiro Eletricista: "*A minha idéia quando eu pensei em ser professor era... Ensinar, eu era motivado por esse tipo de coisa, mas a carreira acadêmica está de tal forma que, para entrar na Universidade o camarada já deve ter feito Mestrado, Doutorado e acaba que o professor já entra na Universidade um pesquisador, então o ensino já inicia em segundo plano. E, termina que, quem dá muita aula, não progride na carreira... A Instituição força isso*".

Além disso, o tempo necessário para os estudantes cumprirem as longas e múltiplas tarefas escolares e para os professores cumprirem as suas atividades docentes – aulas, pesquisa, atividades administrativas e encargos burocráticos associados a essas atividades – não possibilita, em geral, que alunos e professores tenham muito "tempo de sobra" para atividades em comum, de caráter cultural, político ou de lazer. Isso acaba favorecendo e, às vezes, condicionando, a concentração de esforços de alunos e professores nas questões estritamente técnicas, em detrimento das questões mais gerais. Isso parece explicar, em boa parte, as dificuldades de ordem psicossociais relatadas pelos alunos da Pesquisa (LODER, 2009) e que, raramente, é objeto de discussão quando o assunto é a construção de estratégias pedagógicas mais adequadas à formação dos futuros engenheiros.

5 Conclusões

No presente artigo, focou-se a evolução de estudantes ao longo de um curso de engenharia tradicional a partir de um estudo longitudinal feito com estudantes de engenharia elétrica em uma universidade brasileira reconhecida, nacional e internacionalmente, pela qualidade de formação de seus egressos. A partir disso, conclui-se que, em geral, a opção por estratégias pedagógicas fundamentadas nos princípios da Aprendizagem Ativa (MASETTO, 2003) parece contribuir positivamente para a formação desses estudantes em todos os níveis de um curso de engenharia. No entanto, a eficácia dessas estratégias enquanto promotoras da autonomia e da transformação desse estudante em engenheiro requer um acompanhamento mais amiúde do professor que permita identificar o patamar de desenvolvimento psicológico, sociológico e intelectual desse estudante, sob pena de os esforços e os investimentos necessários para a implementação de estratégias ativas serem frustradas em seus propósitos.

6 Referências

CONFEA - Sistema Indústria. Sumário Analítico da Pesquisa: Mercado de Trabalho para o Engenheiro e Tecnólogo no Brasil. Disponível em: <http://www.confea.org.br> Acesso em 25 nov. 2008.

LODER, Liane L. Engenheiro em formação: o sujeito da aprendizagem e a construção do conhecimento em engenharia elétrica, 344 p., 2009. Tese (Doutorado) – Universidade Federal do Rio Grande do Sul.

MASETTO, Marcos. "Competências pedagógicas do professor universitário". São Paulo: Summus, 2003.

PIAGET, Jean. Intellectual evolution from adolescence and adulthood, Human Development, 15:1-12, 1972.

Survey about learning Technology in Logistics at the Faculty of Technology of Guarulhos - FATEC, São Paulo, Brazil based in one Gamified system

Milton Francisco de Brito[1], Robson Santos[1], Marcos Antonio Maia de Oliveira[1], Alexandre Formigoni[1], João Roberto Maiellaro [1], Caio Flavio Stettiner[2], Paulo Ramirez[3]

[1] Faculdade de Tecnologia de Guarulhos, São Paulo, Brazil
[2] Faculdade de Tecnologia de São Paulo - Sebrae, São Paulo, Brazil
[3] Instituto Federal de São Paulo, São Paulo, Brazil

Email: britomf@uol.com.br, robson@fatec.sp.gov.br, marcos.maia@fatec.sp.gov.br, alexandre.formigoni@fatec.sp.gov.br, joaomaiellaro@yahoo.com.br, caio.stettiner@fatec.sp.gov.br, pramirez@uol.com.br

Abstract

Assuming gamification as a system that uses elements of games and designers techniques in a context not game, and that the gamification has been an applied tool to promote behavioral change, it is understood that it may be applied to retain focused students in the disciplines studied. In this scenario, the study aims to know the perception of logistics course students from Guarulhos technology school in São Paulo, Brazil with the use of gamification for teaching and learning. From the perception to be raised by means of a questionnaire applied to the students and answered spontaneously, deploy a learning system content of gamification of course subjects aiming to decrease the dropout rate that today is around 30% in the first semester of the course. At the same time improve the quality of classes with the change of expository methodology for an interactive and shared methodology. It is expected that based on the perception of students is possible to develop and implement a learning system covering the objectives to be achieved, the design of behavior, innovate activities that provide real-time feedback of fun and exciting way for both students and for teachers.

Keywords: Education; Student involvement; Sharing; Gamification.

Pesquisa de opinião sobre aprendizagem de Tecnologia em Logística na Faculdade de Tecnologia de Guarulhos - FATEC, São Paulo, Brasil por meio de sistema Gamificado

Milton Francisco de Brito[1], Robson Santos[1], Marcos Antonio Maia de Oliveira[1], Alexandre Formigoni[1], João Roberto Maiellaro [1], Caio Flavio Stettiner[2], Paulo Ramirez[3]

[1] Faculdade de Tecnologia de Guarulhos, São Paulo, Brazil
[2] Faculdade de Tecnologia de São Paulo - Sebrae, São Paulo, Brazil
[3] Instituto Federal de São Paulo, São Paulo, Brazil

Email: britomf@uol.com.br, robson@fatec.sp.gov.br, marcos.maia@fatec.sp.gov.br, alexandre.formigoni@fatec.sp.gov.br, joaomaiellaro@yahoo.com.br, caio.stettiner@fatec.sp.gov.br, pramirez@uol.com.br

Resumo

Assumindo a gamificação como um sistema que usa elementos de jogos e técnicas de designers em um contexto de não jogo, e que a gamificação tem sido uma ferramenta aplicada para promover mudanças de comportamento, entende-se que esta poderá ser aplicada para reter estudantes focados nos conteúdos das disciplinas estudadas. Neste cenário o trabalho tem como objetivo conhecer a percepção dos alunos do curso de logística da faculdade de tecnologia de Guarulhos – FATEC, São Paulo, Brasil em relação ao uso da gamificação para o ensino e aprendizagem. A partir da percepção, a ser levantada por meio de questionário aplicado aos discentes e respondido espontaneamente, implantar um sistema de aprendizagem do conteúdo gamificado das disciplinas do curso tendo como objetivo diminuir o índice de evasão que hoje se encontra em torno de 30% no primeiro semestre do curso. Ao mesmo tempo melhorar a qualidade das aulas com a alteração da metodologia expositiva para uma metodologia interativa e compartilhada. Espera-se que com base na percepção dos discentes seja possível desenvolver e implantar um sistema de aprendizagem contemplando os objetivos a serem alcançados, o delineamento dos comportamentos, inovar com atividades que forneçam feedback em tempo real de forma divertida e prazerosa tanto para os alunos quanto para os professores.

Palavras-chaves: Ensino; Envolvimento de estudante; Compartilhamento; Gamificação.

1 Introdução

O processo ensino e aprendizagem há muito se apresenta como um enigma, diversos são os desafios a serem vencidos a fim de se atingir os objetivos desse processo. Se por um lado busca-se a convicção de se ter ensinado por outro a convicção de ser ter aprendido.

Muitos fatores contribuem para tornar um indivíduo em um aluno e este em um estudante, sabe-se que o universo de indivíduos que se tornam alunos é diferente daquele dos que se tornam estudantes. Dentre os muitos motivos identificados para essa não transformação de alunos em estudantes infere-se ser a ruptura do processo ensino aprendizagem devido à evasão escolar motivada, em parte, pela falta de atratividade das aulas ministradas.

Entende-se que o índice de evasão escolar esteja vinculado, dentre outros fatores, à metodologia aplicada em sala de aula, e tradicionalmente esta tem sido a expositiva. Com o passar do tempo e com o surgimento de novas tecnologias observa-se mudanças significativas no modelo de comportamento dos alunos, tanto dos que se tornam estudantes quanto daqueles que se limitam ao papel de alunos.

Neste cenário alguns autores, dentre eles Kaap (2012), apresenta uma nova técnica para o atingimento dos objetivos do processo ensino e aprendizagem, denominado *gamification*, que embora não haja uma tradução para o idioma português, neste artigo é referenciado como gamificação.

Simões, Redondo & Vilas (2013) afirmam que os estudantes de hoje tem uma relação próxima com a tecnologia e convivem com o mundo dos vídeos jogos, não só através da própria experiência de jogar, mas com toda a estética relacionada com esses ambientes digitais.

Em consonância com esses autores entende-se que a alteração da metodologia aplicada em sala de aula por uma metodologia com elementos da gamificação pode ser uma ação que contribua para reter alunos no ambiente escolar, além tornar o processo de aprendizagem mais prazeroso.

Assumindo que os resultados oriundos da gamificação tenham vínculo com a participação voluntária e espontânea por parte dos usuários desta, este artigo buscou conhecer a percepção do corpo discente do curso de Logística da Faculdade de Tecnologia de Guarulhos – FATEC, para, se favorável iniciar um projeto de gamificação das aulas ministradas às turmas iniciantes no curso, ou seja, dos primeiros e segundos semestres.

A fim de atingir tal objetivo foi elaborado questionário com questões cujas respostas, quando consolidadas evidenciem se pela percepção dos alunos há descontentamento com a metodologia atual e qual a expectativa caso haja mudança para uma metodologia com elementos da gamificação.

2 Gamificação

Werbach (2012) define gamificação como sendo aplicação de elementos e técnicas de design de jogos em contextos alheios aos jogos. Esse autor complementa sua definição apontando a existência de três partes nessa definição. A primeira são os elementos de jogo. A segunda são as técnicas de design dos jogos. E a terceira são contextos alheios aos jogos.

Assim, aceitando a definição dada por Werbach (2012), o contexto alheio ao jogo será o dado pela necessidade de transferência do conteúdo das disciplinas aos alunos em um ambiente que poderá ser a sala de aula ou não.

A aplicação das técnicas de design deverá ser literalmente estas quando da criação do ambiente de ensino e aprendizagem a ser proposto para aos alunos.

Os elementos de jogos, por analogia alguns já são utilizados tradicionalmente, como a atribuição de pontos aos que completarem as atividades solicitadas, a divulgação dos primeiros colocados quanto ao desempenho, entre outros.

Simões, Redondo & Vilas (2013) justificam que embora os estudantes de hoje tenham certa intimidade com a tecnologia, sentem-se pouco motivados pelas atividades e nesse cenário apresentam a gamificação da educação (Figura 1) como uma tentativa de resposta a essa falta de motivação.

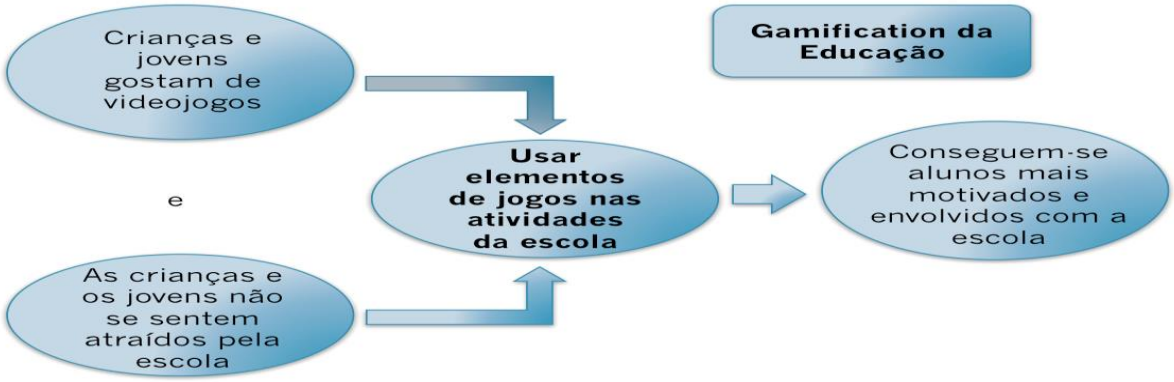


Figura 1 Aplicação da gamificação no contexto escolar – Fonte: Simões, Redondo & Vilas (2013)

Fardo (2013) afirma que "a gamificação é um fenômeno emergente e, por isso, existem poucos relatos de experiências empíricas em processos educacionais, devido ao fato de que os educadores precisam dominar bem essa linguagem antes de serem capazes de utilizá-la em seus projetos".

Nesse sentido, mesmo depois de vencido o desafio proposto aos docentes, o domínio da dinâmica da gamificação, não necessariamente a gamificação deverá apresentará bons resultados, pois os objetivos a serem

alcançados devem ser comuns, ou seja, tanto os docentes quanto o discentes precisam ter suas necessidades atendidas.

3 Pesquisa

A fim de conhecer a percepção dos alunos da FATEC Guarulhos a respeito da metodologia aplicada atualmente e a possibilidade de alteração para metodologia com elementos da gamificação, cujo objetivo maior é o engajamento proporcionado por esta, foi elaborado questionário com as questões a seguir envolvendo os alunos como elementos chaves para a tomada de decisão quanto à gamificação na educação. Antes dos discentes responderem às questões foi exposta a dinâmica da gamificação para que estes pudessem dar suas respostas comparando a metodogia atual com a proposta.

1. No geral, fico satisfeito com as aulas, nem satisfeito nem insatisfeito, ou insatisfeito?
2. Sinto-me animado para vir para a faculdade?
3. Geralmente fico tão envolvido com os assuntos apresentados nas aulas que o tempo passa muito rápido.
4. A metodologia de aulas expositivas usada pelos professores deveria ser alterada, pois as aulas poderiam ser melhores e menos cansativas.
5. Sentir-me-ia mais motivado se as aulas fossem ministradas por meio de jogos educacionais ou metodologia equivalente COM ou SEM o uso de computador e/ou aplicativos em celulares.
6. Independentemente da metodologia usada me sentiria mais motivado se recebesse feedback imediatamente após a execução das atividades solicitadas pelos professores, se possível em tempo real.
7. As aulas seriam muito melhores se houvesse algum tipo de competição entre os alunos da turma tendo como base o conteúdo ministrado.
8. As aulas seriam muito melhores se houvesse uma ferramenta que permitisse aos alunos compartilhar o aprendizado com os demais alunos do curso.
9. Se as aulas fossem mais divertidas e prazerosas meu aprendizado com certeza melhoraria.
10. Até que ponto você acredita que concluirá o curso?

Considerando certa dispersão de faixa etária e também a fim de se perceber possíveis diferenças de percepção entre os gêneros no mesmo questionário foram coletados dados referentes à idade e ao gênero.

Participaram como respondentes cento e dez alunos, representando aproximadamente 80% dos matriculados nos semestres objetos da pesquisa.

4 Resultados e Discussão

Considerando que a gamificação tem sido divulgada como uma nova ferramenta aceita pela nova geração, mas exigindo especificidade para aplicação de seus elementos ao público alvo foi mapeada a amostra quanto ao gênero e faixa etária, conforme se pode observar nos Gráficos 1 e 2 respectivamente.

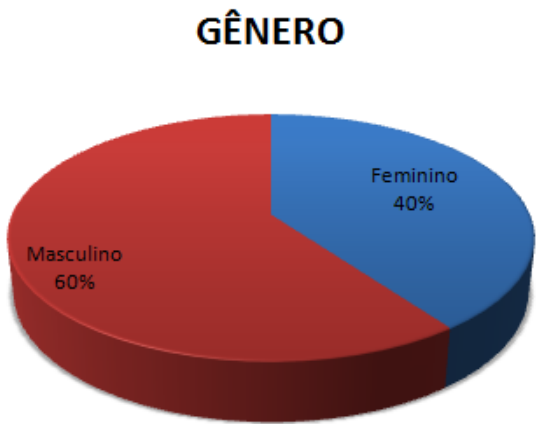


Gráfico 1: Gênero

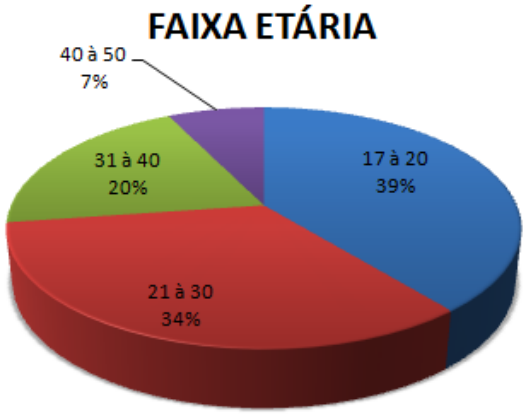


Gráfico 2: Faixa etária

Como se observa no gráfico 2, as faixas etárias de 17 a 20 e de 21 a 30 anos totalizam 83% dos respondentes, faixas estas consideradas adeptas das novas tecnologias, o que é favorável a aplicação da gamificação.

Independentemente da motivação às respostas dadas à questão sobre a intenção de concluir o curso, com duração de seis semestres e, que atualmente apresenta uma taxa de evasão de 30% aproximadamente, percebe-se que 17% daqueles que ainda estão ou no primeiro ou no segundo semestre já sugerem a possibilidade de evadirem-se do curso, conforme se visualiza no Gráfico 3.

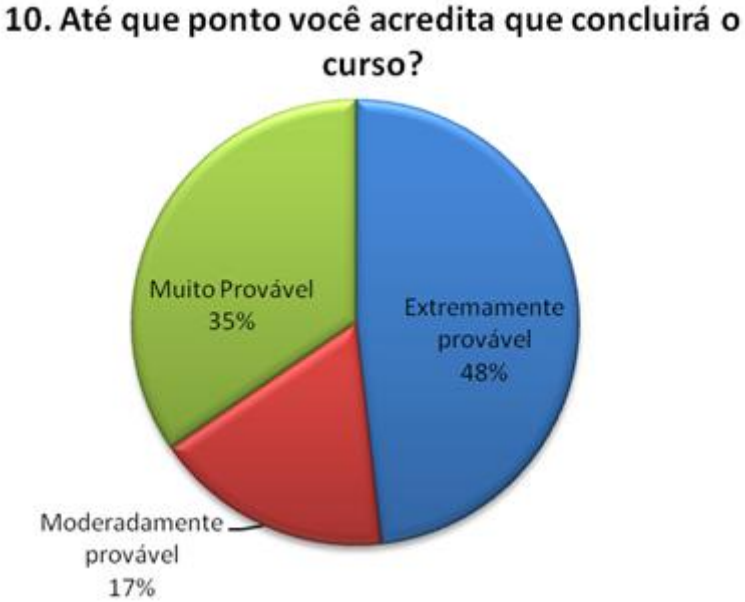


Gráfico 3: Possibilidade de evasão

Por outro lado também se observa que mesmo com a aplicação da metodologia atual, 83% darão o seu melhor a fim de concluir o curso.

Procurando conhecer o grau de concordância com a metodologia atual consolidou-se as respostas dadas às questões dois e três, sendo elas a 2. Sinto-me animado para vir para a faculdade; e a 3. Geralmente fico tão envolvido com os assuntos apresentados nas aulas que o tempo passa muito rápido e o resultado obtido pode ser observado no Gráfico 4.

Gráfico 4: Concordância com a metodologia atual

Considerando o percentual obtido para os que não se posicionam, 77% aceitam a metodologia tradicional.

Se aproximadamente 80% aceitam a metodologia atual, então a metodologia pode não participar com percentagem significativa para a evasão observada, ou seja, não seria ela a motivação para a evasão.

Assumindo que o uso da gamificação se destina à população jovem por esta já ter nascida na era digital, estratificou-se da população total aquela considerada jovem, ou seja, com idade entre 17 a 30 anos, que totalizam 83% dos envolvidos a fim de se verificar se a maior porcentagem dos que concordam com a metodologia atual esta nessa faixa ou na faixa superior. O resultado é o apresentado pelos Gráficos 5 e 6.

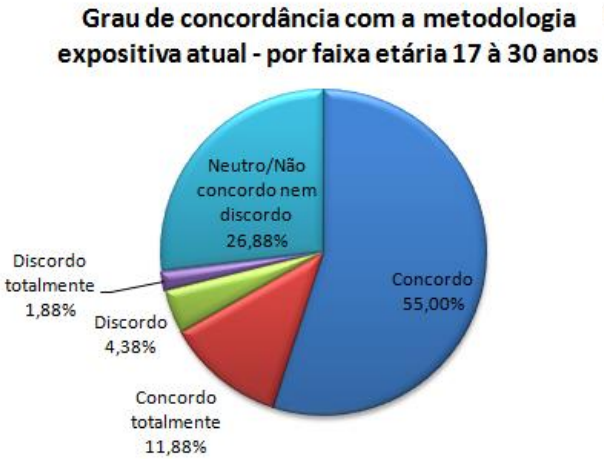


Gráfico 5: Concordância com a metodologia atual faixa etária entre 17 e 30 anos

Gráfico 6: Concordância com a metodologia atual faixa etária entre 31 e 50 anos

Nesse cenário observa-se que há equilíbrio quanto à aplicação da metodologia que vem sendo aplicada, independentemente da faixa etária envolvida.

Como existe nessa análise o componente neutro e os que não concordam com a metodologia atual, ou seja, para aproximadamente 40% sugere-se que uma mudança na metodologia seria aceita, isto é, considerando que para a parcela neutra a gamificação também seria bem vinda, verificou-se por meio da consolidação das

questões que contêm elementos da gamification o grau de aceitação dessa nova metodologia, conforme o Gráfico 7.

Gráfico 7: Concordância com metodologia gamificada

As perguntas que contêm elementos da gamificação que participaram para a composição do Gráfico 7 foram: 4. A metodologia de aulas expositivas usada pelos professores deveria ser alterada, pois as aulas poderiam ser melhores e menos cansativas; 5. Sentir-me-ia mais motivado se a aulas fossem ministradas por meio de jogos educacionais ou metodologia equivalente COM ou SEM o uso de computador e/ou aplicativos em celulares; 7. As aulas seriam muito melhores se houvesse algum tipo de competição entre os alunos da turma tendo como base o conteúdo ministrado; 8. As aulas seriam muito melhores se houvesse uma ferramenta que permitisse aos alunos compartilhar o aprendizado com os demais alunos do curso; e 9. Se as aulas fossem mais divertidas e prazerosas meu aprendizado com certeza melhoraria.

De acordo com as repostas dadas a essas questões, nota-se que para 81% a gamification poderia produzir bons resultados, assumindo-se que aceitação apontada contribuiria com o requisito participação voluntária em ambiente gamificado.

5 Conclusão

Tendo sido o objetivo de pesquisa conhecer a percepção dos alunos do curso de logística da faculdade de tecnologia de Guarulhos – FATEC, São Paulo, Brasil em relação ao uso da gamificação para o ensino e aprendizagem, usando para tanto questionário elaborado de acordo com os requisitos da gamificação e aplicado à população envolvida, assume-se que tal objetivo foi alcançado.

De acordo com os resultados obtidos e apresentados na seção resultados e discussão desse artigo, conclui-se que, embora não haja rejeição da metodologia aplicada atualmente, uma metodologia com elementos da gamificação seria aceita por 80% dos envolvidos.

Considerando que o percentual de respostas à alternativa: Neutro, nem concorda, nem discorda, gira em torno de 30% às perguntas, tanto àquelas que verificam a aceitação da metodologia atual quanto à metodologia proposta, pode inferir que esteja nessa população o índice de evasão medido. Nesse cenário programar um sistema de ensino e aprendizagem gamificado poderá contribuir para com a redução do índice evasão registrado.

Em continuidade a esse estudo sugere-se a determinação, também por meio de pesquisa, de quais elementos da gamificação seriam os que melhor atenderiam os anseios dos alunos do curso de Tecnologia em Logística oferecido pela Faculdade de Tecnologia de Guarulhos – FATEC.

6 Referências

Fardo, M. L. (2013). A gamificação aplicada em ambientes de aprendizagem.*RENOTE*, *11*(1).

Kapp, K. (2012). The Gamification of Learning and Instruction: Game-Based Methods and Strategies for Training and Education. San Francisco: Pfeiffer.

Simões, J., Redondo, R., Vilas, A., & Aguiar, A. (2013). Proposta de modelo de referência para aplicação de gamification em ambientes de aprendizagem social. Challenges 2013: Aprender a qualquer hora e em qualquer lugar, learning anityme anywhere, 1117-1128.

Werbach, K. & Hunter, D. (2012). For the Win: How Game Thinking Can Revolutionize Your Business, Wharton Digital Press.

Integration University and High Schools Program

Laurete Zanol Sauer[1], Isolda Gianni de Lima[1]

[1]Centro de Ciências Exatas e da Tecnologia, Universidade de Caxias do Sul, Brasil

Email: lzsauer@ucs.br, iglima@ucs.br

Abstract

High School teachers from Rio Grande do Sul, Brasil, are being called to study and provide training that includes cooperation with the world of work and production practices, according to documents from State Department and Ministry of Education, proposed as a study reference. Caxias do Sul teachers will be participate in the Integration University and High Schools Program, to be held at University of Caxias do Sul (UCS) in partnership with the Coordination of Education State, seeking guidance and theoretical support on pedagogical practices and management of education. Teachers of interested state school, will participate in the qualification course of the pedagogical work, proposed in three stages, focusing the theme: research projects as a methodological strategy and interdisciplinarity. The first step, Journey Didactic-Pedagogical Possibilities, will consist of a lecture with challenging approach to the planning of a learning situation based on research and evaluation. The teaching staff of each school will build, in outline, the situation who want to plan, guided by teachers of UCS and a high school teacher. As completion of the journey, the proposals considering the work of the teams will be presented. The second step is the collective work, at school, as continuity planning, also accompanied by guiding teachers. The third step will be to share and analyze the produced plans, giving rise to articles to be submitted in Science and Mathematics Education Symposium from Serra Gaucha, performed annually at the University of Caxias do Sul. The article is finalized pointing unfolding prospects of this program and the expected benefits from the academic future of undergraduate courses at the University of Caxias do Sul, especially engineering courses.

Keywords: University and High Schools; Research projects as a methodological strategy and of interdisciplinarity; Pedagogical practice planning.

Programa Integração Universidade e Escolas de Ensino Médio

Laurete Zanol Sauer[1], Isolda Gianni de Lima[1]

[1]Centro de Ciências Exatas e da Tecnologia, Universidade de Caxias do Sul, Brasil

Email: lzsauer@ucs.br, iglima@ucs.br

Resumo

Os professores de Ensino Médio do estado do Rio Grande do Sul estão sendo chamados a estudar e a providenciar uma formação que contemple articulação com o mundo do trabalho e práticas produtivas, segundo documentos da Secretaria Estadual e do Ministério da Educação, propostos como referenciais de estudos. Professores de Caxias do Sul poderão participar do Programa Integração Universidade e Escolas de Ensino Médio, a ser realizado na Universidade de Caxias do Sul em parceria com a Coordenadoria de Educação do estado do Rio Grande do Sul, visando à orientação e ao apoio teórico sobre práticas pedagógicas e gestão do ensino. Professores de escolas estaduais interessadas participarão do curso de qualificação, proposto em três etapas, com o tema: projetos de pesquisa como estratégia metodológica e de interdisciplinaridade. A primeira etapa, Jornada de possibilidades didático-pedagógicas, consistirá de uma palestra, com enfoque desafiador do planejamento de uma situação de aprendizagem com base em pesquisa e respectiva avaliação. A equipe de professores de cada escola construirá, em grandes linhas, a situação que pretendem planejar, orientada por professores da UCS e por um professor representante da escola. Como finalização da Jornada, serão apresentadas as propostas, considerando os trabalhos das equipes. A segunda etapa será de trabalho coletivo, na escola, como continuidade dos planejamentos, também acompanhado por professores orientadores da UCS. A terceira etapa será para compartilhar e analisar os planejamentos produzidos, dando origem a relatos e artigos a serem submetidos no Simpósio de Ensino de Ciências e Matemática da Serra Gaúcha, realizado anualmente na Universidade de Caxias do Sul. Finaliza-se o artigo apontando para perspectivas de desdobramento deste Programa e para os benefícios esperados, junto aos futuros acadêmicos de cursos de graduação da Universidade de Caxias do Sul, especialmente dos cursos de Engenharia.

Palavras-chave: Universidade e Escolas de Ensino Médio; Projetos de Pesquisa como estratégia metodológica e de interdisciplinaridade; Planejamento da prática pedagógica.

1 Introdução

Neste artigo é apresentado o planejamento do Programa Integração Universidade e Escolas de Ensino Médio, a ser realizado na Universidade de Caxias do Sul, em parceria com a 4ª. Coordenadoria Regional da Secretaria Estadual de Educação do Rio Grande do Sul. Tal planejamento é resultado de uma demanda recebida, por parte da comunidade de professores estaduais, no contexto da formação continuada, proposta pelo Pacto Nacional pelo Fortalecimento do Ensino Médio, com base no Plano Nacional de Educação (Brasil, 2014).

Justifica-se o atendimento à referida demanda, por meio do Programa Integração Universidade e Escolas de Ensino Médio, considerando a importância da formação continuada de professores de Ensino Médio para atuarem em conformidade com as orientações das atuais políticas nacionais de educação, em que ambientes tradicionais de aprendizagem precisam dar lugar a ambientes de pesquisa e de autoaprendizagem, que possibilitem o desenvolvimento de competências imprescindíveis para que os estudantes de hoje possam enfrentar, com melhores condições, problemas que ainda não são conhecidos. A capacitação dos professores torna-se, então, imprescindível para que a formação de estudantes, em nível de Ensino Médio, colabore para uma educação de qualidade em nível de graduação. No que diz respeito à Educação em Engenharia, tem-se vivenciado uma realidade em que estudantes passivos não consideram a importância de assumirem, com responsabilidade, a condução da própria formação.

No que se refere aos antecedentes da proposta deste Programa, considerou-se os resultados positivos já obtidos em atividades que vêm sendo desenvolvidas junto ao Programa de Pós-Graduação em Ensino de Ciências e Matemática da Universidade de Caxias do Sul. Os estudantes desse Programa, em sua maioria, são professores das redes municipal e estadual de Ensino Fundamental e Médio. Uma destas atividades foi o curso

para formação de professores com enfoque na aprendizagem baseada em projetos interdisciplinares (Project-Based Learning - PBL), do qual participaram professores do Ensino Fundamental e Médio de várias áreas de conhecimento (Matemática, Física, Química, Biologia, Português e Informática). O mesmo foi o tema do artigo Aprendizagem Baseada em Projetos Interdisciplinares na Formação de Professores de Ciências e Matemática apresentado no PAEE 2015 (Villas-Boas et al., 2015).

Como resultado daquela iniciativa, concluiu-se que o professor necessita de conhecimentos, práticas e análises de estratégias que vão além da sua formação inicial, ou seja, ele necessita de uma formação continuada, que implica na continuidade da formação profissional, proporcionando-lhe que conviva em espaços de reflexão sobre possibilidades de aprimorar o trabalho pedagógico. Esta formação continuada, como um processo de construção permanente de conhecimento e desenvolvimento profissional, pode motivar a realização de práticas pedagógicas interdisciplinares voltadas à pesquisa e ao uso de tecnologias, como metodologias de ensino e aprendizagem.

Considerando as várias mudanças que vêm sendo propostas no Brasil, aos sistemas educacionais, a nível estadual e nacional, é essencial que sejam criadas oportunidades para que os professores se capacitem e possam assumir o papel de mediadores em sala de aula.

Nesse contexto, entende-se ser necessário auxiliar os professores para atuarem, de modo a envolver seus estudantes ativamente nos processos de ensino e de aprendizagem, favorecendo a construção coletiva de ambientes de interação entre colegas, com professores, com conhecimentos e com a comunidade onde estão inseridos. Entende-se que tais espaços de aprendizagem são mais propícios à construção de novos conhecimentos e ao desenvolvimento de habilidades, atitudes e comportamentos para uma formação humana e social adequada aos cenários de trabalho que os estudantes encontrarão ao concluírem os estudos no Ensino Médio, cuja tendência é de que sejam, sempre mais, de convívio em equipes e de conhecimentos e ações interdisciplinares. Ao mesmo tempo, ampliam-se as possibilidades de que se sintam seguros e aptos a continuar a sua formação no Ensino Superior.

Diante dessas considerações apresenta-se, a seguir, a descrição do Programa Integração Universidade e Escolas de Ensino Médio, a ser desenvolvido em três etapas, descritas nas seções 2 e 3, num total de 40 horas. Espera-se que esta seja a primeira edição do Programa, por meio do qual, em cada nova edição, seja possível contar com a participação de um público de até 60 professores, preferivelmente de escolas diferentes, da região de abrangência da 4ª. Coordenadoria Regional de Educação, do estado do Rio Grande do Sul, Brasil. Finaliza-se este artigo com Considerações Finais em que se aponta para perspectivas de desdobramento deste Programa e para benefícios esperados, tanto em relação aos estudantes de Ensino Médio, como junto aos futuros acadêmicos de cursos de graduação da Universidade de Caxias do Sul, especialmente dos cursos de Engenharia.

2 Jornada de possibilidades didático-pedagógicas

No Programa Integração Universidade e Escolas de Ensino Médio tem-se como objetivo propiciar, aos professores participantes, orientação e apoio teórico, discussão e reflexões sobre práticas pedagógicas e gestão do ensino. O foco desta formação consiste no planejamento dos processos de ensino e aprendizagem por áreas do conhecimento, tendo a pesquisa como princípio pedagógico e as metodologias ativas como princípio didático.

Para a produção coletiva dos planejamentos, entre professores de diversas áreas, pretende-se que os professores levem em conta os componentes curriculares de cada área.

Para integrar o Programa junto às escolas, a Universidade de Caxias do Sul conta com uma equipe de professores de diversas áreas, com potencial para colaborar na qualificação do trabalho pedagógico no Ensino Médio.

Ao se denominar Programa, ao invés de identificar esta proposta como curso, oficina ou seminário, por exemplo, destaca-se o fato de que são consideradas diversas atividades, com características próprias das diferentes especificidades de ações, no desenvolvimento da formação continuada.

Assim, com um cronograma em três etapas, o Programa será desenvolvido em 40 horas, destinadas para atividades colaborativas de desenvolvimento de projetos e de planejamento coletivo, em cada uma das escolas de Ensino Médio, além de encontros na UCS, envolvendo todos os participantes.

A primeira etapa – Jornada de possibilidades didático-pedagógicas – descrita nesta seção, será realizada na Universidade de Caxias do Sul, em um dia, com dois turnos de trabalho. Essa Jornada inclui uma palestra e a realização de uma oficina, que terá duas partes. A primeira parte será de planejamento coletivo, por equipes, de uma situação de aprendizagem com base na pesquisa, e respectiva proposta de avaliação; a segunda parte será para a apresentação, pelas equipes de professores de cada escola, das conclusões e encaminhamentos para o trabalho a ser realizado, visando ao aprimoramento, finalização e aplicação do planejamento coletivo.

Em consonância com o Pacto Nacional pelo Fortalecimento do Ensino Médio, a formação continuada de professores precisa colocar em foco a organização do trabalho pedagógico, com o objetivo de levar os professores e coordenadores pedagógicos a refletirem e a interpretarem a importância da sua participação nessa organização (Brasil, 2013a).

Da mesma forma, a atual Proposta Pedagógica para o Ensino Médio Politécnico e Educação Profissional Integrada ao Ensino Médio, no estado do Rio Grande do Sul, convoca os professores para planejarem e efetivarem a prática docente com novo paradigma, de articulação nas áreas e entre as áreas de conhecimento e suas tecnologias, visando a uma formação interdisciplinar e que propicie aos estudantes a construção de projetos de vida pessoais e coletivos (SEDUC, 2011).

Ambas as propostas visam melhorar a educação, esperando que os professores modifiquem as práticas educacionais, com novas formas de seleção e organização dos conteúdos, a partir da prática social, aproximando da escola a vivência dos estudantes, por meio do estreitamento da relação entre teoria e prática, da contextualização e com metodologias que atribuem ao estudante um papel ativo no processo de aprendizagem.

Com isso, nessa Jornada que dará início às atividades do Programa, são previstas a sensibilização e a mobilização dos professores para a formação continuada, e terá como tema: Projetos de pesquisa como estratégia metodológica e de interdisciplinaridade. O propósito, com esse tema da prática cotidiana dos professores, é auxiliar, com reflexões e discussões colaborativas, os professores que atuam numa mesma escola, a tramar a rede de conhecimentos escolares que podem compor as propostas de situações de aprendizagem com base em pesquisa, a serem arquitetadas nas oficinas, como primeiras combinações e ações de organização do planejamento coletivo da ação docente.

No decorrer desta jornada que dará início ao Programa, os professores ministrantes considerarão, de forma transversal, as orientações das Diretrizes Curriculares Nacionais para o Ensino Médio (Brasil, 2013b) e as discussões e contribuições dos brasileiros para a construção de uma Base Nacional Comum Curricular (Brasil, 2015) para a Educação Básica, além de materiais disponíveis sobre o Pacto Nacional pelo Fortalecimento do Ensino Médio (Brasil, 2013a).

Ao pautar-se pela pesquisa como princípio pedagógico, coloca-se o jovem como protagonista e o maior interessado nos conhecimentos que deseja e precisa construir. Assim, em cada área, e entre as áreas, é preciso construir um diálogo para eleger conteúdos e metodologias ativas que colaborem para uma formação adequada e aspirada pelos jovens, animando-os e auxiliando-os, também, a seguirem a sua formação profissional em nível superior, confiantes de que podem ser engenheiros, professores, médicos ou quaisquer outros profissionais que almejam tornarem-se.

Assim sendo, a Jornada de possibilidades didático-pedagógicas marca as atividades de início do Programa, quando todas as equipes apresentam, ao grande grupo, as situações de aprendizagem planejadas com base em pesquisa, visando compartilhar possibilidades vislumbradas e esclarecer possíveis dúvidas, tomando decisões com base nas discussões e orientações que certamente poderão auxiliar na tomada de decisões. Todos os professores orientadores participarão dessa etapa, com contribuições, levando em conta o que foi trabalhado com as equipes.

3 A pesquisa na escola como estratégia metodológica e de interdisciplinaridade

A necessidade de repensar o Ensino Médio, não somente no estado do Rio Grande do Sul, mas em todo o Brasil, justifica-se pela importância de contemplar, na formação continuada de professores, "a qualificação, a articulação com o mundo do trabalho e práticas produtivas, com responsabilidade e sustentabilidade e com qualidade cidadã" (Rio Grande do Sul, p.4). Para tanto, a pesquisa, como princípio pedagógico, é um dos norteadores estabelecidos como metas a serem alcançadas.

Assim entendida, a pesquisa é "o processo que, integrado ao cotidiano da escola, garante a apropriação adequada da realidade, assim como projeta possibilidades de intervenção. Alia o caráter social ao protagonismo dos sujeitos pesquisadores" (Rio Grande do Sul, p.20), auxiliando-os a se tornarem críticos e reflexivos.

Segundo pressupostos teóricos considerados para na elaboração das atuais Diretrizes Curriculares Nacionais para o Ensino Médio do CNE, no que se refere à pesquisa como princípio pedagógico, destaca-se que:

> [...] a pesquisa propicia o desenvolvimento da atitude científica, o que significa contribuir, entre outros aspectos, para o desenvolvimento de condições de, ao longo da vida, interpretar, analisar, criticar, refletir, rejeitar ideias fechadas, aprender, buscar soluções e propor alternativas, potencializadas pela investigação e pela responsabilidade ética assumida diante das questões políticas, sociais, culturais e econômicas [...] uma concepção de investigação científica que motiva e orienta projetos de ação, visando à melhoria da coletividade e ao bem comum (UNESCO, 2011).

Dessa forma, entende-se que a pesquisa, como prática pedagógica, pode proporcionar a construção de novos conhecimentos, por meio da possibilidade de articulação entre várias áreas de conhecimento.

Diante dessas considerações, na atual proposta para o Ensino Médio no Rio Grande do Sul, a disciplina de Seminário Integrado visa promover a articulação entre as áreas, por meio do desenvolvimento de pesquisas, visando à integração de professores em projetos comuns, o que pode ser entendido como uma prática interdisciplinar. Entretanto, tem-se observado a dificuldade dos professores em interagir e compreender a proposta da disciplina de Seminário Integrado.

Assim sendo, com o espaço de discussão a ser promovido no Programa Integração Universidade e Escolas de Ensino Médio, espera-se colaborar, no sentido de fornecer orientações e subsídios teóricos, de forma que os professores possam planejar e colocar em prática projetos interdisciplinares que considerem adequados à realidade dos estudantes, levando em consideração o contexto social da comunidade em que a escola está inserida e as aspirações desses jovens quanto ao seu futuro.

Tem-se como um dos objetivos do Programa, nesta etapa, a orientação e o apoio teórico necessários, por meio de reflexões e discussões sobre práticas pedagógicas e gestão do ensino nas escolas participantes, visando colaborar, também, para o alinhamento dos respectivos projetos pedagógicos com a legislação vigente.

Como metodologia para a realização desta etapa, que acontecerá em cada escola, está sendo prevista a organização de grupos de acompanhamento e orientação, com a presença, sempre que possível, de um professor de cada área, em cada uma das equipes de professores em formação. Um professor orientador, em cada equipe, acompanhará as discussões, colaborando, na medida do interesse e necessidade da equipe, que deverá selecionar um tema de pesquisa e planejar situações de aprendizagem, construindo a metodologia a ser empregada e formas e instrumentos coerentes de avaliação.

Destaca-se que para os momentos de planejamento coletivo de cada equipe de professores, está prevista a presença de um professor orientador, de cada área de conhecimento, a saber: Matemática, Física/Astronomia, Tecnologias, Química, Biologia, Pedagogia, História, Educação, Filosofia, Português, Literatura, Línguas,

Geografia, Sociologia, Pedagogia e Psicologia. Independente do número de equipes formadas, os professores orientadores das diferentes áreas atuarão em sistema de revezamento, de modo a atender as demandas específicas do planejamento e das pesquisas, no que se refere a cada área de conhecimento.

Nessa etapa da implementação, em cada escola, da pesquisa planejada, professores orientadores de diferentes áreas, farão visitas às escolas, com vistas ao acompanhamento e discussões com os professores, na realização das ações necessárias junto aos estudantes. Tais visitas serão agendadas, por demanda de necessidades dos professores participantes, entendendo-se que a participação em determinada(s) área(s) de conhecimento dependerá do tema de pesquisa escolhido.

Conclui-se com novo encontro presencial, em que todas as pesquisas, em andamento, ou já concluídas, serão apresentadas ao grande grupo, dada a importância de compartilhar novas possibilidades, conforme se justifica na próxima seção.

4 Considerações finais

A escola centrada no aluno ou na aprendizagem é vista como um dilema. (Nóvoa, 2007). E ao defender a escola centrada na aprendizagem, Nóvoa argumenta que a prioridade dos docentes deve ser a "aprendizagem dos estudantes". Ao destacar a aprendizagem dos estudantes como foco, sugere deixar de lado a ideia de que eles precisam aprender tudo na escola. Entretanto, recomenda levar para dentro da escola, por meio da renovação dos currículos, problemas enfrentados pela sociedade, lançando o desafio de propor-lhes soluções. Para isso, concorda-se com Nóvoa, ao afirmar que a formação continuada de professores precisa centrar-se nas práticas e na análise e avaliação das ações docentes.

Freire (1996) explica que a formação continuada de professores em serviço não pode ser um acúmulo de palestras, cursos, oficinas, seminários, leituras, mas deve ser concebida como uma reflexão crítica entre o fazer e o pensar sobre o fazer.

Para Becker (2012), a construção de conhecimento ocorre na relação professor-aluno-objeto de conhecimento. Desta forma, a aprendizagem tem boas chances para ocorrer em ambientes de pesquisa, em que estudantes são protagonistas principais no processo de construção do próprio conhecimento. Ambientes de aprendizagem com base em pesquisa podem ser fontes de motivação. Esta, por sua vez, assim como outros resultados de pesquisas em neurociências, sobre o funcionamento do cérebro, tem sido apontada como um componente relevante para a aprendizagem, pois envolve interesse e dedicação. Quando a motivação é desencadeada pelo interesse em atuar, em interação com os colegas, como é o caso de ambientes de aprendizagem com base em pesquisa, o professor pode atuar como mediador, auxiliando os estudantes para que cheguem às próprias conclusões (Santos & Carreno, 2010).

Entende-se, assim, que a formação continuada de professores, por meio do Programa Integração Universidade e Escolas de Ensino Médio, aqui descrito, em que, ao invés de treinamento de professores, propõe-se a realização de atividades acompanhadas com análises, estudos e discussões, poderá provocar mudanças pedagógicas benéficas aos estudantes e que atendam às novas exigências para a educação na atualidade.

Assim sendo, a etapa final do Programa prevê novo encontro entre todos os participantes, a fim de relatarem ao grande grupo todo o processo que envolveu o planejamento, a realização, a análise e a avaliação das pesquisas realizadas nas respectivas escolas. Considera-se indispensável esta etapa, como forma de compartilhar dificuldades vivenciadas pelos participantes, bem como possibilidades de superá-las, além dos sucessos alcançados e possíveis justificativas para os mesmos.

Como produto final, condição para a certificação de participação no Programa, todos os professores participantes deverão apresentar um relatório, que poderá dar origem a um artigo a ser submetido no Simpósio de Ensino de Ciências e Matemática da Serra Gaúcha, realizado anualmente, na Universidade de Caxias do Sul. Entende-se que o referido artigo poderá ser de relato do planejamento e andamento das atividades da pesquisa ainda em desenvolvimento ou de descrição do planejamento com resultados e avaliação da pesquisa realizada, se essa estiver concluída. De qualquer forma, para cada edição do Programa,

desde a primeira, será organizado um livro, contendo todas as produções, a ser colocado a disposição de todas as escolas participantes. Cada capítulo será o relato da pesquisa realizada em cada escola.

Espera-se que as ações do Programa Integração Universidade e Escolas de Ensino Médio causem impacto na educação superior, atraindo estudantes mais autônomos em relação ao processo de aprendizagem, com iniciativa e responsabilidade sobre a própria aprendizagem e com melhores condições para o desenvolvimento de competências, como as requeridas na Educação em Engenharia.

5 Referências

Brasil. Ministério da Educação. Pacto Nacional pelo Fortalecimento do Ensino Médio. Brasília, DF: MEC/SEB. 2013a. Disponível em: <http://pactoensinomedio.mec.gov.br/images/pdf/pacto_fort_ensino_medio.pdf>. Acesso: 12 jan. 2016.

Brasil. Ministério da Educação. Diretrizes Curriculares Nacionais Gerais da Educação Básica. Brasília, DF: MEC/SEB/Dicei, 2013b.

Brasil. Ministério da Educação. Base Nacional Comum Curricular, 2015. Disponível em: http://basenacionalcomum.mec.gov.br/#/site/contribuicao-dados#conteudo-principal. Acesso: mar. 2016.

Brasil. Ministério da Educação. Plano Nacional da Educação, 2014. Disponível em: http://pne.mec.gov.br/. Acesso: fev. 2016.

Becker, F. Epistemologia do professor de matemática. (2012). Petrópolis, RJ: Vozes.

Freire, P. Pedagogia da Autonomia: saberes necessários à prática educativa (1996). 8.ed. Rio de Janeiro: Paz e Terra.

Nóvoa, A. Desafios do trabalho do professor no mundo contemporâneo. Palestra proferida no SINPRO SP. Sindicato dos Professores de São Paulo: Janeiro de 2007.

Rio Grande do Sul. (2011) Proposta Pedagógica para o Ensino Médio Politécnico e Educação Profissional Integrada ao Ensino Médio - 2011-2014. Porto Alegre: Secretaria de Educação.

Santos, B. S; Carreno, A. B. A motivação em diferentes cenários. Porto Alegre: EDIPUCRS, 2010.

Secretaria de Educação do estado do Rio Grande do Sul (SEDUC). Proposta pedagógica para o Ensino Médio Politécnico e Educação Profissional integrada ao Ensino Médio – 2011 – 2014. Porto Alegre, 2011.

UNESCO. Protótipos Curriculares de Ensino Médio e Ensino Médio Integrado: Resumo Executivo. Brasília, Debates ED, n.1, maio 2011.

Villas-Boas, V., Sauer, L. Z., Booth, I. A. S., Lima, I. G., Cunha, G. F., Giovannini, O & Mesquita, D. (2015). Interdisciplinary Project-Based Learning in the Professional Development of Science and Mathematics' Teachers. Proceedings of the International Symposium on Project Approaches in Engineering Education (PAEE2015), Donostia - San Sebastian - Spain.

PAEE/ALE'2016 Full Papers Submissions (Spanish)

Submissions accepted for the PAEE/ALE'2016 papers sessions in Spanish.

The use of Project Based Learning (PBL) by Engineering Students, in Real Learning Environments to Apply the Methodology of the 5S to Improve Work Areas

Francisco Hernández Vázquez Mellado[1], Miriam V. Chan Pavón[1], Jesús Escalante Euán[1].

[1]Cuerpo Académico de Ingeniería en Sistemas de Producción y Logística, Universidad Autónoma de Yucatán, Facultad de Ingeniería Química, Yucatán, México.

Email: francisco.hernandez@correo.uady.mx, cpavon@correo.uady.mx, jesus.escalante@correo.uady.mx

Abstract

"Using the statistical approach to quality control, a group of engineering students implemented four stages of the Japanese 5S methodology. The results of this learning activity are those described in this study.

The research design applied the approach of Project-Based Learning, which aims to enhance the capabilities of self-learning, developing some primary skills according to Galeana (2006), such as: collaborative work, analytical skills, ability learn effectively, social skills, work discipline and the basis for applying a methodology.

The project was developed starting with the integration of a team that identified a local company that had a practical work area for the implementation of the methodology; after obtaining the acceptance of the owner, the following stages were applied: Classification, Organization, Cleaning and Standardization, which were graphically documented so that at the end could contrast a "before" and "after".

The team presented a project report which highlighted the benefits as well as their learning experience. The product was designing a poster to disseminate best practices as a tool to sensitize the staff of the company on the benefits of keeping their areas organized and clean work to improve productivity work."

Keywords: Project Based Learning; 5S; Improving Areas; Productivity; Teamwork; Quality.

Utilización del Aprendizaje Basado en Proyectos (PBL) por Estudiantes de Ingeniería Aplicando la Metodología de las 5S para el Mejoramiento de Áreas de Trabajo, en Escenarios Reales

Francisco Hernández Vázquez Mellado[1], Miriam V. Chan Pavón[1], Jesús Escalante Euán[1].

[1]Cuerpo Académico de Ingeniería en Sistemas de Producción y Logística, Universidad Autónoma de Yucatán, Facultad de Ingeniería Química, Yucatán, México.

Email: francisco.hernandez@correo.uady.mx, cpavon@correo.uady.mx, jesus.escalante@correo.uady.mx

Resumen

"Mediante el enfoque estadístico para el control de la calidad, un grupo de estudiantes de ingeniería implementaron cuatro etapas de la metodología japonesa denominada "Cinco eses" (5S). Los resultados de esta actividad de aprendizaje son las que describimos en este estudio.

El diseño de la investigación utilizó el Aprendizaje Basado en Proyectos, cuyo objetivo es potenciar las capacidades de auto aprendizaje, desarrollando algunas competencias primarias, de acuerdo con Galeana (2006), como son: el trabajo colaborativo, capacidad de análisis, capacidad de aprender eficazmente, habilidades sociales, trabajo disciplinar y las bases para aplicar una metodología.

La gestión del proyecto definió en sus primeras etapas, la integración de un equipo de trabajo, la segunda fue identificar el problema a resolver, definir un plan de acción y finalmente la ejecución de las siguientes fases: Clasificación Organización, Limpieza y Estandarización; cada una de las fases fueron documentas para que al final se pudiera contrastar un "antes" y "después" del proyecto.

El equipo presentó un informe del proyecto en donde resaltaron los beneficios obtenidos así como su experiencia de aprendizaje. Como producto se incluyó el diseño de un poster para difundir esta metodología como una mejor práctica y como herramienta para concientizar al personal de la empresa respecto a los beneficios de tener áreas de trabajo organizadas y limpias para mejorar la productividad laboral."

Keywords: Aprendizaje basado en proyectos, 5S, mejoramiento de áreas, productividad, trabajo en equipo, calidad.

1 Introducción

El Aprendizaje Basado en Proyectos, por sus siglas en inglés (PBL), de acuerdo con Galeana (2006), se orienta hacia la realización de un proyecto o plan siguiendo el enfoque de diseño de proyectos. Las actividades se orientan a la planeación de la solución de un problema complejo; el trabajo se lleva a cabo en grupos; los estudiantes tienen mayor autonomía que en una clase tradicional y hacen uso de diversos recursos. El aprendizaje prepara a los estudiantes para trabajar en un ambiente y en una economía global diversa y, según Méndez I (2016), este método de aprendizaje por proyectos es necesario para que el alumno ponga en práctica sus conocimientos así como para desarrollar e incrementar sus competencias profesionales.

Por otra parte, Monden (1991) indica que las organizaciones, cuando están en tiempos de prosperidad, tienden a dejar de darle importancia a la mano de obra, dinero, espacio, tiempo, información, etc. Sin embargo, cuando las empresas están en competencia hacen énfasis inmediato en tratar de mejorar sus áreas de oportunidad para mejorar la organización e incrementar sus beneficios. Es así que los japoneses llegaron a la conclusión de que cualquier mejora debe ser constante sin importar si son tiempos de prosperidad o adversos; por consiguiente, la aplicación continua de las actividades de mejora abre paso a la metodología denominada como "5S", la cual se traduce en un conjunto de actividades que coadyuva a la mejora integral de las áreas de trabajo de cualquier organización.

El nombre genérico de la metodología proviene de las cinco palabras japonesas con las cuales se le denomina a sus 5 etapas, ya que todas inician con la letra "s": Seiri (clasificar), Seiton (organizar), Seiso (limpiar), Seiketsu (estandarizar) y Shitsuke (disciplina). La implementación de la metodología de las 5S es muy importante en al

ámbito de la calidad porque se considera una herramienta fundamental e inicial para el desarrollo y mantenimiento de un sistema de gestión de la calidad; asimismo a esta metodología se le considera una plataforma básica para iniciar proyectos de mejora continua de procesos, productos y servicios dentro de cualquier organización por lo cual requiere de continuidad, enfoque, atención y compromiso dentro de la misma (Tague, 2005).

Cabe destacar que esta metodología es parte también de un concepto mayor denominado como "Visual Management" (Kingery, 2002), o Gestión Visual en español, como uno de los tres pasos para lograr implementar esta técnica y obtener los beneficios de prevenir y detectar errores que resultan por no mantener limpias y organizadas las áreas de trabajo, tanto productivas como administrativas.

En la Facultad de Ingeniería Química de la Universidad Autónoma de Yucatán (UADY), existen dos modelos educativos con los que se trabaja actualmente: el "Modelo Educativo y Académico" (MEyA) (Universidad Autónoma de Yucatán, 2002) y el "Modelo Educativo para la Formación Integral" (MEFI) (Universidad Autónoma de Yucatán, 2012); ambos mantienen una postura hacia la estrategia de aprendizaje basada en proyectos. De acuerdo con De Miguel (2006), para el plan MEFI, el aprendizaje orientado a proyectos consiste en acercar una realidad concreta a un ambiente académico por medio de la realización de un proyecto de trabajo con la finalidad de resolver problemas a partir de soluciones abiertas que permitan la generación de nuevos conocimientos.

Con fundamento en esta estrategia de aprendizaje, en las asignaturas de "Control estadístico de la calidad" y de "Control total de la calidad", cursadas por alumnos de las licenciaturas de Ingeniería de la Facultad, se les asigna como actividad final de aprendizaje de dichas asignaturas la implementación de las 4 primeras "eses" de dicha metodología en una organización local, para poner en práctica los conocimientos adquiridos en el aula y para descubrir por sí mismos los beneficios de esta herramienta básica para la gestión de la calidad.

2 Contexto y Objetivo

La actividad de aprendizaje se solicitó a los alumnos que cursan las carreras de Ingeniería Química Industrial, Ingeniería en Biotecnología e Ingeniería Industrial Logística; la realización del proyecto final de la asignatura se implementó desde hace más de 3 años por lo que se cuenta con varios semestres de resultados y evidencias de su aplicación en diferentes ámbitos y tipo de organizaciones.

El objetivo principal del proyecto es que los alumnos apliquen la metodología de las 5S en un área de trabajo de una organización local para que dominen la competencia de su utilización y aplicación en un escenario real. Una variante del proyecto es que los alumnos elaboren un poster (cartel) para difundir la utilización de esta metodología. Como parte de las especificaciones de este proyecto se establece una fecha para la entrega de un reporte final y el plazo para la realización es de 3 semanas.

Cabe mencionar que el alcance del proyecto se limita a la implementación de las primeras "4 eses" (cuatro etapas) de la metodología; no se le solicita a los alumnos realizar la quinta etapa ("disciplina") ya que esta última consiste en actividades para asegurar que las personas que trabajan en el área obtengan el hábito de sujetarse a los estándares establecidos para mantener lo logrado con las etapas anteriores. Esto implicaría realizar actividades de concientización, mediciones y evaluaciones constantes en el área del proyecto que están fuera de las posibilidades de los alumnos considerando el plazo del proyecto.

3 Descripción del proyecto

El proyecto asignado a los alumnos consta de seis etapas las cuales se especifican en la Figura 1.

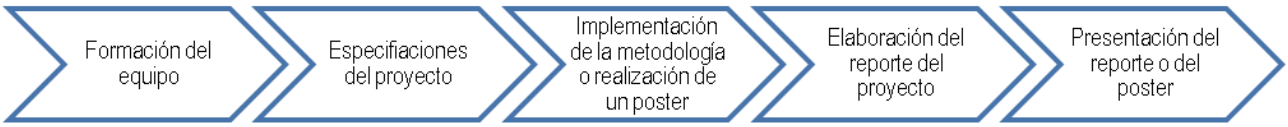


Figura 1. Etapas del proyecto, elaboración propia.

3.1 Formación del equipo.

Dependiendo de la cantidad de alumnos inscritos a las asignaturas previamente mencionadas, y con la finalidad de que la integración a un equipo de trabajo sea diversa, se seleccionó a los alumnos al azar a través de sus apellidos en la lista de asistencia con lo cual se integraron equipos con un promedio de cinco miembros. Cabe aclarar que en ocasiones los alumnos proponen libremente quiénes integrarán cada equipo con el consenso de todo el grupo.

3.2 Especificaciones del proyecto.

3.2.1 Para la elaboración de un poster para la difusión de la metodología de las "5S".

El poster debe presentar imágenes o dibujos animados originales (no bajados de internet) que ilustren las actividades que se realizan en cada una de las etapas de la metodología. El poster debe ser divido en seis secciones cada una de las cuáles corresponde a una etapa de la metodología (Kingery, 2002) y debe ser identificada como sigue:

- Sección 1: "Situación típica del área de trabajo".
- Sección 2: "1S-Seiri (Clasificar). Separar lo necesario de lo innecesario".
- Sección 3: "2S-Seiton (Organizar). Asignar un lugar a cada cosa y situar cada cosa en su lugar".
- Sección 4: "3S-Seiso (Limpiar). Mantener el área siempre limpia y libre de obstáculos".
- Sección 5: "4S-Seiketsu (Estandarizar). Establecer reglas, límites y procedimientos para cumplir las tres primeras eses".
- Sección 6: "5S-Shitsuke (Disciplina). Asegurar hacerlo siempre para que sea un hábito".

De igual manera debe llevar un encabezado con la leyenda "Aplicación de la metodología de las 5S en {*especificar el área*}", y en la parte inferior un pie de poster donde se destaca que fue realizado por alumnos de la licenciatura correspondiente de la Facultad de Ingeniería Química de la UADY e incluye el nombre de los integrantes del equipo y la fecha de realización. Los materiales que se deben utilizar para el poster son los siguientes:

- Lona (con agujeros en las esquinas para poder sujetarla).
- Medidas del poster: 60 cm de ancho x 95 cm de largo.
- Utilizar un tipo y tamaño de letra, así como los fondos y los colores apropiados para que el poster sea legible y llamativo.
- Emplear software para su diseño como: "Publisher", "Corel Draw", "PowerPoint", etc.

3.2.2 Para la implementación de la metodología en el área de trabajo de una organización.

Las especificaciones establecen que el equipo debe seleccionar una organización para aplicar la metodología y se sugiere las siguientes (lista no limitativa): taller, oficina, almacén, tienda, laboratorio, punto de atención al cliente, hogar, etc.

Posterior a la selección de la organización se hace una visita para acordar el área de trabajo con el dueño o la persona facultada a quien se le proporcionara una breve exposición de la metodología y, si así lo requiere, se le entrega una carta firmada por la Secretaria Académica de la Facultad para identificar a los alumnos y solicitar formalmente el permiso para realizar el proyecto.

El reporte a entregar por los alumnos al profesor como evidencia para su evaluación debe contener lo siguiente:

- Identificación de la organización y la descripción del área incluyendo su delimitación y ubicación.
- Plan de trabajo (actividades, responsable y fechas de realización).
- Un "inventario de salida" de las cosas que se eliminaron o movieron del área de trabajo.
- Evidencias del desarrollo de la implementación mediante fotografías del "antes", "durante" y "después" de la aplicación de cada etapa (cada "S") de la metodología.
- Descripción de los beneficios logrados en el área de aplicación.
- Conclusiones del equipo sobre su experiencia y aprendizaje con esta actividad.

3.3 Implementación de la metodología o realización de un poster.

La implementación comienza con la primera entrevista con el dueño o persona facultada de la organización, se identifica el área y se establece el plan de trabajo. Posteriormente el equipo de alumnos realiza las visitas programadas y realiza las actividades que contempla cada una de las etapas de la metodología: Clasificar (Seiri), Organizar (Seiton), Limpiar (Seiso) y Estandarizar (Seiketsu). Anteriormente ya se justificó por qué no se especifica que realicen la quinta etapa (Disciplina).

En cada una de las etapas deben tomar fotografías del "antes y después" y, particularmente en la primera etapa, deben elaborar un "inventario de salida" para especificar los elementos que deben permanecer en el área de trabajo y el destino de aquellos que serán separados de dicha área, con la finalidad de que este documento sea aprobado por el dueño o persona facultada de la organización.

3.4 Elaboración del reporte del proyecto.

Los alumnos deberán realizar por equipo; un reporte sobre la realización de su proyecto, tanto para la elaboración de un poster o para la implementación de la metodología, con base en las actividades realizadas y en las especificaciones para este documento, el cual debe incluir: las ideas que aportaron, las actividades que realizaron, los beneficios que identificaron para el área de trabajo, y sus experiencias de realizar el proyecto. El reporte se debe ser elaborado en archivos electrónicos, en formato de Word y de PowerPoint, para subirse a la plataforma educativa Moodle de la Universidad en la fecha especificada.

3.5 Presentación del reporte o del poster

El reporte y el poster (en su caso) se presentará en clase, en PowerPoint, por cada uno de los equipos de trabajo para exponer sus conclusiones y experiencias de aprendizaje ante el grupo. Parte de la dinámica del profesor consiste en hacerles preguntas para reforzar los conceptos teóricos sobre el tema y para propiciar la reflexión sobre su aprendizaje y sobre las dificultades típicas que se afrontan en la implementación de prácticas para la gestión de la calidad en las organizaciones. En el caso de la elaboración del poster, se resalta el grado en el que este "producto terminado" cumple con los requisitos de calidad especificados por el "profesor-cliente", y se reflexiona sobre las actividades y mecanismos que estableció el equipo para asegurar su cumplimiento.

4 Resultados

La tabla 1 presenta una relación de organizaciones y de áreas de trabajo en donde los alumnos han realizado este proyecto durante los últimos dos años (2014 y 2015) donde se indica el producto obtenido de la actividad.

La figura 2 presenta dos ejemplos de posters orientado a la difusión de la utilización de la metodología en el ambiente administrativo de una oficina y en un laboratorio de análisis de ia Facultad de Ingeniería Química de la UADY. Los posters se han presentado en eventos internos de la propia Facultad como es el "Foro Científico y Tecnológico"; también se les obsequiaron a los dueños de las empresas en donde se implementó dicha metodología.

En la figura 3 se exponen ejemplos de las fotografías tomadas por los alumnos y que deben ser incluidas en el reporte de implementación se incluyen imágenes del "antes" y "después" como evidencia gráfica de la realización del proyecto las cuales también son de suma importancia para visualizar los impactos y beneficios de la metodología.

En la figura 4 se muestra el ejemplo de un "inventario de salida" con la información recabada por los alumnos y que también debe ser entregado conjuntamente con su reporte del proyecto.

Tabla 2. Organizaciones y áreas de trabajo en donde los alumnos han aplicado la metodología de las 5S.

Tipo de organización	Área de trabajo	Producto del Proyecto	#
Educativa	Laboratorios de Análisis	Poster de las 5´s	7
	Laboratorios de Análisis	Reporte de implementación 4's	5
	Bodega	Reporte de implementación 4's	2
Comercial	Bodega de productos de limpieza	Reporte de implementación 4's	1
	Almacén de productos	Reporte de implementación 4's	3
	Bodega de materiales	Reporte de implementación 4's	2
Servicios (Asilo)	Oficina	Reporte de implementación 4's	1
	Bodega materiales	Reporte de implementación 4's	1
	Bodega de mantenimiento	Reporte de implementación 4's	1
Servicios (Taller)	Bodega de herramientas	Reporte de implementación 4's	1
	Área de reparación	Reporte de implementación 4's	4
Industria	Área de desbaste	Reporte de implementación 4's	1
	Área de preparación mezclas	Reporte de implementación 4's	1
Servicios (Arrendadores para fiestas)	Bodega de artículos de sonido	Reporte de implementación 4's	1
	Bodega de sillas y mesas	Reporte de implementación 4's	1
Servicios (Salud)	Bodega de materiales	Reporte de implementación 4's	1
	Bodega de materiales	Reporte de implementación 4's	1
	Área de odontología	Reporte de implementación 4's	1
Gubernamental	Área de bazar	Reporte de implementación 4's	1
	Bodega de mantenimiento	Reporte de implementación 4's	1
Servicios (Belleza)	Bodega de alimentos	Reporte de implementación 4's	1
Servicios ("fast food")	Área de corte y utensilios	Reporte de implementación 4's	1
Servicios (Asesoría)	Bodega de productos	Reporte de implementación 4's	1
	Oficina y bodega	Reporte de implementación 4's	1
		Poster de las 5´s	1

Figura 2. Posters de difusión de la metodología de las 5S en una oficina (izquierda) y laboratorio de análisis.

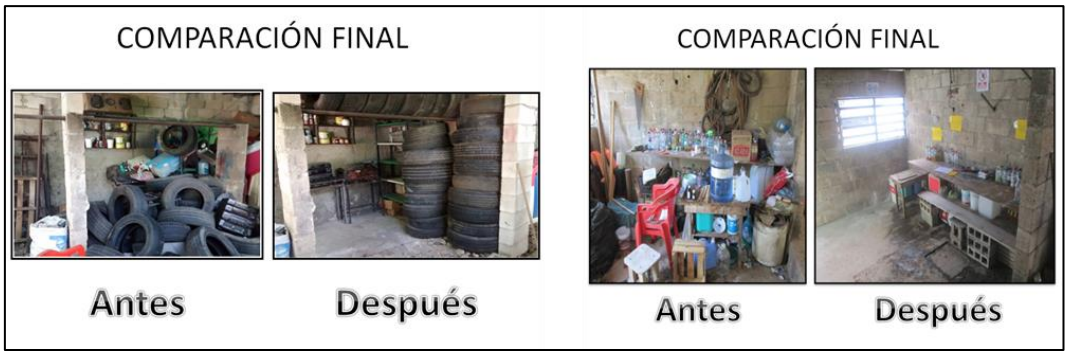


Figura 3. Ejemplos de las fotografías tomadas por los alumnos sobre la metodología en distintas empresas.

1a. S — **Inventario de la clasificación de elementos**

Area: OFICINA-BODEGA — **Fecha:** 10/09/2015

Responsable: LINDA CANTÚ GONZÁLEZ — **Puesto:** DUEÑO

Descripción del elemento	Condición actual	¿Es necesario?	Cantidad requerida	Frecuencia de uso	Decisión sobre el elemento	Ubicación final asignada
Refacción de llanta	inservible	no	0	nula	basura	basurero
Neveras	funcionamiento	no	0	muy baja	almacenamiento	armario
Bolsas de plático	funcionamiento	no	0	baja	almacenamiento	bodega 3
Gorra	funcionamiento	no	0	muy baja	basura	basurero
Periodicos	funcionamiento	no	1	baja	reubicacion	recicladora
Diablo	funcionamiento	si	2	muy alta	reubicación	parte delantera
Pinzas	funcionamiento	no	0	alta	reubicación	tocador

Figura 4. Ejemplo de un "inventario de salida".

El principal resultado del proyecto fue el aprendizaje de los alumnos quienes desarrollaron la habilidad para trabajar en equipo, habilidad para resolver problemas, aprendieron técnicas de comunicación y cooperación entre sus compañeros de clase y con los involucrados en las empresas donde se implemento la metodología.

Experimentaron la aplicación del conocimiento técnico de la disciplina de Ingeniería y de la asignatura de Control de Calidad y Control Estadístico de la Calidad en una situación real.

Durante la implementación del proyecto, el grupo de alumnos aprendió la importancia de la organización, planeación y administración de tiempo y recursos, sobre todo cuando tenían que proporcionar los resultados a la empresa para dar continuidad al proyecto.

Desarrollaron la capacidad para formular objetivos, metas y propósitos para iniciar y terminar un proyecto dentro de los límites y estructuras determinadas.

Varios equipos tuvieron que ampliar su capacidad de análisis para especificar criterios de solución a problemas así como sus habilidades de juicio crítico que les permitió apreciar el valor de la información para la toma de decisiones.

5 Conclusiones

El desarrollo de este tipo de actividades de aprendizaje basadas en PBL permite a los alumnos adquirir competencias para desempeñarse eficazmente como profesionistas dentro de las organizaciones experimentando un "ambiente real" de trabajo para desarrollar habilidades personales y de gestión. Los alumnos aprenden a aprender y el profesor, en su rol de experto, apoya y guía a los alumnos durante el proyecto quienes al final de la implementación, se perciben más responsables e innovadores, con una conciencia clara de las oportunidades de mejora en el área en donde se llevó a cabo el proyecto.

Los estudiantes adquieren competencias que se observan en otros países (Valero, 2013, citado por Méndez I, 2016), donde la metodología de aprendizaje basado en proyectos aborda de manera integral los requerimientos del "Espacio Europeo de Educación Superior": retos tales como la planificación el trabajo del estudiante dentro y fuera de clase o el desarrollo de competencias transversales.

Con esta técnica la mayoría de los alumnos adquirieron un compromiso de actuar como agente de cambio en el desarrollo de vida profesional. Algunos beneficios adicionales que el estudiante tendrá al utilizar la metodología son: interdisciplinariedad, motivación, mejor comunicación, respeto a fechas límites, toma de decisiones.

El Modelo Educativo para la Formación Integral de la UADY, establece que los alumnos de las diversas licenciaturas que se imparten, particularmente de ingeniería, pueden hacer frente al compromiso social de resolver problemas con base en seis ejes de formación integral que son: educación centrada en el aprendizaje, internacionalización, flexibilidad, innovación, responsabilidad social y educación basada en competencias (Universidad Autónoma de Yucatán, 2013).

Se considera que los alumnos lograron los objetivos de aprendizaje del proyecto a través de su realización en un escenario real y al cumplir con las especificaciones de proceso y de los productos entregables, adjuntando en un reporte las evidencias que lo avalan.

6 Reconocimientos

Los autores agradecen las facilidades otorgadas por la Facultad de Ingeniería Química de la UADY para la elaboración de este artículo así como la valiosa colaboración del Br. Carlos Álvarez Farelas, alumno de la licenciatura en Ingeniería Industrial Logística de esta Facultad.

7 Referencias

De Miguel, M. (2006). Metodologías de enseñanza y aprendizaje para el desarollo de competencias. Orientaciones para el profesorado universitario ante el espacio de europeo de educación superior. Madrid: Alianza Editorial.

Galeana, L. (2006). Investigación en Educación a Distancia. Revista Digital. Recuperado el 7 de Marzo de 2016, de http://ceupromed.ucol.mx/revista/PdfArt/1/27.pdf

Kingery, C. (2002). The Lean Enterprise Memory Jogger. United States of America: GOAL/QPC.

Méndez I, P. L. (2016). Competencias profesionales desarrolladas mediante el método de Aprendizaje por Proyectos caso aplicativo. Revista Electrónica ANFEI Digital, 2.

Monden, Y. (1991). Toyota Production System. An Integrated Approach to Just-In-Time (Segunda ed.). Tokyo: Engineering & Management Press.

Tague, N. R. (2005). The Quality Toolbox (Segunda ed.). Milwaukee: America Society For Quality.

Universidad Autónoma de Yucatán. (2013). Programa Institucional de Habilitación en el Modelo Educativo para la Formación Integral. Mérida: UADY.

Valero García, M. (2013). Técnicas de Aprendizaje Basado en Proyectos. Universidad Politécnia de Catalunya.

Implementation of Education for Sustainable Development in Engineering Education. Adjustments in the Curriculum Design of a Course that has Elements of Project-Based Learning

Hernán Gustavo Cortés Mora[1], Alfonso Herrera Jiménez[1], José Ismael Peña Reyes[1]

[1] Industrial and Systems Engineering Department, Faculty of Engineering, Universidad Nacional de Colombia, Colombia

Email: hgcortesm@unal.edu.co, aherreraj@unal.edu.co, jipenar@unal.edu.co

Abstract

The Faculty of Engineering of the Universidad Nacional de Colombia has made approaches to curriculum design from a problem-based learning perspective. In particular, the Interdisciplinary Projects Workshop course created in 2009 has been the subject of study and design in order to strengthen the problem-based learning focus. During the second half of 2015 the course changed its structure and organization. More specifically, one of the groups of the course tried to involve the Education for Sustainable Development topic as an important part of its contents. This article describes the development undergone by the course and the how Sustainable Development has been involved in it. First, it describes the changes in the structure of the course and how to involve students in project definition and work group creation. Subsequently, we present the way in which Education for Sustainable Development is involved in a particular group of the course and its application in the curriculum, including learning outcomes and the inclusion of relevant methodologies. Finally, the perception of students who took the course is presented, with some quantitative and qualitative instruments.

Keywords: Education for Sustainable Development; Project Based Learning; Interdisciplinary Projects Workshop; Curriculum Design; Learning Outcomes in Sustainability.

Implementación de la Educación para el Desarrollo Sustentable en la Educación en Ingeniería. Ajustes en el Diseño Curricular de un Curso que Cuenta con Elementos de Aprendizaje Basado en Problemas

Hernán Gustavo Cortés Mora[1], Alfonso Herrera Jiménez[1], José Ismael Peña Reyes[1]

[1] Departamento de Ingeniería de Sistemas e Industrial, Universidad Nacional de Colombia, Facultad de Ingeniería, Colombia

Email: hgcortesm@unal.edu.co, aherreraj@unal.edu.co, jipenar@unal.edu.co

Resumen

En la Facultad de Ingeniería de la Universidad Nacional de Colombia se han hecho acercamientos al diseño curricular a partir del Aprendizaje Basado en Problemas. En particular el curso Taller de Proyectos Interdisciplinarios creado en 2009, ha sido objeto de estudio y diseño con el fin de fortalecer el enfoque de Aprendizaje Basado en Proyectos. Para el segundo semestre del año 2015 el curso modificó su estructura y organización y en particular uno de los grupos, ha intentado involucrar la Educación para el Desarrollo Sustentable como una parte importante del curso. En el presente artículo se describe la evolución que ha tenido el curso y la manera como se han involucrado aspectos del Desarrollo Sustentable en uno de los 51 proyectos y en la evaluación de impactos generados en las habilidades de los estudiantes. En primer lugar se describen los cambios que en la estructura del curso y la manera de involucrar a los estudiantes en la definición de proyectos y en la conformación de grupos de trabajo. Posteriormente se indica cómo se ha involucrado la Educación para el Desarrollo Sustentable en un grupo en particular del curso y su aplicación en el diseño curricular incluyendo una propuesta de resultados de aprendizaje y la inclusión de metodologías pertinentes, y finalmente, se presenta la percepción de los estudiantes que tomaron el curso, mostrando resultados de forma cuantitativa, producto de algunas preguntas tipo encuesta y otros resultados de carácter cualitativo producto de la evaluación de preguntas abiertas.

Palabras clave: Educación para el Desarrollo Sustentable; Aprendizaje Basado en Proyectos; Taller de Proyectos Interdisciplinarios; Diseño Curricular; Objetivos de Aprendizaje en Sustentabilidad.

1 Introducción

La asignatura de Taller de Proyectos Interdisciplinarios (TPI), ha sido diseñada dentro del componente de formación disciplinar o profesional de los planes de pregrado de la Facultad de Ingeniería de la Universidad Nacional de Colombia para desarrollar en los estudiantes:

- El trabajo en equipo y el espíritu colaborativo y solidario, en pro del desarrollo integral fomentando los derechos individuales y colectivos, la diversidad de creencias, pensamiento, género, cultura, entre otros.
- El desarrollo del pensamiento estratégico y habilidades mentales de orden superior, la capacidad conceptual y experimental, la sensibilidad estética y creativa, la responsabilidad ética, humanística, ambiental y social, y la capacidad de plantear, analizar y resolver problemas complejos, generando autonomía, análisis crítico, capacidad propositiva y creatividad.
- El trabajo desde la interdisciplinariedad, como estrategia en la construcción, formulación, evaluación y desarrollo de un proyecto.
- El desarrollo de las competencias blandas como negociación, comunicación, empatía y capacidad de relación, liderazgo, gestión del conocimiento, manejo del tiempo, adaptabilidad.

1.1 Aprendizaje basado en proyectos - ABP.

El aprendizaje basado en proyectos es un modelo donde el estudiante adquiere herramientas para resolver un problema (Labra, 2006), originándose con una idea de proyecto (Schmidt y Moust 2000) que involucra al grupo, reactiva los conocimientos previos, fomenta el trabajo colaborativo y permite la adquisición de competencias tanto transversales como técnicas. Es ampliamente utilizado por las universidades ofreciendo una visión

interdisciplinaria fortaleciendo el trabajo cooperativo y la investigación (Estruch y Silva, 2006); requiere de mayor exigencia por la interacción requerida y la disposición hacia la innovación con soluciones creativas (Cañete y Martín, 2009; Traver y Pérez, 2009).

Dentro de las competencias transversales se citan la expresión oral, la capacidad crítica, la autocrítica y el trabajo en equipo (Rivas y Velasco, 2009). Igualmente la competencia creativa (Porto 2008) ya que el campo laboral así lo exige (López et al., 2009).

El aprendizaje basado en proyectos y en problemas requiere que el estudiante desarrolle competencias, entendidas como el resultado de procesos evaluativos que miden conocimientos, habilidades y actitudes (Villardón, 2006). Al respecto existen diferentes enfoques como el centrado en el desempeño que se relaciona con niveles de complejidad (Miller, 1990).

Para DeLacey y Leonard (2002) el aprendizaje basado en proyectos es una estrategia innovadora que no ha tenido la suficiente motivación de uso.

1.2 Breve Historia del Taller de Proyectos Interdisciplinarios

El taller de proyectos interdisciplinarios (TPI) nace como resultado de cerrar las brechas encontradas en dos tipos de evaluación: una interna referida a la necesidad de desarrollar las habilidades blandas de trabajo en equipo, negociación, comunicación eficaz y el trabajo interdisciplinar y otra externa relacionada con la necesidad de que los egresados de las facultades de ingeniería obtengan las competencias de formulación y evaluación de proyectos.

TPI se presentó como una experiencia pedagógica innovadora que busca suplir tales carencias. (Duarte O., et al, 2011) y ha sido objeto de algunos trabajos de investigación como el de Rodríguez, F. J. & Peña, J. I, (2015) quienes muestran la evolución del curso en los pasados seis años, o el de Cortes-Mora & Peña-Reyes (2015).

2 Evolución del Curso. Ajustes a partir del segundo semestre de 2015

El curso fue creado al implementarse la última reforma académica de la Universidad Nacional de Colombia en el año 2009. Durante estos años, la asignatura, conformada por cerca de 250 estudiantes de ingeniería distribuidos en alrededor de 25 grupos, cada uno con un docente diferente (mentor), ha tenido un profesor coordinador quien articula el trabajo de los 25 docentes y grupos. Durante el año 2015, la asignatura contó con un nuevo profesor coordinador quién recibió el material del curso y propuso algunas modificaciones que se resumen en la Tabla 1:

Tabla 1. Modificaciones en el diseño de la asignatura.

	Antes de 2015-02	A partir de 2015-02
Cantidad de estudiantes	Alrededor de 250 de ingeniería	Alrededor de 300 estudiantes de ingeniería y algunos de otras facultades
Organización de Grupos	Los estudiantes se inscriben en una idea de proyecto que alguien externo al curso propone	La idea surge de los estudiantes. Hay unos líderes que proponen la idea de proyecto como un reto y forman sus grupos
Selección de Proyectos	Elección de un banco de proyectos	Cada estudiante propone una idea
Distribución de Profesores	Los profesores son asignados a los proyectos	Los estudiantes escogen a sus profesores como si fueran un par.
Evaluación del impacto curso	Sin estructura	Rúbricas, con enfoque de evaluación de competencias relacionándolas con desempeños.
Modalidades de proyectos	Sin definir	Cuatro modalidades: Emprendimiento, consultoría, innovación, investigación
Habilidades a desarrollar	Trabajo en equipo y trabajo interdisciplinar (ingeniería)	Trabajo en equipo, trabajo interdisciplinario (Ingeniería, diseño industrial, medicina), habilidades comunicativas

De forma consecuente con los cambios mostrados anteriormente, se ha definido que el proyecto a desarrollar en TPI debe cumplir con los siguientes requisitos:

- Resolver una problemática o aprovechar una oportunidad con un impacto social en Colombia (mejora en calidad de vida de una población seleccionada).
- Debe ser sustentable (social, económico, cultural y ambientalmente), realizable y que se mantenga en el tiempo.
- Debe contar con un experto que guiará el componente especializado del proyecto.

Durante el desarrollo de curso, la formulación y ejecución de los proyectos se divide en cuatro fases que se describen a continuación. En la figura 1 se muestra un resumen de la estructura de la asignatura:

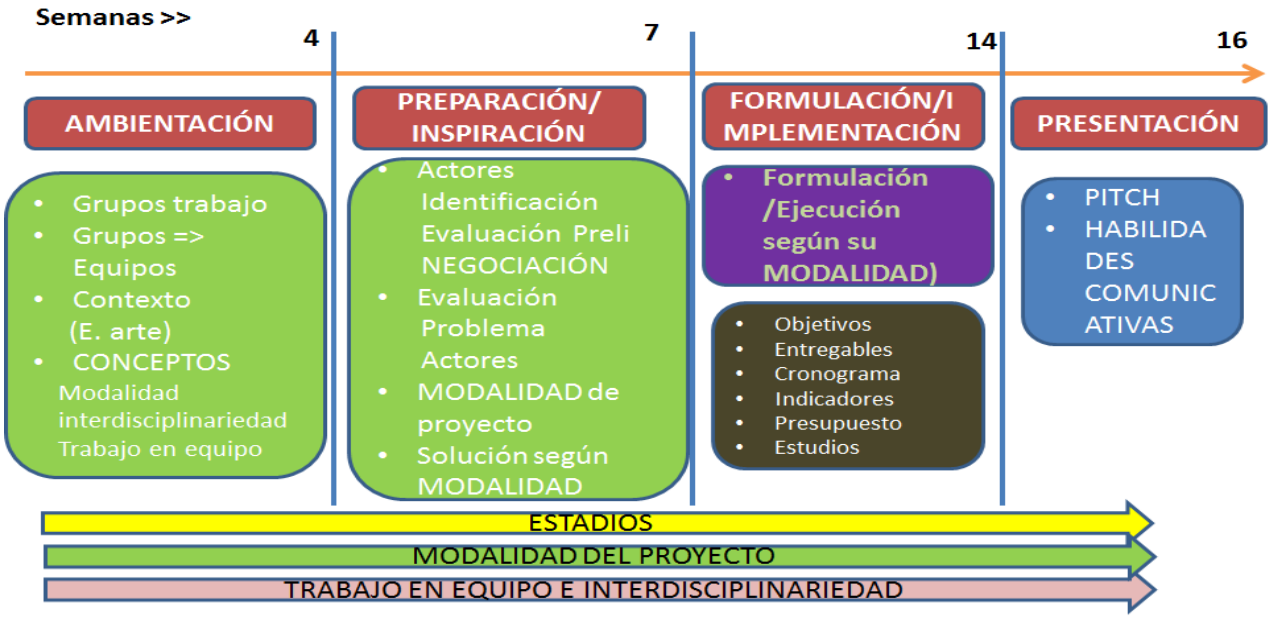


Figura 1. Estructura de la asignatura Taller de Proyectos Interdisciplinarios. Elaboración propia.

a) **Fase de Ambientación**. Consiste dejar claras las reglas de juego de la asignatura, dando a conocer el Syllabus, organiza los equipos de trabajo procurando sus sinergias, se trabajan temas claves como el trabajo en equipo de trabajo, la negociación y la comunicación; la interdisciplinariedad; la sustentabilidad y ética en los proyectos, y se repasan las técnicas para la formulación de proyectos que se requieren dependiendo del campo, modalidad y enfoque del proyecto. Duración: 4 semanas.

b) **Fase de Preparación o Inspiración**. Enfatiza en la contextualización del proyecto, reconociendo e identificando antecedentes, el contexto del problema, dimensionando la situación problemática y los actores o partes interesadas dentro de la idea de proyecto, el estado del arte de la problemática y la opinión de expertos. Es la forma de acercarse a una solución pertinente, promoviendo el trabajo interdisciplinar, enfatizando en el estadio estratégico y potenciando las habilidades blandas de trabajo en equipo, comunicación y negociación, a la vez, que reconociendo y asimilando propuestas interdisciplinares para aproximarse a la solución. El ejercicio interdisciplinar y el pensamiento crítico y complejo es lo que debe inspirar la propuesta de solución al proyecto. Duración: 3 semanas

c) **Fase de Formulación/Implementación**. Resalta las habilidades en lo táctico, precisa en los estadios táctico y operativo, con las metodologías analíticas para escoger, proponer y desarrollar la mejor solución dentro de las diferentes alternativas y las diferentes modalidades de proyectos dependiendo del campo, modalidad y enfoque del proyecto, lo que determina la metodología a utilizar. Enfatiza, entre otros, y dependiendo de la modalidad del proyecto, los diferentes estudios como el técnico, el legal, el organizacional, el de mercados, el de riesgos, el ambiental, el financiero, entre otros; la definición de objetivos, indicadores, entregables, la organización de cronogramas. Adicionalmente se resalta sobre los aspectos claves para la gestión y realización de los proyectos en las modalidades

descritas anteriormente. Cuando son proyectos que traen una solución definida por estudios bien cimentados ésta fase puede encargarse de la realización o implementación. Duración: 7 semanas

d) **Fase Final o de Presentación**. Enfatiza en las competencias comunicativas para "vender la solución", evidenciando una formulación sólida y una solución pertinente, con argumentos desde lo estratégico, funcional y operativo. Destaca la capacidad comunicativa de argumentación y de síntesis a la hora de presentar un proyecto. Duración: 2 semanas.

3 Introducción de la Educación para el Desarrollo Sustentable -EDS- en TPI

Existen algunas iniciativas de implementación de la EDS en ambientes que utilizan ABP como metodología de aprendizaje. En particular, el trabajo adelantado por Aida Guerra en la Universidad de Aalborg, permite reconocer los retos que existen, pero también la importancia que representa la articulación de los dos elementos. En general se puede afirmar que el PBL soporta la integración de la EDS en la educación en ingeniería (Guerra, 2014).

En estudios anteriores se describía la estrategia de implementación de la EDS en el curso TPI (Cortés_Mora & Peña-Reyes, 2015) distribuidos en resultados educativos y cambio social. Allí se mencionaban los resultados esperados, sin embargo, allí no se enfatiza en la manera de alcanzar dichos resultados. A continuación se presentan algunos elementos implementados para alcanzar los resultados propuestos divididos en resultados educativos y cambios sociales. Así mismo se presentan los resultados de aprendizaje del curso, cuya definición recoge el aporte resultado de esta experiencia.

3.1 Resultados educativos:

- Proyectos que cuentan con elementos de Desarrollo Sustentable en su formulación y ejecución: Se ha incorporado en la formulación de los proyectos, el componente de sustentabilidad, exigiendo a los estudiantes que tengan en cuenta el equilibrio entre lo ambiental, lo social y lo económico y la duración en el tiempo del mismo en sus proyectos.
- Adquisición de habilidades como el razonamiento crítico y el pensamiento sistémico: Para lograr éstos resultados, se han incorporado dinámicas de clase como las que proponen Booth Sweeney, L., & Meadows, D. (2010) entre otras, permitiendo que los estudiantes desarrollen su habilidades de razonamiento y pensamiento. Adicionalmente se confronta al grupo de trabajo con las implicaciones políticas, económicas, sociales, tecnológicas, ambientales, legales y éticas de sus proyectos.
- Fortalecer las habilidades comunicativas de los estudiantes: Durante el desarrollo del curso, se realizan diferentes presentaciones y actividades que permitan entender la importancia de una comunicación eficaz al interior del grupo y de éste con el entorno. Para ello se implementan actividades como variaciones del juego del teléfono roto entre otras, y simulacros de presentaciones de los avances de los proyectos incluyendo jurados invitados con diferentes perfiles a las sesiones de clase.

3.2 Cambio Social:

- Al esperar que con la implementación del proyecto se logre mejorar las condiciones de vida de comunidades, se guía a los estudiantes para que enfoquen sus soluciones en el beneficio de las comunidades. Esto incluye la comunicación constante con los beneficiarios para realizar un proceso de co-creacion de la solución, y la entrega de los resultados a las mismas, Adicionalmente la metodología posibilita el aprendizaje in situ y en contexto por parte de los estudiantes. Algunos de los proyectos realizados durante el 2015 utilizando la misma Facultad de Ingeniería como comunidad son: propuesta para la implementación de biciparqueaderos en la sede Bogotá de la Universidad Nacional de Colombia; Diseño de una alternativa de medio de comunicación (podcast) que permita el intercambio de información en la Facultad de Ingeniería – TPI Radio, y propuesta de campaña para el mejoramiento del campus de la Facultad de Ingeniería de la Universidad Nacional de Colombia Sede Bogotá, concentrada en la disminución de colillas de cigarrillo arrojadas al piso.

- Después de la realización de los proyectos, los estudiantes no sólo aprendieron a formular e implementar proyectos, sino que aprendieron de la comunidad y lo que es más importante, dejaron algo concreto y tangible a la misma. Así, el proyecto de las colillas de cigarrillo implementó unos botes de basura especiales para la recolección de colillas de cigarrillo, ubicados en distintas zonas del campus. Algunos de los estudiantes del proyecto de radio se convirtieron en parte del equipo de la Unidad de Medios y Comunicación de la Facultad de Ingeniería, y el proyecto de los biciparqueaderos entregó su propuesta a las directivas de la Facultad quienes se encuentran estudiándola para entregarla a la oficina de movilidad del Campus de la Universidad Nacional en Bogotá.

3.3 Resultados de Aprendizaje

Como se ha mencionado, el presente trabajo, sumado a las experiencias de los demás profesores del grupo y al trabajo de la coordinación del curso, permitió la redefinición de los resultados de aprendizaje para todos los estudiantes que cursen la asignatura Taller de Proyectos Interdisciplinarios, así como también la actualización del objetivo general del curso:

Desarrollar en los estudiantes las habilidades para: abordar, formular e implementar un proyecto de manera interdisciplinar, mediante el trabajo en equipo, desde la perspectiva del pensamiento estratégico y crítico, brindando soluciones sustentables, pertinentes e innovadoras desde la disciplina de la ingeniería. Dentro de las habilidades a fomentar se encuentran la comunicación eficaz, el trabajo en equipo, el liderazgo y la negociación; a la vez de un trabajo ético con la sociedad.

Al finalizar el curso, los estudiantes deben:

- Fortalecer el trabajo en equipo, de una manera interdisciplinar.
- Comprender la importancia de reconocer sus habilidades, las de sus compañeros de equipo, las de los actores del proyecto, entendiendo sus visiones, sus puntos de vista y sus intereses en pro de la mejor solución al problema estudiado.
- Asumir una actitud crítica, sistémica y estratégica, lo que le permite argumentar la solución propuesta para su proyecto, desde la concepción compleja y el discurso de las analíticas utilizadas.
- Reconocer la importancia del trabajo ético en las diferentes perspectivas de un proyecto, bien sea con los actores y con la sociedad
- Entender la importancia y la necesidad de formular proyectos desde una perspectiva de sustentabilidad, incorporando las consideraciones y elementos de sustentabilidad para la solución de problemas y en la formulación e implementación de proyectos, respetando y reconociendo la propiedad intelectual.

4 Percepción de los estudiantes

Se realizaron dos evaluaciones de carácter sumativo al finalizar el curso, buscando con ello comprobar si los estudiantes han logrado los resultados, en particular los relacionados con las competencias (Jorba y Sanmartí, 2000). Se realizó una evaluación del grupo al cual fueron incorporados los elementos de EDS y una evaluación a la totalidad de estudiantes del curso. Con respecto a la evaluación de un grupo, conformado por dos equipos de trabajo, es decir dos proyectos, por parte de los estudiantes, se concluye que:

Todos los estudiantes evaluados consideran que se promovió en ellos la argumentación o la reflexión crítica y la adquisición de herramientas para el aprendizaje autónomo. En contraste, sólo uno de los estudiantes consideró que no se inspiró o motivó suficientemente el interés por los temas tratados, los demás estudiantes consideraron que sí.

Con respecto a la evaluación de todos los grupos de la asignatura, se realizó una encuesta tipo Lickert, enviada por correo electrónico a los 315 estudiantes. Fue contestada por 112 y los resultados fueron se resumen en la figura 2.

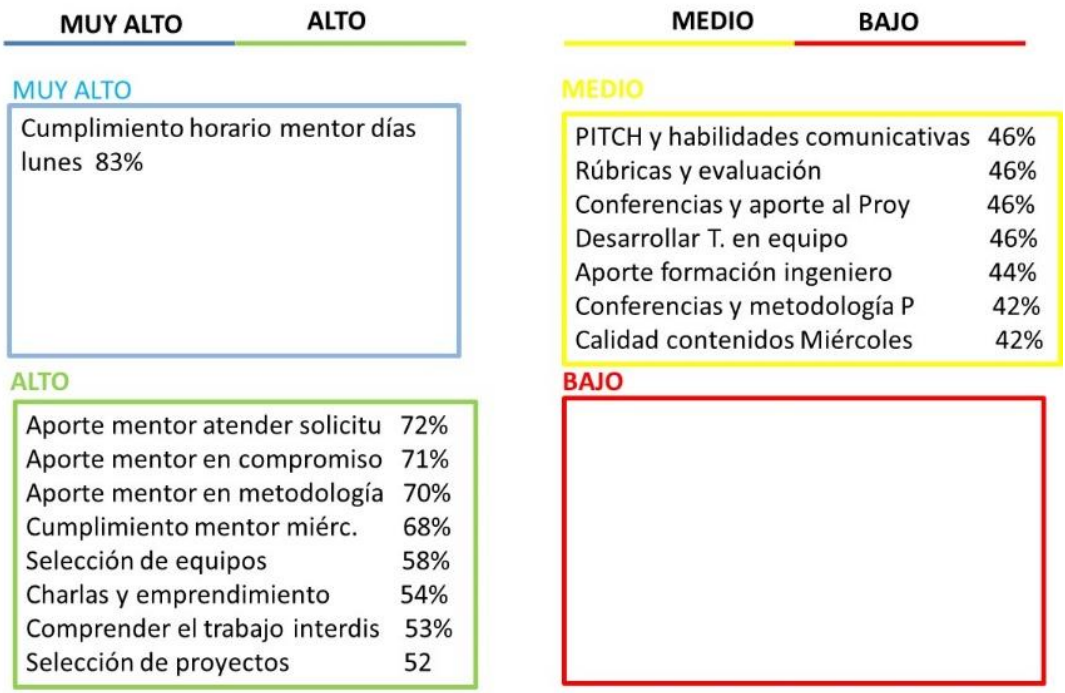


Figura 2. Resumen de las respuestas de los estudiantes en la evaluación del curso. Elaboración propia.

En cuanto a las preguntas relacionadas con el trabajo interdisciplinario y la forma de seleccionar los equipos y su conformación, sus resultados puntuaron en la escala ALTO, evidenciando así el logro de los objetivos planteados en cuanto a la visión interdisciplinar y, además, que la propuesta del curso de preferir las ideas de proyecto por parte de los estudiantes, efectivamente es una de las buenas practicas que sugiere el Aprendizaje Basado en Proyectos. De otra parte, lo relacionado con las habilidades desarrolladas aparece el trabajo en equipo, las habilidades comunicativas y el aporte en la formación de los ingenieros. Todas estas variables puntuaron en la parte baja en la evaluación del semestre anterior.

5 Conclusión.

Si bien el aprendizaje basado en proyectos no posee una amplia divulgación y hasta ahora se está reconociendo su efectividad de diferentes campos de conocimiento, la asignatura TPI muestra avances en el desarrollo de habilidades, enfocando la labor pedagógica en su desarrollo, a través de contextos reales y en un ámbito social de aplicación, permitiéndoles un futuro desenvolvimiento en su entorno social y alejándonos de afirmaciones de algunos autores como Castillo y Rodríguez (2011) quienes sostienen que la Universidad se enfoca exageradamente en la instrucción.

Por otro lado, los estudiantes han reconocido la implementación de éstas metodologías como algo positivo y necesario para su formación, lo que impulsa para continuar con su investigación y desarrollo.

Incorporar elementos de la EDS puede convertirse en una tarea sencilla si se tiene la motivación y disposición para hacerlo.

El trabajo ha permitido llevar la investigación directamente a las aulas y evolucionar el los objetivos de una asignatura de la Facultad de Ingeniería. Éstos se pueden llevar, con algunas adaptaciones, a otras asignaturas de los currículos de ingeniería, en incluso a otras facultades, aportando así al acercamiento a una metodología curricular completamente basada en ABP.

6 References

Booth Sweeney, L., & Meadows, D. 2010. The Systems Thinking Playbook: Exercises to Stretch and Build Learning and Systems Thinking Capabilities: Chelsea Green Publishing Company.

Cañete, J. y Martín, O. (2009). Una experiencia en el diseño y la impartición de una asignatura en torno a la metodología del aprendizaje basado en proyectos. XV Jenui. Métodos pedagógicos innovadores. 395 - 402.

Castillo, G. y Rodríguez, A. (2011). De la universidad al puesto de trabajo. Estrategias y recursos para acceder al primer empleo. Pirámide: Madrid.

Cortés-Mora H.G. & Peña-Reyes J.I. (2015). Introduciendo la Educación para el Desarrollo Sustentable en el curso Taller de Proyectos Interdisciplinarios de la Facultad de Ingeniería de la Universidad Nacional de Colombia. Encuentro Internacional de Educación en Ingeniería EIEI ACOFI 2015. Una formación de calidad en ingeniería, para el future. Cartagena, Colombia, 2015.

DeLacey, B. J. y Leonard D. A. (2002). Case study on technology and distance in education at the Harvard Business School. Educational Technology & Society. 5(2), 13-28.

Duarte, O., Orjuela, A., Rodríguez, G., Salazar, J., Soto, R. (2011). Taller de Proyectos Interdisciplinarios: una experiencia innovadora en la Facultad de Ingeniería de la Universidad Nacional de Colombia. In 2011 ACOFI Annual Conference. Colombia

Estruch, V. y Silva, J. (2006). Aprendizaje basado en proyectos en la carrera de Informática. XII Jornadas de Enseñanza Universitaria de la Informática, JENUI 2006. 339 – 346.

Guerra, A. (2014). Problem Based Learning and Sustainable Engineering Education: Challenges for 21st Century. Department of Development and Planning, Aalborg University

Jorba, J y Sanmartí, N. (2000). La función pedagógica de la evaluación. En Ballester, M. et al. Evaluación como ayuda al aprendizaje. Caracas: editorial laboratorio educativo 21 – 42.

Labra, J. et al. (2006). Una experiencia de aprendizaje basado en proyectos utilizando herramientas colaborativas de desarrollo de software libre. XII Jornadas de Enseñanza Universitaria de la Informática, 395 – 402.

López, R. et al. (2009). Proceso de gestión de trabajos fin de carrera. XV Jornada de Enseñanza Universitaria de la informática - JENUI 2006. Disponible en: http://upcommons.upc.edu/revistes/bitstream/2099/8024/1/p134.pdf. (Última visita: mayo 2012).

Miller, G. (1990). The assessment of clinical skills/competence/performance. Acedemic Medicine. 65(9), S63 – 7.

Porto, M. (2008). Evaluación para la competencia creativa en la educación universitaria. Cuadernos FHyCS-UNJu. 35, 77 – 90.

Rodríguez, F. J. & Peña, J. I. de Graaff, E.; Guerra, A.; Kolmos, A. & Arexolaleiba, N. A. (Eds.) Achievements in interdisciplinary engineering education at Universidad Nacional de Colombia: Showing six years of experiences. *Global Research Community: Collaboration and Developments, Aalborg University Press,* 2015, 106-114

Schmidt, H. G. y Moust, J. H. C. (2000). Factors affecting small-group tutorial learning: A review of research. In Evensen, D., and Hmelo, C. E. (eds.), Problem-Based Learning: A Research Perspective on Learning Interactions, Erlbaum, Mahwah, NJ, 19 – 51

Traver, J. y Pérez, J. (2009). Dedicación de los estudiantes en un contexto de aprendizaje cooperativo basado en proyectos: medición, análisis e implicaciones. Revista Iberoamericana de Tecnologías del Aprendizaje. 4(2), 117 – 128.

Villardón, L. (2006). Evaluación del aprendizaje para promover el desarrollo de competencias. Educatio siglo XXI. 24, 57 – 76.

Industrial Engineering Laboratory to Real Learning Scenarios

Jesús Escalante Euán[1], Ileana Monsreal Barrera[1], Francisco Hernández Vázquez Mellado[1]

[1]Cuerpo Académico de Ingeniería en Sistemas de Producción y Logística, Universidad Autónoma de Yucatán, Facultad de Ingeniería Química, Yucatán, México.

Email: jesus.escalante@correo.uady.mx, ileana.monsreal@correo.uady.mx, francisco.hernandez@correo.uady.mx

Abstract

Our research describes the experiences documented, and we emphasize the management model implemented in risk analysis cargo handling in local markets project. The framework project is conducted during a semester, being a complementary activity to the course of engineering methods for logistics industrial engineering students, , being a subject that promotes, among other teaching strategies, project-based learning (PBL). The project was sponsored by the Higher Education Enterprise Foundation (FESE).

Keywords: PBL; laboratory; learning scenarios; management; complex projects.

Del laboratorio de Ingeniería Industrial a un Escenario Real de Aprendizaje

Jesús Escalante Euán[1], Ileana Monsreal Barrera[1], Francisco Hernández Vázquez Mellado[1].

[1]Cuerpo Académico de Ingeniería en Sistemas de Producción y Logística, Universidad Autónoma de Yucatán, Facultad de Ingeniería Química, Yucatán, México.

Email: jesus.escalante@correo.uady.mx, ileana.monsreal@correo.uady.mx, francisco.hernandez@correo.uady.mx

Resumen

La investigación describe las experiencias documentadas con énfasis en el modelo de gestión implementado en el proyecto intitulado análisis del riesgo en la manipulación de carga en mercados municipales. El proyecto marco se realizó durante un semestre, como una actividad complementaria al curso de ingeniería de métodos para estudiantes de ingeniería industrial logística, siendo una asignatura que propicia entre otras estrategias de enseñanza, el aprendizaje basado en proyectos (PBL). El proyecto fue auspiciado por la Fundación Educación Superior Empresa (FESE).

Palabras clave: PBL, Laboratorio, escenarios de aprendizaje, gestión, proyectos complejos

1 Introducción

En años recientes hemos sido testigos de los grandes retos que la educación implica y de las brechas existentes entre la vinculación de los conocimientos y el ejercicio responsable de una profesión, en nuestro caso, la ingeniería. Existen estudios que han valorado el impacto del aprendizaje tradicional en contraste con estrategias basadas en proyectos aplicados (Johnson, B., Ulseth, R., Smith, C., & Fox, 2015). Otros consideran que la explosión de la información, aunada a los acelerados avances de la ciencia y de la tecnología, hacen que el ciclo de vida del conocimiento útil para un profesional sea cada vez más corto (Kirkup & Kirkwood, 2005; Pingali, 2012; Santangelo, 2001). Al interior de las aulas los estudiantes exigen una vinculación más estrecha entre los saberes y la aplicación práctica del conocimiento al mundo real.

La investigación describe las experiencias en el proceso de gestión implementado en el marco del proyecto intitulado: "Análisis del riesgo en la manipulación de carga en mercados municipales" (Escalante, Monsreal, & Hernández, 2015). Nuestra aportación tiene el enfoque de describir las fases que nos condujeron a potenciar las competencias para un grupo de estudiantes, como una actividad complementaria al curso de ingeniería de métodos durante un semestre. Siendo una asignatura que propicia, entre otras estrategias de enseñanza, el aprendizaje basado en proyectos (PBL). El proyecto marco se estableció bajo el auspicio de la "Fundación Educación Empresa".

La actividad se realizó en tres fases: en la primera describimos las bases y los alcances del proyecto, que en su definición tuvo como eje central el diseño de un plan de acción que permitiera el tránsito natural de los estudiantes del laboratorio a un escenario real de aprendizaje. La segunda fase consistió en la selección de los aspirantes, ya como equipo de trabajo constituido, definimos y delimitamos el problema. Declaramos la identificación del nivel de riesgo para diagnosticar las prácticas de manipulación y disposición de la carga, en dos de las locaciones más importantes en la ciudad de Mérida, México.

Las sedes se focalizaron por la afluencia de clientes y el tráfico de productos perecederos en la zona. En lo sucesivo utilizamos diversas herramientas para el registro de información tales como: diseño y aplicación de encuestas, registro y edición de video, elaboración de carteles, elaboración de infografías, guías de buenas prácticas y finalmente la redacción de los informes ejecutivos.

Para la tercera fase ejecutamos el plan de acción que consistió en el desarrollo de un conjunto de saberes a partir de la planeación de actividades, desde la concepción de nuestra organización como equipo de trabajo,

la asignación de tareas, la dirección y la ejecución de los planes de acción. Los resultados preliminares nos fueron conduciendo a explorar y valorar soluciones a problemas reales.

Sus primeros impactos fueron en dos sentidos: aprendimos a vincular de forma vivencial los conocimientos del aula, con las necesidades del entorno, siempre tuvimos como soporte el enfoque PBL, siendo un modelo de aprendizaje en el que los estudiantes planean, implementan y evalúan proyectos, propiciando su aplicación en el mundo real, más allá del aula de clases (Hmelo-Silver, 2004; Lefrere, 2009).

2 Objetivo

El objetivo particular de este trabajo de investigación es describir el modelo de gestión de proyectos complejos y contribuir con sus alcances al fortalecimiento de algunas de las habilidades declaradas en el perfil de egreso del ingeniero Industrial Logístico. Con especial interés en la creatividad, la capacidad de pensamiento convergente y divergente, la capacidad de análisis, la capacidad de trabajo en equipo, la capacidad de comunicación y el aspecto humanístico.

3 Contexto

Los proyectos complejos requieren una aproximación transversal que comprenda el conjunto, que contextualice todos los elementos que la componen y sea capaz de interpretar cada momento y cada decisión teniendo en cuenta el todo. Y esto se consigue reuniendo el capital humano, ante la creciente complejidad de la realidad y la creciente especialización en la formación.

De acuerdo con (Guillot & Barceló, 2014) debemos ser capaces de integrar el conocimiento a partir de las propias capacidades pero a partir del trabajo en equipo. Si pretendemos gestionar la complejidad, necesitamos romper la dinámica de la especialización académica.

Un proyecto complejo se distingue esencialmente por el gran número de variables interrelacionadas que deben gestionarse, es decir personas, intereses, entidades, entre otros elementos. Diversos autores refieren que para lograr una gestión eficaz, será importante organizar las acciones hacia un objetivo, organizar científicamente el trabajo (Ahern, Leavy, & Byrne, 2013; Lynda, 2015; Remington & Pollack, 2010). Será imprescindible entender, tener referentes, establecer la estructura, un proceso, definir los elementos en juego y su relación a partir de los cuales plantear el proyecto complejo.

Cada proyecto es un proceso de aprendizaje, sobre todo al introducir la innovación. Uno debe ser perseverante y a la vez reconocer errores, corregirlos, aprender y seguir adelante en el objetivo de conseguir los resultados previstos (Ahern et al., 2013). En contraste, en algunas ocasiones otro elemento que está inmerso en la ecuación es el azar, por mucho que planifiquemos y controlemos los procesos, siempre aparece un elemento sorpresa que no habíamos previsto.

Si pretendemos progresar en la comprensión de la lógica de la gestión de proyectos complejos, debemos hacerlo desde la transversalidad del conocimiento y no sólo aumentando el conocimiento especializado, que podría dificultar la comprensión de la complejidad. El análisis de los diez factores de acuerdo al modelo propuesto por (Guillot & Barceló, 2014) nos sirvió de pauta y contribuyó de en gran medida para gestionar los esfuerzos, talentos y los incidentes del día a día. A continuación haremos referencia a los componentes del modelo.

3.1 Factores clave

En un proyecto complejo intervienen muchas variables, así como la distinta naturaleza de estas variables y sus relaciones definen su nivel de complejidad (Ahern et al., 2013). Para avanzar con pragmatismo por este escenario complejo, es necesario modelizar, es decir dividir y simplificar. Dividir el problema complejo en distintos aspectos y simplificarlo, seleccionando las variables principales y la relación entre ellas (Guillot & Barceló, 2014).

Debemos ser conscientes de que esta simplificación, si bien nos permite actuar, nos puede dificultar la comprensión de la complejidad del escenario real y puede eliminar aspectos fundamentales.

Modelizar no es reproducir la realidad, no dibuja su imagen exacta, si no que la simplifica y, por tanto, la modifica. Pero cuando modelizamos estamos actuando en aras de una mayor operatividad, es decir, simplificando la realidad para poder avanzar y no vernos abocados al colapso o a la inacción.

3.2 Descripción del modelo de gestión

Este aspecto conceptual, fueron los cimientos en los que se sustentó nuestro proyecto. Nos dio sentido y solidez y estructura nuestras acciones futuras. El modelo tiene como premisa intentar representar la realidad y definir los elementos que nos permiten actuar sobre ella, según lo que queremos conseguir.

A continuación describiremos los componentes que fueron la base y hacer crecer el proyecto en la dirección correcta.

3.2.1 Modelo

El modelo aporta la visión, la misión y los valores para cohesionar el proyecto y la organización. Nos ayuda a definir la estrategia, el terreno de juego, a identificar los recursos, las herramientas de gestión y para crear una buena organización. Un modelo no es un plan, es una visión, se sostiene basándose de una estrategia y ayuda a cohesionar la organización interna y externa.

La buena estrategia de acuerdo con (Jimenez, 2008; Kolmos, 2004; López & Ugalde, 2015; Saenz de Arteaga, 2012) consiste en tres grandes acciones: (i) realizar el diagnóstico del entorno junto con definir cuál es el desafío, (ii) establecer unas políticas orientadoras hacia este desafío, identificando las ventajas y los obstáculos, y (iii) determinar unas acciones coherentes situadas en el calendario y ordenadas por prioridad.

Es decir, la estrategia, con carácter innovador y ambicioso, abre el camino, identificando cómo, por qué y dónde deberán aplicarse liderazgo y la determinación. La estrategia establece cómo la organización se mueve hacia adelante, una buena estrategia aporta coherencia y, por tanto fortaleza a un proyecto.

El modelo es la representación de la estrategia, un modelo sin estrategia no tiene sentido. Existen elementos del modelo que son complementarios de la definición estricta de la estrategia, si cambia la estrategia, cambia el modelo, pero no necesariamente un cambio en el modelo produce un cambio en la estrategia. En la sección de resultados (véase la Figura 1) ilustramos sus componentes.

3.2.2 Su utilidad y alcances

El modelo concentra en su presentación los cuatro elementos esenciales en la gestión de proyectos complejos, son elementos críticos para llevar adelante cualquier proyecto:

- En primer lugar, el modelo cohesiona a la gente y a las organizaciones implicadas, y da sentido a su trabajo.
- En segundo lugar, el modelo comunica, explica el proyecto, le da cierta estabilidad en el tiempo y le hace ganar prestigio (story).
- El modelo define prioridades al ofrecer un marco conceptual a partir del que tomamos decisiones y conectamos las ideas de la estrategia.
- Finalmente, el modelo nos da una perspectiva global del lugar y el momento en el que nos encontramos a medida que el proyecto evoluciona.

4 Resultados

Esta sección describe algunas de las experiencias documentadas, y que hoy día siguen siendo un referente para la gestión de proyectos vigentes. La Figura 1 ilustra las 6 fases de gestión, se han numerado para ser

referidas, consideramos que todas son significativas y mantienen una relación entre todas para que el funcionamiento sea eficaz.

La idea del proyecto véase etapa 1, fue concebir una iniciativa en el que los estudiantes pudieran transitar de las sesiones prácticas que se conciben en el laboratorio, hacia un entorno real. Pero que también la experiencia pudiera fortalecer las competencias de los estudiantes que formaron parte del equipo, y que se declaran en el plan de estudios (FIQ, 2016). La evaluación interna fue a través de la siguiente métrica:

Tabla 1. Evaluación del modelo de gestión

Ítems para el modelo	1	2	3	4	5
Está claramente definido					
Está alineado con la estrategia					
Lo comunicamos regularmente hacia el interior/exterior					
Tenemos un relato para distintos clientes					
El relato transmite la esencia del proyecto					

La etapa dos fue realmente interesante, como parte del equipo de tutores mantuvimos una comunicación constante para definir la idea, atender los aspectos de la convocatoria véase (Fese, 2016), responder a los requisitos, lineamientos, y finalmente administrar los recursos durante todo el ciclo del proyecto.

La etapa tres, inició con la redacción de una convocatoria para reclutar a los futuros colaboradores, de acuerdo al calendario académico. El plan inicial para esta actividad estaba previsto para cumplirla en tres meses. Al finalizar la primera semana ya contábamos con más de 10 aspirantes.

Consideramos que una de las características de esta convocatoria, respecto a otras opciones que estuvieron en oferta, fueron los siguientes aspectos:

El proyecto relató una vivencia especial, es decir, narraba en forma breve una historia que transmitía los valores del proyecto, y que el relato conectaba con la realidad y con la historia.

El relato debía ser capaz de situar el proyecto en el tiempo y espacio. Es decir, hacia atrás con la perspectiva de la historia y hacia delante proyectando la visión de futuro. En cuanto al espacio, relacionando el proyecto con otras realidades, en el ámbito local particularmente. Además de que el proyecto tenía en su condición un claro interés público, de responsabilidad social y para un territorio determinado.

Hoy día, creemos que la invitación incluyó en su esencia una motivación. Procuramos alimentar las emociones de los futuros participantes, concebimos la idea de que la iniciativa no debería ser fría, tecnocrática, porque sólo a través de la emoción compartiríamos el entusiasmo y la participación.

Los proyectos complejos no pueden tener éxito sin este factor psicológico que aumentará la complicidad de las personas hacia el interior y hacia afuera. Con una cierta dosis de trascendencia, que será la que motive a los futuros colaboradores a comprometerse en el proyecto.

Para seleccionar a los estudiantes, les solicitamos una carta donde declararán en qué medida podrían contribuir al proyecto. Esta carta representó para nosotros como tutores un compromiso o micro ciclo de Deming entre el manager y cualquier persona de su equipo para definir sus objetivos vea (Gartner & Naughton, 1988; Manage, 2005). Otros autores como (Drucker, 2004) refieren que al realizar un contrato informal y por escrito contribuye en buena medida para recordar lo que hemos propuesto y cómo lo vamos a conseguir.

El hecho de que se haga por escrito, no es circunstancial, ya que en demasiadas ocasiones, por falta de sistemática (no por falta de tiempo), no se formalizan estas decisiones, y en consecuencia se pueden producir ambigüedades y distintas interpretaciones.

Para nuestro enfoque y lógica de reclutamiento fue que los propósitos de la carta podrían ser cualitativos, pero durante la entrevista abordamos reflexiones acerca de su cumplimiento. Concluimos y estuvimos convencidos de que no todo es medible numéricamente en un proyecto complejo, o en la gestión del conocimiento.

La etapa cuatro nos fue de suma utilidad establecer reuniones informales de máximo 10 minutos, y no implicaba necesariamente la participación de todos los participantes. Propusimos otro esquema que fueron las reuniones semanales de revisión de avances, donde había un quorum mínimo para iniciar y procuramos acompañarlos con refrigerios, celebración de algún acontecimiento importante. Por ejemplo entrega de los uniformes.

La etapa cinco la valoramos desde el principio durante la entrevista de selección. Fue allí donde indagamos acerca de algunos supuestos tales como:

1. En caso de tener que asistir a actividades de campo un sábado por la mañana, ¿cuál sería su disponibilidad?
2. En caso de tener una agenda de múltiples compromisos, ¿cómo resolverían su calendarización?
3. La disponibilidad de viajar, entre otros aspectos.

Finalmente la etapa seis, al igual que el apartado anterior, también la pudimos discutir durante la fase de entrevista. Allí valoramos en qué medida los futuros colaboradores se sentían identificados como estudiante universitario y con el proyecto. Pero también su compromiso social.

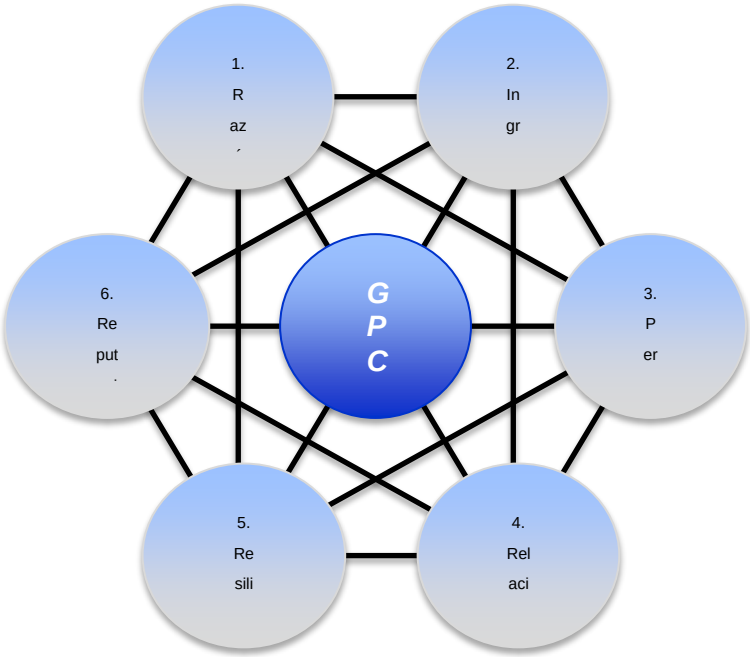


Figura 1. Modelo del Proyecto inspirado en el modelo de gestión de (Guillot & Barceló, 2014)

5 Conclusiones

A continuación presentamos un listado de algunas evidencias y contribuciones de participación en diversos foros y eventos del área de ingeniería industrial, tales como el foro científico y tecnológico de la Facultad de Ingeniería Química (FIQ, 2016), participación en congresos de ingeniería industrial, entre otros.

Tabla 2. Lista de control de resultados

No	Actividad	Frecuencia
1	Capacitación software RULA	2
2	Capacitación software UGM	2
3	Presentación del proyecto a los "stakeholders"	3
4	Redacción de informes de resultados	8
5	Redacción de resúmenes para congresos	3
6	Publicación de artículos	1
7	Asistencia a congresos	2
8	Diseño de encuestas	2
9	Visitas de campo	14
10	Diseño de carteles	2
11	Elaboración de infografías	1
12	Elaboración de guías de buenas prácticas	1
13	Entrevistas con diferentes actores	16
14	Producción de documental	1
15	Asistencia a talleres	4
16	Reuniones de trabajo	15

Consideramos que la evolución de esta iniciativa, en tan sólo seis meses de gestión nos ofreció gratas experiencias, así como incursionar en actividades de difusión en revistas especializadas, potenciar las destrezas para el diseño de carteles, elaboración y edición de guías prácticas, infografías y otros medios para divulgar las evidencias hacia diversos sectores.

Mediante una consulta utilizando las redes sociales, algunos meses después de haber concluido esta actividad, les pedimos a los participantes que nos retroalimentarás de cómo les había servido haber participado en esta actividad, a continuación listamos algunas de sus respuestas:

- *Haber participado como becaria en este proyecto ha sido muy útil como base para la incursión e implementación de otros.*
- *Hoy día estoy siendo candidata para iniciar estudios de maestría en Alemania, un requisito es haber tenido la oportunidad de trabajar en un proyecto afín a tópicos de ergonomía.*
- *Haber trabajado con un grupo muy activo e inteligente.*
- *Aprender a gestionar recursos didácticos y de investigación.*
- *Me gustó la aplicación de los conocimientos a un problema social.*
- *La experiencia fue apasionante al pensar que podríamos mejorar su condición laboral.*
- *Sugiero ampliar el enfoque del estudio investigando casos en un entorno global.*

6 Reconocimientos

Los autores agradecen a la Fundación Educación Superior Empresa (FESE), por depositar su confianza en esta iniciativa de investigación. Asimismo a la Facultad de Ingeniería Química de la Universidad Autónoma de Yucatán (UADY).

Un sincero reconocimiento a los trabajadores afiliados al sindicato de carretilleros del mercado Lucas de Gálvez, por sus facilidades y disposición para acceder en todo momento a las entrevistas, consultas, responder a las encuestas durante las diferentes fases de la investigación.

Una mención especial a cada uno de los estudiantes del proyecto por su compromiso y entusiasta participación, esperemos que se identifiquen con los resultados obtenidos, pensamos que resultó muy enriquecedor para todos. Cada uno en las diferentes etapas del proyecto: *José Rosas Peniche, Nathalie Rodgon Rodríguez, Ricardo Ancona de Arredondo, Vianney Vázquez Mayorga, Estefanía López Padilla, Jhonatan Espinosa Cabrera y Manuel Paredes Medina*.

Cualquier error u omisión en el estudio son responsabilidad de los autores.

7 Referencias

Ahern, T., Leavy, B., & Byrne, P. J. (2013). Complex project management as complex problem solving: A distributed knowledge management perspective. *International Journal of Project Management*, *32*(8), 1371–1381.

Drucker, P. F. (2004). What makes an Effective Executive.pdf. *Harvard Business Review*, (September).

Escalante, J., Monsreal, I., & Hernández, F. (2015). Análisis del riesgo en la manipulación de carga en mercados municipales. *Pakbal*, 18–25. Retrieved from https://es.calameo.com/read/00212561872825567af76

Fese. (2016). Aprender, emprender, innovar. Retrieved March 18, 2016, from http://fese.org.mx/index.php

FIQ. (2016). Facultad de Ingeniería Química-UADY. Retrieved March 18, 2016, from http://www.ingquimica.uady.mx

Gartner, W. B., & Naughton, M. J. (1988). The Deming theory of management. *Academy of Management Review*, *13*(1), 138–142.

Guillot, S., & Barceló, M. (2014). *Gestión de proyectos complejos* (Ediciones .).

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn? *Educational Psychology Review*, *16*(3), 235–266.

Jimenez, T. M. (2008). *Guía de los Fundamentos para la Dirección de Proyectos (Guía del PMBOK)*. *Management*. Retrieved from www.pmi.org

Johnson, B., Ulseth, R., Smith, C., & Fox, D. (2015). The impacts of project based learning on self-directed learning and professional skill attainment: A comparison of project based learning to traditional engineering education. In *In Frontiers in Education Conference (FIE)*.

Kirkup, G., & Kirkwood, A. (2005). Information and communications technologies (ICT) in higher education teaching—a tale of gradualism rather than revolution. *Learning, Media and Technology*, *30*(2), 185–199.

Kolmos, A. (2004). Estrategias para desarrollar currículos basados en la formulación de problemas y organizados en base a proyectos. *Educar*, (33), 77–96. Retrieved from http://www.raco.cat/index.php/Educar/article/view/20789/20629

Lefrere, P. (2009). Activity-based scenarios for and approaches to ubiquitous e-Learning. *Personal and Ubiquitous Computing*, *13*, 219–227. doi:10.1007/s00779-007-0188-6

López, A., & Ugalde, A. (2015). La enseñanza por proyectos: una metodología necesaria para los futuros docentes. *Opción*, *31*, 395–413.

Lynda, B. (2015). *Gestión Stakeholders:gestión de grupos de interés*. (Digiprint Editores E.U., Ed.) (Universida.). Bogotá, D.C. Colombia.

Manage, T. (2005). Deming Cycle (PDSA). *Twelve Manage*. Retrieved from http://www.12manage.com/methods_demingcycle.html

Pingali, P. L. (2012). Green Revolution: Impacts, limits, and the path ahead. *Proceedings of the National Academy of Sciences*, *109*(31), 12302–12308.

Remington, K., & Pollack, J. (2010). What is a Complex Project. In *Tools for Complex Projects* (pp. 1–13). doi:10.1002/pmj

Saenz de Arteaga, A. R. (2012). El Éxito de la Gestión de Proyectos. *Tesis*, 242. Retrieved from http://tesisenred.net/handle/10803/117483

Santangelo, G. D. (2001). The impact of the information and communications technology revolution on the internationalisation of corporate technology. *International Business Review*, *10*(6), 701–726.

PBL applied to graduation projects that demand incorporate new academic knowledge

Karen Lemmel Vélez[1], Carlos Alberto Valencia Hernandez[2]

[1]Department of Electric and related, Faculty of Engineering, Pascual Bravo University Institution, Medellin, Colombia
[2]Department of Electronic and related, Faculty of Engineering, Pascual Bravo University Institution, Medellin, Colombia

Email: karen.lemmel@pascualbravo.edu.co , carlos.valencia@pascualbravo.edu.co

Abstract

Project-based learning has proven to be an effective tool for developing self-learning skills. The adaptation of this methodology in coaching and consulting in graduation projects has presented positive results by encouraging teamwork, and allows students to find useful prior knowledge acquired during the execution of the projects, and proper use of time also incorporating new academic knowledge not included in the curriculum. As an example of graduation project is shown: Classification of animal species through an aerial device unmanned, this project showed that with proper planning of activities, allocation of roles, and a mentoring program students can incorporate new knowledge even in the preparation of their final project.

Keywords: Active learning; Engineering education; Project based learning; Self-learning.

PBL aplicado a proyectos de grado que demandan incorporar nuevos conocimientos académicos

Karen Lemmel Vélez[1], Carlos Alberto Valencia Hernández[2]

[1]Departamento de Eléctrica y afines, Facultad de Ingenierías, Institución Universitaria Pascual Bravo, Medellín, Colombia
[2] Departamento de Electrónica y afines, Facultad de Ingenierías, Institución Universitaria Pascual Bravo, Medellín, Colombia

Email: karen.lemmel@pascualbravo.edu.co , carlos.valencia@pascualbravo.edu.co

Resumen

El aprendizaje basado en proyectos ha demostrado ser una herramienta efectiva para el desarrollo de habilidades de auto aprendizaje. La adaptación de esta metodología en tutorías y asesorías de proyectos de grado para optar al título de tecnología e ingeniería ha presentado resultados positivos al incentivar el trabajo en equipo, además de permitir a los estudiantes encontrar utilidad a los conocimientos previos adquiridos durante la ejecución de los proyectos, y la utilización adecuada del tiempo, además de incorporar nuevos conocimientos académicos no incluidos en el plan de estudios. Como ejemplo se presenta el proyecto de grado titulado: Clasificación de especies animales a través de un dispositivo aéreo no tripulado, proyecto que demostró que con una adecuada planificación de las actividades, asignación de roles, y un programa de tutorías los estudiantes pueden incorporar nuevos conocimientos aun en la elaboración de su proyecto final de carrera.

Palabras claves: Aprendizaje activo; Educación en Ingeniería; Aprendizaje basado en proyectos; Auto aprendizaje.

1 Introducción

El PBL es un modelo de aprendizaje con el cual los estudiantes trabajan de manera activa, planean, implementan y evalúan proyectos que tienen aplicación en el mundo real más allá del aula de clase (Martí, Heydrich, Rojas, & Hernández, 2010), es así como el aprendizaje basado en proyectos propone situar al alumno en un contexto directamente relacionado con su vida y con sus intereses personales, mediante los frutos de su aprendizaje; unos frutos que, tanto el alumno como su entorno, puedan apreciar, criticar y valorar en una escala que no sea exclusivamente académica.(Urquiza Castello, 2015).

La enseñanza universitaria ha cambiado en estos años adaptándose a las nuevas demandas de la sociedad (Casasola, Pérez, & García Álvarez, 2005). el constructivismo considera el aprendizaje como un proceso interno de entendimiento, que se produce cuando el alumno participa activamente en la comprensión y elaboración del conocimiento (Cenich & Santos, 2005), todo esto pone de manifiesto la necesidad de que los profesores universitarios adopten un nuevo papel, un rol que favorezca el trabajo cooperativo entre los estudiantes, la motivación por los contenidos y la relación entre lo que sucede en el aula con el mundo real (Galindo Merino, 2013).

Casasola et al., 2005 expone la importancia de las competencias a adquirir por los estudiantes, como son la creatividad, flexibilidad y la capacidad de aprender de forma permanente. Sin embargo, la vida fuera del aula exige tanto dominar ciertas materias como saber integrar unas con otras, en un modelo productivo con un marcado componente creativo, interdisciplinar, colaborativo y apoyado en las nuevas tecnologías. (Urquiza Castello, 2015).

Por las anteriores ideas es que el PBL desde hace algún tiempo, se ha constituido en una herramienta útil para los educadores (Martí et al., 2010) y en este caso de provecho para el desarrollo y feliz término de proyectos de grado en la Institución Universitaria Pascual Bravo, proyectos donde los estudiantes deben incorporar competencias académicas adicionales a las entregadas por el plan de estudios, articular las adquiridas y terminar de desarrollar las competencias blandas. El uso del PBL en el desarrollo de los proyectos de grado permite a los estudiantes incorporar nuevos conocimientos aunque no sean impartidos en su plan de estudios, llevando así a que propongan ideas aún más audaces en sus proyectos de grado, proyectos que logran superar la barrera académica e incorporar nuevos conocimientos en sus haberes durante el desarrollo de los mismos.

2 Metodología PBL aplicada a proyectos de grado

Según Rebollo Aranda, 2010 para que un proyecto se lleve a cabo de forma satisfactoria es necesario que ciertos elementos estén bien establecidos. Entre ellos, se destaca la importancia de resolver la problemática para la cual se va a trabajar en proyecto, los objetivos del proyecto global, las instrucciones iniciales que cada participante recibe, además, el tipo de evaluación final. El uso de metodologías activas como ésta facilita el aprendizaje de nuevos conceptos y la aplicación de los ya establecidos, desarrolla habilidades transversales, en especial la demandada por la Sociedad de trabajo en equipo y permite obtener una mayor motivación del alumnado (Casasola et al., 2005)

En los últimos niveles de estudio cobra especial interés conseguir un puesto de trabajo, donde tiene mayor peso las capacidades del aspirante que el grado de experiencia o la titulación específica. Es tarea de la educación superior no solo contribuir a la formación de nuestros estudiantes a partir de sus conocimientos sobre la materia que cursan, sino incentivar y promover el desarrollo de distintas competencias que resultan cruciales en el entorno laboral: competencias sociales y emocionales, creatividad, trabajo en equipo, resolución de problemas, empatía, comunicación, liderazgo, autoestima (Galindo Merino, 2013), es en esta etapa donde cobran sumo valor el aprender haciendo.

Como estrategia para reforzar competencias tanto académicas como blandas se utiliza el PBL en proyectos de grado, siempre y cuando la idea del proyecto planteado conlleve a que los estudiantes deban desarrollar competencias académicas más allá de su plan de estudios. El proyecto así a su vez promueve el autoaprendizaje indispensable para que los proyectos lleguen a feliz término y acorde al tiempo, además que sea posible reforzar los conocimientos adquiridos durante el plan de estudios y engranar los conocimientos previos.

Así, los objetivos de aprendizaje se enmarcan en los siguientes pasos enunciados por Lorenzo, Fernández, & Carro, 2011 :

1.- Propuesta de temas.
2.- Fomentar el autoaprendizaje.
3.- Desarrollar habilidades para planificar el trabajo.
4.- Desarrollar habilidades para las relaciones interpersonales.
5.- Mejora de la calidad de la enseñanza-aprendizaje por medio de la integración de las tecnologías.

2.1 "Clasificación de especies animales a través de un dispositivo aéreo no tripulado" como proyecto ejemplo.

El constructivismo social argumenta que la cultura y el contexto son importantes en la formación del entendimiento (Cenich & Santos, 2005), es así como el aprendizaje sólo ocurre en el contexto significativo de la actividad y, por tanto, es importante analizar la actividad y el contexto como parte del proceso de diseño educativo (Cenich & Santos, 2005).

Es entonces basados en ese contexto como se plantean y desarrollan los pasos descritos por Lorenzo et al., 2011. Es de destacar que las etapas 2, 3, 4 y 5 se desarrollan de forma paralela durante todo el proyecto.

1.- Propuesta de temas-problemas a los alumnos, descritos de forma mínima para centrar y definir el problema. Los temas a desarrollar están relacionados con aspectos cotidianos en nuestro entorno, en el caso de clasificación de especies animales a través de un dispositivo aéreo no tripulado se pretende abordar una problemática constante en los entornos ganaderos de nuestro país, donde la ganadería ha sido uno de los pilares y el monitoreo y control del ganado en grandes extensiones de tierra requiere altos costos en tiempo y mano de obra calificada.

2.- Fomentar el autoaprendizaje: Búsqueda y manejo de bibliografía a través de la biblioteca de la institución, utilizando libros, revistas, bases de datos, etc. Para recabar información sobre todas y cada una de las etapas del proceso analítico asociado al problema planteado, siendo una de las principales la visión artificial, temática que no es abordada en el plan de estudios.

3.- Desarrollar habilidades para planificar el trabajo, en esta etapa en base a la búsqueda y hallazgos hechos en la etapa anterior y en compañía del tutor se plantea la metodología (Figura 1) y los tiempos para la solución del problema en el cronograma de actividades, ambos claves para la gestión del proyecto y planificación de tutorías, definiendo metas tempranas como cada una de las etapas de la metodología, también se define la evaluación del proyecto como la entrega de un algoritmo que permita establecer la cantidad de bovinos en un área determinada y su ubicación aproximada en el terreno.

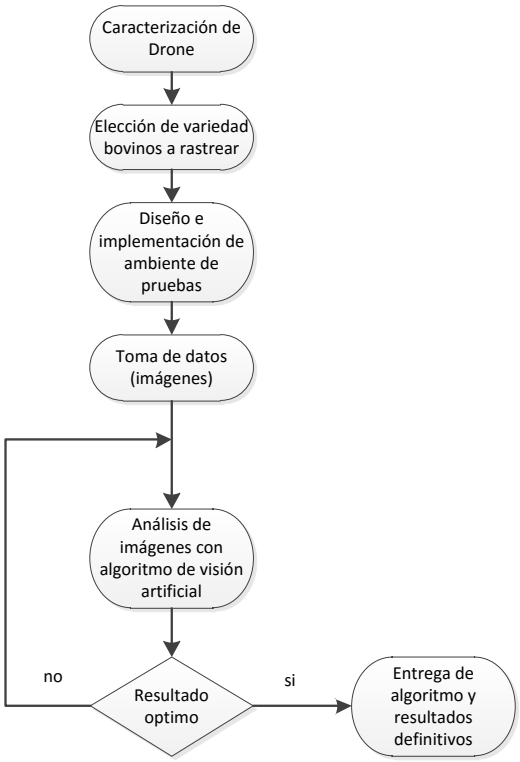


Figura 1 Metodología implementada en el sistema de identificación de bovinos por medio de un Dron con visión artificial.

4.- Desarrollar habilidades para las relaciones interpersonales, estimulando el sentido de colaboración, el trabajo de dinámica de grupo, la elaboración del informe escrito de trabajo experimental realizado para su presentación oral y defensa del trabajo de grado, además del fomento de capacidad de síntesis, liderazgo y empatía durante todo el proceso.

5.- Mejora de la calidad de la enseñanza-aprendizaje por medio de la integración de las tecnologías, en este caso identificación de ganado por medio de un vehículo aéreo no tripulado (Dron) el cual empleando una cámara y un algoritmo de visión artificial implementado en el software MATLAB® puede establecer la cantidad de bovinos en un área determinada y su ubicación aproximada en el terreno.

En la Figura 2 se muestra el resultado de la etapa de caracterización del dron, donde el modelo escogido fue el wltoys V959 con cámara incorporada.

Figura 2 Cuadricóptero con el cual se desarrolló el proyecto de clasificación de especies animales a través de un dispositivo aéreo no tripulado

Además, se realizaron pruebas de calibración de la cámara como parte de la fase de diseño e implementación de ambiente de pruebas, obteniendo como resultado las características extrínsecas de la cámara (figura 3)

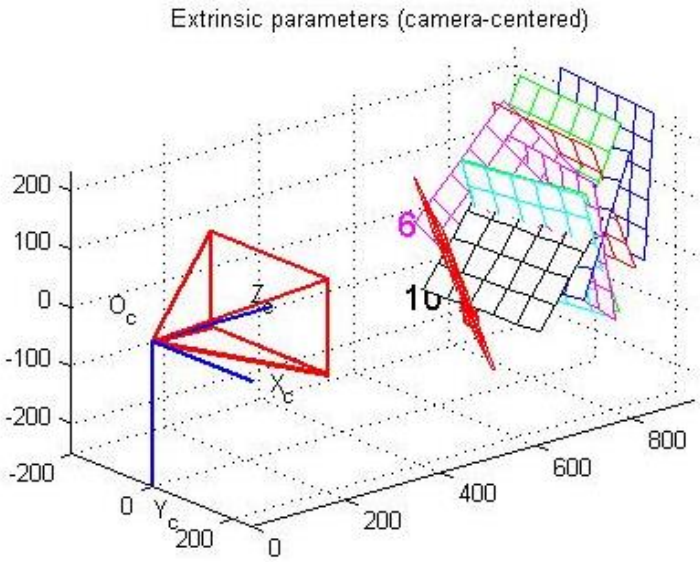


Figura 3 Características extrínsecas de la cámara

Y como resultado final del proyecto de grado se presentan los resultados del algoritmo que permitió establecer la cantidad de bovinos en un área determinada y su ubicación aproximada en el terreno (figura 4), donde se muestra la imagen original, el paso a blanco y negro, posteriormente la segmentación de la imagen y por último la localización y contaje de los bovinos, estos enmarcados en recuadros verdes.

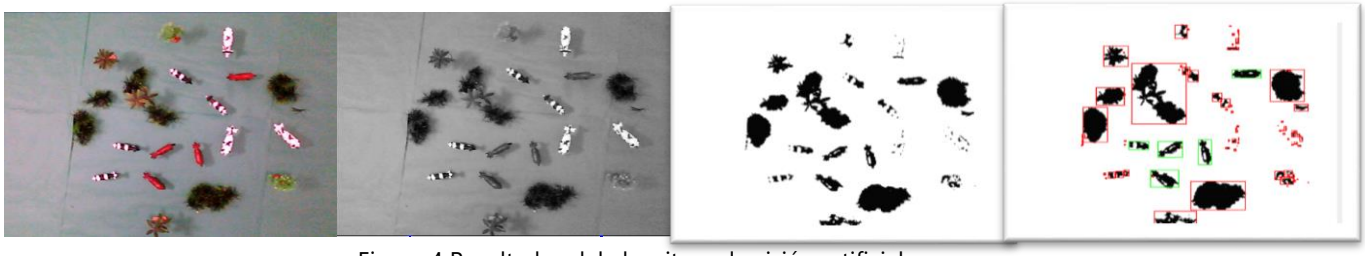


Figura 4 Resultados del algoritmo de visión artificial.

3 Resultados

El uso del PBL en los proyectos de grado ha mostrado mejora en el tiempo de respuesta de los estudiantes, en los casos donde se ha usado el PBL no ha sido necesario pedir extensión de tiempo para la entrega del proyecto. Por otro lado se ha observado que los estudiantes usan las habilidades y herramientas de autoaprendizaje en este proceso, como ejemplo el caso mostrado de clasificación de especies animales a través de un dispositivo aéreo no tripulado donde el procesamiento digital de imágenes no se encuentra entre las habilidades adquiridas con el plan de estudios de tecnología Mecatrónica y en el cual el direccionamiento del tutor es fundamental.

Se ha identificado aumento en el uso de materiales como libros, fotocopias, internet, bases de datos entre otros con mayor autonomía, aprendizaje de habilidades sociales y personales mediante el trabajo en grupos, mejor comprensión, integración y uso de lo aprendido, familiarización e implicación del alumno en situaciones y problemas de la vida cotidiana destacando el interés que muestran los estudiantes al resolver un proyecto que se encuentre entre las posibilidades de su práctica profesional.

La aplicación de la metodología del PBL promueve un procesamiento estratégico y permite el recuerdo de la información a mediano y largo plazo, fomenta la capacidad de solución de problemas de diferente naturaleza y estimula una actitud activa hacia la exploración y la indagación, además, por su carácter multidisciplinar permite la integración de conocimientos de diferentes campos.

La mayoría de estudiantes considera que el trabajo colaborativo les permite integrarse con otros compañeros, y que este proyecto concreto favorece la interdisciplinariedad, de modo que pueden comprender mejor ciertos conceptos y dimensiones implicados en el desarrollo del proyecto. Del mismo modo fomenta la adquisición de competencias como la capacidad de comunicación oral y escrita, el trabajo en equipo y la capacidad de análisis y síntesis, según el alumnado, logrando de esta manera los estudiantes se comprometan en un proceso colaborativo continuo de construcción de conocimiento.

4 Conclusiones

El uso del PBL en los proyectos de grado ha resultado una experiencia gratificante para docentes y estudiantes de la Institución Universitaria Pascual Bravo, traduciéndose esto en tiempos de respuesta tanto de los estudiantes como de los tutores, en la utilización de habilidades de autoaprendizaje, la consolidación de saberes previos y la adquisición de nuevos, además de permitir la solución de problemas de la vida cotidiana que impacten en el medio.

La definición de metas tempranas logro que los estudiantes administraran mejor su tiempo pues estaban consientes en todo momento cuanto faltaba para culminar el proyecto general, de igual manera esto contribuyó al enfoque de los estudiantes dándoles metas a corto plazo que para ellos eran más fáciles de alcanzar si se veían de forma individual; caso contrario a lo que pasaba cuando los observaban dentro del bloque completo de un macro proyecto.

5 Referencias

Casasola, M. A., Pérez, V., & García Álvarez, J. (2005). Aprendizaje Basado En Proyectos Y Trabajo En Equipo : Innovando En La Docencia De La Asignatura " Sistemas Contables Informatizados." *Revista Universidad Pablo de Olavide Sevilla Innova*, *I*, 107–122.

Cenich, G., & Santos, G. (2005). Propuesta de aprendizaje basado en proyecto y trabajo colaborativo: experiencia de un curso en línea. *Revista Electrónica de Investigación Educativa*, *7*(2). Retrieved from http://redie.uabc.mx/index.php/redie/article/view/133\nhttp://redie.uabc.mx/index.php/redie/article/download/133/228

Galindo Merino, M. M. (2013). Trabajo cooperativo, competencias emocionales, aprendizaje basado en proyectos e innovación docente. In *XII Jornadas de Redes de Investigación en Docencia Universitaria. El reconocimiento docente: innovar e investigar con criterios de calidad* (Vol. 53, pp. 1689–1699). http://doi.org/10.1017/CBO9781107415324.004

Lorenzo, R. a, Fernández, P., & Carro, A. M. (2011). Experiencia en la Aplicación del Aprendizaje Basado en Problemas en la Asignatura Proyecto de Licenciatura en Química. *Formación Universitaria*, *4*(2), 37–44. http://doi.org/10.4067/S0718-50062011000200005

Martí, J. A., Heydrich, M., Rojas, M., & Hernández, A. (2010). Aprendizaje basado en proyectos: una experiencia de innovación docente. *Revista Universidad EAFIT*, *46*(158), 11–21. Retrieved from http://www.redalyc.org/pdf/215/21520993002.pdf

Rebollo Aranda, S. (2010). "Aprendizaje basado en proyectos." *Revista Digital Innovacion Y Experiencias Educativas*, *26*.

Urquiza Castello, D. (2015). *Aprendiza je basado en proyectos: Aplicación pedagógica del diseño y análisis de las bicicletas de montaña*. Universidad de Navarra.

PAEE/ALE'2016 Abstract Submissions (Portuguese)

Submissions of abstracts accepted for the PAEE/ALE'2016 abstract sessions in Portuguese.

The Contribution of Project Based Learning for Developing a Competence Based Curriculum

Diana Mesquita[1,2]; Maria A. Flores[1]; Rui M. Lima[2]

[1] Instituto de Educação, Universidade do Minho, Braga, Portugal
[2] Department of Production and Systems, School of Engineering, University of Minho, Campus of Azurém, Guimarães, Portugal

Email: diana@dps.uminho.pt, aflores@ie.uminho.pt, rml@dps.uminho.pt

Abstract

In Higher Education the meaning of *curriculum* is frequently limited to a course or a sum of courses that draw up an entire program. Engineering Education has been increasingly concerned about curriculum innovation within engineering programs, regarding to implementation of student-centered strategies, such as Project Based Learning (PBL). Most of the studies highlight the results and benefits of this approach, namely students' motivation and engagement, the link with professional practice, the demands for teaching practice, amongst other. However, there are a lack of studies with in-depth analysis of the engineering curriculum as a whole, in which the different components of curriculum might be presented related to each other (planning, assessment, content, resources, methodology, the professional profile and competences). This work aims to analyze the curriculum of an engineering program in Portugal (Industrial Engineering and Management at University of Minho), taking into account the curriculum levels presented by Goodlad (1979). Different methods of data collection were used, including document analysis concerning to the program, focus group with students and teachers and interviews with graduates. The results of this analysis allows discussing the idea of developing a competence based curriculum and the contribution of PBL for engineering training.

Keywords: Engineering Education; Curriculum Development; Project Based Learning (PBL); Competences Development.

O Contributo da Aprendizagem Baseada em Projetos Interdisciplinares para o desenvolvimento de um Currículo por Competências

Diana Mesquita[1,2]; Maria A. Flores[1]; Rui M. Lima[2]

[1] Instituto de Educação, Universidade do Minho, Braga, Portugal
[2] Department of Production and Systems, School of Engineering, University of Minho, Campus of Azurém, Guimarães, Portugal

Email: diana@dps.uminho.pt, aflores@ie.uminho.pt, rml@dps.uminho.pt

Resumo

No contexto do Ensino Superior o conceito de currículo é, por vezes, entendido de uma forma redutora sendo associado a uma disciplina ou à organização de um conjunto de disciplinas que compõem um curso. Em vários contextos, a Educação em Engenharia tem demonstrado uma preocupação crescente com a inovação curricular dos cursos de Engenharia, através da implementação de metodologias centradas na aprendizagem do aluno, de que é exemplo a aprendizagem baseada em projetos interdisciplinares (*Project-Based Learning* - PBL). Na sua maioria, os estudos decorrentes deste contexto colocam a ênfase nos resultados e vantagens desta abordagem, tais como a motivação e envolvimento dos alunos no processo de aprendizagem, a aproximação à prática profissional, as exigências ao nível da prática docente, entre outros aspetos. Contudo, os estudos ainda são escassos no que diz respeito a uma análise aprofundada do currículo de Engenharia como um todo, isto é, envolvendo a relação entre diversas componentes, tais como a planificação, a avaliação, os conteúdos, os recursos, a metodologia, o perfil profissional e as competências. Neste sentido, este artigo visa analisar o currículo de um curso de Engenharia em Portugal (Mestrado Integrado em Engenharia e Gestão Industrial da Universidade do Minho), considerando os diferentes níveis de currículo propostos por Goodlad (1979). Para tal, foram utilizados diferentes métodos de recolha de dados, nomeadamente a análise documental do curso em questão, grupos focais com alunos e professores e ainda entrevistas com antigos alunos. Os resultados desta análise permitem refletir criticamente sobre a ideia de um currículo por competências e o contributo do PBL para a formação inicial de Engenharia.

Palavras-chave: Educação em Engenharia; Desenvolvimento Curricular; Project Based Learning (PBL); Desenvolvimento de competências.

Reference Matrix for Assessment of Profile and Competences in Higher Education

Claisy M. Marinho-Araújo[1], Mauro L. Rabelo[2]

[1] Faculty of Psychology, University of Brasilia, Brasilia, Distrito Federal, Brazil
[2] Mathematics Department, University of Brasilia, Brasilia, Distrito Federal, Brazil

Email: claisy@unb.br, rabelo@unb.br

Abstract

The Brazilian higher education system has been experienced significant changes. In recent years, some educational and political landmarks influenced especially the system expansion from some dimensions: assessment (National Evaluation System of Higher Education); financing (establishment of specific programmes for democratization of access and expansion of the network); different forms of entrance exams (creation of Unified Selection System and affirmative action policies); pedagogical orientation (deployment of National Curriculum Guidelines). This scenario impacts curricular projects, Faculty training and process improvement of evaluation of students' profiles. The Brazil has accumulated great experience in large-scale assessment systems, from basic education up to the top level. In all of these systems the reference matrices are used as centring tool to guide the elaboration of evaluation items. In this work, will be presented the theoretical-conceptual and methodological bases of the reference matrix for evaluation of professional profiles and skills used in the National Examination Performance of Students, based on a critical-emancipatory design. This conception is based on theoretical assumptions of dialectic critical thinking, which conceives the profile and skills as multidimensional (considering socio-cultural and historical dimensions as contexts, spaces and times; social class, gender, ethnicity, generational groups), and articulates the educational, professional and ethical-political dimensions as a complex methodological tool. The matrix can be useful both to the development of evaluation instruments and procedures, and to support curricular guidance with the focus on the expected profile, with ramifications for process evaluation, programs, or for scientific research. The possibilities for using the matrix in the evaluation of professional profiles and competences can be extended and adapted to different contexts and countries, favouring the establishment of indicatives for the regulation and supervision of higher education.

Keywords: Educational assessment; Professional profile; Competences; Reference Matrix; Higher education.

Matriz de Referência para Avaliação de Perfil e Competências na Educação Superior

Claisy M. Marinho-Araújo[1], Mauro L. Rabelo[2]

[1] Faculty of Psychology, University of Brasilia, Brasilia, Distrito Federal, Brazil
[2] Mathematics Department, University of Brasilia, Brasilia, Distrito Federal, Brazil

Email: claisy@unb.br, rabelo@unb.br

Resumo

O sistema de Educação Superior brasileiro vem experimentando mudanças significativas. Nos últimos anos, alguns marcos políticos e pedagógicos influenciaram especialmente a expansão do sistema a partir de algumas dimensões: avaliação (implantação do Sistema Nacional Avaliação da Educação Superior); financiamento (criação de programas específicos para democratização do acesso e expansão da rede); formas de ingresso (criação do Sistema de Seleção Unificada e de políticas de ações afirmativas); orientação pedagógica (implantação das Diretrizes Curriculares Nacionais). Esse cenário vem impactando projetos curriculares, a formação do corpo docente e o aperfeiçoamento de processos de avaliação de perfis discentes. O Brasil tem acumulado grande experiência em sistemas de avaliação em larga escala, desde a educação básica até a superior. Em todos esses sistemas são utilizadas matrizes de referência como instrumento centralizador para orientar a elaboração de itens de avaliação. Neste trabalho, serão apresentadas as bases teórico-conceituais e metodológicas da Matriz de Referência para Avaliação de Perfil e Competências utilizada no Exame Nacional de Desempenho de Estudantes, apoiada na concepção crítico-emancipatória. Essa concepção fundamenta-se nos pressupostos teóricos do pensamento crítico-dialético, concebe o perfil e as competências como multidimensionais (considerando dimensões socioculturais e históricas como contextos, espaços e tempos; classe social, gênero, etnias, grupos geracionais) e articula as dimensões educacional, profissional e ético-política como complexa ferramenta metodológica. A Matriz pode ser útil tanto à elaboração de instrumentos e procedimentos avaliativos, quanto para subsidiar orientação curricular com o foco no perfil esperado, com desdobramentos para avaliação de processos, programas, ou para pesquisa científica. As possibilidades de utilização da Matriz na avaliação do perfil e das competências pode ser ampliada e adaptada para diversos contextos e países, favorecendo o monitoramento de indicativos para a regulação e supervisão do ensino superior.

Palavras-chave: Avaliação educacional; Perfil professional; Competências; Matriz de referência; Educação superior.

Students' perceptions of assessment: a study in five Portuguese public universities

Diana Pereira[1], Maria Assunção Flores[1]

[1] Institute of Education, University of Minho, Campus of Gualtar, Braga, Portugal

Email: dianapereira@ie.uminho.pt, aflores@ie.uminho.pt

Abstract

The implementation of the Bologna Process has brought changes in the organization of curricula and in the process of teaching, learning and assessment. Particularly with regard to the assessment, there is the debate around new assessment methods and strategies to assess learning. This communication is part of a broader study on assessment in higher education and focuses on the students' perceptions of assessment and, in particular, on the effectiveness and fairness of traditional assessment methods and the so-called alternative methods. This paper also analyzes the influence of the assessment methods in the learning process. In total, 624 students participated in this study in five Portuguese public universities attending courses in different areas of knowledge. In this study we selected the 4 areas of knowledge covered by the Portuguese Foundation for Science and Technology: Social Sciences and Humanities (SSH), Life and Health Sciences (LHS), Natural and Environmental Sciences (NES) and Exact Sciences and Engineering (SE). Data were collected through a questionnaire. The results suggest that assessment is seen as more effective and fair when it is carried out through assessment methods centred on student than when performed by traditional assessment (eg, written tests or exams). Students also say that devote more time to study when the assessment is performed through assessment methods centred on student than by traditional methods. The effectiveness of the assessment process is also related to the development of skills needed in real life and its impact on the quality of learning. However, students' claim that the written test is the most widely used assessment method. These and other issues will be discussed in the article.

Keywords: Assessment; Higher Education; Bologna Process.

Perceções de alunos universitários sobre avaliação das aprendizagens: um estudo em cinco universidades públicas portuguesas

Diana Pereira[1], Maria Assunção Flores[1]

[1] Institute of Education, University of Minho, Campus of Gualtar, Braga, Portugal

Email: dianapereira@ie.uminho.pt, aflores@ie.uminho.pt

Resumo

A implementação do Processo de Bolonha implicou mudanças quer na organização dos currículos, quer na organização dos graus de ensino com repercussões no processo de ensino, de aprendizagem e de avaliação. Particularmente, no que se refere à avaliação, destaca-se o debate em torno de novos métodos de avaliação e novas estratégias para avaliar as aprendizagens. Esta comunicação insere-se num estudo mais amplo sobre avaliação no ensino superior e centra-se nas perceções dos alunos universitários acerca da avaliação e, em particular, na eficácia e justiça dos métodos tradicionais de avaliação e dos chamados métodos alternativos. Esta comunicação analisa também a influência dos métodos de avaliação no processo de aprendizagem. No total, participaram 624 alunos neste estudo em cinco Universidades Públicas Portuguesas que frequentavam cursos de diferentes áreas do conhecimento. Neste estudo selecionamos as 4 áreas do saber contempladas pela Fundação para a Ciência e Tecnologia: Ciências Humanas e Sociais (CHS), Ciências da Vida e da Saúde (CVS), Ciências Naturais e do Ambiente (CNA) e Ciências Exatas e Engenharia (CEE). Os dados foram recolhidos através do inquérito por questionário. Os resultados sugerem que a avaliação é vista como mais eficaz e mais justa quando é realizada através de métodos de avaliação centrados no aluno do que quando realizada através da avaliação tradicional (por exemplo, testes escritos ou exames). Os alunos também afirmam que dedicam mais tempo para estudar quando a avaliação é realizada através de métodos de avaliação centrados no aluno do que pelos métodos tradicionais. A eficácia do processo de avaliação está ainda relacionada com o desenvolvimento das competências necessárias na vida real e o seu impacto na qualidade da aprendizagem. Contudo, os alunos afirmam que o teste escrito é o método de avaliação mais utilizado. Estas e outras questões serão discutidas no artigo.

Keywords: Avaliação das Aprendizagens; Ensino Superior; Processo de Bolonha

The contribution of Assessment for Learning in Higher Education: an intervention project in Engineering

Patrícia Santos[1], Maria Assunção Flores[1], Paulo Flores[2], Rui Pereira[3], Nuno Dourado[2]

[1] Institute of Education, University of Minho, Campus of Gualtar, Braga, Portugal
[2] School of Engineering, University of Minho, Campus of Azurém, Guimarães, Portugal
[3] School of Sciences, University of Minho, Campus of Gualtar, Braga, Portugal

Email: patricia.santos@ie.uminho.pt, aflores@ie.uminho.pt, pflores@dem.uminho.pt, rmp@math.uminho.pt, nunodourado@dem.uminho.pt

Abstract

Pedagogical innovation and teachers' pedagogical training are key issues in Higher Education, in a context where the educational priorities point out to the need to strength the teaching quality levels. With the Bologna Process, the renewed framework in the curricula has brought about changes with implications for teaching, learning and assessment methodologies, considered key issues to achieve pedagogical excellence in Higher Education. In this sense and since it emphasises assessment and continuous feedback mechanisms between teacher and student for adjustment of teaching strategies and learning activities, the Assessment for Learning (AfL) approach has been pointed out as a pedagogical innovation where the priority is to enhance students' learning. Literature highlights that AfL practices stimulate students' engagement in the learning process in a more active way, providing them with more positive formative experiences, such as: greater teacher support, flexible curricular design, dialogue opportunities through formal and informal feedback, peer learning, research opportunities, competencies testing, questioning and self-regulated learning. This paper draws on data from an ongoing PhD project (SFRH/BD/94152/2013) aimed at investigating AfL in Sciences, Engineering and Social Sciences in two public universities in Portugal. With three different research phases, the study combines the development of focus groups, a survey and the development of an intervention project with students and teachers. Data reported in this paper were collected through the development of the intervention project focused on AfL, namely with the survey and the monitoring strategies of teaching, learning and assessment. In total, 2 university teachers and 100 students enrolled at an Engineering programme participated in this research phase, in a perspective of co-training and professional development and in articulation with the pedagogical practice. Findings reflect about AfL potentialities and implications in the teaching, learning and assessment processes, as well as in the academic outcomes in Higher Education.

Keywords: Assessment for Learning; Teaching; Engineering Education.

O contributo da Avaliação para a Aprendizagem no Ensino Superior: um projeto de intervenção em Engenharia

Patrícia Santos[1], Maria Assunção Flores[1], Paulo Flores[2], Rui Pereira[3], Nuno Dourado[2]

[1] Instituto de Educação, Universidade do Minho, Campus de Gualtar, Braga, Portugal
[2] Escola de Engenharia, Universidade do Minho, Campus de Azurém, Guimarães, Portugal
[3] Escola de Ciências, Universidade do Minho, Campus de Gualtar, Braga, Portugal

Email: patricia.santos@ie.uminho.pt, aflores@ie.uminho.pt, pflores@dem.uminho.pt, rmp@math.uminho.pt, nunodourado@dem.uminho.pt

Resumo

A inovação pedagógica e a formação pedagógica de docentes assumem particular enfoque no Ensino Superior, num contexto em que as prioridades educativas contemplam o reforço dos níveis da qualidade do ensino. Com o Processo de Bolonha, o atual quadro renovado nos *curricula* impõe mudanças ao nível das metodologias de ensino, de aprendizagem e de avaliação, fundamentais para a excelência pedagógica. Neste sentido, a abordagem *Assessment for Learning* (AfL), que recorre à avaliação e a mecanismos contínuos de *feedback* entre professor e aluno para o ajustamento das estratégias de ensino e das atividades de aprendizagem, tem sido apontada como base para a inovação pedagógica cuja prioridade é a promoção da aprendizagem. Estudos comprovam que esta abordagem envolve os alunos ativamente nas aprendizagens, proporcionando-lhes experiências formativas mais positivas como maior apoio do professor, *design* curricular flexível, oportunidades de diálogo pelo *feedback* formal/informal, aprendizagem entre pares, oportunidades de investigação, teste de competências, questionamento e aprendizagem autorregulada. A presente comunicação insere-se num projeto de doutoramento em curso (referência SFRH/BD/94152/2013) que procura investigar a abordagem AfL em duas universidades públicas portuguesas e em cursos no âmbito das Ciências Exatas e Engenharia e das Ciências Sociais. Ao longo de três fases de investigação, o estudo contempla a realização de grupos focais, a aplicação de inquéritos por questionário e o desenvolvimento de um projeto de intervenção com alunos e docentes. Nesta comunicação apresentamos os resultados obtidos com o inquérito por questionário e com as estratégias de monitorização do ensino, da aprendizagem e da avaliação que integraram o projeto de intervenção focalizado na abordagem AfL. Esta fase contou com a participação de 2 docentes e 100 alunos de um Mestrado Integrado em Engenharia, numa lógica de co-formação e desenvolvimento profissional e em articulação com a prática pedagógica. Os resultados permitem refletir sobre as potencialidades e as implicações da avaliação para a aprendizagem no processo de ensino, de avaliação e de aprendizagem e nos resultados académicos no Ensino Superior.

Palavras-chave: Avaliação para a Aprendizagem; Ensino; Educação em Engenharia.

PAEE/ALE'2016 Submissions for the Students Paper Award

Submissions accepted for the PAEE/ALE'2016 Students Paper Award in English.

Proposal for Setup Time Reduction of a Cold Chamber Die Casting Machine

Hector Carlo Bosso[1]

[1] Faculty of Science and Technology, PUC São Paulo, Campus Marquês de Paranaguá, São Paulo, Brazil

Email: hbosso@outlook.com

Abstract

Due to the coverage of the use of die-cast parts in several industry segments, it is necessary to constantly develop cost saving solutions in this productive process. The exchange of dies is one of the operating variables in the cold chamber die casting process, that, if poorly performed, increases costs and setup times, reducing the machine productivity. The objective of this work was to reduce the setup time of dies in an aluminum cold chamber die casting machine and explore the involvement of an engineering student in this productive process through specific activities and a multidisciplinary team composed by a die casting professional, a machine operator and a production engineering student. The work happened by the analysis of the setup time before any change to the operations, followed by the proposal and implementation of improvements and further evaluation of the results, considering the application of some SMED principles. Initially, the machine production schedule was evaluated and a team was defined for the current study, being managed in order to follow the proposed project. A single machine was selected to be analysed over a month, so that the changed molds had similar characteristics. The setup study consisted in chronoanalysis, separating the time for each operation and identifying their problems. According to the measured times, the setup time reduction achieved in this study was of 54,14% or 16 minutes and 53 seconds.

Keywords: Cold Chamber Die Casting Machine; Setup; Multidisciplinarity; Team Management.

1 Introduction

The high pressure die casting its manufacturing process of non-ferrous metals able to produce light parts with thin walls and complex geometry (Wu & Zhang, 2005). Due to the high pressure applied in the injection of the molten material into the die, it is possible to obtain products with excellent superficial finishing, avoiding, in some specific cases, additional machining processes (Cardinali & Toledo, 2011).

The quick die changeover it's one of the tools that cooperates for the cost reduction and the improvement of a productive process. It aims reducing the setup times in order to gain more production times. (Neha et al, 2013). According to Shingo (2000), the SMED (Single Minute Exchange of Dies) principles helps for the setup time reduction due to the standardization and simplification of the operations done.

This work approaches the application of the quick die changeover to the high pressure die casting process under the management of a predefined and multidisciplinary team, considering the didacticism of the research and the creation of new procedures and systematic through the harmonic interaction of an engineering student (researcher) and the rest of the team. Thus, special and new activities were introduced from the other specialists to the student in order to familiarize him to the study and the high pressure die casting process.

2 Objectives

The objective of this work it's to reduce as max as possible the molds setup time in an aluminum cold chamber die casting machine of 180 tons of clamping force. To achieve the proposed objective, were used tools like chronoanalysis, conversion of internal to external operations and the creation of new devices and systematic to facilitate the changeover. The involvement of the team and the sum of ideas intended to create a sustainable working model that could absorb the knowledge of all the specialists and bring satisfactory results was hardly emphasized.

In addition to the primary objective, the ability of the student (researcher) to get actively involved with the study and the productive process by doing specific and manual activities that could collaborate to the research and his learning was tested, being a crucial factor to validate this study and his learning about it.

3 The mold changeover in cold chamber die casting machines

The high pressure die casting uses permanent metallic bipartite molds, made of steel and heat treated (Pereira, Williams & Du Preez, 2012). The die is composed by the molding cavity, an ejector board, an injection sleeve and, sometimes, mechanical or hydraulic drawers, that shape the holes of the parts (Reinert & Santana, 2004).

The cold chamber die casting machines, the ones that use these dies, have two main elements: the injection of the molten material and the mechanical opening and closing movement of the die (Cardinali & Toledo, 2011).

Since every mold has its molding cavity, with a particular part format inside of it; in the necessity of producing different parts, it is necessary to change the mold. The studied company has the characteristic of having constant mold changeovers during a day, due to the production of small lots and different parts in a machine; thus, this peculiarity made favorable the realization of this research.

4 The multidisciplinarity in the high pressure die casting process

Owing to the built-in big complexity of this casting process, it is possible to claim that every human component present in the industrial environment has its contribution in terms of knowledge to the development and evolution of the process. From operators to maintainers, preparers and managers. The multidisciplinarity stands out here as one of the main sources of solutions for the problems, as a single object its evaluated from several views of different subjects. The comprehension of the system and the identification of its mostly significant elements depends of the acquaintance, experience and ability of the specialist (Sakurada & Miyake, 2009).

Thereby, this environment offers a synergy and cohesion between the different knowledges needed and the active learning of who is studying the determined system. The active learner learns from the active experimentation, discussing and testing the obtained information and results (Felder & Silverman, 1988). The active learner works well in groups, since pieces of information from different sources are exposed, creating a dynamic atmosphere where the student feels more comfortable to work and, consequently, more capable to absorb new knowledges.

This work has put in practice a situation in which the multidisciplinarity was a key-element to the obtainment of useful results. The connection of different specialists in the team and the participation of an engineering student allowed the analysis from different viewpoints, favoring, in addition, his stimulus.

5 Methodology

An intensive use machine and dies with similar characteristics and components were selected, running the study for a month. Initially, the present situation of the exchanges was analyzed, which consisted in the study of the operations performed before the implantation of any improvement or change. The setup operations and analysis were made with a predefined team, composed by the machine operator, the preparer and the researcher (student). The study happened by chronoanalysis, documentation of the operations and the classification of internal and external activities.

In rotation with the technical procedures, it was considered the existence of a multidisciplinary team, engine for the thorough examination of the system and the consequent creation of ideas coming from different viewpoints. This multidisciplinarity comes from the knowledge of the preparer about the handling of the dies and the machine regulation, the acquaintance of the operator about operating the machine and the scientific and innovative insight of the student. Below, in the Figure 1, the studied machine and one of the studied dies, respectively:

Figure 1. 180 tons of clamping force cold chamber die casting machine (left) and a casting die (right).

5.1 Materials

The materials used in this study were:

- Cold chamber die casting machine Alpresse Model Cast 180 t
- 5x cold chamber die casting molds (700 to 1000 kg)
- 2x moving pulleys of 1 ton of lifting capacity
- 2x box wrench
- Mondaine Wasom Chronometer
- Sony Cybershot DSC-P93A Camera
- Wood pieces for the adaptation of the tools panel in the current working table

5.2 Methods

The methods, step by step, for the analysis of the setups happened in the following sequence:

1. Selection of an intensive use machine and selection of molds with similar characteristics for the exchanges
2. Chronoanalysis of five setups and its operations in the present situation, before any modification
3. Classification of internal and external activities
4. Identification of the problems during the setups
5. Analysis of the possible conversions of internal to external operations, brainstorming with the team aiming the solution of the current problems and proposal of additional improvements
6. Definition of the new setup operations sequence and implantation of the suggested improvements
7. New five chronoanalysis of the setups after the insertion of the changes to the procedures
8. Comparison of the setup times before and after the implantation of the improvements and conclusion of the study

6 Results

Considering the use of only internal operations, five setups were measured, providing the following times and an average, as the Table 1 shows:

Table 1. Consumed times for the setups before the modifications and its average (m:s).

Setup 1A	Setup 2A	Setup 3A	Setup 4A	Setup 5A	Average
40:06	39:30	38:37	31:36	34:18	36:49

Each one of the operations were timed individually during the chronoanalysis, so it was possible to know which one of them consumed more time during the setup, as the Figure 2 shows below:

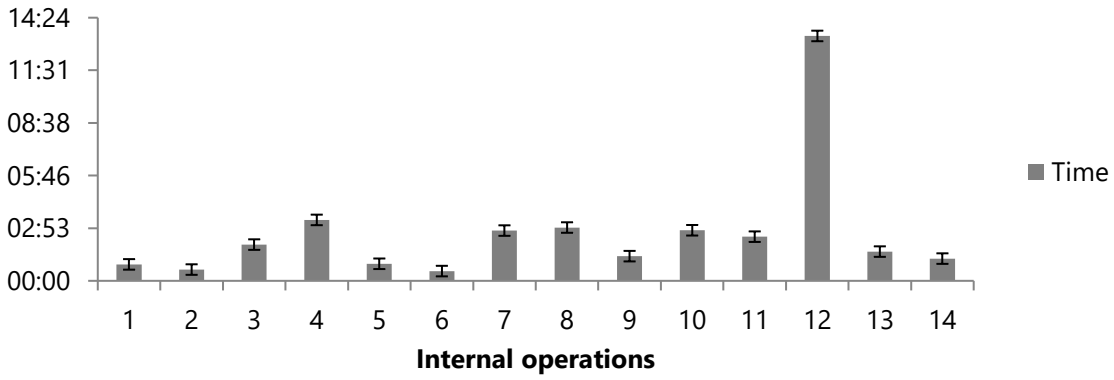


Figure 2. Average consumed times in the internal operations before the modifications.

6.1 Problems identified during the setups

Below, the problems detected from the notes made along the changeovers:

a) Existence of moments in which the operator remained inactive while the preparer was doing some operation and vice versa
b) Lack of organization in the working tools (box wrenches and clamps)
c) Only internal operations
d) Big distance between the dies and the machine, implying in too much movement
e) Considerable difficulty in fasten the die clamps with shims
f) Non-standardized operations

The Figure 3 shows the die clamps with shims and the tools table used in the machine before the modifications applied:

Figure 3. Die clamp with shim (left) and the old tools table (right).

6.2 Proposal and implantation of improvements to the identified problems

This work considered legitimate and specific practices to the reduction of the setup time, adapting itself to the reality of the studied company, its culture and the workstation. Obviously, some SMED principles were considered, but new ideas were implemented in this work. Therefore, from the observed problems and inefficiencies in the setup, the following solutions and additional improvements were proposed to the current operations:

a) Separation of operations to be done by the operator and the preparer: creation of an ideal order, so that both could familiarize with their respective activities and, in the long run, could perform them intuitively.
b) Definition of parallel operations: simultaneous operations, aiming keep both of the setup team active most of the time. Certain activities can be inserted in the middle of others, since they have synergy between them.

c) Use of the 5S concept in the used tools: a tools panel was built in order to arrange the used tools in the setup on it. The panel was adapted in the current table used near the machine, reducing costs and taking advantage of the existent structure.
d) Conversion of internal to external operations: proposal of improvement already present in the SMED literature, leading to a shorter time of inactive machine, since it starts the changeover when the machine is still producing the previous lot.
e) Replacement of die clamps with shims for clamps with levelers: the built-in levelers in the clamps will abolish the shims, as it regulates the die holding height using an adjustable screw. Besides the better ergonomy, the removal of the shims in the workstation keep the working area cleaner.
f) Creation and documentation of a standardized procedure for the setup operations: the document containing the standardized procedures considered that the changeover would start when the previous lot hit approximately 90% of its completion.
g) Introduction of the documents near the machine
h) Approach of the dies close to the machine: it was created an area called the "dies island" a delimited area in front of the machine where all the dies used on it could be placed side by side, avoiding the use of two moving pulleys for the transportation operations. The proximity of the dies to the machine eliminates unnecessary times of movement inside the factory and streamlines the external operations made by the preparer.
i) Creation of a notification system for the next setup in the machine: the development of this device was necessary due to the conversion of internal to external operations. The called "setup panel" allows the preparer to know when to start the external operations using the current lot in production as a reference (the one of the output die). It's about an implement that "automates" the activity of the preparer, as it avoids the excessive communication among human components of the department. This panel works by cards with unique meanings, that represent:

- Output die and the produced lot quantity
- Input die and lot quantity to be produced
- Green card: indicates that the last changeover operation was already done
- Red card: indicates that a new changeover operation has to be done

The cards are manipulated by the supervisor of the department and by the machine preparer, that, when refreshing the cards, establish an indirect contact through the panel. It was stipulated that the preparer should start the external operations when the output lot quantity (the one producing) hit 90% of its completion, giving enough time for the external operations to occur while the operator finishes the output production. The cards work cyclically in the panel, as it's shown in the Figure 4:

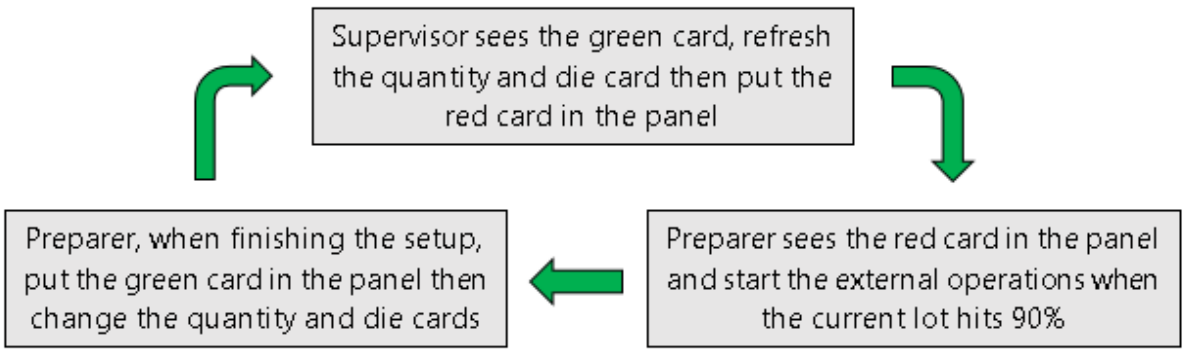


Figure 4. Cards cycle in the setup panel.

Situation	Setup information			
	Input die	→	362	
	Quantity to produce	750	+	10%
	Die in the machine	→	993	
	Quantity to produce	400	+	10%

Figure 5. Representation of the setup panel.

Above, in the Figure 5, for example, it means that the die number 993 has been put in the machine and the 362 is the next. Then "10%" is the additional quantity to be produced to compensate losses from pauses, which is defined by the programmer.

The Figure 6 describes the modifications made in the study, exposing the new die clamps, the tools panel, the dies island and the setup panel, respectively:

Figure 6. Die clamp with leveler, tools panel, dies island and setup panel, respectively.

The table 2 lists the new sequence of setup operations defined by the team:

Table 2. Sequence of setup operations after the modifications.

Number	Operation	Who performs	Type
1	Approximate the trolley to the input die	Preparer	External
2	Approximate the moving pulley to the input die, hoist it over the trolley and take it to the front of the rear door of the machine	Preparer	External
3	Get the injection chamber and the piston for the input die	Preparer	External
4	Approximate the moving pulley to the machine and put the hook into the eye bolt of the output die	Both	Internal
5	Remove die clamps	Both	Internal
6	Hoist the output die and put it over the trolley	Operator	Internal
7	Remove the ejector pins and change the injection chamber and piston	Preparer	Internal
8	Hoist the input die and put it inside the machine (suspended between the machine plates)	Operator	Internal
9	Align the fixed die plate to the injection chamber	Both	Internal
10	Fasten the die clamps of the fixed die plate	Both	Internal
11	Open the machine die plate holder and put the ejector pins	Preparer	Internal

12	Close the machine die plate holder and fasten the remaining die clamps	Both	Internal
13	Remove the moving pulley from the workstation	Both	Internal
14	Adjust the die height	Preparer	Internal
15	Check the injection parameters sheet and insert them in the machine panel	Preparer	Internal
16	Stow the used tools in the tools panel and clean the workstation	Operator	Internal
17	Conduct the trolley with the output die close to the dies island. And put it in its right place with the pulley	Operator	External

The Table 3 shows the new setup times measured using the new operations sequence:

Table 3. Consumed setup times after the modifications and its average (m:s).

Setup 1B	Setup 2B	Setup 3B	Setup 4B	Setup 5B	Average
20:03	23:02	20:31	17:40	18:25	19:56

In the Figure 7, below, it's possible to notice that the time spent in the operations are better distributed, being more homogeneous:

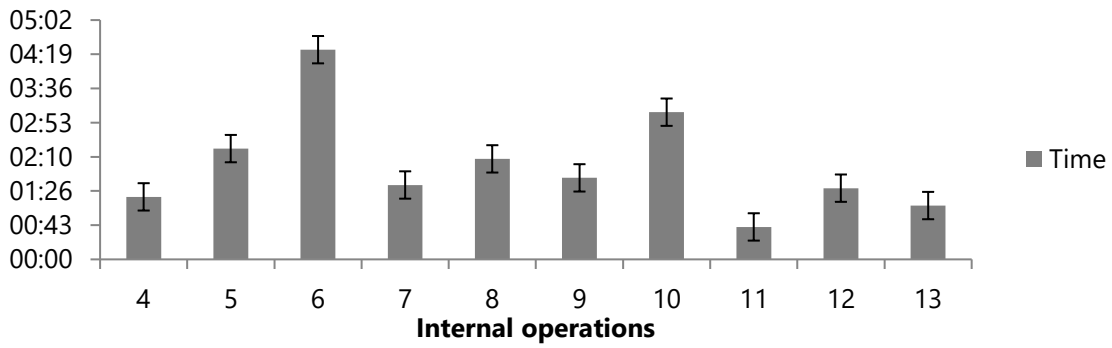


Figure 7. Average times consumed in each operation after the modifications applied.

Comparing the times before and after the changes, it's noticeable a difference between the setup time average before and after the changes

Table 4: Comparison between the average times before and after the changes.

Average consumed time in the setups (m:s)		Setup time reduction after the modifications	
Before	After	In minutes	In %
36:49	19:56	16:53	54,14

6.3 Crucial elements to the learning of the engineering student in this study

Some activities had an important role in the learning of the engineering student during the work. Since it has the focus in the active learning, practices in which the student literally took action as a change agent must be clearly mentioned, as it is cited below:

- The setup panel was designed and manually built by the student
- The yellow demarcations to limit the "dies island" were painted by the student

- The tools panel was designed and built by the student, from the cut of the woods to the adaptation of the old table

7 Conclusions

The current work evolved very well due to the solid rapport of the setup team and the union of ideas during the brainstorming, "filling gaps" in the existent problems with actions and solutions coming from different angles. The operator contributed with ideas about how to make the process more ergonomic, the preparer helped teaching the best ways to manipulate the dies with the pulley and the student brought the intelligent idea of the setup panel alongside with the harmonic management of the team. It is possible to claim that the approach of the dies to the machine, the creation of the parallel and external operations and the change of the die clamps were the improvements with the biggest impact in the setup, contributing positively for the results of the study.

The approach of the dies allied to the external operations eliminated transportation and handling times; the parallel operations undermined the idleness of the team and the new die clamps eliminated the adjustments of the shims and provided way more ergonomy during the fasten process.

However, one of the factors that had more influence in this study was the creation of the favorable and harmonic atmosphere among the team components. The involvement of the student with the specialists allowed the nurture of confidence among them, everyone in favor of the resolution of the exposed case. The activities and the constant necessity of action during the work shaped a stimulant environment, consolidating the link among the team components; the specialists and the student.

Thus, considering the chronoanalysis and the obtained results, this study could reduce the setup time of the studied machine in 54,14% or 16:53 minutes, validating the methodology and results for the proposed objective.

8 References

Cardinali, A & Toledo, E.F. (2011). A influência do teor de alumínio em injetados sob pressão nas ligas de zinco. Brazil: Faculdade de Tecnologia SENAI "Nadir Dias de Figueiredo".

Felder, R. .M & Silverman, L. .K. (1988). Learning and teaching styles in engineering education. Engr. Education, 78(7(, 674-681.

Neha et al.. (2013). Lean manufacturing tool and techniques in process industry. International Journal of Scientific Research and Reviews, 2(1), 54-63.

Pereira, M.F.V.T, Williams, M & Du Preez, B. (2012). Application of laser additive manufacturing to produce dies for aluminium high pressure die casting. South African Journal of Industrial Engineering, 23(2), 147-158.

Reinert, A & Santana, H.A. (2004). Moldes de injeção. Brazil: Centro de Educação Tecnológica do Paraná.

Sakurada, N & Miyake, D. (2009). Aplicação de simuladores de eventos discretos no processo de modelagem de sistemas de operações de serviços. Gestão & Produção, 16(1), 25-43.

Shingo, S. .S. (2000). Sistema de troca rápida de ferramenta: uma revolução nos sistemas produtivos Tradução de Eduardo Schaan, Cristina Schumacher. Brazil: Bookman.

Wu, W & Zhang, Y. (2005). An optimization of injecting system in die casting. China Academic Journal Electronic Publishing House, 2(2), 112-116.

Distance Learning for Training Business Game Bom Burguer tutors

Mariana de Toledo Marinho[1], José de Sousa Rodrigues[2], Kátia Lívia Zambon[2]

[1] Computer Department, Universidade Estadual Paulista, Campus of Bauru, São Paulo, Brasil
[2] Department of Industrial Engineer, Universidade Estadual Paulista, Campus of Bauru, São Paulo, Brasil

Email: mariana.tmarinho@gmail.com, jsrod@feb.unesp.br, katia@feb.unesp.br

Abstract

This work is result of research that proposes incorporation of Distance Learning to Business Game Bom Burguer as strategy to enhance tutors training considering difficulties presented by public school's teacher about entrepreneurship. Part of this could be attributed to curricular grade, because, in general, it is not common to find entrepreneurship in it. The Distance Learning activities was developed using Moodle platform and structured in topics to increase educational flexibility and achieve better balance between individual reflection and online discussion. It developed in four steps: course content development; course evaluation by computer technicians; course restructuring based on course evaluation by computer technicians; course evaluation by teachers from the public school system. A preliminary test was performed with informatics technicians to evaluate learning environment technically. Based on this, the course was restructured, applying corrections and adjustments to make better usability of environment. After corrections, a final test was conducted with public school system teacher to analyse user perception, having a positive result. Virtual learning environment evaluation is complex and multidisciplinary, requires technical knowledge of programming for internet and conceptual knowledge about education, especially in the field of learning. When examined the evaluation done by teachers, it was found that deficiencies pointed out by computer technicians have been resolved, given positive rating. Concluded then that Bom Burguer game can comply with an important function in Brazilian educational scenario because it allows the noncurricular use, as a complementary activity, disengaged from classroom. Now enriched with Distance Learning environment, become even more accessible as it could be used both to educate tutors and students.

Keywords: Entrepreneurship; Business Game; Distance Learning Course.

1 Introduction

This paper is result of previous research that showed that although Business Game (BG) Bom Burguer (www.bomburguer.net) is an innovation, public school teachers presented difficulties in using it due to deficiencies related with entrepreneurship, because this topic is not part of undergraduate curriculum.

Teaching learning process in interconnected society demand new solutions, such as Distance Learning (DL), which is strongly supported by technology. It is characterized by intensive Information and Communication Technologies (ICT) use, interaction facilitation between teachers and students physically distant, audiovisual resources employment to develop contents and activities, greater adaptability to user in distribution and content use, among other advantages (Keegan, 1996).

For Moran *et. al* (2008), DL is strategic to make profound changes in education as a whole, becoming more and more an important option for learning throughout life, continuing education, vocational acceleration and enables reconcile study and work.

Thus, we created subsidies for Bom Burguer use to support learning process with DL using Moodle platform. With it, you can create inline courses, disciplines pages, working groups and learning communities (ALVES *et. al*, 2009). Aiming at facilitate use of Distance Learning like an institutional manner, the University UNESP created NEaD (*Núcleo de Ensino à Distância*), which is responsible for providing academic Moodle. Content developed in Moodle addresses topics such as entrepreneurship, Business Games and Bom Burguer to achieve the goal of training tutors.

Initially, association Business Games and entrepreneurship occurred in training executives (BURCJ Jr., 1969). Over time, it was notice that many features associated with entrepreneur are demanded of professionals

currently, requiring them to be developed throughout education process of modern professionals. In a way, business games are a way to develop skills and abilities that are recognized as typical entrepreneur. For Goldschmidt (1977, p. 43) "the business games allows to continuously simulate various type of decisions, several alternatives, so that participants are able to evaluate results of different decisions".

For these characteristics, learning mediated by business games has great potential synthesis and interconnection contents for being a multidisciplinary didactic and pedagogical resource. In addition, business games have advantage of allowing student to experience decision-making process without risk of causing injuries or damage to real organizations (SCARELLI, 2009). It is a tool that facilitates theoretical knowledge improvement of subjects related to business management, encourages entrepreneurship and systemic view of organizations, requiring student a proactive attitude in education process (Nagamatsu et. al, 2006; SANTOS et. al, 2007).

Business game Bom Burguer is available on a web platform and consists of selling kit with sandwich and soda. The teacher parametrizes rooms, in which enterprises managed by one student or students team compete against each other. Each enterprise can participate in several rooms, but its result is specific in each room. In other words, the result is not global, but local. So, students can test distinct strategies playing in different rooms.

In student environment, company management involves purchase of materials, pricing, marketing investment, inventory control and company resources. These decisions are made based on sales of kits, which generates material requirements. In decision page, the manager must fill fields with quantities of material necessary to make kits, like soda, bread, lettuce, cheese, tomato, hamburger it will. The data generated by decision process are presented in reports and charts that can be used to build scenarios to support making decision for next round. Each round are generated new reports and charts, plus a raking representing company competitiveness in "market" (room) proposed in game (RODRIGUES et. al, 2010).

2 Objectives

The main objective of research it was analyse if Distance Learning can be used to overcome barriers diagnosed in performed tutor's training course to teachers of Public Schools of region of Bauru, with specific objectives:

a) Create teaching materials with using quiz, crossword, chat, forum, briefing, video, reporting, COLLES and ATTLS questionnaire in the Moodle environment;

b) Improve environment with resources by user's feedback, using the assessment framework proposed by Juwah et al. (2004);

c) The activities involve the contents of how to use game, entrepreneurship and identity learning, as proposed by Kolb and Kolb (2009).

3 Methods

The platform Moodle was used for course development, it is an open source support for distance learning, which allows create online courses, disciplines pages, working groups and learning communities. Academic Moodle was provided by the Núcleo de Ensino à Distância - NEaD (Distance Teaching Center) from UNESP (Universidade Estadual Paulista).

Course was designed using topics to increase educational flexibility and achieve better balance between individual reflection and online discussion (ALVES, BARROS and OKADA, 2009). It was developed in four steps, in order to evaluate it technically and conceptually:

Step 1 - Course content development;
Step 2 - Course evaluation by computer technicians;
Step 3 - Course Restructuring based on course evaluation by computer technicians;
Step 4 – Course validation by teachers from public school system.

From a methodological point of view, this research is applied, because it involves DL course development. Environment evaluation was made by activities with computer technicians and volunteer teachers from the public school system, analyzing facilities of its use and supplied material content.

In order to identify the experience of using Bom Burger and Moodle in learning process, data were analyzed which aims to answer questions such as: if course for tutors promoted subsidies needed to use this tool to support learning process, if available resources help in preparing lessons, if teacher used resources learned in their classes, and if learning was facilitated by course in distance education environment.

To collect data we used two questionnaires, one multiple choice and one in Likert scale, developed by authors, to determine students profile and analyze course structure, respectively. To Gil (2010), survey questionnaire requests information to a large group of people about problem studied for through quantitative analysis, get conclusions corresponding to data collected.

During test phase, part of experiment was conducted in person to use observation technique, as defined by Marconi et. al (2007), analyzing whether there were difficulties in environment use.

4 Results

This section present results obtained in four steps of course development.

4.1 Step 1

In first step, the course was split into three main themes: identity of learning, entrepreneurship and BG Bom Burguer. The first aimed to take student and/or tutor to reflect on how they deal with challenges which they face in their lives, that is it deal with learning itself. This reflection was included in environment as a way to bring student and/or tutor to think about how his/her postures affect results he/she get. The second theme aimed to generate learning about entrepreneurship, including reflection on entrepreneurship under two optics: the work and creation world and business management. The third aimed to eliminate as much as possible, game and environment interface on entrepreneurship learning.

4.2 Step 2

In Step 2, were invited five computer technicians of "Colégio Técnico de Bauru" to use and evaluate the course. Technicians were between 15 and 14 years old, 40% were male sex and 60% female sex. Everyone knew Bom Burguer and 80% had already done least of one distance education course.

Technical evaluation was analysed by Likert scale questionnaire and interview. Data analysis showed that they considered the course appropriate. However, they suggested some adjustments in course usability and changes in some activities.

Like see Table 1, course questions have two negative evaluations, where 60% of technicians been indifferent about usability and 80% did not agree totally with affirmation that there were no errors in system. During interview they told too "sometimes felt lost in course" and reported some consistency error in activities.

Table 1 - Evaluation of the course in Moodle according to computer technicians.

Afirmative/Scale	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Moodle is a good tool to support teaching learning.	0	0	1	2	2
I liked the modules division of course.	0	0	0	1	4
The usability of course is good.	0	0	3	0	2
I hadn't problem with respect to system errors.	0	1	1	2	1

About learning resources evaluation, seen in Table 2, PDF texts, Prezi presentations, Hot Potatoes activities and essay tasks were not well accepted. In interview, technicians argued that PDF texts were “long and tedious”, Prezi presentation were “vague”, Hot Potatoes activities were “vague, confusing and presented consistency error” and essay tasks were “very extensive”.

Table 2 - Evaluation of the learning resources according to computer technicians.

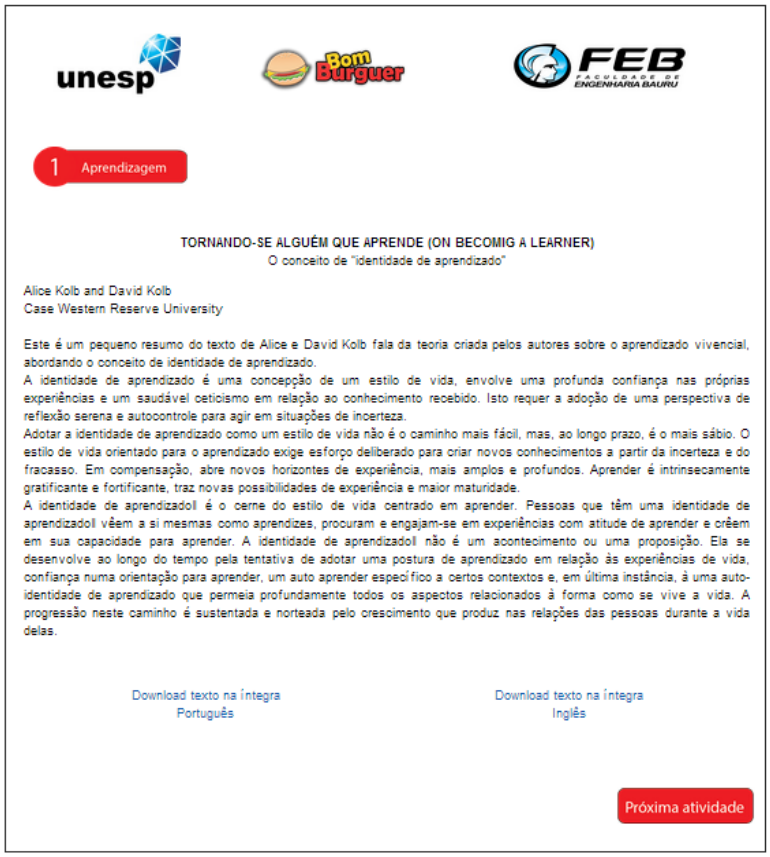
Afirmative/Scale	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Youtube videos	0	0	0	1	4
PDF texts	1	0	1	2	1
Prezi presentation	0	1	0	1	3
Hot Potatoes	2	0	1	1	1
BG Bom Burguer	0	0	0	3	2
Links directed to other sites	0	0	2	1	2
Activities with Moodle questionnaires	0	0	2	2	1
Essay tasks in Moodle	0	1	1	3	0

4.3 Step 3

To solve problems identified in Step 2, the course was restructured. For usability question, Moodle topics were linked using HTML files. According Silva (2008), HTML allows creating links between files, enabling virtual navigation.

Figure 1 - Course Activity interconnected by HTML.

Others problems cited have also been corrected. To resolve consistency errors in Hot Potatoes activities and extensive essay tasks, they were changed to eliminate errors. Prezi presentations were enriched and became the main text of page. PDF texts, considered extensive, were replaced by a summary on homepage and created a link to download full version, transforming them into background material.



1 Aprendizagem

TORNANDO-SE ALGUÉM QUE APRENDE (ON BECOMIG A LEARNER)
O conceito de "identidade de aprendizado"

Alice Kolb and David Kolb
Case Western Reserve University

Este é um pequeno resumo do texto de Alice e David Kolb fala da teoria criada pelos autores sobre o aprendizado vivencial, abordando o conceito de identidade de aprendizado.
A identidade de aprendizado é uma concepção de um estilo de vida, envolve uma profunda confiança nas próprias experiências e um saudável ceticismo em relação ao conhecimento recebido. Isto requer a adoção de uma perspectiva de reflexão serena e autocontrole para agir em situações de incerteza.
Adotar a identidade de aprendizado como um estilo de vida não é o caminho mais fácil, mas, ao longo prazo, é o mais sábio. O estilo de vida orientado para o aprendizado exige esforço deliberado para criar novos conhecimentos a partir da incerteza e do fracasso. Em compensação, abre novos horizontes de experiência, mais amplos e profundos. Aprender é intrinsecamente gratificante e fortificante, traz novas possibilidades de experiência e maior maturidade.
A identidade de aprendizadoII é o cerne do estilo de vida centrado em aprender. Pessoas que têm uma identidade de aprendizadoII vêem a si mesmas como aprendizes, procuram e engajam-se em experiências com atitude de aprender e crêem em sua capacidade para aprender. A identidade de aprendizadoII não é um acontecimento ou uma proposição. Ela se desenvolve ao longo do tempo pela tentativa de adotar uma postura de aprendizado em relação às experiências de vida, confiança numa orientação para aprender, um auto aprender especí fico a certos contextos e, em última instância, à uma auto-identidade de aprendizado que permeia profundamente todos os aspectos relacionados à forma como se vive a vida. A progressão neste caminho é sustentada e norteada pelo crescimento que produz nas relações das pessoas durante a vida delas.

Download texto na íntegra
Português

Download texto na íntegra
Inglês

Próxima atividade

Figure 2 - Course activity using PDF files as background material.

4.4 Step 4

To validate course and verify Step 1 and 2 problems and changes, was conducted a new experimental test with five public school teachers with aged between 25 and 54 years old. Only 20% had not made distance learning course and no participant knew Business Game.

As can be seen in Table 3, questions about usability and system errors received positive evaluations. The same applies in learning resource questions, as can been in Table 4: Prezi presentation, Hot Potatoes activities and PDF texts received better ratings.

Table 3 - Evaluation of the course according Moodle teachers.

Afirmative/Scale	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Moodle is a good tool to support teaching learning.	0	0	0	1	4
I liked the modules division of course.	0	0	0	3	2
The usability of course is good.	0	0	0	2	3
I hadn't problem with respect to system errors.	0	0	1	2	2
Moodle is a good tool to support teaching learning.	0	0	1	2	2

Table 4 - Evaluation of the learning resources according to teachers.

Afirmative/Scale	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Youtube videos	0	0	0	3	2
PDF supporting texts	0	0	0	2	3
presentations in Prezi	0	0	1	3	2
Hot Potatoes	0	0	2	1	2
BG Bom Burguer	0	0	1	1	3
Links directed to other sites	0	0	1	1	3
Activities with Moodle questionnaires	0	1	0	1	3
Essay tasks in Moodle	0	1	0	1	3

5 Conclusion

Evaluation of a virtual learning environment is complex and multidisciplinary, requires technical knowledge of the programming environment for internet and conceptual knowledge about education, especially in the field of learning.

Research objectives were achieved, since it has been produced a DL environment to support learning process mediated by game Bom Burguer. When examined evaluation done by teachers of public schools, it was found that deficiencies pointed out by computer technicians have been resolved, given positive ratings. There was an environmental enrichment in terms of learning support both future tutor and learner. The activities that have as quiz, for example, carry with them evaluation, generating an immediate feedback to user DL environment. Thus, it can be affirmed that built environment could absorb elements of formative assessment proposed by Juwah et al. (2004).

Another element that seems relevant to the formulation of future research concerns the vision one has of theme entrepreneurship in education. It is still seen as an important issue, but it is still a barrier and not included in educational curriculum, as shown by Lima (2010).

Concluded then that the game Bom Burger can comply with an important function in Brazilian educational scenario because it allows use of noncurricular way, as a complementary activity, disengaged from the classroom. Now enriched with distance learning environment, become even more accessible as it could be used both to educate tutors (the game features and content, skills and competencies related to entrepreneurship), and students (abilities and skills related to entrepreneurship).

6 References

Alves et. al, Moodle: Estratégias pedagógicas e estudos de caso. 1 ed. Bahia: EDUNEB, 2009.

Kolb A.; Kolb D. A. On becoming a learning: the concept of learning identify. CAEL Forum and News, 2009.

Gil, A. C. Como elaborar projeto de pesquisa. 5 ed. São Paulo: Atlas, 2010.

Goldschmidt, P. C. Simulação e jogo de empresas. Revista de administração de empresas. Rio de Janeiro: FGV, 1977.

Juwah, C. et al. Enhancing student learning through effective formative feedback. The Higher Education Academy, 2004.

Keegan, D. Definition of distance education. 3 ed. Londres: Routledge Taylor & Francis, 1996.

Lima, J. F. Parecer CNE/CEB Nº 13/2010 emitido sobre a consulta acerca da inclusão do empreendedorismo como disciplina no curriculo do Ensino Fundamental, do Ensino Médio, da Educação Profissional e da Educação Superior. Despacho do Ministro.

Marconi, M.A.; Lakatos, E. M. Técnicas de pesquisa: planejamento e execução de pesquisas, amostragens e técnicas de pesquisa, elaboração, análise e interpretação de dados. São Paulo: Atlas, 2008.

Nagamatsu, F. A. et al. A aplicação do jogo de empresas no desenvolvimento gerencial: um estudo aplicado em cursos de graduação e pós graduação. IX SEMEAD, São Paulo, 2006

Moran, J. M. et al. Novas tecnologias e mediação pedagógica. Campinas, SP: Papirus, 2008.

Rodrigues, J. S. et al Projeto 'Empreendedorismo na escola': utilização do jogo de empresas Bom Burguer. XXX Encontro Nacional de Engenharia de Produção. São Carlos, SP, 2010.

Santos, M. R. G. F.; Lovato, S. Os jogos de empresas como recurso didático na formação de administradores. CINTED, Porto Alegre, RS, 2007.

Scarelli, A. Mediação do processo ensino aprendizagem com o jogo de empresas Mercado Virtual: uma pesquisa de opinião. UNESP, Bauru, SP, 2009.

Silva, M. S. Construindo sites com CSS e (X)HTML. São Paulo, SP: Novatec Editora, 2008.

Self-Regulated Learning in Higher Education: Strategies Adopted by Computer Programming Students

Daniela Pedrosa[1, 2], José Cravino[1, 2], Leonel Morgado [3, 4], Carlos Barreira [5]

[1] Universidade de Trás-os-Montes e Alto Douro (UTAD), Vila Real, Portugal.
[2] Research Centre "Didactics and Technology in Education of Trainers", Aveiro, Portugal.
[3] Universidade Aberta, Coimbra, Portugal.
[4] INESC TEC, Porto, Portugal
[5]Faculdade de Psicologia e Ciências da Educação da Universidade de Coimbra, Coimbra, Portugal.

Email: dpedrosa@utad.pt, jcravino@utad.pt, leonel.morgado@uab.pt, cabarreira@fpce.uc.pt

Abstract

To help students overcome their learning difficulties in the transition from entry-level to advanced computer programming, developing an appropriate set of learning strategies, the SimProgramming teaching approach has been adopted at the University of Trás-os-Montes e Alto Douro (Portugal). This approach is based on four conceptual foundations: business-like learning environment, self-regulated learning, co-regulated learning, and formative assessment. In this approach the students develop an activity based on problem-based learning, with a specific set of tasks based on those four conceptual foundations.

The approach was implemented in two courses from the second and third curricular years of the bachelor programmes in Informatics Engineering and Information & Communication Technologies. We conducted semi-structured interviews with students (n=32) at the end of the courses, to try to identify the students' strategies for self-regulation of learning in the activity developed within the SimProgramming approach. The main strategies identified were: organization, planning, time management, identification of difficulties, resolution of the difficulties encountered, work review, identification of the factors that influenced their motivation, and structure of the environment.

The factors influencing the motivation most often identified by students were the impact of the assessment in the final course grade, the completion of the course, learning, skills development, and teamwork. Generally, students applied strategies to solve the difficulties, in particular by searching for social help and information search. Procrastination was also often identified by students. Strategies of time management, transformation of information, in-depth review, self-reflection, and self-evaluation were referenced scantily. We found that students changed some of their strategies from one course edition to the next.

We conclude by recommending the development of educational practices to help students review their work, treat and process the information they find, conduct self-reflection and self-evaluation of their performance during tasks, adopt concentration strategies, and become aware of their specific difficulties.

Keywords: Self-Regulation Learning; Strategies of Self-Regulation Learning; Computer Programming.

1 Introduction

A common trend in computer programming courses in higher education are the high rates of academic failure and students struggling, particularly in the transition from entry-level programming to advanced programming. Reasons pointed out in the literature include the teaching approach and the attitudes/strategies used by students in computer programming (Gomes & Mendes, 2007).

In higher education, self-regulated learning (SRL) is a key element, because it allows students to be proactive and manage their learning and development of life skills (Fernández et al., 2013). The application of SRL strategies typically predicts high academic achievement (Broadbent & Poon, 2015), and the self-regulatory processes can be improved with appropriate interventions (Zimmerman, 2008; Fernández, 2013). For example, it is recommended that teachers contribute to the development of metacognitive activities, of skills for implementing and adapting strategies for self-monitoring, make strategic use of feedback, and promote students' development of metacognitive knowledge about academic work and task-specific strategies (Cazan, 2013).

We applied the SimProgramming pedagogical approach (Pedrosa et al., 2016), in the academic years 2012/2013 and 2013/2014, in two intermediate programming courses from the second and third curricular years of the bachelor programmes in Informatics Engineering (IE) and Information & Communication Technologies (ICT). In the SimProgramming approach, the students develop a problem-based learning activity within the syllabus of the respective course, with a specific set of tasks based on the conceptual foundations detailed ahead.

We conducted semi-structured interviews with students at the end of the activity (n=32), to identify the self-regulation learning strategies that students employed, in two cycles: one in the Programming Methods 3 (PM3) course and another in the Programming Methods 4 (PM4) course.

2 Background

Computer programming courses are complex (Robins, Rountree & Rountree, 2003), students experience difficulties learning (Lahtinen, Ala-Mutka & Järvinen, 2005), and lack motivation and involvement in study (Morgado et al., 2012; Nunes et al., 2015). In intermediate and advanced programming courses, the level of complexity is much greater than entry-level programming courses. For example, students have difficulties grasping architectural styles such as Model–View–Controller (MVC) and other software engineering concepts (Cagiltay, 2007; Morgado et al., 2012), or dealing with the context of Web programming, where code is neither written nor executed in a single location, but rather distributed between the server and the client, and applications need to operate over the HTTP protocol which was designed to be stateless, hence encumbering applications with kludge-like solutions such as passing around session data in cookies or address parameters, among other difficulties (Liu & Phelps, 2011).

In learning computer programming, the students that apply SRL and metacognitive strategies have a good performance (Bergin, Reilly & Traynor, 2005). However, the most students in computer science are not aware of SRL and metacognitive strategies, and it is necessary to infuse them in this context (Alharbi et al., 2011).

SRL is considered a meta-process that depends on the active participation of students developing academic skills, in the selection of learning strategies when conducting an academic assignment (Clark, 2012). Students demonstrate their proactive competences, monitoring and adapting the learning processes, for the regulation of metacognitive, cognitive, motivational, behavioral and environmental strategies for achieving personal goals (Zimmerman & Schunk, 2007). The interaction between the compromise, self-control, autonomy and students' self-discipline allows regulating their actions to achieve their learning goals (Hattie & Timperley, 2007).

Self-regulated learners are characterized by constructing their own meanings, goals, and strategies from the information available in the external environment and in their own minds (Pintrich, 2004). Their level of domain of self-efficacy and self-knowledge, appeals to various learning strategies (Zimmerman, 2013), and the acquisition of effective practices for their study, such as: time management; resource management; environmental management; incorporating feedback; management of learning objectives and results (Nicol & Macfarlane-Dick, 2006, Clark, 2012).

3 Teaching context

The two programming courses were Programming Methods 3 (PM3, 2nd curricular year) & Programming Methods 4 (PM4, 3rd curricular year). Prior to these, students learned introductory programming in two previous courses, plus extra concepts in a Computational Logic course. These courses were provided in parallel (joint lectures, but separate hands-on lessons) to students in the IE and ICT programmes of studies. Course goals are described next.

In PM3: The goal is to introduce the students to large-scale programming concepts, one of the learning objective of the ACM/IEEE Computer Science Curricula (CSC). Specifically, students are introduced to the MVC architectural style, which divides programs among three blocks: the model (e.g., program state), the view (e.g., output), and the controller (e.g., program flow). The original MVC style proposal of Krasner & Pope (1988),

which handles input in the controller, is contrasted with a more recent flavour proposed by Curry & Grace (2008), which handles input in the view (Nunes et al., 2015).

In PM4: The goal is for students to develop the knowledge and skills necessary to develop web applications. Students work with the client-server concept of web applications and study their operation, including analysis of the HTTP protocol and the processing of its messages by web clients and servers. PM4 includes data formats and metadata for web applications, including the meta-languages SGML and XML, and languages specified by them. It finishes with the study of various types of Web applications and the specific case of Web services.

4 The SimProgramming approach and learning assignment

The SimProgramming approach is based on four conceptual foundations: 1) business-like learning environment, 2) self-regulated learning; 3) co-regulation learning, and 4) formative assessment. Based on these, the learning activity process develops along four phases, and students have specific tasks in each phase (Pedrosa et al., 2016).

Learning assignment in PM3: For each team a specific problem using a software architecture is assigned, in order to stimulate and foster advanced programming skills. Students must develop a written document with a detailed explanation of the coding approaches they used to apply an MVC related architectural style involving different frameworks, libraries, and/or specific APIs (Morgado et al., 2012; Nunes et al., 2015).

Learning assignment in PM4: For each team a specific problem using protocols, web applications, and markup languages is assigned, to develop skills on the development of web applications. Students must develop a technological solution using a web system and a given web access platform (e.g. mobile devices), and explain in detail (including code examples) how it is possible to exchange information between systems using different markup languages.

Our development of the assignment in PM4, included some differences (detailed in Table 1) regarding the PM3 assignment described by Pedrosa et al. (2016):

Table 1 Differences between PM3 and PM4.

Variable	PM3 (2012/ 2013)	PM4 (2013/2014)
Professor	Professor A	Professor B
The impact of the assignment in the final grade	6/20	5/20
Students in the assignment	N=97 (IE:60; ICT:37)	N=49 (IE:32; ICT:17) – All, except 4 students, participated in PM3.
Established teams	N=15	N=9
Teams that concluded the assignment	N=13	N=9
Students with a final grade	N=66	N=49
Task changes	Weekly individual forms Reports (practitioners' on-line communities, status and final) Individual students forms for self and hetero-assessment	Fortnightly team forms There were no reports Meetings of tutors with teams for self and hetero-assessment

5 Methodology and data collection

We conducted semi-structured interviews (Cohen, Manion & Morrison, 2011) about self-regulation learning strategies applied by student in the assignment. The goal of the interviews was to have students describe their self-regulation learning strategies throughout the assignment. In the two research cycles 32 interviews were carried out.

The interview guide was constructed based on the literature (Zimmerman, 2008), and organized with five sets of questions/categories, including the one under scrutiny in this paper: *self-regulation learning strategies applied in the assignment.*

The interviews were conducted with students selected based on: role in the team (e.g. team leader), results in the assignment, special status (e.g. working-students). We also interviewed students whose assignment quality increased during the process.

Interviews were subjected to thematic analysis (Braun & Clarke, 2006). Content analysis matrixes were organized into categories, subcategories, indicators, and recording units (snippet sentences mentioned in interview. The content analysis matrixes were built based on the literature about SRL (Zimmerman, 2008, 2013), and during the analysis changes were made according to is identified in interviews, and we conducted a cyclical process of improvement, synthesis, and reflection.

The answers for the question/category set *"self-regulation learning strategies were applied in assignment"* were grouped into seven sub-categories about SRL strategies (Zimmerman, 2013), and are organized by indicators about the types of strategies that student adopted, identifying difficulties and factors that they believed have influenced their motivation. The indicators are the clear definitions/topic for each theme identified by answers in the interviews. After completing the content analysis matrixes, we organized and presented the results in tables, with the number of students who mentioned each indicator to identify what are the SRL strategies adopted by students.

6 Results and discussion

As shown on Table A.1, the most common strategy was information search, as in most interviews students said that they searched for content related to their work. Other strategies were mentioned less often. For example, few students explained what they did after retrieving information (information processing, information organization, and transformation or applicability of the information). We did find that some students said they had prepared a preliminary work plan. Another strategy mentioned was to follow guidelines provided by the teaching team. Only in Cycle 1 did some students (n=6) report not having any work planning strategy.

Table A.1 – Organizing, planning and transforming strategies.

Indicators	*Interviewed students*	
	Cycle 1 (N=21)	*Cycle 2 (N=11)*
A.1.1. Organizing - Information search	16	9
A.1.2. Organizing – Collected information	2	0
A.1.3. Planning – Work plan development	6	2
A.1.4. Planning - Following guidelines provided by tutors and teachers	3	2
A.1.5. Had no planned strategy	6	0
A.1.6. Transforming – Drafting notes about collected information	2	0
A.1.7. Transforming - Application of existing knowledge about the practice	1	0

Regarding time management strategies for the assignment, detailed in Table A.2, students mentioned several strategies, without any single one standing out. A few students explained that they worked during the week, and some mentioned devoting only one day per week. Procrastination was mainly mentioned in Cycle 1, decreasing in Cycle 2. Students explained that as being due to feeling the pressure (to deliver before the deadline) instilled on them to accomplish the task. They also explained being unable to manage their time due to other duties or responsibilities.

Table A.2 - Time management strategies.

Indicators	*Interviewed students*	
	Cycle 1 (N=21)	*Cycle 2 (N=11)*
A.2.1. Lack of time	3	2
A.2.2. Lack of time due to other responsibilities	1	0
A.2.3. Initiating the activity at the last moment (procrastination)	6	2

A.2.4. Organization on weekends	1	1
A.2.5. Submitted in next week	1	0
A.2.6. Realization of the assignment tasks at night	1	0
A.2.7. Grade impact factor of the assessment versus other courses	1	0
A.2.8. Division of tasks in the timeline	1	1
A.2.9. Devoted one day per week for resting	1	0
A.2.10. Placed extra activities aside	0	2
A.2.11. Working week to week	2	3
A.2.12. Devoted a specific day to work on the assignment	3	1

The difficulties students encountered while performing the assignment, as shown on Table A.3, were at the level of theoretical content and practical implementation of the assignment. Although the difficulties expressed by students were at the individual level, when asked about difficulties felt by their team they mentioned several. Some said that they hadn't experienced any difficulties carrying out the assignment. In Cycle 2, students specifically mentioned several difficulties.

Table A.3 - Identifying of the difficulties in the assignment.

Indicators	*Interviewed students*	
	Cycle 1 (N=21)	*Cycle 2 (N=11)*
A.3.1. Difficulties – Theoretical knowledge about the technology being studied	0	5
A.3.2. Difficulties – More than the previous year	0	1
A.3.3. Difficulties – The practical component implementation	0	1
A.3.4. Difficulties – Didn't find it complex to perform	5	4
A.3.5. Difficulties – Didn't experience any due to previous experience in PM3	0	1

The most mentioned strategy by students to resolve their difficulties, as shown on Table A.4, was the search for information (in Cycle 1, n=15; in Cycle 2, n=5), followed by seeking social assistance from both teacher (in Cycle 1, n=12; in Cycle 2, n=3) and peers (in Cycle 1, n=10; in Cycle 2, n=6). However, several Cycle 1 students (n=13) reported not having sought help: 2 students did not seek any help, 5 students did not seek help from the teacher and 5 students did not seek help from their peers. Some reasons pointed out for not seeking the teacher were feelings of shyness, shame, fear, or inferiority. In Cycle 2 students mentioned seeking social assistance and they do not mention the opposite (not seeking it, as it happened in Cycle 1). There were students who gave up trying to solve the difficulties, e.g. did not clarify their doubts/problems. Working-students explained their difficulties seeking help from colleagues as being due to differences in work patterns.

Table A.4 - Resolution of difficulties strategies.

Indicators	*Interviewed students*	
	Cycle 1 (N=21)	*Cycle 2 (N=11)*
A.4.1. Seeking Social Assistance (SOA)– Did not seek any	2	0
A.4.2. SOA – Did not seek help from teacher	5	2
A.4.3. SOA - Did not seek help from peers	5	1
A.4.4. SOA - Did not seek help due to different work pace (worker-student)	1	0
A.4.5. Resolution of Difficulties (RD)– Information search	15	5
A.4.6. RD - Use of practical exercises	1	1
A.4.7. SOA – Teachers	12	3
A.4.8. SOA – Team peers	10	6
A.4.9. SOA - Senior colleagues	3	1
A.4.10. SOA – Family member	1	0
A.4.11. SOA – Others	1	1
A.4.12. RD - Gave up seeking help, even after finding information from searching	2	2

On the review of the tasks required for the assignment, as shown on Table A.5, students' most common strategies were checking for misspellings, revising sentence construction, and correcting theoretical content. In Cycle 2, the focus of the review was more on content, instead of the mostly superficial revisions of Cycle 1. Some students from Cycle 1 stated not having reviewed their work, something which in Cycle 2 was not mentioned. A fact that emerged in Cycle 2 was a student reporting to have done the review by reflecting upon comments that were given by teacher to other teams.

Table A.5 - Work review strategies.

Indicators	*Interviewed students*	
	Cycle 1 (N=21)	*Cycle 2 (N=11)*
A.5.1. No revision made	5	0
A.5.2. Component programming practice	1	2
A.5.3. Additional information	2	1
A.5.4. Typo correction and sentence construction fixes	8	2
A.5.5. Overall review and general changes	9	1
A.5.6. Portuguese-language errors and content corrections	6	4
A.5.7. Global content (not specific)	1	0
A.5.8. Avoiding repetition of information	1	0
A.5.9. Reflecting feedback provided by teacher to other teams	0	1

As shown on table A.6, students expressed several factors has having affected their motivation, either positively or negatively (lack of motivation). Most are of a personal nature, but some are linked to interpersonal and social dimensions. For example, the completion of the programme of studies, and the perception that the work contributed to learning and skill development. The grade impact of the assignment was the single aspect most mentioned by students has having had an influence on motivation.

In Cycle 2, students mentioned other factors has having influenced their motivation, including believing that the assignment helped develop interpersonal skills, programming skills, and also that it helped understand the content of course (n=3). In addition, students in Cycle 2 almost did not mention factors has having created lack of motivation: only one student mentioned lack of motivation due to having a grade (in others grades - tests) too low to complete the course.

Table A.6 - Factors influencing the motivation.

Indicators	*Interviewed students*	
	Cycle 1 (N=21)	*Cycle 2 (N=11)*
A.6.1. Finish the course programme of studies	6	2
A.6.2. Completing the PM3 or PM4 course	4	1
A.6.3. Maintaining their scholarship fund	1	0
A.6.4. Showing the ability to complete the activity	1	0
A.6.5. Achieving good results	3	1
A.6.6. Interest in programming	2	1
A.6.7. Comply with an obligation	1	2
A.6.8. Grade impact of the assignment	17	8
A.6.9. To present work that he/she agreed to do	1	0
A.6.10. Throwback to previous life experience	1	0
A.6.11. Responsibility for teamwork	1	0
A.6.12. Found the process interesting (SimProgramming approach)	1	0
A.6.13. Learning	3	3
A.6.14. Preparation for the labor market	2	2
A.6.15. Avoiding the stress of procrastination	1	0
A.6.16. Working in new team	0	1

A.6.17. Assignment helps to develop programming skills	0	9
A.6.18. Assignment helps develop interpersonal skills	0	4
A.6.19. Assignment helps to PM3 or PM4 course	0	3
A.6.21. Lack of motivation – Is tired (of studying)	1	0
A.6.22. Lack of motivation – Overall grades are not enough to complete the course	1	1
A.6.23. Lack of motivation – Didn't learned anything new or useful	5	0
A.6.24. Lack of motivation - Wanted to learn but could not	1	0

In both cycles, most students working alone said they preferred to do it at home (see table A.7). Other places were mentioned, like the library or city bars. As for concentration strategies, there is a preference for quiet places. However, no explanation was given by the students on specific strategies they used to stay focused.

Table A.7 - Environmental structuring strategies.

Indicators	*Interviewed students*	
	Cycle 1 (N=21)	*Cycle 2 (N=11)*
A.7.1. The Physical Setting (TPS)– Home	16	7
A.7.2. TPS – Library	4	2
A.7.3. TPS - Multiple locations	3	2
A.7.4. Concentration Strategy (CS) - Silence	6	1
A.7.5. CS - Studying with music	3	1
A.7.6. CS - Background noise	2	0
A.7.7. CS – Place without distractions	5	2
A.7.8. CS – Inconstant	2	1

7 Conclusions and future work

In this work, students mentioned applying several self-regulated learning strategies, such as: information search; work reviewing; time management; social seeking assistance; resolution of difficulties; and environmental structuring. However, other strategies were mentioned by fewer students, namely: strategies about information processing, organization, or application; self-reflection and self-assessment; psychological strategies to improve attention; and awareness of their difficulties.

From Cycle 1 to Cycle 2, we verified improvements in strategies for time management, work review, social assistance seeking, difficulty awareness, and motivational factors related to skill development. We hypothesize that participation in PM3 activities using the SimProgramming approach may have helped students develop the self-regulation learning strategies that emerged in Cycle 2.

For example, the work reviewing strategies improved from Cycle 1 to Cycle 2: students mentioned more specific content revisions. Also, in Cycle 2, students demonstrated some awareness of their difficulties, something not seen in Cycle 1. In Cycle 1 there were students who did not seek assistance, reportedly due to factors such as shyness, fear, or shame. No such factors were mentioned in Cycle 2. Procrastination behaviours were also recorded in Cycle 1, but in Cycle 2 procrastination was no longer mentioned by the students.

The motivational factors also influenced the students' perception about their self-regulation learning and progress in the assignment. In Cycle 2, the students felt that the assignment helped develop programming and interpersonal skills, and contributed to a better understanding of the content of course.

We suggest the development of activities to raise awareness in students about the various types of strategies that can be pursued for success in academic tasks. Further research about the SimProgramming approach should strive to achieve a better understanding of the impact of team work and assignment grade on the self-regulation of student learning.

8 Acknowledgments

Pedrosa, D. thanks the Fundação para a Ciência e Tecnologia (FCT), Portugal, for Ph.D. Grant SFRH/BD/87815/2012. We would like to thank all the students and teachers who collaborated on this research.

9 References

Alharbi, A., Paul, D., Henskens, F., & Hannaford, M.(2011). An investigation into the learning styles and self-regulated learning strategies for computer science students. In Proceedings ascilite.

Association for Computing Machinery (ACM) & IEEE Computer Society (IEEE-CS), 2008. "Computer Science Curriculum 2008: An Interim Revision of CS 2001." Computing Curriculum Series [on-line],http://www.acm.org//education/curricula/ComputerScience2008.pdf.

Broadbent, J., & Poon, W. L. (2015). Self-regulated learning strategies & academic achievement in online higher education learning environments: A systematic review. *The Internet and Higher Education*, 27, 1-13.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative research in psychology*, 3(2), 77-101.

Cazan, A. M. (2013). Teaching self regulated learning strategies for psychology students. *Procedia-Social and Behavioral Sciences*, 78, 743-747.

Cagiltay, N. E. (2007). Teaching software engineering by means of computer-game development: Challenges and opportunities. *British Journal of Educational Technology*, *38*(3), 405-415.

Clark, I. (2012). Formative Assessment: Assessment Is for Self-regulated Learning. *Educational Psychology Review*, 24(2), 205–249.

Cohen, L; Manion, L; Morrison, K. (2011). *Research Methods in Education*. 7th Edition. London, Routledge-Taylor & Francis Group.

Curry, E., & Grace, P. (2008). Flexible self-management using the model-view-controller pattern. *Software*, IEEE, 25(3),84-90.

Fernández, E., Bernardo, A., Suárez, N., Cerezo, R., Núñez, J. C., & Rosário, P. (2013). Predicción del uso de estrategias de autorregulación en educación superior. *Anales de psicología*, 29(3), 865-875.

Gomes, A., & Mendes, A. J. (2007). Learning to program-difficulties and solutions. In *International Conference on Engineering Education–ICEE*, 2007, Coimbra, Portugal.

Hattie, J., & Timperley, H. (2007). The Power of Feedback. *Review of Educational Research*, 77(1), 81–112.

Lahtinen, E., Ala-Mutka, K., & Järvinen, H. M. (2005). A study of the difficulties of novice programmers. *In ACM SIGCSE Bulletin*, 37(3), 14-18.

Liu, Y., & Phelps, G. (2011). Challenges and professional tools used when teaching web programming. *Journal of Computing Sciences in Colleges*, *26*(5), 116-121.

Morgado, L.; Fonseca, B.; Martins, P.; Paredes, H.; Cruz, G.; Maia, A. M.; Nunes, R.; Santos, A. (2012). Social networks, microblogging, virtual worlds, and Web 2.0 in the teaching of programing techniques for software engineering: a trial combining collaboration and social interaction beyond college. In *Global Engineering Education Conference (EDUCON)*.1-7. IEEE. doi:10.1109/EDUCON.2012.6201129.

Nicol, D. J., & Macfarlane-Dick, D. (2006). Formative assessment and self-regulated learning: a model and seven principles of good feedback practice. *Studies in Higher Education*, 31(2), 199–218.

Nunes, R. R., Pedrosa, D., Fonseca, B., Paredes, H., Cravino, J., Morgado, L., & Martins, P. (2015). Enhancing students' motivation to learn software engineering programming techniques: a collaborative and social interaction approach. In *Universal Access in Human-Computer Interaction*. *Access to Learning, Health and Well-Being*. 189-201. Springer International Publishing.

Pedrosa, D.; Cravino, J.; Morgado, L.; Barreira, C.; Nunes, R.R.; Martins, P. & Paredes, H. (2016). Simprogramming: the development of an integrated teaching approach for computer programming in higher education. In *Proceedings 10th annual International Technology, Education and Development Conference (INTED 2016).* Valencia, Spain.

Pintrich, P. R. (2004). A conceptual framework for assessing motivation and self-regulated learning in college students. *Educational psychology review*,16(4), 385-407.

Robins, A., Rountree, J. & Rountree. N. (2003). Learning and teaching programming: A review and discussion. *Computer Science Education*, 13(2), 137–172.

Zimmerman, B. J., & Schunk, D. H. (2007). Motivation: An essential dimension of selfregulated learning. In D. H. Schunk & B. J. Zimmerman (Eds.), *Motivation and self-regulated learning: Theory, research, and applications* (pp. 1–30). Mahwah, NJ: Lawrence Erlbaum.

Zimmerman, B. J. (2008). Investigating Self-Regulation and Motivation: Historical Background, Methodological Developments, and Future Prospects. *American Educational Research Journal*, 45(1), 166–183.

Zimmerman, B. J. (2013). From cognitive modeling to self-regulation: A social cognitive career path. Educational Psychologist, 48(3), 135-147.

Measuring Sustainable Lifestyles of Engineering Students from the Universidad Nacional de Colombia. Construction of the Instrument

Hernán Gustavo Cortés Mora[1], Juan Carlos Espinosa[2], Jonatan Hans Tovar R.[3], José Ismael Peña Reyes[1]

[1] Industrial and Systems Engineering Department, Faculty of Engineering, Universidad Nacional de Colombia, Colombia
[2] Department of Statistics, Faculty of Sciences, Universidad Nacional de Colombia, Colombia
[3] Department of psychology, Faculty of Social Sciences, Universidad Nacional de Colombia, Colombia

Email: hgcortesm@unal.edu.co, jucespinosamo@unal.edu.co, jhtovarr@unal.edu.co, jipenar@unal.edu.co

Abstract

In order to study the structuring process of sustainability in the Faculty of Engineering of the Universidad Nacional de Colombia, we compare the lifestyles of students with that of the aspirants. According to the structuration theory of Anthony Giddens, the constituent agents of the social structure present intentions and have a conscience that can be seen in their lifestyles. These styles can be measured at sustainability levels through the implementation of qualitative or quantitative instruments. The starting point is in the practical consciousness and discursive consciousness that determine how to set the lifestyles on the agent´s part, which in turn, have the ability to modify the structure, based on their practices. Lifestyle and the structure of the organization are materialized in the practices of the system and the social structure. In this sense, it is necessary to measure the sustainable lifestyles of the agents, in the particular case of a group that is aspiring to be admitted at the Universidad Nacional de Colombia, with the purpose of establishing in future research if their stop by the University influences their lifestyle from a sustainability point of view. This article presents the form in which an instrument has been constructed to measure sustainable lifestyles in students of the faculty of Engineering of the Universidad Nacional de Colombia taking a sample from the applicants' to the University. After exploring and reviewing the concepts on the literature, the constructs and dimensions of the instrument are specified, as well as the way to measure the variables and how the content validity of the instrument was decided. Finally, future work that will initiate with the application of the instrument built and the analysis of the results is described.

Keywords: Sustainability; Sustainable Lifestyles; Structuration Theory; Education for Sustentable Development; Paralell Analysis; Exploratory Factorial Analysis.

1 Introduction

In order to identify Sustainability as a valid construct and how it is structured in the Faculty of Engineering of the Universidad Nacional de Colombia (FEUNC), we proposed a model to find the aforementioned structuration level in the institution. In particular, this study strives to understand how the sustainability is structured and how it is evidenced in the lifestyles of the agents who aspire to be admitted to the university, so later on it can be compared with the lifestyles of students of the institution.

For Anthony Giddens (1984), the constituent agents of the social structure possess intentions and conscience, which can be reflected in their lifestyles. These are susceptible of measurement under the application of qualitative or quantitative instruments. This work shows the development process of a tool that makes possible to carry out a standardized approach to the sustainable lifestyles of the agents taking part of the study. For the development of the evaluation tool, it is understood that the discursive and practical consciousness are the starting point, which allows us to determine the way in which the lifestyles are formed on the agents. The structuration process of sustainability in the FEUNC is formed by the context, the implementation systems -determined by the norms- and the existing resources of the institution, resulting in emergent structures conditioning agents, although simultaneously being susceptible to transformation by its members. Consequently, exploring the discursive and practical conscience of the agents by means a systematic approach allows the analysis of the sustainability structures underlying their lifestyles and allows to know better some of the relations between these and the context. This article presents the way in which an instrument to measure sustainable lifestyles was built, using applicants to the Universidad Nacional de Colombia as the base

population, with the goal to be able to carry out future applications on University students, as well as other applicants, and compare their lifestyles in the frame of sustainability.

2 Construction of the instrument

Based on the literature review, constructs of the model are prepared and the descriptive analysis of the information is obtained for the development of the instrument to be applied to aspirants to the Universidad Nacional de Colombia and students of the faculty of Engineering of the same institution. The goal was to compare the sustainable lifestyles between these groups in future research and to be able to infer the influence of the university in their lifestyles. Starting from the instrument developed by FraijoSing *et al.* (2012), which measures the orientation towards sustainability in secondary school students, the categories subject to study are gathered to prepare the items of the instrument to be developed: austerity, deliberation, equity, altruism, propensity to the future, beliefs, motives, pro-environmental behavior, and skills (FraijoSing *et al.*, 2012). As a result of a content validation of the categories subject to study by means of the review by 15 contacted experts (engineers carrying out postgraduate studies), it was decided to group the nine categories subject to study into six emergent categories (austerity, deliberation, social world, propensity to the future, skills, and self care), since, according to the experts, there were redundancies among the initial categories.

The methodological frame for the research where this instrument was designed and applied is Critical Realism (Bhaskar, 1975); thus three domains are gathered from its ontology over which the world is differentiated: the real one, the current one, and the empirical one (Mingers, 2006). The causal forces located in the real domain may originate the events in the current domain which, at the same time and once identified, came to be experienced in the empirical domain. Although critical realism suggests that it is necessary to be a critic of positivism, and in particular of statistical analysis when the studied object is a social construction, it is necessary to admit that some methods can be used in different forms and they can be applied under an alternative paradigm (Mingers, 2006).

Thus, it is possible to assert that three constituents of the world exist (Habermas, 1981). Starting from the recognition of the personal and subjective world, where, thanks to evolutionary processes, human beings are capable of, not only thought and self-reflection, but also of communication through a language, which grants them access to a social world. Such interpretations can give form to the material constructions, including the practices and organizational forms of the material world (Sayer, 2004).

In this sense, the six emergent categories were synthesized in three general constructs: personal world, material world, and social world. Based in the operationalization of the constructs and the suggestions given by the team of experts, an 82-item questionnaire that evaluates the level of agreement and the occurrence frequency of certain behaviors, beliefs, and feelings associated with sustainable lifestyles is proposed. The measurement is done with a five point Likert scale.

The structure of the test is related in Table 1. It presents the construct definitions and evaluated dimensions. The operational definitions are taken from the multi-methodological approach of the three worlds stated by Habermas (1981) as proposed by Mingers (2006). It also shows the items corresponding to each dimension and the number of items per construct.

3 Validation of the instrument

A convenience sampling was performed to validate the instrument as it was not possible to have access to the population of high school graduates by probabilistic selection. Information was taken in a sample of 904 high school graduates in Bogota D.C. Approximately 63% of them are female in gender and more than 50% of the sample belong to families of low economic resources. Approximately 54% of the participants are located at the periphery areas of the city. Close to 56% have a monthly income between USD$200 and USD$450 within their family nucleus and 27% have an approximate income below USD$200.

Table 1. Structure of the test.

Factor or Construct	Dimension	Items	# items
Personal world: It suggests giving answers expected to deal with the social requirements of conservation. This means to have the necessary skill to find answers to problems regarding the care of the environment. It raises the need to study the sustainable conduct as a behavioral competence, which would need additional factors beside skills, such as beliefs and motives. Therefore, it gathers beliefs, motives, and skills and it splits them into affective, cognitive and, behavioral dimensions.	**Affective Personal World:** It refers to the motives. Indicated by the level of personal comfort in situations associated with the environmental and social contexts	1, 2, 3, 4, 5, 6, 7	7
	Cognitive Personal World: It contemplates opinions, beliefs, thoughts, values, and knowledge.	8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18	11
	Behavioral Personal World: Behavioral evidence in favor or against the object or necessary situation to answer the challenges imposed by the care of the environment, or that contain statements that contemplate gender equity, ages, socioeconomic conditions, ethnic groups, etc.	21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35	15
Social world: It gathers the whole interpersonal relations recognized by the members as legitimate (roles, norms, culture practices, power relationships).	**Behavioral Social World:** This is the disposition to take part in environment protection and social benefit actions. It gathers evidence of the performance in favor or against the object or situation of the attitude when related with others.	36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64	29
Material world: It refers to the processes and material or physical arrangements that exist independently from the observer.	**Behavioral Material World**: It recognizes the self-awareness and represents evidence in favor or against the object or situation of the attitude in contexts not controlled by the individual.	65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 19, 20	21

The questionnaire was applied by electronic means on an individual basis. In addition to the 82 items of the instrument, sociodemographic questions were presented in order to estimate the scale for future investigations. After debugging the database, a case without value was identified in one of the variables and was imputed through the analysis method for non-linear main components for imputation of categorical information.

3.1 Analysis by dimension

In order to corroborate the indicators for reliability and validity of the instrument, a reliability analysis was done using the ordinal alpha, and an analysis of construct validity was done using a parallel analysis and an exploratory factor analysis for each dimension.

The exploratory factor analysis goal is to obtain a simplified representation of the information that facilitates the study of the relations between variables, obsevations, and the characterization of the observation by its variables (Abascal and Grande Esteban, 2005). It allows reducing the information from the correlations to find a limited number of factors that explain them (Catena *et al.*, 2003). Additionally, it allows the imputation of missing values from an imputation algorithm.

An imputation algorithm is implemented in a matrix of ordinal data with missing or lost values. Analysis of main not linear components in a subset of data without loss is alternated with sequential imputations of missing values, using the method of the nearest neighbor (Barbiero *et al.*, 2014).

3.1.1 Reliability of data analysis

To measure the reliability inside each construct, the ordinal alpha coefficient is applied due to the ordinal nature of the scale that is being measured with the instrument itself. Significant items are meant to be determined, in order to evaluate whether they should be kept in the instrument.

Elosua Oliden and Zumbo (2008) reviewed the relevance of the use of other reliability estimators for internal consistency in the case of items that have less than five answer options. This is the case for the ordinal Alpha from the model of the common factor and the coefficient Theta de Armor from the model of main components. Mathematical expressions appear for its calculation, supported with the polychoric correlation output (Domínguez, 2012). A determined threshold does not exist to accept if a dimension is trustworthy or not. Values greater than 0.6 are accepted in academic literature.

3.1.2 Validity of the instrument – Parallel analysis – PA

In order to determine the unidimensionality of each construct, a parallel analysis is made to establish the number of dimensions present in a construct. Costello and Osborne (2005) discuss common practices in the studies that use these techniques and provide researchers with a compilation of recommended practices in exploratory factor analysis. One of the most discussed topics is the number of factors to be retained, as this is the most important decision to make after the extraction of the factors. The extraction of few or too many factors can lead to erroneous conclusions in the analysis. One of the most recommended methods to treat with the problem of number of factors to be retained is PA (Ledesma *et al.*, 2007).

Horn (1965) proposes PA as a method based on the generation of random variables to determine the number of factors to be retained. He compares the observed eigenvalues extracted from the matrix of correlation with the ones obtained from normal variables not correlated. It is recommended to use the eigenvalue that corresponds to a given percentile -95% for example- of the distribution of eigenvalues derived from random data (Cota *et al.*, 1993; Glorfeld, 1995).

Ledesma *et al.* (2007), conclude that sufficient agreement exists in the use of PA as the best alternative available to determine the quantity of factors to be retained in the exploratory factor analysis and in the main component analysis. The association measurement in every pair of variables is polichoryc correlation, that is, multivaried normal distribution of the underlying variables. This correlation can be estimated by maximizing the logarithmic probability of the multinomial distribution (Olsson, 1979).

3.1.3 Instrument validity – Exploratory factor analysis –EFA

After carrying out PA, EFA is done in order to decide what questions must stay in the instrument and what questions will be removed for future applications. The EFA requires reaching a balance between the reduction and the representation of the correlations that exist in a group of variables. Therefore, an error in the selection of the number of factors can significantly alter the solution and the interpretation of the results of the EFA (Ledesma *et al.*, 2007). Factor analysis consists of a series of organized steps: review of the correlations matrix, extraction of the factors, factorial rotation, importance of the factors, obtained solution interpretation, and coefficients calculation to obtain the punctuation of every subject in every factor (Catena *et al.*, 2003).

The matrix contains the correlations between all pairs of variables studied. To obtain it, it is necessary to calculate for each variable the distances of every subject to the average of the variable; when it is premultiplied by its transposition, a matrix of sums of squares is obtained (in the positive diagonal) and a matrix of sums of products between the variables of the diagonal. Then, this is divided by the number of remarks minus 1 to obtain the variances-covariances matrix.

The correlation is obtained by dividing all the elements of the matrix by the typical deviations corresponding to the variables for which the correlation is required to be obtained. Therefore, it is necessary to have indexes that allow knowing if there are high correlations in the matrix in order to extract factors (Catena *et al.*, 2003)

Factor extraction is one of the fundamental aspects of the analysis; the idea is to reduce the information contained in the variables into a small number of latent variables. This is why the interrelation coefficients are very sensitive to the size of the samples. They are considered to be slightly unreliable when the samples are small and, although the entire number of subjects can depend on the grade of real relation between the

variables, Comrey and Lee, quoted by Catena *et al.* (2003), suggest that a good sample would be composed by an *n* equal or greater than 300 subjects. Results are reported in Table 2:

Table 2. Item analisys. Factorial charges.

Item	Ordinal Alpha	KMO	Affective Personal World	Cognitive Personal World	Behavioral Personal World	Behavioral Social World	Behavioral Material World
1	0.77	0.83	0.69				
2	0.76	0.83	0.75				
3	0.78	0.83	0.58				
4	0.78	0.83	0.55				
5	0.77	0.87	0.65				
6	0.79	0.84	0.52				
7	0.79	0.89	0.48				
1 to 7	***	0.85	***	***	***	***	***
8	0.8	0.81		0.49			
9	0.79	0.87		0.57			
10	0.78	0.78		0.7			
11	0.78	0.77		0.73			
12	0.79	0.86		0.48			
13	0.79	0.75		0.52			
14	0.78	0.85		0.73			
15	0.82	***		-0.22			
16	0.81	***		0.34			
17	0.78	0.81		0.6			
18	0.8			0.37			
8 to 17	***	0.81	***	***	***	***	***
21	0.72				0.1		
22	0.72				0.19		
23	0.71				0.32		
24	0.68	0.72			0.61		
25	0.69	0.73			0.56		
26	0.71				0.38		
27	0.69	0.76			0.52		
28	0.71				0.33		
29	0.7				0.41		
30	0.7				0.36		
31	0.69	0.79			0.48		
32	0.7				0.41		
33	0.7				0.43		
34	0.69	0.79			0.47		
35	0.73				-0.1		
24 to 34	***	0.75	***	***	***	***	***
36	0.89	0.9				0.57	
37	0.89	0.9				0.6	
38	0.89					0.47	
39	0.89					0.44	
40	0.89	0.94				0.64	
41	0.89	0.95				0.63	
42	0.88	0.94				0.72	
43	0.89	0.93				0.62	
44	0.89	0.89				0.51	
45	0.88	0.93				0.72	
46	0.88	0.94				0.65	
47	0.89					-0.05	
48	0.89	0.9				0.57	
49	0.89					0.45	

50	0.89					0.3	
51	0.88	0.88				0.63	
52	0.88	0.91				0.7	
53	0.89					0.47	
54	0.89					-0.1	
55	0.89					0.29	
56	0.89					-0.26	
57	0.89					-0.32	
58	0.89					-0.22	
59	0.89					0.42	
60	0.89	0.94				0.52	
61	0.89					0.44	
62	0.89					-0.36	
63	0.89					-0.34	
64	0.89					0.28	
36 to 60	***	0.92	***	***	***	***	***
19	0.73						0.1
20	0.72						-0.11
65	0.69						0.56
66	0.69						0.54
67	0.7						0.32
68	0.71						0.22
69	0.71						0.3
70	0.71						-0.2
71	0.71						0.35
72	0.7						0.55
73	0.71						0.42
74	0.7						0.6
75	0.72						-0.05
76	0.7						0.54
77	0.7						0.54
78	0.69						0.51
79	0.72						-0.13
80	0.74						0.14
81	0.73						-0.01
82	0.7						0.4
19, 20, 65 to 82	***	0.73	***	***	***	***	***

Note: Grouped KMO punctuation items are considered only with the items included in the final group of 35 items.

The variation of the ordinal alpha of the dimension calculated without each of the elements was used as exclusion criteria to estimate the reliability of every dimension, as shown in Table 2. The ordinal alphas estimated for every complete dimension were: Affective Personal World (α:0.8); Cognitive Personal World (α:0.81); Behavioral Personal World (α:0.72); Behavioral Social World (α:0.89) and; Behavioral Material World (α:0.72)

Assuming that dimensions are independent, PA was done in each and every theoretical dimension to establish the quantity of the present dimensions in the questionnaire. From this PA it is concluded that only one dimension is sufficient to summarize the variables in each of the dimensions of the instrument. In Table 2, factorial charges of the items used as criteria to preserve or eliminate them for each dimension are presented. In the EFA, factorial charges are considered satisfactory if they overcome the criteria of having an absolute value bigger than 0.45. Additionally the index of Kaiser-Meyer-Olkin (KMO) was used to ratify the previous result. In Table 2 it is shown that after the verification processes, the remaining items are suitable for the instrument in development.

Finally, EFA is done, with its results shown in Table 3. The final version of the instrument kept 35 of the items distributed across the five dimensions.

Table 3. Results of the EFA.

	Affective Personal World	Cognitive Personal World	Behavioral Personal World	Behavioral Social World	Behavioral Material World
Items that remain	1, 2, 3, 4, 5, 6,	8, 9, 10, 11, 13, 14, 17	24, 25, 27, 31, 34	36, 37, 39, 41, 42, 43, 45, 46, 48, 51, 52, 60	65, 72, 74, 76, 77
Items to be eliminated	7	12, 15, 16, 18	21, 22, 23, 26, 28, 29, 30, 32, 33, 35	38, 40, 44, 47, 49, 50, 53, 54, 55, 56, 57, 58, 59, 61, 62, 63, 64	66, 67, 68, 69, 70, 71, 73, 75, 78, 79, 80, 81, 82, 19, 20
# of final items	6	7	5	12	5

4 Conclusions

After carrying out the validation process, we have an instrument composed by 35 items to measure sustainable lifestyles. This will be applied to students of the faculty of Engineering so it allows us to compare the results and determine if their passing through the University modifies the sustainable lifestyles of individuals.

Under the sustainability framework, the instrument of sustainable lifestyles (S.L.) becomes a useful tool to gather information regarding practices, beliefs, and preferences of the participants concerning their personal, social, and material worlds.

It is possible to compare sustainable lifestyles between different populations where the instrument is properly validated.

It is necessary to combine the application of this type of instruments with other quantitative and qualitative methods in order to obtain more complete information and to be consistent with basic research theories.

If themajority of items investigate different attribute magnitudes, it is possible to infer that the spectrum is better represented than when there are few items that evaluate a smaller sector of the spectrum magnitude. Therefore, the material world dimension can be sub-represented in the instrument, because the dimensions are not shaped in equall number of items relative to each other.

The affective and cognitive forms of the social and material world could not be captured in the final instrument because all their items were eliminated from it. There were theoretical dimensions that could not be measured by the final tool. This limits the possibilities of establishing relationships between beliefs, feelings, and their behavioral manifestation. This opens up the possibility to develop future research works in the development of instruments that allow to address all modalities or to study the relation between them.

The Likert scale used to measure the behavioral form references the frequency of appearance of the conduct in question, therefore, the items that represent the behavioral form in the three worlds of Habermas turned out to be simple to measure. In contrast, the affective and cognitive forms were evaluated by the accordance level with the affirmations, making its measurement more complicated. So, it is possible to conclude that the Likert scale format is more efficient when it alludes to frequencies than when referring to an agreement level.

The characteristics of the sample and the form of its selection limit the possibility of extending the applicability of the instrument to other groups like children, people with low educational level, or other groups without having to validate it again. Then, it is necessary to validate the model proposed in other populations to guarantee the quality of the estimations for future investigations.

5 References

Abascal, E. and Grande Esteban, I. (2005). Analisis de encuestas. Madrid, España.
Barbiero, A., Ferrari, P. A., and Manzi, G. (2014). Imputation of Missing Values Through a Forward Imputation Algorithm.
Bhaskar, R. (1975). A Realist Theory of Science SE - Radical Thinkers.
Catena, A., Ramos, M. M., and Trujillo, H. M. (2003). Análisis Multivariado. Un manual para investigadores. Madrid, España.

Costello, A. B. and Osborne, J. W. (2005). Best Practices in Exploratory Factor Analysis: Four Recommendations for Getting the Most From Your Analysis. Practical Assessment, Research & Evaluation, 10(7):1–9.

Cota, A. A., Longman, R. S., Holden, R. R., Fekken, G. C., and Xinaris, S. (1993). Interpolating 95Th Percentile Eigenvalues from Random Data: An Empirical Example. Educational and Psychological Measurement, 53(3):585–596.

Domínguez, S. (2012). Propuesta Para El Cálculo Del Alfa Ordinal Y Theta De. Revista de Investigación en Psicología, 15(1):213–217.

Elosua Oliden, P. and Zumbo, B. D. (2008). Coeficientes de fiabilidad para escalas de respuesta categórica ordenada. Psicothema, 20(4):896–901.

Fraijo Sing, B., Corral Verdugo, V., and Tapia Fonllem, C. (2012). Adaptación Y Prueba De Una Escala De Orientación Hacia La Sustentabilidad En Niños De Sexto Año De Educación Básica. Revista Mexicana de Inveistigación Educativa, 17(55):1091–1117.

Giddens, A. (1984). The Constitution of Society: Outline of the Theory of Structuration.

Glorfeld, L. W. (1995). An Improvement on Horn's Parallel Analysis Methodology for Selecting the Correct Number of Factors to Retain. Educational and Psychological Measurement, 55(3):377–393.

Habermas, J. (1981). Teoría de la acción comunicatival. Racionalidad de la acción y racionalización social.

Horn, J. (1965). A rationale and test for the number of factors in factor analysis. Psychometrika, 30(2):179–185.

Ledesma, R. D., Universidad, C., Mar, N. D., Valeromora, P., and Valencia, U. D. (2007). Determining the Number of Factors to Retain in EFA: an easy-to-use computer program for carrying out Parallel Analysis. Practical Assessment, Research & Evaluation, 12(2):2–11.

Mingers, J. (2006). Realising systems thinking: knowledge and action in management science. Springer Science & Business Media.

Olsson, U. (1979). Maximum likelihood estimation of the polychoric correlation coefficient. Psychometrika, 44(4):443–460.

Sayer, A. (2004). Why critical realism? In S Fleetwood& S Ackroyd (eds), Critical realist applicationsin organisation and management studies, pages 6–20.Routledge, London.

Incorporating Agile Project Management Methodologies to the Production Systems Project 5 Course within the Production Engineering Undergraduate Program at the University of Brasília

Filipe Henrique S. Santos[1], Simone Borges[1], André Luiz Aquere[2]

[1] Department of Production Engineering, University of Brasília, Campus Darcy Ribeiro, Brasília, Brazil
[2] Department of Civil Engineering, University of Brasília, Campus Darcy Ribeiro, Brasília, Brazil

Email: filipehssantos@gmail.com, simoneborges@unb.br, andre@unb.br.

Abstract

The Production Engineering major offered by the University of Brasilia (UnB) is essentially hinged on Project-Based learning practices. Thus, the main core of this undergraduate program is the seven Production Systems Project (PSP) courses, which occur between the fourth and the tenth semesters. During those courses the students are exposed to different demands from external clients, and are consequently responsible for managing a project in order to provide a final solution for the customer. On most of the Production Systems Project courses, the students are generally expected to apply the traditional Project Management practices presented by the PMBOK guide, considered as one of the best sources of project management standards. However, in order to meet faster demands, inherent in the modern market, the Production Systems Project 5 course aims to take a different approach and focus on the application of Agile Project Management Methodologies, such as Scrum, adapted to the Production Engineering context. This new perspective should allow the students to further develop concepts based on Lean Production, Six Sigma and other Quality Management principles and to apply them in a practical situation. Therefore, the main objective of this paper is to discuss the challenges and opportunities within structuring the Production Systems Project 5 course, based on Agile Project Management methodologies, in order to ensure that the stakeholders' needs and expectations are met.

Keywords: Active Learning; Engineering Education; Agile Project Management Methodologies; Agile models applied to Education; Project Approaches.

1 Introduction

In a context where a constant and accelerated modernization drives the transformations within the world in the most various spheres, the development of some essential factors has become even more crucial in order to survive in such competitive markets. One of these factors is the bargaining power of the customers, which, according to Michael Porter (1998), is one of the five strategic forces that define the competition in an industry. The author also explains that the good competition is characterized by demanding customers with enough influence to induce the suppliers to improve their quality and reduce their costs. Therefore, in such an environment, the customers began to demand products with higher quality standards and that could be delivered in a shorter period.

In order to meet the new delivery speed requirements and also respect the quality constraints inherent to the modern products, new methodologies and tools were developed to adapt the product development and management processes to these new capabilities. According to Massari (2014), it was during the 1990's that the agile development methodologies and tools emerged to the industry. Approaches focusing on reducing the delivery times, but that could still ensure quality and compliance for the products were successfully implemented, mainly, in the software industry during that time.

Considering the adaptability and the adequacy of the agile methods for different markets, this paper aims to analyse the suitability of implementing the agile frameworks as the project management methodologies in an undergraduate discipline at the University of Brasília.

The curriculum of the Industrial Engineering undergraduate program offered by the University of Brasilia has a regular duration of twelve semesters and was designed centred on the Project-Based Learning (PBL) methodology. The program encompasses seven project disciplines, which are offered from the 4th to the 10th semesters and that are entirely based on the active learning approach. The main objective of having these project disciplines is to stimulate the development of both technical and soft skills within the students, by exposing them to real problems related to the Industrial Engineering and Management fields. During these courses, the students have the opportunity to play the roles within a project team, such as project manager, in order to develop a feasible solution that would meet the stakeholders' expectations (Aquere et al, 2012). In addition to that, most of these courses still adopt a traditional linear project management methodology, essentially based on the best practices presented by the PMBOK® (PMI, 2014).

2 The next sections provide a detailed explanation on how this study was executed and the results obtained by the research team. Relevant Factors in Project Management

Currently, project management represents an essential part of the modern organizations, which have been focusing more on results and using the project approach as their business model to deliver products and achieve improvements in their performance. However, along with this market trend, emerged a new operational question: How should the companies properly manage their projects in order to succeed?

According to a survey conducted by Standish Group International (2009) there was a decrease in project success rates between the years of 2000 and 2008. Only 32% of all projects were successful (fulfilled term time, cost and scope), 44% were challenging (they were late, over budget and did not deliver what was agreed between the parties) and 24% failed (they were cancelled prior to completion or never used).

Montes-Guerra et al (2015) say that the adoption of standards and good practices in organizations has increased in recent years. Some studies reported by Montes-Guerra et al (2015) already show the high percentage of professionals using project management methodologies, techniques and tools. Therefore, the adoption of project management practices has started to play a very important role in the success of competitive companies. In addition to that, some other factors that affect the projects success rate are the project structure, the competence of the project manager and project size, according to Patah and Carvalho (2015).

Nowadays, there are already several project management methodologies available in the market, which are easily accessible to managers from any industry. However, the real challenge now is to define which one has the proper suitability for each context, and what are the right procedures to correctly implement them. According to Patah and Carvalho (2015), there are already institutes and associations from all over the world that can be used as references with their respective project management methods and best practices. Table 1 presents some of the existing institutes and their brief characterization.

Table 1 – Main frameworks adopted in Project Management (adapted from Patah and Carvalho, 2015).

Institute	Set of methods	Home country	Methodology focus
Project Management Institute (PMI)	Project Management Body of Knowledge (PMBoK)	EUA	General project management
International Project Management Association (IPMA)	ICB – IPMA Competence Baseline	European Union	General project management
Australian Institute of Project Management (AIPM)	AIPM – Professional Competency Standards for Project Management	Australia	General project management
Association for Project Management (APM)	APM Body of Knowledge	United Kingdom	General project management

Office of Government Commerce (OGC)	Projects in Controlled Environments (PRINCE2)	United Kingdom	Management information systems projects
Japan Project Management Forum (JPMF)	ENAA Model Form-International Contract for Process Plant Construction	Japan	Construction project management
Agile Project Management International (APMG International)	AgilePM Guidance	United Kingdom	Software Project Management

In an environment where there are so many different project management methodologies available and accessible for the managers, the actual challenge relies on how to choose which one is the most appropriate for each business model, as discussed in the next sections.

2.1 Traditional linear project management

The traditional linear project management dates from around 1950, according to Wysocki (2009). The author also explains that in the beginning, since there was a huge lack of tools and technology to support it, the linear project management approach was basically a "sequence of phases such as define, plan, execute, and close with tasks identified within each phase" (WYSOCKI, 2009). However, it is visible that even back in the day in such a challenging environment to achieve operational excellence, there was already concern about how to organize the tasks in order to deliver the products according to what was planned.

Nowadays, with the emergence of advanced software tools and techniques, project management has become a lot more complex and valuable for the market. In 1996, the first edition of the Guide to Project Management Body of Knowledge (PMBOK) was published by the Project Management Institute (PMI). The guide gathers the best practices related to Project Management and present them under a traditional linear approach. According to the PMBOK® (PMI, 2013) a project is composed by five basic process groups, which are: Initiating, Planning, Executing, Monitoring and Controlling and Closing. For each of these groups, the guide presents the best practices available in order for the project managers to analyse, adapt and implement them according with their own needs and requirements. Wysocki (2009) explains that the linearity of this method relies on the sequential structure of the five basic groups, whereas for the next group to be started, the previous one must be finished.

2.2 Agile adaptive project management

Agile Project Management is a relatively new trend that dates back to the year of 2001, when the Agile Manifesto was written by seventeen professionals from the software industry (Highsmith, 2009). The agile approach was first designed as an alternative for the software developers to efficiently deal with the new constraints of the modern world, such as delivering high quality systems in an even shorter amount of time with the focus on adding value to the customers. According to Schuh (2005), "Agile development is a method of building software by empowering and trusting people, acknowledging change as norm, and promoting constant feedback".

Nowadays, there are different agile project management models available, and although they all follow the agile principles, they still have different targets and capabilities among themselves. Wysocki (2009) explains that the agile methodologies could be divided into two main models: The adaptive and the iterative. According to the author, the iterative model is recommended for projects where some features of the products are unknown, whilst the adaptive model should be used in cases where the whole solution is not clearly defined (Wysocki 2009).

Although the Agile methodology was initially intended to meet the requirements from the software industry, its range of applicability is growing increasingly in the past few years. According to Wysocki (2009), the

Adaptive Project Framework is an example that can also be easily applied for the non-software industry. The author explains that: "Its application to product development, process design, and process improvement projects has been successfully demonstrated" (WYSOCKI, 2009). To sum up, as long as the project strategic goals are aligned with the core values of the agile principles, the agile methodologies could be successfully applied to different industries in different contexts.

Table 2, shown below, illustrates the main differences between the Traditional Linear Project Management Life cycle and the Agile Adaptive Project Management Lifecycle (APM):

Table 2 – Differences between Linear and Adaptive Project Management Life cycles (adapted from Wysocki, 2009).

Linear Traditional Project Management	**Agile Adaptive Project Management**
Complete and clearly defined: Goal, Solution, Requirements, Functions and Features;	Critical problem with an unknown solution;
Few expected change requests	Thrives on change through learning and discovery;
Project is composed by routine and repetitive activities;	Project is composed interactive activities and meaningful client involvement is essential;
Large use of established templates;	Does not waste time planning uncertainty;
Entire project is scheduled at its beginning;	Just-in-time planning;
Not focused on client value.	Does not waste time on non-value added work.

The next section covers the methodology applied during this study, as well as the data collection tools and the analysis performed by the research team.

3 Research Method

The method applied by the team during the present research was the case study, aiming to evaluate and identify which project management methodology would be the most appropriate to be taught during the discipline of Production System Project (PSP) 5. Based on the definitions proposed by Yin (1994), the research questions were built from an explanatory nature, being structured with words such as "why", "what", "which" and "how". In addition to that, the research approach was qualitative, since the focus of the research was not to enumerate or measure the events, but to describe them in order to understand the phenomena of the situation analysed, as explained by Godoy (1995. In addition, the data collection technique used was a questionnaire, which will be detailed in the next section of this document.

3.1 Data Collection

In order to obtain a more comprehensive understanding regarding the subject of this paper, the research team developed a structured questionnaire. The questionnaire was available through an online tool and was directed to students who are majoring or have already graduated in Industrial Engineering at the University of Brasilia, and have also concluded the Production System Project 5 course. The students responded to the questionnaire during the months of February and March of 2016 and the total number of responses obtained was equal to 37, which represents more than the average number of students per class on the PSP 5 course (approximately 25 students) and ensures a significant representation for the data analysis.

The design of the questionnaire was based on the objective of retrieving three different sets of information, as shown in the figure 1, presented below:

Survey Structure			
Introduction - Greetings			
13 questions	Group 1	*Detailed characterization of the projects developed by the students during the course of Production System Project 5.*	**Five** (5) choice questions – single answer
	Group 2	*Assessment on the applicability of agile management tools within projects developed during the course of Production System Project 5.*	**Three** (3) choice questions – single answer
	Group 3	*Evaluation of the importance of learning agile project management methodologies for the formation of the modern Industrial Engineer.*	**Two** (2) Likert scale questions
			Three (3) choice questions – single answer

Figure 1 - Questionnaire structure.

The first set was composed by questions focused on the characterization of the projects developed by the students during the course of PSP5. In order to obtain a detailed understanding of these characteristics and to correlate it with the analysis on the proper suitability of the project management approach for these projects, the questions were mainly based on the definitions and parameters established by Wysocki (2009) and illustrated in the Table 2 of the present paper. The research group gathered the requirements, the strengths and the weaknesses inherent to both the adaptive agile and to the traditional linear project management models, and formulated questions that asked the students to compare which one would describe better their experience with the past projects. This information allowed to comprehend the common characteristics and scopes of the projects developed, in order to foresee the applicability of agile project management methodologies in that context.

The second group of questions had a similar approach to the first one, but with the objective of providing the research team with a drilled down understanding of the student's needs, focusing on the specific tools used to manage the projects and also evaluating how successful they were during those experiences. Therefore, this set of questions focused on assessing the applicability of agile management tools in the scope of the projects developed during the course of PSP5, by comparing their experience with the agile tools against the traditional tools in that context.

The third set of questions was focused on obtaining feedback from the students regarding the importance of learning agile project management methodologies for the development of the modern Industrial Engineer, according to their perspective. This data would allow a better understanding on how the students see the agile methodologies and what are their expectations on the development of this knowledge area, according to the current Industrial Engineering undergraduate program offered by the University of Brasilia.

To sum up, the questionnaire was used to gather the necessary data to perform the analysis about the agile project management methodologies and their relationship with the development of an Industrial Engineer in the modern days from the perspective of students who had already experienced the application of these approaches in the analysed context of the Production System Project 5 discipline.

4 Data Analysis

In order to align the data analysis with the structure presented on the data-collecting tool, this section was also arranged in the same three topics presented with the questionnaire design. The topics below address each group of questions with a more detailed approach.

4.1 Group of questions 1: Are the projects executed during the PSP5 courses suitable for the implementation of agile project management methodologies?

Regarding the need for interactions with clients the data showed a very consistent evaluation: 92% of the students affirmed that the projects executed during the Production System Project 5 course require lots of interactions with the customers. This is a highly relevant fact that could imply in the application of adaptive agile project management models in general. Agile projects are very customer-driven and they tend to demand a higher interaction with the active client. According to Wysocki, in the adaptive agile projects, "clients have a more directive role in the project than they do in the Linear" (WYSOCKI, 2009).

Another very important finding based on the data analysed is that 81% of the respondents affirmed that the solution for the project is not known in its beginning, and needs to be discovered and developed during its execution. According to Rauniyar (2010), this information reinforces the suitability for the implementation of an adaptive agile project management model, since it is a context where both depth and breadth of the solution are missing and need to be discovered along the way. The author also mentions that "The adaptive strategy is the first approach encountered where the solution is not known or partially unknown" (RAUNIYAR, 2010)

The results of the questionnaire show that 72% of the students also affirmed that the scope and the complexity of the project typically allow the team to start its execution with a brief planning phase, which relies on an adaptive process along the project execution. According to Hass (2007), the agile project management approach provides a better balance between the initial planning time and an iterative change management process focusing on adding value to the customers. In addition, the author emphasizes: "The team is supposed to do just enough planning up-front. As each increment of the system is built, the team gathers input and learns from the customer feedbacks" (HASS, 2007).

Looking at the data regarding the type of activities executed during the projects, 97% of the respondents affirmed that those activities seek for transformation through an active learning and discovery process, instead of being consisted of routine and repetitive procedures. In addition to being an almost unanimous response, this data is very important because it fits precisely in one of the characteristics of the adaptive agile project management life cycle presented by Wysocki, who defines that the adaptive projects "Thrive on change through learning and discovery" (WYSOCKI, 2009).

Based on the analysis performed upon the data related to the first group of questions, the feedbacks regarding the suitability of adopting agile methodologies are extremely positive. The data shows that the context and the scopes of the projects developed during the PSP 5 course have a high tendency to facilitate the implementation of an adaptive agile project management model, considering aspects such as the amount of interaction with the clients, the proper time distribution and the knowledge regarding the solution at the beginning of the project.

4.2 Group of questions 2: Are the agile tools and approaches appropriate for the specific needs of the projects developed during the PSP 5 course?

According to 83% of the responses, the students consider the Project Canvas as a more suitable tool for the type of projects developed during the PSP5 than the regular project management plan, suggested by the PMBOK® Guide. In addition to that, the questionnaire results also showed that 76% of the students would prefer the implementation of a visual management board to support the project management rather than the traditional WBS, Gantt chart or other conventional tools. Both responses corroborate the suitability of implementing an agile project methodology in that context. According to Hass (2007), the preference for visual documentation over the formal documentation is one of the conditions that allow the project team to implement agile methods.

Considering the approach of the project team regarding quality assurance, mostly respondents also agreed that this process is intrinsic to the members, and each one is responsible for ensuring the quality of their own parts. This approach was chosen by 89% of the respondents, in comparison with the utilization of a standard

traditional quality plan to document and manage the quality of the products. This information reiterates that the students who were evaluated already had the maturity needed to coordinate the quality management as a team through a process-oriented perspective during the course, which is essential for a successful agile project. According to Highsmith (2009), having a self-organized team is the core to success in agile projects. The author explains that "in a self organized team, individuals take accountability for managing their own workload, shift work among themselves based on need and best fit and take responsibility for team effectiveness" (HIGHSMITH, 2009).

4.3 Group of questions 3: Is the learning of agile project management methodologies important for the formation of the modern Industrial Engineer, according to the students' opinions?

Based on the responses obtained, it is possible to affirm that the students already see the process of learning project management methodologies and, specifically, the agile ones, as a high value added part for their development. The average rate for the question related to how important the students consider learning project management methodologies, in general, for an industrial engineer was 4.78, in a scale from 0 to 5. Furthermore, the students also assessed that the learning of agile project management methodologies has a very high importance for the industrial engineer, rating this attribute with an average of 4.51 in the same scale from 0 to 5.

The vast majority of the respondents also understood that the market values the professional that possesses knowledge on that subject, since 86% answered affirmatively to this question. In addition to that, the students already envision that agile project management surpasses the barriers of the software development industry, and that its principles could be adapted to different realities faced by an Industrial Engineer in the modern world, considering that also 86% of the respondents agreed with that affirmation.

The results obtained from the third group of questions reinforce the potential of this study for the student community. The assessments provided by the students show the learning of agile project management methodologies as a high value added step for the industrial engineer development. Therefore, this indicates a high potential of students' adherence to implement and continuously improve a new structure developed for the Production System Project 5 course based on the agile project management principles.

The next section digs deeper on a first proposal of a new structure based on the agile principles for the discipline of Production System Project 5.

5 Results: New proposed structure for the PSP5

After analysing the collected data and confirming the feasibility of implementing the agile model in the discipline of Production System Project 5 at the University of Brasilia, this paper aims to initialize the structuring of the new course from the agile perspective. Based on the comparison between the requirements, objectives, inputs, outputs, tools and methods present in each phase of the project life cycle for both agile and traditional models, the present study suggests a first broad overview of what could be the new framework for the discipline. The Figure 2 presents the basic transformative structure from the traditional project management approach to the agile model, based on the findings of this study for the PSP5 discipline.

The proposed structure consists on an initial framework to be implemented and continuously improved within the next PSP5 courses. During this process, the research group will collect additional data regarding the evolution of the model and the experience of the students, which will be further detailed in future papers.

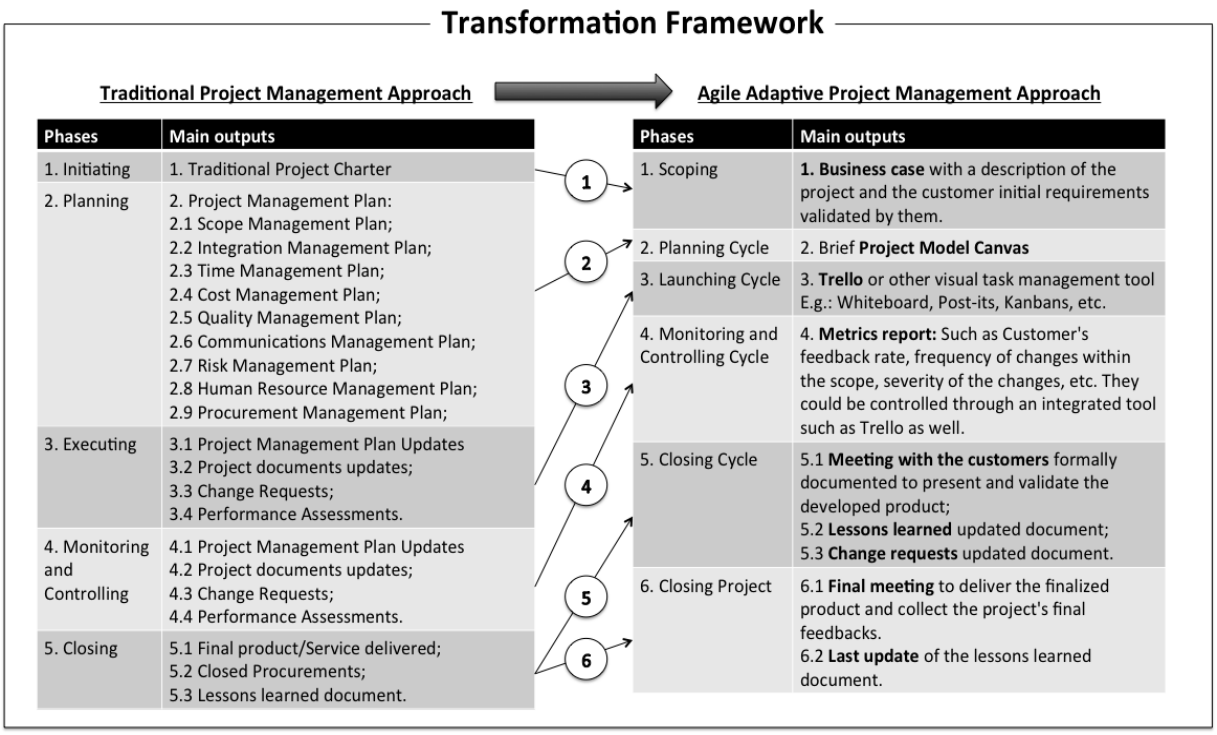


Figure 2 – Transformation Framework: From the traditional method to the Agile Adaptive - adapted from Wysocki (2009).

6 Final Considerations

The presented paper provided a qualitative assessment regarding the applicability of agile project management methodologies within the context of Industrial Engineering education at the University of Brasília. In addition to that, the study also suggested an initial framework to support the implementation of this new structure for the PSP5 courses, as described in the section 5. Also, the findings discovered through this study will be used as relevant inputs in order to finalize the structuring process for the new PSP 5 disciplines, based on the Agile project management methodologies.

7 References

GODOY, A. S. Pesquisa Qualitativa – Tipos Fundamentais, ERA/EAESP/FGV, vol.35, nº 3, p. 20-29, São Paulo, maio/junho 1995.

HASS, Kathleen. The Blending of Traditional and Agile Project Management. Originally published on www.pmworldtoday.net, May 2007

HIGHSMITH, Jim. Agile Project Management: Creating Innovative Products. Addison-Wesley Professional, 2009.

MASSARI, Vitor. Gerenciamento Ágil de Projetos: Uma visão preparatória para a certificação PMI (PMI-ACP), Brasport, Rio de Janeiro, 2014.

MONTES-GUERRA, M. I., De-Miguel, A. R., Amaya Pérez-Ezcurdia, M., Gimena Ramos, F. N., & Díez-Silva, H. M. Project Management in Development Cooperation. Non-Governmental Organizations. Innovar, 25(56), 53-68, 2015.

PATAH, L. A.; Carvalho, M. M. Sucesso a partir de investimento em metodologias de gestão de projetos. Revista Produção, São Paulo, ISSN: 01036513, 2015.

PORTER, Michael E. On Competition. Harvard Business Review. United States, 1998.

Project Management Institute (PMI). A guide to the Project management Body of Knowledge (PMBOK guide). Newtown Square, PA. United States, 2013.

SCHUH, Peter. Integrating Agile Development In The Real World, Charles River Media. United States, 2005.

STANDISH GROUP INTERNATIONAL. (2009). CHAOS Summary 2009. Retrieved from http://www.standishgroup.com

WYSOCKI, Robert K. Effective Project Management: Traditional, Agile, Extreme. Wiley Publishing, Inc. Indianapolis, IN. United States, 2009.

YIN, R.K. Case study research: design and methods, Applied Social Research. Methods Series, Sage Publications, Thousand Oaks, London, New Delhi, 1994.

Learning by doing approach implementation in project management courses

Krzysztof Pikoń[1], Magdalena Bogacka[1]

[1] Department of Technologies and Installations for Waste Management, Faculty of Power and Environmental Engineering, Silesian University of Technology, Gliwice, Poland

Email: magdalena.bogacka@polsl.pl, krzysztof.pikon@polsl.pl

Abstract

Recent development of technology and access to information forces the change of teaching methods. Previously, the transfer of knowledge was the key element which determined the level of education. Today, access to the resources like digital libraries, online resources and books is common. It shall be followed by a change of academic teacher's role. Pedagogical evolution is essential to the further development of education systems. The educational system should deliver knowledge together with skills. Particularly important is the ability to solve problems and how to practically use the knowledge gained. It is essential to develop students' soft skills. Therefore, studies should be the basis for testing ideas, capabilities, and talents in a safe environment, where student, can you make a mistake and correct it without serious consequences. Companies require from employees experience, independence and self-reliance at the beginning of a professional career. These elements should be delivered during studies.

Practical application of the idea of learning by doing in the framework of the project management course is presented in the manuscript. At the beginning of the course the theoretical basis of project management was delivered to students. In next step challenge to organize a scientific conference for students and young researchers was set. Students were responsible not only for theoretical preparation, planning, but also for the practical implementation of the project. The conference was nationwide, so pressure on the quality of the organization was huge. The students themselves also suffer the consequences of their decisions. The conference was organized before the 3 years by different groups of students, which gives the possibility to make comparisons and proper assessment of pedagogical evaluation and educational outcomes.

In the manuscript the aims and objectives of the project, its framework and the results of a survey conducted for students after completing the conference are presented. This project could serve as a good example of the implementation of learning by doing and project based learning approach in engineering courses.

Keywords: learning by doing; project management; methods of learning; idea.

1 Introduction

MSc Clean Fossil and Alternative Fuels Energy (CFAFE) is one of the seven MSc programmes offered by KIC InnoEnergy. It primarily focuses on technologies that lead to the efficient thermal and chemical conversion of coal, with reduced pollutant emissions to air, water and land at all levels and stages of the operation, as well as the application of biomass or unconventional hydrocarbons, e.g., shale gas. The program, is focused on implementation of new methodologies of teching - like case teching, challenge driven education and project based learning - as well..

Learning by doing is a methodology based on performing by students of tasks close to real problems, instead of passively listening to a teacher. The notions of teacher and student can be defined as "student as worker" and "teacher as manager" or "teacher guide on the side". Learning by doing is not a "teacher cantered" approach. *(Charles M, 2013)*. However, lectures are large part in the education system despite the fact that students and academic leaders are becoming less satisfied with this approach. (*KIC InnoEnergy, 2015)*

The general advantages of all active learning methodologies including learning by doing are: *(Bonwell, 1991)*:

- Students are involved in more than listening.
- Less emphasis is placed on transmitting information and more on developing students' skills.
- Students are involved in higher-order thinking (analysis, synthesis, evaluation).

- Students are engaged in various activities (e.g., reading, discussing, writing).
- Students are exploring their own attitudes and values.

Despite the name of the methodology, the best results are connectred with methods of learning which are based on the active attitude of a student who are acting in close to reality conditions .

The concept of active learning with higher students' involvement in the learning process was implemented in the classes of KIC Innoenergy Clean Fossil and Alternative Fuels Energy program carried out at the Silesian University of Technology sponsored.

2 Boundary of classes

The course "Project Management" is part of Clean Fossil MSc Programme and the purpose of the course is to learn its students new soft-skills in field of project managing and not in a conventional way, but by "learning-by-doing". This approach is based on executing real projects with real incomes and outcomes. The main goal of our project is to make CFAFE program more visible and recognizable. In other words, to attract more students to apply for CFAFE programme.

Identifying the KPIs

- Brainstorming strategies to conduct the conference
- Review the ideas
- Creating Work Breakdown Structure
- Creating Gantt Chart and setting deadlines
- Assigning tasks
- Contacting KIC students to write article
- Reserving room for the conference
- Inviting professors for the conference
- Gathering reviewed articles
- Creating list of speakers with time schedule
- Design posters and leaflets
- Distribution of posters among Faculty of Mechanical Engineering, Faculty of Energy and Environmental Protection, Faculty of Chemistry, Faculty of Mining and Geology
- Creating Facebook event page
- Sharing this event via official SUT Facebook page, Student Union (Samorzad studencki) Facebook page, EESTEC LC Gliwice Facebook page and IAESTE Gliwice Facebook page
- Creating feedback forms for visitors
- Ensuring promotional and informational materials to KIC InnoEnergy stand
- Buying presents for professor speakers
- Ensuring technical matters for the conference
- Conference day
- Creating design for the monograph
- Finishing and publishing monograph

All KPIs are defined at the beginning of the course and are implemented in accordance with the plan presented in the Gantt chart (Fig.2).

3 Work Breakdown Structure

During the very first phase of the Conference Project students created Work Breakdown Structure (WBS). WBS, in project management and systems engineering, is a deliverable-oriented decomposition of a project into smaller components. A work breakdown structure is a key project deliverable that organises the team's work into manageable sections. Student preparing scheme of conference and Gant project.

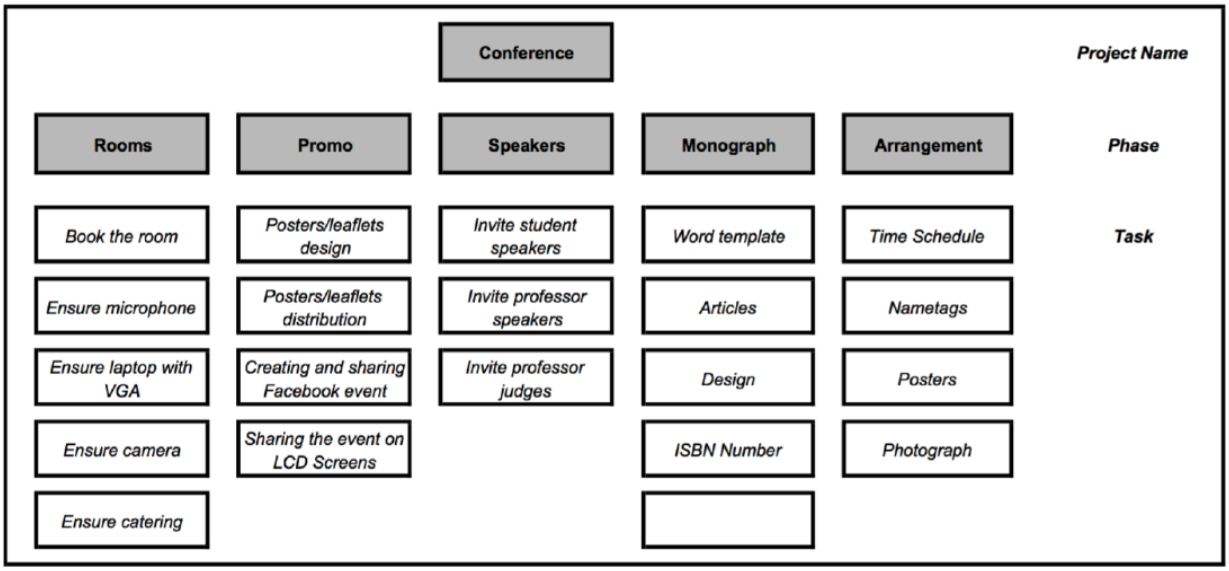


Figure 1. Scheme of preparing conference by students

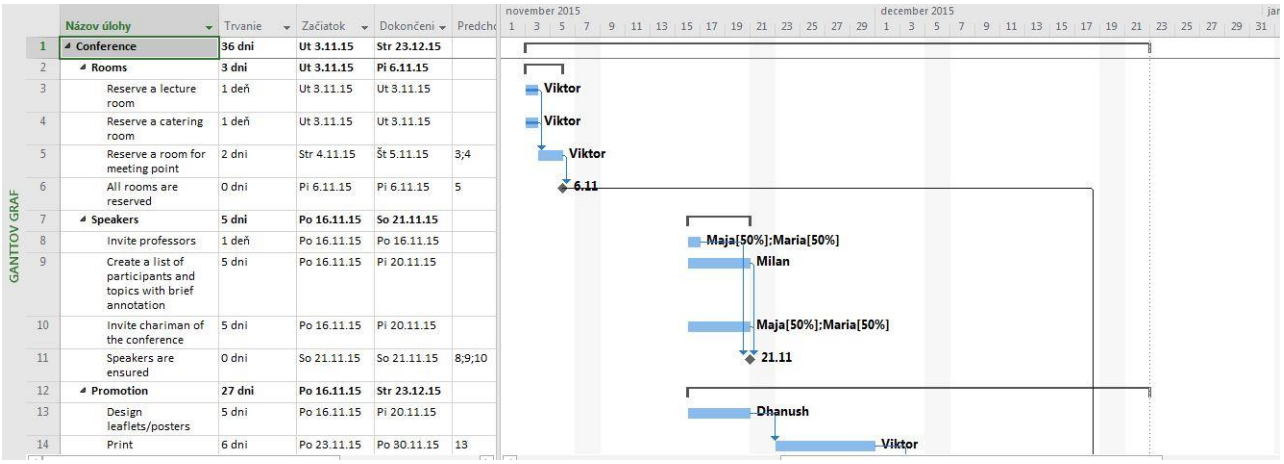


Figure 2. The Gant chart of conference project prepared and performed by students

The all elements was created by students. Teacher acted as moderator, which indicates the objectives and direction of activities.

4 Feedback

Two types of survey was created. One of them is feedback from participants, the second is questionnaire from students preparing about organization of classes by learning by doing.

A survey (from participants) was conducted with few set of questions. The aim of the survey was to find the satisfaction level from the participants and how we organisers can improve next time. The results from the survey is mentioned below and copy of the questionnaire is attached at the end.

The results survey 1:

Q1: **How did you learn about this conference?**

A:

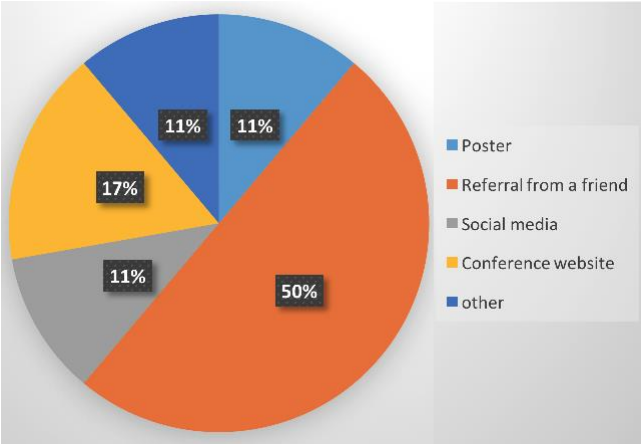


Figure 3. Answers on Q1 of participants

Q2: **Please specify the main reason for attending this conference**

A:

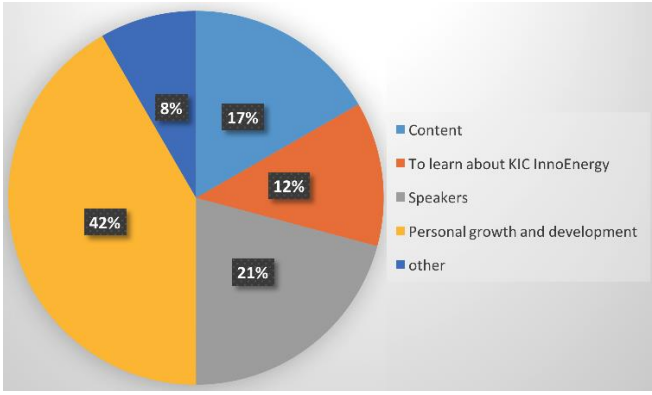


Figure 4. Answers on Q2 of participants

Q3: **Did the conference fulfil your reason for attending?**

A:*Yes – Absolutely – 71%*

Yes – Not to my full extent - 23%

Maybe – I don't know - 6%

No – It was waste of my time – 0%

Q4: **Would you recommend this conference to others?**

A: *Yes 88%*

No 12%

Q5: **What was the most beneficial aspect of the conference?**

A:

- *To improve knowledge about energy*
- *For food and catering*
- *Information about fuels*
- *Learning about new topics*
- *Listening to presentation in English*

- *Speeches from professors*

Q6: **Please indicate your overall satisfaction with this conference**

A:

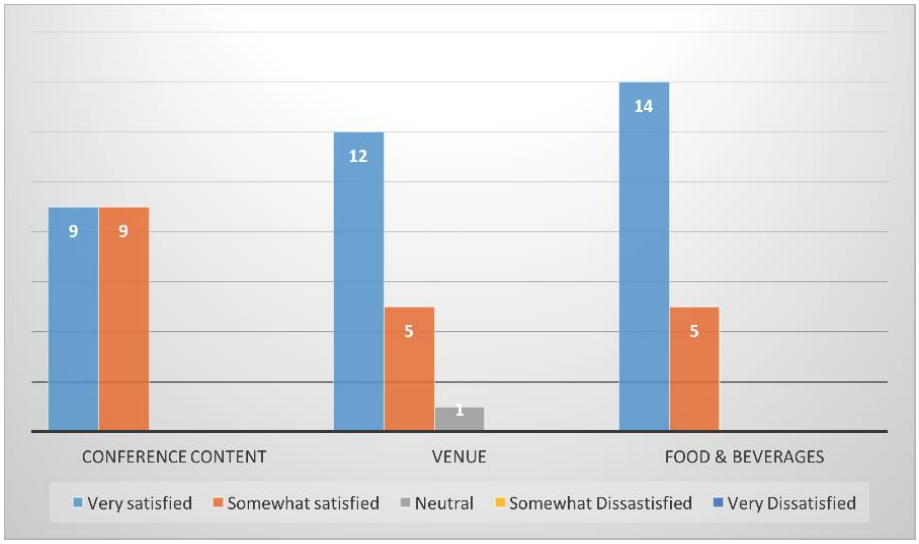


Figure 5. Answers on Q6 of participants

Q7: **What is your profession?**

A: *Student – 90%*

Professor – 10%

Conclusion of survey 1:

From the feedback we can conclude that the conference was successful both from students' and professors' point of view. There were no negative feedback from the participants. Communication played an important role in increasing participants in the conference. Most of the participants were satisfied attending the conference and they would happily recommend this type of conference to their friends in future.

The results of survey 2:

Students' evaluation of conference framework:

"*At the very beginning we got to know several project management tools such as brainstorming, KPIs, work breakdown structure, Gantt chart, etc. We applied all these tools in different phases of the project and we could and we saw they can be useful. Not less important thing, that is underestimated very frequently, is to set feasible deadlines and dedicate enough time for every task. By making this we can avoid stress and time pressure and focus more concentration and energy to make project better. In other words, proper and precise planning is essential part of project management. Or, as it is often said, failing to plan is planning to fail. Another important thing, especially for project managers, is to assign tasks as much as possible among all of team members. Again, if one of the team members or project manager himself has lot of task to execute, there can come pressure which can end in failure in project. As a project manager I can say, that I learn to divide tasks equally and I also learn how important is to ensure proper communication between team members and project management. Project manager should also connect, motivate and push forward the team when there is a need. He should also estimate team member's abilities and assign tasks according to it. No team member should feel overlooked or too busy.*

During our presentations on conference, we also learnt and developed our presentation and assertive communication skills. Because of all these experiences I consider Project Management course and the way it is conducted, when "learning by doing" is applied, as very contributing and somehow different from other courses. Organising the conference gave us practical hands-on experience on how to organising this type of events and also motivation to organise such events in future." (CFAFE students, 2016)

Pluses and minuses of students:

- *One of the biggest minus is that we were not allowed to establish own Facebook page. This would be very effective tool to share our events, posts, articles, etc. With Facebook page we would be able to reach much more people than with posters. As a recommendations for future year it is to get permit to initiate own Facebook page.*
- *Communication with officials from KIC headquarters was ineffective and ended up in failure in Linkedin subgroup.*
- *Better communication and clarity of the goals and timeline for our tasks between CEO and the Team. It would be more effective if there was clearer presentations of what CEO wanted from us.*
- *After successful end of the conference we would like to continue in developing our organising skills and organise a conference type event, where KIC start-ups and people from industry would present to students. This would give students another point of view on current energy issues and it would also give to this star-ups a good opportunity to promote themselves.*

THE RESULTS SURVEY 2:

Q1: **Is the method "learning by doing" better than the standard classes that perform the project?**

A:*Yes – 77,3%*

No – 9,1%

Maybe – 13,6%

Q2: **Would you organize a conference once again, if you knew all the obstacles that were on your way?**

A: Yes – 68,2%

No – 0%

Maybe – 31,8%

Q3: **What could have been done better, according to your experiences at organization process?**

Often written answers:

- *Bigger audience*
- *More funds for activity*
- *Try to improve the idea of scientific committee and evaluations method (either organize it properly or resign from the competition) also try to promote more the event*
- *Besides the practical part, there should be more focus on theoretical knowledge, that we have never been taught*
- *Could have invited kic students from other programmes*

Q4: **What was most difficult in the organization of conference?**

Often written answers:

- *Finishing tasks before deadlines*
- *Doing the groundwork*
- *Preparation of the article and the presentation*
- *The most difficult part was to keep up with all the activities going on*
- *Communication*

Q5: **What was the most important element that taught you most valuable things?**

Often written answers:

- *Importance of planning*
- *Organizing*
- *Giving the presentation in front of public*
- *The fact that the most important part is to communicate with others*

- *Teamwork*

Q5-Q11: **(Applies to acquire soft skills) Using a scale from 1 to 5, select how you rate (1 – not good, 5 very good):**

1. **Communication skills**
2. **Teamwork and collaboration**
3. **Adaptability**
4. **Problem solving**
5. **Critical observation**
6. **Conflict resolution**

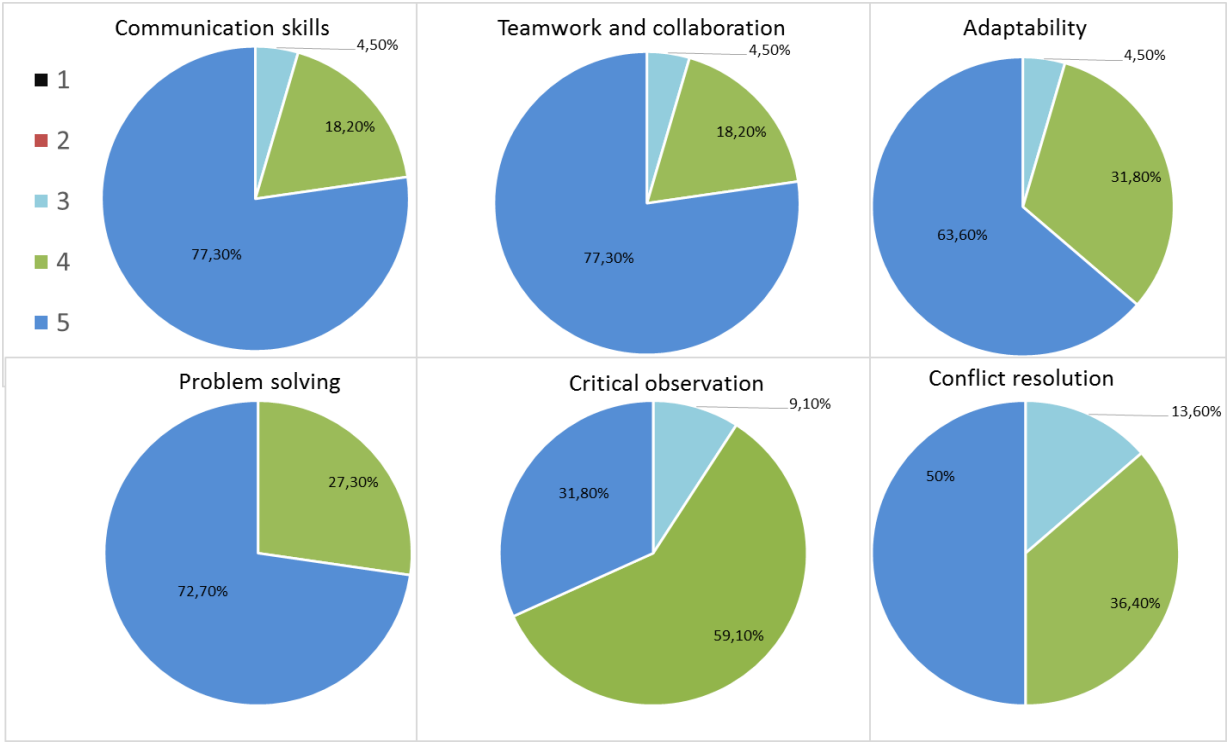


Figure 6. Answers on Q5-Q11 of students

The vast majority of students evaluated positively the subject. More than 77% of students believe that learning by doing is a better method of teaching, and 13% believe that it MAYBE. In similar proportions of students knowing all the obstacles, then they resume their organizations 68% determined YES, MAYBE believe the rest of students. In open questions, students showed the most problems associated with the occurrence of a large audience and organizational issues. However, the overall result - a conference for more than 130 people is a great success.

5 Conclusion

Learning by doing is the methodology which can be easily implemented in many courses like project management. Majority of student's activities are focused on real issues what creates the added value for effectiveness of teaching process. The project described in the manuscript was successfully performed and gained very positive opinion of students. It was significantly better assessed than classes conducted in "board and chalk" manner. However, some difficulties were identified. They were mostly connected with higher time consumption of activities both on students and teachers side. Positive aspects like effective shaping of skills including behavioural ones, together with higher knowledge could be observed. Even if in some part of their activities they suffered a defeat the final result of work was extremely satisfying. Going out of the comfort zone, always gives a new experience and creates new abilities for the future. The big advantage was the fact that students were interacting not only with themselves but with people from the outside of the organization. This

made the situation very close to reality. Solving problems, even very basic, could teach how to manage time in difficult situations and teach how to think independently and culture ability to solve problems.

In order to evaluate the results of the project the specific KPI were designed. All project's goals were reached. The special pride and satisfaction for students came from the fact that 94% of participants were satisfied with the way how the conference was conducted.

Acknowledgement

This paper has been developed as a part of KIC Innoenergy activity in Clean Fossil and Alternative Fuels Energy Msc program.

6 References

Bonwell, C. and Eison, J., Active Learning: Creating Excitement in the Classroom AEHE-ERIC Higher Education Report No. 1, Washington, D.C., Jossey-Bass, ISBN 1-878380-08-7, 1991.

Charles M. Reigeluth Instructional-design Theories and Models: A New Paradigm of Instructional Theory, Tom 2, chapter 8 Learning by doing, Routledge, 2013,

CFAFE students (2016). PROJECT REPORT Clean Fossil Recognitionots. *report created within the framework of project management course, 2016*

KIC InnoEnergy EDU Teaching in the Knowledge Triangle with Challenges – internal communication by Henrik Svensson, KIC IE, 2015

Teaching Problem-Based Learning to engineering interdisciplinary graduate students

Fernando J. Rodriguez[1], José Ismael Peña Reyes[2]

[1]Department of Mechanical Engineering and Mechatronic, Faculty of Engineering, Universidad Nacional de Colombia, Bogotá, Colombia
[2]Department of Computers Sciences, Faculty of Engineering, Universidad Nacional de Colombia, Bogotá, Colombia

Email: fjrodriguezm@unal.edu.co, jipenar@unal.edu.com

Abstract

Like worldwide, at the Universidad Nacional de Colombia, by the Direction of the Engineering Faculty, there is a growing interest in modifying the traditional lectured-based teaching model. A PBL course was designed to encourage problem-based learning (PBL), and to improve teaching practices within graduate students. In the PBL course participated students who were teaching assistant at the engineering program. Often, graduate students have their pedagogical training by imitation due to their formation process; therefore, they don't have pedagogical knowledge. The course was organised in two parts: the first one focused on issues about learning and philosophical theories of learning as a teaching model, using lectures and workshops. The second part was to learn PBL using the PBL model to do so. The 64-hour course was done in the second half of 2015. It had the participation of 24 graduate students, between different disciplines of engineering. After students had been training, we collected student views from both, PBL course program and the importance of PBL as a method for undergraduate students learning. The results were analysed by qualitative methods.

Keywords: Curriculum design; Problem-based learning; Inter-disciplinarily; Engineering Education.

1 Introduction

Nowadays around the world, the traditional educational systems do not respond to emerging demands from the workplaces. There is a general clamour about knowledge and skills for demanding performance at work. There are a substantial number of government initiatives to change the old methods to teach or learn for more innovative and efficient ones to fit social requirements. Some universities are implementing new models or incentive the change. Also in Colombia, there is a growing interest to get better indicators in education. At Universidad Nacional the Colombia, there are some initiatives concerns with curricular change. Currently, some teachers are exploring new models because many options are ranging from IT tools to active learning approaches. We try to explore with PBL because it could fill many of the expectations from graduates (Kolmos & Graaff, 2007; Prince & Felder, 2006). In this work, we explore some student's perceptions about the PBL initiative in engineering at Universidad Nacional in Bogotá.

2 Educational context

At the European Unión, the European Commission 2010 began an initiative to promote innovation and transversal skills Hoidn & Kärkkäinen (2014). The council takes action plans of UE and roadmaps in which priorities are set for cooperation between the Member States and the Commission (CE, 2015a). To improve economic growth as one of the key elements that it has set is develops necessary skills to have success in the labour market, with a policy of clear objectives through 2020 (ET-2020, 2013). In the December 2014 meeting, it was established that the venture requires the development of a set of skills that need to be addressed at all levels of education and training. Also, education ministers of the participating countries in this Commission pointed the importance to strengthening the links between education and the business world (CE, 2015b).

Like in Europe, the US government calls for change to prepare for the challenges of the 21st century and created organisations like the 'New Commission on the Skills of the American Workforce'. In Japan, the Ministry of Education, Culture, Sports, Science, and Technology uses funds for projects that encourage experimentation

on technological innovation and learning in Higher Education. In the year 2004 in Australia, the Australian Council for Teaching and Learning was established to improve the quality of Higher Education and practice with awards, scholarships, and grants. In Germany, across of the national contest for Excellence in Teaching is a newly introduced subsidy program that recognises and supports innovative teaching in education. In France, in 2008, the education reform includes a plan to encourage innovation in undergraduate teaching (Hoidn & Kärkkäinen, 2014).

As is said in the McKinsey report about the worldwide graduate educational problems, there is a significant lack of talent in the graduates (Mourshed, Farrell, & Barton, 2012).In 2014, in Colombia, 57 % of companies reported having difficulty finding required talent, but 35 % in 2010 (CPC, 2014). Mainly there is a lack of expertise, lack of education and lack of certifications and experience. The competencies require for more companies are handling technological tools, capacity for analysis and decision making, oral and written expression, math skills and second language. As for attitudes, companies report needing for staff emotional intelligence and teamwork, ethical sense, service orientation and achievement, adaptability, creativity and efficiency (Manpowergorup, 2014).

There is an awareness on improving the Colombian educational system. With the 2034 vision of a flexible system of HE, academic quality and vocational training, the proposal for education reform began with difficulties in 2011, to change the actual education law. This process started with strengths and had to be rethought. Reflexion meetings with roundtables, forums, debates, etc., took place in 2012. It worked on several proposals: quality, coverage, equity, relevance, sustainability, autonomy, internationalisation, inclusion and diversity (MEM, 2013). It was recommended to improve tertiary education in many ways. But one could be to invest in innovation and programs. Likewise, it should create a program of evaluation of qualifications to review in broad the graduate skills needed (CPC, 2014, p. 34). But there are some difficulties.

Most university systems are based on the Humboldtian tradition, which emphasises the freedom of research and teaching. At first, universities were administered by teachers with strong autonomy and independence, though it has been lost as time has passed by and it has given space to the neoliberal ideas of postmodernism which has taken the power of the university´s management, and has altered patterns of university education. The student is seen as a customer and the teacher as a tool to produce and use resources efficiently. Thus, decisions are not taken from the teachers, but from staff members, at high levels of the organisation, affecting the program´s evaluation, in favour of the sovereignty of these clients (Bellah, 1999 cited by ; Levine, 2000).

As a consequence, they are focused on strengthening the quality of teachers in some cases and in others to allow lower academic performance. Change efforts on the educational model have been difficult to implement and many teachers do not want to betray the old model, as indicated Pritchard (2004) in relationship to the German ideas about Humboldt.

Therefore, educational policies should be continually reviewed and reflect on the university management or adapt this to new approaches or models of teaching. Social requirements indicate that efforts to improve education at all levels must be from teachers and university staff, schools, government policies and society, including businesses and also various groups and associations, who should be part of the efforts and change strategies. There is growing interest in taking new actions.

Harvard University, in 2011 received a donation of $40 million to support excellence and innovation in teaching and learning. This grant was motivated by the need for new methods to make a better and efficient Higher Education for this generation (Walsh, 2011). In its 2014 report (cit. HILT, 2014), some of the most exciting projects have involved multiple generations of students, graduates, doctoral and staff members with student-centered methods. The innovation projects for teaching-centered learning have shown fewer experiences and shorter conclusions.

The Stanford University has made profound changes in the curriculum models. In 2007, the Business School changed its curriculum to a much more customizable, more global and deeper regarding intellectual experiences (Stanford Business School, 2006).

The Olin College of Engineering was funded since 1997 with the idea of training engineers differently. The learning experience occurs through independent study group, led by students, teachers or staff members and also in competitions or clubs. Its orientation is to promote technical innovation through a less structural curriculum or different to traditional and giving real authentic spaces from young students (Olin College of Engineering, 2015).

The MIT, is worried about change its educational model. The initiative for future of education proposed an online survey to determine how it should be that education. In its 2014 report determined among other things that should be expanding the use of different methodologies such as PBL and Flipped classroom projects and an inclusion of a flexible curriculum, and study new approaches to assessing students (MIT, 2014). Also on interdisciplinary approaches, creating a 'synergy' between different institutions; build learning communities designed to help students establish pathways engagement between the university and the world.

The University of Berkeley in California also has a program called Instructional Improvement Grants 2015-2016 to strengthen academic innovation. It focuses on multidisciplinary, project-changing education involving social services, improving diversity, foster teamwork, active learning, and participation in acquiring the skills of literacy or to improve assessment (UCLA, 2015).

In the UK, the University of Cambridge has a fund to finance programs for implementing innovative practices in teaching and learning. Its focus is on creative or exploratory projects. Additionally, it provides strong support for personal, professional and career of all members by its mission and core values. To achieve this supports people in the ongoing development of a variety of academic skills and training (University of Cambridge, 2015).

Aalto University in Helsinki was founded in 2010 with a multi-disciplinary approach. Combines science, art, technology, and business to create solutions to meet the greatest challenges faced by society through high-quality research and pioneer education (Aalto, 2015).

The 'Pohang University of Science and Technology was founded in 1986 in South Korea. The main idea is providing a student-centered education in a highly collaborative community that encourages students to work in close collaboration (POSTECH, 2015). This university is financially supported mostly by Folco, the largest steel industry in South Korea. By 2012, was leading of the group of best new universities (Adams, 2012)

The Hong Kong University of Science and Technology, founded in 1991 is the third in the same scale. The global plan 2011-2016 has as main initiatives, including flexible programs, strengthen the internationalisation and interdisciplinary, service, personal development and related skills (HKUST, 2015).

Problem-based learning and its variations are methodologies that truly responds to these needs change. The main characteristic can be found in Graaff and Kolmos (2003). It could be an extensive review of the effectiveness of the models of PBL, but these are outside the scope of this study. For historical reasons of implementation, there are numerous review papers in the area of medicine and health, so there are contradictory conclusions. For instance, there are reviewed papers such as Colliver (2000), Norman and Schmidt (2010)), and other with a more center position as Wilder (2015) indicating that there is not strong evidence of effectiveness in changing this model, but interestingly, these same studies also fail to demonstrate that traditional methods are better than PBL. Also, in contrast, other authors like Enarson & Cariaga-Lo (2001), Sungur & Tekkaya (2006); Polyzois et al. (2010) have found advantages in the use of these methods.

However, in the case of engineering, there are many study cases about courses, research, and reports indicate that despite, the difficulties of implementing this student-centered methodology, there are advantages that justify it. For instance, Galand et al. (2012) report about the promotion of soft skills. For Prince and Felder (2006) inductive methods such as PBL, have a cumulative evidence in favour and these are supported by theories of learning, cognitive and social constructivism, Neuro-medicine and empirical findings. Also, help raise intellectual development, thoughts, analysis and learning skills for engineering and science. For De Graaff and Kolmos (2007) with PBL students achieve cognitive skills such as metacognition, critical thinking and problem solving. The effectiveness of PBL also indirectly demonstrated by the decrease in desertion rates, the motivation given, in accentuating the institutional profile and help with the development of competencies (Kolmos & Graaff, 2007).

To move from traditional to PBL, this kind of research results aren't enough to argument changing to PBL. It needs to have complementary studies about PBL effectiveness. Changing to PBL implies some strategies, from the staff level or the low level (Kolmos & Graaff, 2007). In this sense, and to become to empower people, the faculty of engineering design and open a course for training graduate students in PBL.

The initiative was planned during the first half of 2015 and implemented a course for teaching PBL for master and Ph.D. students of postgraduate engineering programs. This course had four credits and was called "Introduction to Problem-Based Learning in Engineering and Technology". The program can be consulted in Daza (2015). The course was an excellent opportunity to capture thoughts about PBL from graduates. So the feedback from the course includes a particular aspect about the PBL as a method for engineering courses.

3 Research question

One of the key aspects to improve educational changes is to think about the course content and understand PBL relevance to fill out the lack of skills in graduate students. Graduate student can be reflective about how their learning was, in relationship with their self-experiences in work. It is because all of the students in this course were working and studying at the same time. After learning how PBL operates, their opinions receive higher importance because necessary they compare the old tradition with the new one. In this sense, the research question is What is the graduate student's views about problem-based learning?

The course was an excellent opportunity to capture thoughts about PBL from graduates. So the feedback from the course includes a special aspect about the PBL as a method for engineering courses.

4 Course description

Detail of this past two months course for interdisciplinary master students is shown in Table 1. The course name is "Problem-based Learning for engineering and technology" and was given at Bogota Campus.

Table 1 Course description

Issue	Description
Teachers	A teacher expert in pedagogy, as course coordinator . A consultant teacher for educational theories and philosophy. An engineering teacher, with knowledge about education. An engineering teacher with PBL knowledge. Some lecturers in specific issues.
PBL Approach	Lecture on the first part and PBL on the second.
Facilitation on PBL part	As a consultant in group management, writing and reading skills.
Group strategy	We try to make up the following groups the Felder & Silverman (1988)
PBL Assessment	Sharing traditional grades by homework and group performances and a final essay
Credits	4
Week hours	8
Total course hours	64, two parts, 32 for each.
Course part 1	Education in Colombia and Latin America, philosophy of education, paradigms and philosophical trends; Pedagogy, technological tools, sustainable engineering and constructivism. At this stage, numerous activities were performed on extra class time, including reading and writing. Each of the lecturers was autonomous but they followed the topic. They were asked to prepare some specific topics and load the material on Moodle.
Course part 2	PBL model, group work, facilitation and assessment in four weekly sessions. This part of the PBL model is working. It was used an average of three problems by session and worked in groups of one to five students. The groups were defined at the beginning of the semester. The Same group in all semesters. When the session started, we spent 15 minutes in a short introduction and trigger talk to beginning the learning process. Students individually did problems and at the end of the semester, they had to do a short reflection in an essay.
Student	24

5 Methodology

We used a qualitative approach. It reflects the views and comments of some of the engineering graduate students. Participants are male and female students from various programs and different professions. In this qualitative part, no distinction was made with age, sex or curriculum.

The opinion of students was taken in two different ways. The main measure was using an open-ended question: "After taking this course: What are your thoughts? In this sense, the usual bias caused by directing questions about the course development is not present. The second one was an internet questionnaire, which was designed to test the course, teachers and outcomes. We took advantage using it to triangulate some findings and coding words to process and analyse information.

In some cases, qualitative methods have advantages over quantitative methods. Special situations were seen in the case of open questions, which in fact, they could have a greater impact without the bias that other questionnaires have.

The open-ended question was written and had the participation of 20 students, but the questionnaire had only 14. Because students were native Spanish speakers, the open-ended question was made in Spanish and also the analysis. The analysis was made using NVivo 11 (QSR, 2015). All opinions were codified according to the word frequency and focused in classifying it according to with knowledge or skills. It was possible because there were a lot of answers in that sense.

Obviously, the language to write thoughts was informal. Here some extracts in Spanish,

"Entre los aprendizajes logrados se destaca el trabajo en grupo, el modelo de aprendizaje de los adultos, teniéndo en cuenta que enseño differences conceptos para personas adultas y me es de gran ayuda conocer como motivarlos a aprender…" Student A

Another example, one extract about the importance of work in teams,

"Además, mejorar la manera de escribir y conocer los diferentes textos literarios que se puedan utilizar en la academia. El ABP me ayudó a aprender como conformar grupos de trabajo y la manera óptima de resolver problemas…". Student B

And one more example, with some pedagogical language

"El ABP para mi es un método genial para aplicarlo en diferentes abientes como laborales, personales, profesionales, educativos; siento que me aportó diferentes herramientas para manejo de grupo, identificar cognición y la metacongnición, la humildad, manejo de actividades con grupos interdisciplinarios…". Student C

In the analysis with Nvivo, we discard comments about the behaviour, teaching style or materials given because the main interest is to know the views about PBL from the students.

6 Results

With Nvivo, we have to read all of the comments and code in. After the text was code, we use cloud queries to graph the information. The table below shows some of the figures we obtained in this process. As we said before, the text was kept in Spanish and also the results appear in Spanish. Next to the pictures, we make comments regarding the findings. The Table 2 summarize the results after code and process it.

In spite of the long text and ideas from the students, we can find coherence in the results. They are consistent with the benefits of PBL and it is summarised below. We can't generalise our findings, but we compare it with affirmations from some authors.

Table 2 Results and comments about PBL student views

Graphical result	Comment
	. The course was very useful to improve soft skills. Students said they had implemented their capacity to writing to communicate, critical thinking, time management and verbal communication. Agree with (Dolmans & Schmidt, 2006; Graaff & Kolmos, 2003; Neville, 2009)
	Students received a foundation in education. They were sensitised on the importance of learning theories and training for teaching. It is necessary to improve pedagogical skills in engineering education (Irby, 1996; Kupriyanov & Gorodetskaya, 2015) Some of this group the student working given adult training so they think PBL is useful to train adults.
	There is a high potential to encourage teamwork. The subject demands too much time. A semester is not enough to achieve the objectives and complete the program. Agree with (Graaff, 2000)
	About PBL, students understand its usefulness especially in professional life and the relevance of the work over traditional methods. They feel PBL strengthens professional performance. They also believe that PBL is suitable for learning. They said very few about the difficulty to implement it but said that demand too long. Core skills for engineering work are recognised in PBL. They are co-operation, project management, communication, etc. (Kolmos & Kofoed, 2002)
	Students found useful PBL to encourage work in groups. Probably, it was the main aspect to considered with PBL. They were agreeing about PBL gives skills to management time and organising projects. Specific group skills are mention in (Woods, 2014). There are many authors agree with this aspect.

Graduates of engineering think PBL useful to enhance knowledge and skills like interdisciplinary communication and writing. In that sense, it is better than traditional lectures. However, students believe that demands lots of time and excessive reading. Also, there is a consensus about training needs in this kind of methods to be more effective in teaching.

Many "tools" could be given for training or instructional proposes to students. The students had the opportunity to learn from the lectures at the beginning of the course when they taught learning theories and pedagogy. For the students, there were lots of tools to teach, but without enough time to prove it.

Students were convinced about new educational foundations. They also recognised in this course formation aspects to improve in their class. Many of the students were assistant teachers in their master studies, and they could take the value of teaching improvements and its importance.

Regarding other aspects of the course, students mentioned having learned from PBL and have met the goals and objectives of the course. However, there were comments about the lack of time in class. Extra time was needed to do too much work left in class as the main problem. It is accord with some authors because PBL and similar learning methodologies demand more time than the usual one (Bédard, Lison, Dalle, & Boutin, 2010)

About PBL, students understand its usefulness especially in their professional life and the relevance of the work over traditional methods. They feel PBL strengthens professional performance. They also believe that PBL is suitable for teaching. They said few thinks about the difficulty of implementing it but, said it demanded too much time.

There is a high potential to encourage teamwork. The subject requires too long and a semester is not enough to achieve the objectives and to complete the program (Graaff, 2000).

7 Conclusion

We have shown enough illustration about the need for change academic systems. Like many educational institutions, there is a growing interest at the Universidad Nacional de Colombia to improve learning outcomes for its graduates. There are many initiatives to promote innovation, training and new courses.

In spite, this is not a representative group for generalising; this experience is useful to do some changes and begin to create awareness about the importance on alternative methodologies like PBL. Its importance arises because it was not a simple survey or question for some graduates about their reflexions about education. They were part of a group graduates, who were immersed in a PBL course combining pedagogical theories and PBL. So the mental perspective about education is changed in comparison with current undergraduate students. Additionally, taking into account that they recently had graduated and that they have some experience in the industry, their opinion is very important because it gathers in just one question the opinion of both students and graduates.

The collect comments showing that this experience has been crucial to outline and begin doing some changes, and the idea is to create sensitivity about the existence of alternative teaching technologies such as PBL.

Regarding the course program, it is necessary to make some changes in its contents. It is important to reduce the amount of working programs and the work left for home and also, the need program adjustment to a PBL focus. In this sense, it is necessary to split into two parts this course. It was shown that one semester is not enough to prepare students for PBL with such amount of learning themes.

Regarding the relevant importance that the PBL methodology has, we confirmed that as happen worldwide, graduate students (professionals) think that PBL improved a lot of skills and it can raise their awareness about the importance of these learning tools.

8 References

Aalto. (2015). Aalto University. Recuperado a partir de http://www.aalto.fi/en/about/
Adams, S. (2012). The World's Best New Universities. *Forbes.com*.

Bédard, D. ., Lison, C. ., Dalle, D. ., & Boutin, N. . (2010). Predictors of student's engagement and persistence in an innovative PBL curriculum: Applications for engineering education. *International Journal of Engineering Education*, *26*(3), 511-522.

Bellah, R. (1999). Freedom Coercion and Authority. *Academe*, *85*(1), 16-21.

CE. (2015a). El Consejo de la Unión Europea. Recuperado a partir de http://www.consilium.europa.eu/es/council-eu/

CE. (2015b). El Consejo de la Unión Europea. Fomentar la educación en favor del crecimiento económico y el empleo. Recuperado a partir de http://www.consilium.europa.eu/es/policies/education-economic-growth/

Colliver, J. A. (2000). Effectiveness of problem-based learning curricula: Research and theory. *Academic Medicine*, *75*(3), 259-266.

CPC, E. C. P. de C. (2014). *INFORME NACIONAL DE COMPETITIVIDAD 2014-2015*. Zetta Comunicadore .

Daza, C. E. (2015). *Aprendizaje Basado en Problemas e n Ingeniería y Tecnología: El laboratorio en la Enseñanza y Aprendizaje de la Ingeniería y la Tecnología. Universidad Nacional de Colombia. Facultad de Ingeniería. Bogotá*.

Dolmans, D. H. J. M., & Schmidt, H. G. (2006). What do we know about cognitive and motivational effects of small group tutorials in problem-based learning? *Advances in Health Sciences Education*, *11*(4), 321-336.

Enarson, C., & Cariaga-Lo, L. (2001). Influence of curriculum type on student performance in the United States Medical Licensing Examination Step 1 and Step 2 exams: problem-based learning vs. lecture-based curriculum. *Medical Education*, *35*(11), 1050-1055.

ET-2020. (2013). Council Conclusions on investing in education and training - a response to «Rethinking Education: Investing in skills for better socio-economic outcomes» and the «2013 Annual Growth Survey». *Official Journal of the European Union*, *56*(2013/C 64/06).

Galand, B., Frenay, M., & Raucent, B. (2012). Effectiveness of Problem-Based Learning In Engineering Education: A Comparative Study on Three Levels of Knowledge Structure. *International Journal of Engineering Education*, *28*(4, SI), 939-947.

Graaff, E. De. (2000). *Assessment and Educational Development* (Vol. Aalborg Un). Aalborg Universitet.: Aalborg : Videncenter for Læreprocesser:

Graaff, E. De, & Kolmos, A. (2003). Characteristics of Problem-Based Learning. *International journal of engineering education*, *19*(5), 657-662.

Graaff, E. De, & Kolmos, A. (2007). History of Problem-Based and Project-Based Learning . (E. de Graaff & A. Kolmos, Eds.). Rotterdam: Sense Publishers.

HILT. (2014). *{Harvard Initiative for Learning and Teaching}. Transforming education from the inside out: Three years of hilt grants to seed experimental teaching and learning at harvard*.

HKUST. (2015). Hong Kong University of Science and Technology. Recuperado a partir de http://strategicplan.ust.hk/eng/six_areas.html

Hoidn, S., & Kärkkäinen, K. (2014). Promoting Skills for Innovation in Higher Education: A Literature Review on the Effectiveness of Problem-based Learning and of Teaching Behaviours. *OECD Education Working Papers*, (100), 64.

Irby, D. M. (1996). Models of faculty development for problem-based learning. *Advances in Health Sciences Education*, *1*(1), 69-81.

Kolmos, A., & Graaff, E. De. (2007). Management of change-Implementation of Problem-based and Project-base Learning in Engineering . (E. de Graaff & A. Kolmos, Eds.). Rotterdam: Sense Publishers.

Kolmos, A., & Kofoed, L. (2002). *Developing process competencies in co-operation, learning and project management*.

Kupriyanov, R. V, & Gorodetskaya, I. M. (2015). Global trends in higher education and thier impact on engineering training in Russia. En *Proceedings of 2015 International Conference on Interactive Collaborative Learning (ICL)* . Florence, Italy.

Levine, D. N. (2000). The idea of the university, take one: on the genius of this place .

Manpowergorup, C. (2014). *Diversidasd y Talento: Bases de la innovación y la sostenibilidad para Colombia*. Manpowergorup Colombia .

MEM. (2013). *Reformas a la Educación Superior en América Latina: Ecuador, Chile, México, Perú y Colombia. Memorias del encuentro Bogotá, 23 de octubre de 2013* .

MIT. (2014). Institute-wide Task Force on the Future of MIT Education: Final Report.

Mourshed, M., Farrell, D., & Barton, D. (2012). *Education to employment: Designing a system that works* .

Neville, A. J. (2009). Problem-based learning and medical education forty years on: A review of its effects on knowledge and clinical performance. *Medical Principles and Practice*, *18*(1), 1-9.

Olin College of Engineering. (2015). About Olin. Recuperado a partir de http://www.olin.edu/about/

Polyzois, I., Claffey, N., & Mattheos, N. (2010). Problem-based learning in academic health education. A systematic literature review. *European Journal of Dental Education*, *14*(1), 55-64.

POSTECH. (2015). Pohang University of Science and Technology. Recuperado a partir de http://www.postech.ac.kr/

Prince, M. J., & Felder, R. M. (2006). Inductive teaching and learning methods: Definitions, comparisons, and research bases. *JOURNAL OF ENGINEERING EDUCATION*, *95*(2), 123-138.

Pritchard, R. (2004). Humboldtian Values in a Changing World: Staff and Students in German Universities. *Oxford Review of Education*, *30*(4), pp. 509-528-528.

Schmidt, H. (2010). A review of the evidence: Effects of problem-based learning on students and graduates of Maastricht medical school. En *Lessons from Problem-Based Learning*. Erasmus University, Department of PsychologyRotterdam, Netherlands: Oxford University Press. doi:10.1093/acprof:oso/9780199583447.003.0024

Stanford Business School. (2006). Stanford Graduate School of Business Adopts New Curriculum Model. Recuperado a partir de https://www.gsb.stanford.edu/stanford-gsb-experience/news-history/stanford-graduate-school-business-adopts-new-curriculum-model

Sungur, S., & Tekkaya, C. (2006). Effects of problem-based learning and traditional instruction on self-regulated learning. *JOURNAL OF EDUCATIONAL RESEARCH*, *99*(5), 307-317.

UCLA. (2015). University of California Berkeley. Instructional Improvement Grants. Recuperado a partir de https://teaching.berkeley.edu/instructional-improvement-grants

University of Cambridge. (2015). Teaching and Learning at Cambridge. Recuperado a partir de http://www.teachingsupport.cam.ac.uk/teaching-and-learning-innovation-fund-0

Walsh, C. (2011). Harvard Gazette: Education and innovation.

Wilder, S. (2015). Impact of problem-based learning on academic achievement in high school: a systematic review. *EDUCATIONAL REVIEW*, *67*(4), 414-435.

Woods, D. R. (2014). Problem-oriented learning, problem-based learning, problem-based synthesis, process oriented guided inquiry learning, Peer-Led team learning, model-eliciting activities, and project-based learning: What is best for you? *Industrial and Engineering Chemistry Research*, *53*(13), 5337-5354.

Architecture Programme for freshmen students: A Teaching proposal

Monique Guerreiro Bastos[1], Andréa Pereira Mendonça[2]

[1] Academic, Department of Post Graduation - Master in Technological Teaching, IFAM – Federal Institute of Education, Science and Technology of Amazonas, Campus of Manaus-Centro, Manaus, Brazil
[2] Professor, Department of Post Graduation - Master in Technological Teaching, IFAM – Federal Institute of Education, Science and Technology of Amazonas, Campus of Manaus-Centro, Manaus, Brazil

Email: monique.bastos@gmail.com, andrea.ifam@gmail.com

Abstract

Freshman Architecture students can benefit from anticipating the Architecture Programme learning in their undergraduate course and from dealing with the client's needs. In a 15-hour workshop with students from a Northern Brazilian University, we were able to implement a problem-based and blended-learning approach, considering station-rotation and flipped-classroom models. We used Moodle learning management system and FloorPlanner drawing software. Students were asked to perform activities in order to capture the client's needs and convert them into requirements to build a compact version of the Architecture Programme, compatible with their current skills, which served as basis for sketches presented by the end of the workshop. Results were that their works achieved more than 70% of the client's requirements. Advantages regarding it were that students projects went beyond solely technical norms: aspects like security requirements, restrictions, wishes and habits of a client, observed in a real-world scenario, were considered. Innovative aspects of this work are the teaching and the content complexity management addressed to freshmen students, as the Architecture Programme is approached usually later in the undergraduate courses. Besides, this work also allowed the implementation of a blended learning approach in Architecture, following an emerging trend in Education. Results made us believe that architecture freshmen will benefit from our approach in a short to long-term period, considering that the sooner we teach the Architecture Programme to them, their comprehension of the client's needs as well as their project skills will enhance, potentializing possibilities of well succeeded projects in a future work performance. The next steps are: (i) consider the Architecture Programme as a subject to be taught for freshmen, inside disciplines of project practice and not as an extracurricular workshop, as we experienced, and (ii) write guidelines and make them available to other teachers.

Keywords: Active Learning; Architecture programme, teaching, freshmen

Programa arquitetônico para alunos iniciantes: uma proposta de ensino

Monique Guerreiro Bastos[1], Andréa Pereira Mendonça[2]

[1] Acadêmica de mestrado, Departamento de Pós-Graduação – Mestrado em Ensino Tecnológico, IFAM – Instituto Federal de Educação Ciência e Tecnologia do Amazonas, Campus Manaus Centro, Manaus, Amazonas, Brazil.
[2] Professora, Departamento de Pós-Graduação – Mestrado em Ensino Tecnológico, IFAM – Instituto Federal de Educação Ciência e Tecnologia do Amazonas, Campus Manaus Centro, Manaus, Amazonas, Brazil.

Email: monique.bastos@gmail.com, andrea.ifam@gmail.com

Resumo

Calouros de Arquitetura podem ter benefícios com a aprendizagem do Programa Arquitetônico associado ao contato com o cliente, em seu primeiro ano de graduação. Em um *workshop* de 15 horas com estudantes de uma Universidade do Norte do Brasil, implementamos uma abordagem baseada em problemas e ensino híbrido, considerando modelos de Rotação por Estações e Sala de Aula Invertida. Usamos os softwares Moodle para a gestão da aprendizagem e Floorplanner para os desenhos. Os alunos realizaram atividades para captar as necessidades do cliente e convertê-las em requisitos, e para construir uma versão compacta do Programa Arquitetônico compatível com suas habilidades atuais, que foi base para estudo preliminar apresentado ao final do *workshop*. Como resultados os trabalhos atingiram mais de 70% dos requisitos de avaliação considerados, com os estudantes relatando clara percepção de seu próprio aprendizado. A proposta permitiu que os estudantes fossem além do partido formal: questões como requisitos de segurança, restrições, desejos e hábitos de um cliente, observados em um cenário que reproduz o mundo real, foram considerados nas soluções. Aspectos inovadores deste trabalho são o ensino e a adaptação do conteúdo para alunos calouros, dado que o Programa Arquitetônico é abordado geralmente mais tarde na graduação. Além disso, este trabalho permitiu a implementação de ensino híbrido em Arquitetura, seguindo uma tendência emergente em Educação. Os resultados indicam que calouros de Arquitetura podem se beneficiar da nossa abordagem a longo prazo, pois quanto mais cedo nós ensinamos o assunto, sua compreensão sobre ele melhorará, aumentando possibilidades de projetos bem-sucedidos num futuro desempenho como estudante e profissional. Os próximos passos são: (i) considerar o Programa Arquitetônico como um assunto a ser ensinado para calouros, em disciplinas de prática do projeto e não como uma oficina extracurricular, como a que vivemos, e (ii) escrever diretrizes e torná-las disponíveis para outros professores.

Palavras-chave: Aprendizagem ativa; Programa Arquitetônico, Ensino, Calouros

1 Introdução

Embora não seja uma prática comum nas universidades, é possível ensinar o programa arquitetônico para alunos iniciantes de Arquitetura. Em geral, os cursos focam no ensino de técnicas de desenho com alunos iniciantes e somente em etapas posteriores do currículo tratam sobre as necessidades do cliente e de como transformá-las em um programa para subsidiar soluções projetuais.

O programa arquitetônico, também chamado de plano de necessidades ou *briefing*, consiste em descrever o contexto onde o projeto arquitetônico vai operar, estabelecendo o problema que a forma deverá responder (Kowaltowski & Moreira, 2008). Este problema é motivado por necessidades do cliente, porém norteado por uma série de fatores internos (orçamento, terreno do cliente, finalidade do lugar, atividades do lugar) e externos (meio ambientes, legislações, normas, técnicas construtivas) a ele.

A elaboração do programa arquitetônico é uma atividade fundamental na atuação de um arquiteto, especialmente de um profissional recém-formado. Tais profissionais, geralmente, não lidam com projetos encomendados de grandes construtoras. Frequentemente, seus clientes são pessoas que pretendem construir ou fazer uma reforma na sua própria casa ou escritório. Estes clientes são, na maioria dos casos, os próprios usuários do espaço e cabe ao arquiteto dialogar com eles para descobrir e entender suas necessidades, expectativas e desejos. Desse diálogo deve resultar um conjunto de informações que integradas constituem-se em um marco documental que registra os requisitos que devem ser contemplados para a satisfação do

cliente/usuário. Esse documento precede a fase de projetação que corresponde a concepção do desenho arquitetônico, propriamente dito.

Dada sua importância, acreditamos que a habilidade de construir um programa arquitetônico é tão importante quanto a habilidade de desenhar e, por isso, precisa ser tratado mais atenta e repetidamente nas disciplinas de projeto, desde o início do curso. Acreditamos que o ensino desse conteúdo não deve ser minorizado pelas restrições de repertório inicial dos estudantes, e que pode ser contornado com uma proposta de ensino que permita o seu aprendizado ativo, com conteúdo ajustado ao momento presente desses alunos.

Dada esta crença, planejamos e implementamos um *workshop* de 15 horas para ensinar alunos iniciantes sobre o programa arquitetônico. Neste *workshop*, implementamos uma abordagem de ensino-aprendizado a partir de problemas e ensino híbrido (utilizando rotação por estações e sala de aula invertida). Adotamos o sistema de gerenciamento educacional Moodle e sistema de desenho Flooplanner.

Para apresentar os resultados obtidos com esta experiência de ensino sobre o programa arquitetônico com alunos iniciantes, nós organizamos o artigo da seguinte forma. Na seção 2, nós apresentamos o planejamento do *workshop*. Na seção 3, descrevemos a sua execução com alunos iniciantes de arquitetura de uma universidade no Norte do Brasil. Na seção 4, apresentamos os resultados obtidos, seguido da apresentação de trabalho relacionados. Por fim, apresentamos as conclusões e trabalhos futuros.

2 Fundamentos

A concepção do *workshop* está fundamentada em três pilares: (i) exploração do conteúdo tendo como elemento motivador um *problema mal definido*; (ii) adoção do *ensino híbrido* para organização da sala de aula e administração das atividades de ensino presenciais e não-presenciais; e, (iii) *construção de artefatos* pelos alunos a fim de solucionar o problema proposto.

Problemas mal definidos são problemas cujo enunciado não é tão claro. As informações disponíveis são incompletas, podendo haver ambiguidades, contradições e até informações incorretas (VanLehn 1989; Lynch et al. 2006 apud Mendonça A. P., 2010). No caso deste trabalho, os problemas mal definidos foram utilizados com a finalidade de motivar os estudantes a esclarecerem as informações com um cliente e assim, descobrirem as necessidades que precisam ser atendidas no projeto. No nosso *workshop*, a narrativa do problema mal definido consistia em caracterizar algumas necessidades de uma cliente, chamada Sara, para um projeto de reforma de sua cozinha.

Para administrar as atividades de ensino presenciais e não presenciais utilizamos o ensino híbrido. Segundo Christensen, Horn e Staker (2013), denomina-se Ensino Híbrido (ou *blended learning*) uma proposta de ensino que combina ensino presencial (tradicional) e ensino *online* (e-learning). Dos modelos de ensino híbrido registrados na literatura, adotamos dois deles – para os momentos presenciais, Rotação por Estações de Trabalho *(Rotation-Station Model),* e não presenciais a Sala de Aula Invertida (*Flipped Classroom*).

O modelo de Rotação por Estações de Trabalho consiste em aplicar atividades presenciais e *online*, dentro de sala de aula, organizando-as em estações, com uma programação fixa. Ao fazer o rodízio em todas as estações, e sendo submetidos a atividades diversas (tais como em grupo, orientada pelo professor ou no computador individualmente), os alunos têm contato com o conteúdo da aula (Souza & Andrade, 2015). No nosso *workshop*, as estações tinham por finalidade conduzir os estudantes a um processo de aprendizagem no qual eles pudessem aprender os aspectos teóricos sobre o programa arquitetônico e também colocá-los em prática.

No Modelo de Sala de Aula Invertida os alunos estudam de maneira autônoma e online o conteúdo, seja em casa ou na universidade, e utilizam o tempo de sala de aula para desenvolverem atividades de aprendizagem contando com a assistência do professor. No nosso *workshop*, o modelo de sala de aula invertida foi utilizado como complemento as atividades presenciais. Neste caso, os alunos recebiam roteiros de aprendizagem que indicavam os conteúdos que deveriam ser estudados antes de os alunos chegarem em sala de aula. Estes conteúdos eram disponibilizados no Moodle em formato de texto e vídeo.

A prática foi efetivada por meio da construção incremental de três artefatos (produtos) – *requisitos*, *programa* arquitetônico e *estudo preliminar*. O artefato de requisitos diz respeito a um documento que contem a relação de necessidades do cliente/usuário capturados pelos alunos. O programa consiste em um artefato que converte o conjunto de necessidades apuradas com o cliente em nortedores projetuais que expressam, por exemplo, tamanho da área, lista das funções de determinado espaço, equipamentos e mobiliários envolvidos, etc. O estudo preliminar é um artefato que converte as decisões projetuais em um desenho arquitetônico, expressando uma proposta de solução para o problema apresentado.

No caso de nosso *workshop*, o artefato de requisitos deveria conter o registro das necessidades da cliente Sara com relação a sua cozinha, de maneira topificada, conforme apurado pelos alunos. O artefato programa deveria expressar a interpretação desses requisitos em norteadores projetuais para a demanda de Sara e, consequentemente, o estudo preliminar deveria expressar a solução proposta para Sara com base nas informações anteriores, através de desenhos. No *workshop* os alunos foram incentivados a utilizar o software Floorplanner para construir esses desenhos.

Considerando que o *workshop* teve por objetivo atender alunos iniciantes, fizemos uma adaptação no conteúdo referente a programa arquitetônico. Nós tratamos apenas dos fatores internos, isto é, das informações do cliente como usuário do espaço. Embora saibamos que existem fatores externos (legislação, normas, orçamento, etc.) envolvidos na elaboração de um programa, esta adaptação foi feita para minimizar a demanda por pré-requisitos de conteúdo técnico e também para permitir que os alunos façam uso de suas referências prévias, podendo associar o conteúdo aprendido com suas próprias experiências como usuário.

Na próxima seção apresentamos a forma como este planejamento foi colocado em prática com os alunos.

3 Execução

O *workshop* sobre programa arquitetônico aconteceu por cinco dias consecutivos com 3h diárias de atividades, totalizando 15 horas. Os estudantes eram alunos regularmente matriculados no curso de Arquitetura e Urbanismo da Universidade Nilton Lins, sediada no norte do Brasil, mais precisamente, na cidade de Manaus no Amazonas. Os estudantes estavam cursando a disciplina de Ateliê I, ministrada no segundo semestre acadêmico, no turno noturno. Esta é a primeira disciplina que trata a prática de projeto no Curso de Arquitetura.

O *workshop* foi oferecido como um curso complementar, no turno vespertino e a professora da disciplina Ateliê I indicou os alunos que poderiam se inscrever no *workshop*, selecionando-os conforme disponibilidade de horário para fazer o *workshop* e rendimento acadêmico (notas na disciplina). Estes alunos receberam informações para inscrição por e-mail, e o efetivaram através de preenchimento de um questionário online via Google Forms. O questionário tinha por objetivo capturar os conhecimentos prévios dos alunos e suas expectativas para o curso. Dezesseis (16) alunos foram selecionados para o *workshop*.

O *workshop* foi administrando em uma sala equipada com computadores com acesso à internet, com fones de ouvido individuais, e televisão para projeção de slides com caixas de áudio integradas. Como mencionado anteriormente, o *workshop* integrou as seguintes tecnologias:

- *Moodle* (*Modular Object Oriented Distance LEarning*), um sistema de gerenciamento para criação de cursos online. O *Moodle* foi utilizado para auxiliar no *feedback* e comunicação entre alunos e professores durante o curso, gerenciamento de conteúdo (em texto e vídeo), e nas atividades ensino híbrido, presenciais e não-presenciais;
- *FloorPlanner,* programa de modelagem digital que permite criar plantas baixas interativas e publicá-las online;
- *Microsoft Word* e *PowerPoint,* utilizado para a edição de textos e apresentações, respectivamente.

Para favorecer a dinâmica de diálogo com o cliente (chamada Sara), o *workshop* foi ministrado por duas professoras que desempenhavam papéis diferentes durante o tempo de aula, alternando-se a cada dia (vide Figura 1). Uma exerceu o papel de *instrutora*, responsável por repassar o conteúdo de referência para as atividades dos alunos e a outra, a de *cliente-usuário*, que ficava responsável por responder às perguntas dos alunos sobre o problema que deveria ser resolvido. No caso, a reforma de sua cozinha.

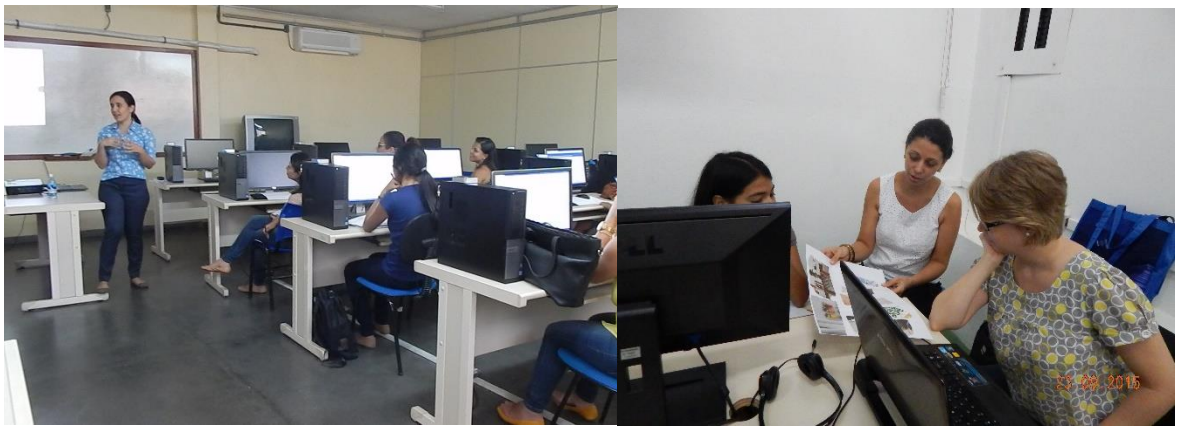


Figura 1. Professores no papel de instrutor, no dia 1 (a esquerda) e de cliente no dia 3 (a direita). Fonte: A autora, 2015.

As atividades presenciais contemplavam aulas expositivas com as professoras, contato com a cliente-usuário e trabalho em grupo para a elaboração dos artefatos – requisitos, programa e estudo preliminar. Nas aulas presenciais, o trabalho em grupo era organizado obedecendo ao modelo de Rotação por Estações de Trabalho. As atividades não presenciais eram online e administradas via Moodle. Neste sistema, os alunos tinham acesso ao conteúdo (em texto e vídeo) e exercícios, e também ao *feedback* provido pelas professoras. Nas Tabelas 1 e 2 apresentamos uma síntese da execução do *workshop*, incluindo os conteúdos e atividades desenvolvidos.

Tabela 1. Síntese da execução do *workshop* (prévia, dia 1 e dia 2). Fonte: As autoras, 2016.

Dia	Modalidade	Descrição		
		Atividade	Execução	Produto
Prévia	Não presencial	Estudar de forma autônoma as funcionalidades disponibilizadas pela ferramenta *Floorplanner*.	No modelo de sala de aula invertida, os alunos acessaram a plataforma *Moodle* e estudaram os tutoriais da ferramenta.	Os alunos testaram a ferramenta com a elaboração de pequenos desenhos.
Dia 1	Presencial	Apresentação dos professores; dinâmica de grupo para apresentação dos alunos; estudo sobre perfil do cliente e programa arquitetônico.	Aula expositiva sobre perfil do cliente e programa arquitetônico. Ao final, os alunos realizaram sua primeira entrevista com a cliente.	Os alunos utilizaram o *Moodle* para registrar as primeiras informações (necessidades) do cliente.
	Não presencial	*Feedback* individualizado via *Moodle* das anotações dos alunos. Sala de aula invertida: Relato da cliente - Narrativa hipotética da própria cliente.	Alunos visualizaram *feedback* dos professores. Na sala de aula invertida separaram informações aplicáveis ao projeto.	Os alunos utilizaram o *Moodle* para registrar seu progresso quanto às informações (necessidades) do cliente.
Dia 2	Presencial	Modelo de Rotação por Estações de Trabalho: Estudo sobre Ergonomia, Usabilidade, Segurança e Higiene. Entrevista com o cliente.	Divisão em três estações, cada uma com tempo definido de 40 minutos. Cada estação possuía parte do conteúdo e um exercício relacionado a ele, no *Moodle*. Terminadas as estações, houve mais uma entrevista com a cliente.	Os alunos utilizaram o *Moodle* para registrar seu progresso quanto às informações (requisitos) do cliente.
	Não presencial	*Feedback* individualizado via *Moodle* das anotações dos alunos. Sala de aula invertida: Relato da cliente - Narrativa hipotética da própria cliente.	Alunos visualizaram *feedback* dos professores. Na sala de aula invertida separaram informações aplicáveis ao projeto.	Os alunos utilizaram o *Moodle* para registrar seu progresso quanto às informações (requisitos) do cliente.

Tabela 2. Síntese da execução do *workshop* (dia 3, dia 4 e dia 5). Fonte: As autoras, 2016.

Dia	Modalidade	Descrição		
		Atividade	Execução	Produto
Dia 3	Presencial	Modelo de Rotação por Estações de Trabalho: Cores, texturas, materiais. Entrevista com o cliente. Elaboração de painel conceitual. Apresentação para o cliente. A aula foi manejada para seguir a sequência *conteúdo das estações – entrevista ao cliente - desenvolver painel conceitual - apresentar ao cliente.*	Divisão em três estações, com tempo restrito de 1 hora e 20 minutos para permutar as estações, sem tempo marcado em cada, com um único exercício relativo aos conteúdos. Entrevista com cliente. Desenvolvimento do painel conceitual, com colagens e desenhos. Apresentação ao cliente.	Os alunos confeccionaram o painel conceitual. Utilizaram o *Moodle* para registrar seu progresso quanto às informações (requisitos) do cliente.
	Não presencial	*Feedback* individualizado via *Moodle* das anotações dos alunos.	Alunos visualizaram *feedback* dos professores.	Os alunos utilizaram o *Moodle* para registrar seu progresso quanto às informações (requisitos) do cliente.
Dia 4	Presencial	Modelo de Rotação por Estações de Trabalho: Programa arquitetônico, características do ambiente, pre-dimensionamento, circulações. Entrevista com o cliente.	Rotação por estações: Conteúdo do dia em três estações, com tempo restrito de 1 hora para permutar entre elas, sem tempo marcado em cada. Ao final desse processo, o aluno preencheu um modelo de programa arquitetônico, anotando suas conclusões para os requisitos de projeto. Terminada a atividade receberam os dados do espaço (planta-baixa).	Os alunos preencheram o modelo de programa arquitetônico. Iniciaram os desenhos no *Floorplanner*.
Dia 5	Presencial	Modelagem da solução no *Floorplanner*. Apresentação das soluções.	O dia destinou-se aos alunos usarem os dados do programa arquitetônico para modelar uma proposta de solução no *Floorplanner*, e juntamente com o *Powerpoint* fazer uma apresentação disto para a turma.	Apresentações das soluções de projeto propostas.

4 Resultados e discussões

Nesta seção apresentamos os resultados obtidos com a execução do *workshop*. Para descrevê-los utilizaremos: a) os dados do questionário de auto-avaliação respondido pelos alunos no início e no final do *workshop*; e b) dois artefatos produzidos: (i) programa arquitetônico, entregue no formato de documento textual; (ii) apresentação do estudo preliminar na forma de um desenho arquitetônico, utilizando o aplicativo *Floorplanner*. Não avaliamos especificamente o artefato que compila os requisitos apurados incrementalmente durante o *workshop* porque consideramos que a avaliação do programa arquitetônico produzido sintetiza as informações apreendidas pelo aluno nos processos anteriores.

4.1 Avaliação dos questionários de auto avaliação

Dos dezesseis (16) alunos inscritos, dois (02) desistiram do *workshop*, sem declarar o motivo. Os dados apresentados, portanto, farão referência aos 14 alunos que concluíram o *workshop*. Os alunos responderam um questionário de auto-avaliação sobre o conhecimento dos assuntos relacionados ao programa

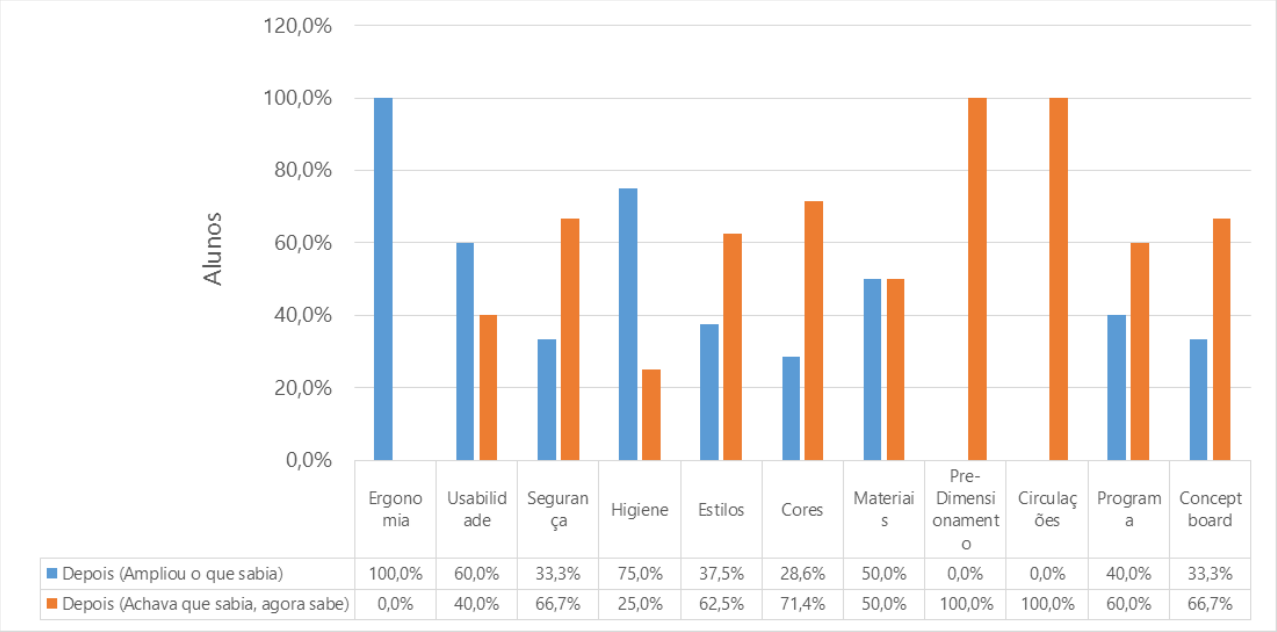
arquitetônico, em dois momentos – antes de iniciar o curso e após concluir o curso. Os resultados serão descritos abaixo.

Dos dezesseis (16) alunos inscritos, 50% deles tinha idade abaixo de 21 anos, sendo que 75% dos alunos da turma nunca havia tido experiência prática relacionada a arquitetura. Essa porcentagem, embora alta, revela um procedimento comum no Curso de Graduação em Arquitetura - destinar as atividades práticas do curso para os alunos em nível mais avançado, geralmente, a partir do segundo ano. Consideramos que retardar as atividades práticas pode favorecer os índices de desinteresse e, por conseguinte, desistência do curso.

Perguntamos aos alunos se eles tinham algum conhecimento prévio sobre assuntos que iriamos abordar durante o curso. Selecionados onze (11) temas. Do total de inscritos, a média dos percentis levantados para cada assunto, foi de 66,2% de alunos que relataram não conhecer, contra 33,8% que relatam conhecer os referidos assuntos. Considerando o percentil individual de cada tema, os maiores se concentraram em assuntos convergentes a dados objetivos do programa arquitetônico, tais como pré-dimensionamento (86%), circulações (86%) e painel conceitual (79%).

Dentre os alunos que declararam possuir algum conteúdo prévio, avaliamos se houve alteração na percepção do próprio conhecimento, conforme Figura 2. Procedeu-se da seguinte maneira: no questionário inicial, identificamos os alunos que afirmavam compreender determinado assunto, tema por tema; no questionário final, verificamos se desses alunos selecionados a cada tema, como mudavam de opinião quanto ao próprio conhecimento. As duas opções marcadas pelos alunos foram: a) o aluno marcava "ampliou o que sabia" quando, ao final do curso, lhe pareceu ter mais repertório sobre determinado tema do que antes do curso e b) o aluno marcava "achava que sabia, agora sabe" quando após o curso sua percepção quanto ao próprio conhecimento se modificara, validando para si uma nova visão do assunto.

Conforme observado na Figura 2 há mudanças na percepção dos alunos sobre o conhecimento dos assuntos relacionados ao programa arquitetônico. Do total de assuntos pesquisados, em 63,6% deles o percentil relacionado a mudança de percepção quanto ao próprio conhecimento é maior do que o de ampliação do mesmo. Cabe observar que nos assuntos diretamente relacionados a elaboração do programa (pre-dimensionamento, circulações) 100% dos alunos relataram mudança de conceito a respeito do próprio conhecimento; quanto ao programa, o maior percentil também se refere a esta mesma condição.



	Ergonomia	Usabilidade	Segurança	Higiene	Estilos	Cores	Materiais	Pre-Dimensionamento	Circulações	Programa	Concept board
Depois (Ampliou o que sabia)	100,0%	60,0%	33,3%	75,0%	37,5%	28,6%	50,0%	0,0%	0,0%	40,0%	33,3%
Depois (Achava que sabia, agora sabe)	0,0%	40,0%	66,7%	25,0%	62,5%	71,4%	50,0%	100,0%	100,0%	60,0%	66,7%

Figura 2. Percepção de conhecimento dos temas abordados, após o curso, pelos que relataram já saber algo dos temas tratados. Fonte: As autoras, 2016.

No questionário no final do curso, considerando apenas os alunos que trabalhavam na área (25% dos alunos), foi questionado se eles consideravam os conhecimentos tratados no *workshop* aplicáveis para uma realidade de projeto. Desses, 94% responderam que sim, e desse percentil que respondeu positivamente, 75% ainda relatou que muitos dos conceitos aprendidos eram até o momento desconhecidos.

Os alunos que concluíram o curso foram também questionados quanto a importância do desenho como pré-requisito para prover soluções de projeto. Do total, 82% dos alunos responderam acreditar que não. Isto provê evidencias de que os alunos desvinculam, em algum grau, a relação comum do processo de solução ligado somente ao desenho. Em termos de ensino, podemos prospectar outras pesquisas que nos levem a repensar o ensino de prática projetual, na medida em que repensar uma matriz curricular que prepare o aluno para os processos analíticos e cognitivos de projeto que não dependem necessariamente do desenho pode ser considerada uma premissa viável para estudos futuros.

Uma evidência da efetividade da assimilação do conteúdo, que endossa a auto avaliação dos alunos pode ser demonstrada através da apresentação dos trabalhos. Todos os alunos apresentaram soluções de projeto que atendiam, de diversas maneiras, requisitos importantes para a satisfação do cliente-usuário com o qual dialogaram ao longo de todo o *workshop*.

4.2 Avaliação dos artefatos dos alunos

Conforme descrito anteriormente, consideramos a avaliação de dois artefatos – programa arquitetônico e estudo preliminar. Ambos desenvolvidos pelos alunos trabalhando em grupos, de até duas pessoas. Na avaliação do programa arquitetônico foram considerados os seguintes aspectos:

- Cálculo da área mínima e apresentação de um esboço de pré-dimensionamento do espaço, considerando atividades a serem realizadas pelo cliente-usuário, equipamentos e circulações;
- Listagem de restrições projetuais pertinentes ao Problema de Projeto. Neste caso, os alunos deveriam listar as atividades fundamentais do ambiente (cozinha), as condições especiais (hábitos do usuário, restrições de uso), os usuários do espaço e suas características, considerando cores, estilos, texturas e desenhos de preferência do cliente-usuário.

Tendo como referência de avaliação os aspectos listados anteriormente, a turma obteve um aproveitamento mínimo de 71%. Isto é, o programa arquitetônico apresentado por todas as equipes conseguiu cobrir 71% dos critérios avaliados. Considerando a média de nota para aprovação na universidade que frequentam, que é 70% de aproveitamento, o rendimento dos alunos está acima da média.

O segundo artefato consistiu na "apresentação da solução", isto é, no estudo preliminar. A partir do programa arquitetônico, os alunos deveriam apresentar uma proposta de solução para o problema do cliente-usuário, através de um desenho, utilizando o software *Floorplanner*. Para a apresentação da proposta, os alunos utilizaram o *PowerPoint* associando os desenhos a imagens de texturas e objetos que pudessem ajudar a esclarecer a ideia geral da solução proposta para o problema de reforma da cozinha.

Neste artefato, foram considerados na avaliação:

- Desenho da planta da cozinha;
- Desenho do layout conforme especificações do cliente-usuário apuradas no programa arquitetônico;
- Apresentação da justificativa para as decisões de projeto apresentadas.

De acordo com a avaliação, todas as equipes apresentaram soluções de projeto que atendiam requisitos importantes para a satisfação do cliente-usuário com o qual dialogaram, representadas de maneira compreensível, utilizando o *Floorplanner*. As equipes tiveram um aproveitamento mínimo de 74%. Na Figura 3 é apresentada algumas imagens referentes as apresentações dos alunos.

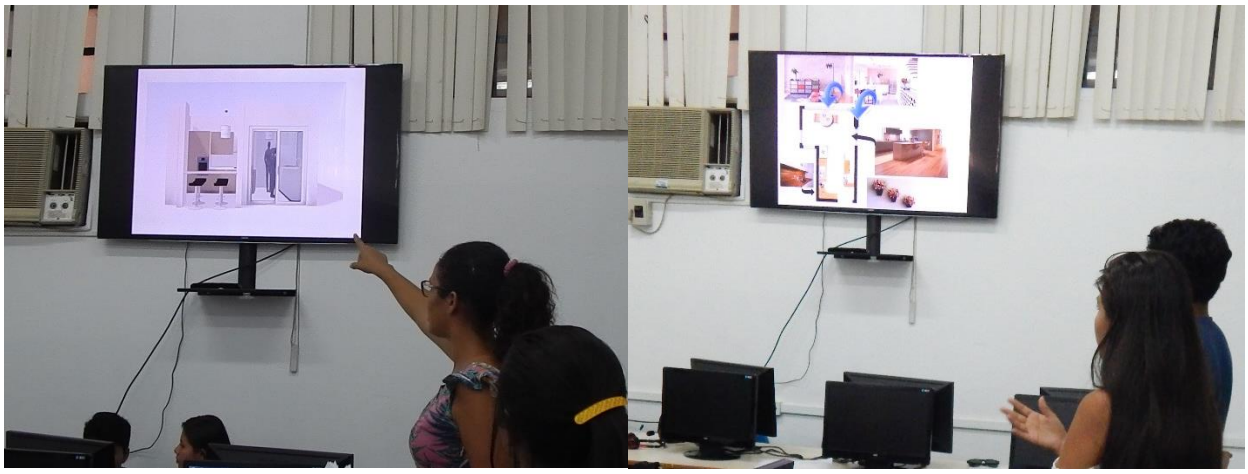


Figura 3. Exemplos de trabalhos apresentados, dia 5. Fonte: A autora, 2015.

4.3 Lições aprendidas

Quanto ao direcionamento do *workshop* com a finalidade de preparar os alunos para resolver um problema, verificamos que esta proposta é adequada para o contexto do ensino de Arquitetura, na medida que mantém os alunos engajados na aplicação do conhecimento adquirido para uma causa que lhes parece muito próxima da realidade de atuação profissional futura.

A administração dos conteúdos através de rotação por estações de trabalho mostrou-se apropriada, principalmente, quando se tem um tempo curto para administrar uma quantidade de conteúdos maior. Quanto a delimitação do tempo para as atividades, este *workshop* relevou que os alunos se sentiram mais confortáveis com a definição de um tempo total para cumprir as atividades do dia, devendo eles próprios controlarem o seu próprio tempo em cada estação. Neste caso, ressaltamos que é fundamental no planejamento a definição das demandas de cada estação, para que os alunos saibam, claramente, os resultados que devem produzir antes de passar para outra estação.

Com respeito as tecnologias adotadas, verificamos que as mesmas atenderam aos objetivos pretendidos para o seu uso. Contudo, temos uma ressalva quanto a plataforma *Moodle*. Inserimos esta plataforma sem que tivéssemos ministrado cursos para seu uso junto aos alunos, confiando que sendo os alunos jovens e usuários de tecnologias (computadores, *tablets*, comunidades virtuais, etc.), essa capacitação pudesse se dar com o próprio uso da plataforma no *workshop*. Entretanto, os alunos demonstraram dificuldades em manipulá-la e isso nos leva a acreditar que a adoção mais eficiente desta tecnologia possa ocorrer se houver um treinamento anterior.

As atividades de sala de aula invertida tiveram pouca adesão dos alunos durante o curso. Os alunos não acessaram o tutorial do *Floorplanner* com a antecedência desejada e, mesmo tendo atingido os resultados pretendidos, tiveram dificuldades quando em contato com o programa. Apesar de terem tido interesse em buscar o *feedback* dos professores no *Moodle*, os alunos não acessaram as demais atividades de sala de aula invertida, como os relatos da cliente-usuário que haviam sido disponibilizados. Nossa percepção é que a adesão seria maior em condições vinculadas a uma nota ou avaliação efetiva para a atividade realizada no modelo de sala de aula invertida.

5 Conclusões

Neste artigo relatamos uma experiência de ensino do programa arquitetônico com alunos iniciantes de Arquitetura. Nesta experiência, consideramos a combinação de dois modelos de Ensino Híbrido (Rotação por Estações de Trabalho e Sala de Aula Invertida), a utilização da Plataforma *Moodle* e do software *Floorplanner* para a criação de plantas baixas pelos alunos, todos administrados a partir de da motivação de se resolver um problema, a partir da elaboração de uma solução (veiculada por um projeto).

Lawson (2011) considera que projetar é uma habilidade que deve ser aprendida e treinada assim como tantas outras, e que o projetista atinge os melhores resultados quando pensa menos em suas técnicas. No entanto o autor frisa que os iniciantes, entretanto, devem primeiro analisar e praticar todos os elementos de sua habilidade. Acreditamos que o caráter diferenciador deste trabalho é o fato de tratar o ensino do programa arquitetônico e treinar sua execução com alunos iniciantes, dado que as pesquisas na literatura que precederam a execução deste trabalho apontam que a maioria das experiências de ensino que envolvem esse assunto é tratado apenas com alunos em um nível mais avançado no curso.

Esta experiência de ensino aponta desdobramentos para trabalhos futuros. Um deles, é o de executar o *workshop* como parte integrante de uma disciplina para alunos iniciantes, o que será feito no segundo semestre de 2016. Além disso, consideramos que a elaboração de *guidelines* com a orientações de como conduzir o assunto segundo a dinâmica do ensino híbrido deva favorecer a adoção do ensino deste conteúdo por outros professores.

6 Agradecimentos

Gostaríamos de agradecer especialmente alguns profissionais e instituições envolvidas no processo descrito neste artigo. A Profa. Rafaela Sampaio que atuou no planejamento e execução deste *workshop*; Ao Departamento de Idiomas do IFAM, na pessoa da Prof. Iandra Maria Weirich Coelho, que disponibilizou o laboratório de informática para a realização do *workshop*; A Universidade Nilton Lins, em especial a Profa. Ana do Nascimento Guerreiro, ao Pró-reitor de graduação Prof. Vitângelo Plantamura, e Vice-reitora Prof. Karla Pedrosa pela cooperação entre instituições; Ao colega Carlos Eduardo Rosas, pela edição do vídeo contendo a narrativa resumida da experiência de ensino (ver endereço: https://youtu.be/o22aR3G6u64); e à FAPEAM (Fundação de Amparo à Pesquisa do Estado do Amazonas) pelo suporte financeiro dado a pesquisa.

7 Referências

Christensen, C., Horn, M., & Staker, H. (2013). *Ensino Híbrido: uma inovação disruptiva? Uma introdução à teoria dos híbridos.* Clayton Christensen Institute for Disruptive Innovation. Fonte: http://www.christenseninstitute.org

Kowaltowski, D. C., & Moreira, D. C. (2008). O programa de necessidades e a importância da APO no processo de projeto. *In: ENTAC 2008 – XIIEncontro Nacional de Tecnologia do Ambiente Construído: geração de valor no ambiente construído: inovação e sustentabilidade* (pp. 1-10). Fortaleza, CE: Disponível em: http://www.dkowaltowski.net/920.pdf Acesso em: 02/06/2015.

Lawson, B. (2011). *Como arquitetos e designers pensam.* São Paulo: Oficina de textos.

MEC. (2010). *Resolução MEC, Nº 2, DE 17 de junho de 2010.* . Disponível em: www.mec.gov.br. Acesso em 30/03/2015.

Mendonça, A. P. (2010). Programação Orientada ao Problema: Uma Metodologia para Entendimento de Problemas e Especificação no Contexto de Ensino de Programação para Iniciantes. *Tese de doutorado*. Campina Grande, PB: UFCG.

Mendonça, A. P. (2015). Alinhamento Construtivo: fundamentos e aplicações. Em A. P. Gonzaga, *Formação de professores no Ensino Tecnológico: fundamentos e desafios* (pp. 109-130). Curitiba, PR: CRV.

Souza, P. R., & Andrade, M. d. (2015). Ensino Híbrido - Modelo de rotação por estações de trabalho e sala de aula invertida. Em A. P. Mendonça, *Tendências e Inovações no Ensino* (pp. 27-42). Curitiba, PR: CRV.

How can we prepare future engineers to the labour market? A University-Business Cooperation project using Context and Problem-Based Learning approaches

Gonçalo Cruz[1,2], Caroline Dominguez[1,3]

[1] Departamento de Engenharias, Escola de Ciências e Tecnologia, Universidade de Trás-os-Montes e Alto Douro, Vila Real, Portugal
[2] INESC TEC - Instituto de Engenharia de Sistemas e Computadores - Tecnologia e Ciência, Porto, Portugal
[3] LabDCT-CIDTFF – Laboratório de Didática de Ciências e Tecnologia - Centro de Investigação 'Didática e Tecnologia na Formação de Formadores', Aveiro, Portugal

Email: goncaloc@utad.pt, carold@utad.pt

Abstract

The goal of this paper is to characterize the impact of a University-Business Cooperation (UBC) project on the students' learning outcomes and its added value for companies. It is based on an experience which was implemented in a 2015/2016 Mechanics Engineering Master's degree, focusing on one component of the Industrial Management course syllabus (operations and lean management). Students got acquainted with the industry/business world and experienced how companies tackle the challenge of operations' continuous improvement. Based on quantitative and qualitative analysis of students' and experts' general expectations, perceptions and attitudes towards the experience, results show very positive outcomes, pointing out critical factors to take into account for the success and improvement of this kind of UBC projects.

Keywords: Context-Based Learning, University-Business Cooperation, Active Learning, Problem-Based Learning, Engineering Education

1 Introduction

University-Business Cooperation (UBC) projects are nowadays of utmost importance in the preparation of future workers and participatory citizens. Employers frequently complain about the existing gaps between the graduates' competencies/profiles and the labour market needs, in particular with respect to the called "soft skills" (Andrews and Higson, 2008; Jackson, 2014). Current changes in society, mainly due to the rapid technological innovation, make hard skills rapidly obsolete in the search for new solutions to complex problems and tasks. Efforts need to focus on the development and daily practice of soft skills, less tangible to quantify, which include the ability for complex thinking (*e.g.* taking initiatives and solving problems), interpersonal communication and participatory learning (*e.g.* team-working, communication and leadership), personal shaping of knowledge (*e.g.* progressive mastery, internal drive/motivation, long-life learning) and managerial abilities that will turn individuals ready for today's dynamic and unpredictable career paths.

Growing European awareness of this concern (European Commission, 2013; OECD, 2015) has led to the inclusion of these skills in higher education curricula, along with an attempt to change the pedagogical methods and develop closer collaboration with experts and companies for curriculum reform and the redefinition of learning outcomes. Nevertheless, even though promoted by educational policies, the opportunities to develop the aforementioned skills (which are not intuitive) are generally scarce and undervalued within the Higher Education Institutions (HEI) standardized curricula - which still, in a large scale, underline the memorization, retrieval and transmission of knowledge. Evidence on this matter suggests that the adoption of UBC projects for educational purposes is less common than for research and development. Furthermore, there are few studies which assess the benefits of UBC for the educational process (European Commission, 2014), and most of them focus on technology and knowledge transfer procedures.

This paper presents a UBC project using active learning approaches in order to prepare the transition of engineering students to the labour market. It aims to contribute with a reflection on the impact of UBC projects' adoption, offering pedagogical guidance on how these can be effectively developed, retrieving a set of key conditions for their success. It discusses the results of an academic semester experience in an industrial management course, linking university and local business companies, and characterizes the impact of this approach, both at the students' and companies' levels.

2 Background

Context-Based Learning (CBL) refers to a pedagogical methodology in science and technology education that uses real-life cases in order to help students to learn through the practical experience on a subject rather than just by its mere theoretical knowledge (Rose, 2012). Some authors (Kelley and Kellam, 2009) highlight that Context and Problem-Based Learning (PBL) approaches can work together in order to produce highly conceptualized and meaningful learning experiences that focus on real-world problems, thus helping students to develop flexible problem-solving activities. However, CBL and PBL challenges teachers to acquire new competencies, such as: context handling (the transfer of concepts to other contexts), regulation (the guide and regulation of students' own learning), emphasis (the practical reason that argues why the concepts should be learnt), design (the flexibility and skill to adapt learning activities and problems to student's needs) and school innovation (these approaches should be supported by a large number of teachers in a collaborative and professional development way) (De Putter-Smits *et al.*, 2013).

CBL and PBL can be applied within University-Business Cooperation (UBC) projects, helping learners acquire knowledge, skills and competences which are essential in working life. Many studies highlight the benefits for higher education institutions in cooperating with businesses to enrich education (Forsyth *et al.*, 2009), curriculum design/delivery (Plewa *et al.*, 2014) and students' employability skills (Baaken *et al.*, 2015). According to the students' perspective, PBL within UBC projects provides a contextualised understanding of the knowledge acquired in the lectures, enhancing their motivation for learning and encourages social interactions with employers, promoting their entrepreneurial behaviour (Rossano *et al.*, 2016). However, renewing the teaching and learning processes (*e.g.* collaborative learning, solving of real-life problems, teamwork, work-based learning, professional mentoring) requires not only highly professionalised faculty, with openness and flexibility to adopt new approaches, but also the integration of new actors like tutors and trainers from the industry (Quintana *et al.*, 2016).

This rethinking process on higher education is opening alternative learning pathways. It leads to a loss by the Universities of their central role as the learning venue (University-Business Cooperation Forum, 2014), and promotes a global interaction between students and teachers, employees, organizations, public authorities and other stakeholders, creating new opportunities for cooperation through different channels, such as: research (research contracts, joint-ventures, licenses, joint scientific papers), learning/training (internships for students, graduate recruitment, conferences, workshops and seminars) and consulting (consulting services for business partners or for public institutions) (Dan, 2013).

3 Description of the approach and Research Methodology

This UBC project took place in the academic year of 2015/2016 during the 2nd semester of the Mechanics Engineering Master's degree. It focused on one component of the Industrial Management course's syllabus (operations and lean management) which is credited with 3 European Credit Transfer units. Its main objective was to get students acquainted with the industry/business world, learn how companies tackle the challenge of operations' continuous improvement and present solutions to some problems provided by the companies.

More specifically, this UBC project involved 21 mechanical engineering students who had to get acquainted with 1) value and waste concepts/activities in an industrial environment (and in general), 2) the potential of some of the most popular tools of lean management and 3) management metrics. One of the main personal and interpersonal expected outcomes included the improvement of self-confidence in solving problems and in tackling the real-world entrepreneurial challenges.

The teacher established a close collaboration with 13 different companies: 7 from the service sector (food and drinks, hospital, car parts distribution logistics, large retailer, consulting, car sales and repair, bus transportation), and 6 from the industrial production (optic lens, optic glasses, paper bags, jackhammers construction, air force, ventilation systems), which resulted in the delivery (by the contacted professionals) of a 2 hours session in the classroom with an interactive discussion of their case and context with the students, or in an interactive on site visit by the whole class in which industrial challenges were presented as well as how companies tackled them.

A previous talk between the teacher and each one of the professionals was held in order to clarify the objectives and the content of the course. It focused, in particular, on the need for the professionals, either in class (4) or in the visits (9), to provide the necessary conditions for students to observe, question and discuss the problems (inefficiencies in the processes) and the tools used to solve them.

After students went through all the visits and talks, students were organized in groups of 4 and challenged to characterize/draw the operations flow of one of the companies (each group worked on a different company) to identify the main wastes (pointed out by the lean management literature) and offer a solution for one of the identified problems using the Toyota A3 systematic problem solving sheet (Shook, 2009). Finally, they were incited to share their work with the companies. In this course component, students were evaluated based on their individual visits' reports and A3 output.

Besides preparing the visits and talks with each company, the teacher's role was to help students preparing themselves for an active engagement in the project (giving insight on "questioning" strategies), to give an overview on lean management theory, to create (with the students) and provide a template for their reports (to make sure that all the important points were covered and as a way to prepare the talks and the visits), and to review students' A3 problem sheet work with frequent feedback. It also involved the evaluation of the whole project with the collection and analysis of the companies and students' opinions about the project as well as the delivery of feedback to the companies on the results of their cooperation.

The research methodology was based on a case study research (Yin, 2013) supported by participatory observation and two questionnaires of quantitative and qualitative questions applied to all students and companies' experts involved in the experience. Both questionnaires were designed to collect students' and experts' general expectations, perceptions and attitudes towards this UBC project in order to evaluate how this kind of projects and pedagogical approach can impact students' learning and to which extent it can bring value for the companies involved.

4 Results

4.1 Students' profiles and expectations

Out of 21 students involved in the experience, 16 responded to the questionnaire (71%). The majority were male (66%), their average age was 23 years old with a very small deviation and 33% had a previous part-time work experience in small businesses like shops or bars. Almost all of them had high expectations at the beginning of the semester with this course. Only one student had a similar experience of participating in this kind of activities during his academic pathway.

4.2 Students' appreciation about the UBC project design

Most of the students (66%) found the total number of visits/talks adequate. The others found it excessive due the repetition of the same theoretical concepts in the first part of the talks/visits: "Despite being interesting and take notice of how companies work, there was a repetition of unnecessary content. It is important to understand how lean is applied in different contexts (I was surprised with the application in the case of the hospital, for example), however in the total of the 13 talks there were some cases that constantly addressed the same theoretical concepts and became repetitive." (Student 4, 29th December 2014). This aspect will lead us to address the design of the activity, namely a better preparation of the visit/talks and the selection of the professionals (*e.g.* objectives, goals, related topics, necessary background, communication skills and expert profile, etc.).

Most of the students found the talks/visits diverse (80%), covering a large scope of situations and contexts: "Having a talk with the head nurse of a hospital and a visit to the Air Force shows how diverse the activities were" (Student 6, 5th January 2015). Also, most of the students (80%) found the length of each visit (from 2 to 4 hours) and/or talk (2 hours) adequate. They agreed that the topics presented in each visit/talk matched the curricular cognitive objectives. However, two students would like to have a longer contact with each professional/company.

Although some students found the visits more useful than the talks in class, the great majority found both important and complementary (80%). If in the talks they had the opportunity to indirectly get acquainted with professionals' work, in the visits they could observe by themselves and confront different realities: "There is nothing better than checking what each professional transmits in relation to the reality of companies. Professionals explain in detail that information, but it is also important to see how it really happens and is processed, in real, because sometimes a picture is worth than a thousand of words" (Student 9, 10th January 2015).

4.3 Students' perceptions about the UBC project's outcomes

Students had a high attendance rate: they were present in 10 or more visits/talks, the average being 12 (92%). However, when asked about their level of participation (measured by the type and frequency of the questions that they made), results show that the average number of questions per student in each visit/talk was very low (2) - which we found quite worrying. Although we think that the main cause of this situation is students' shyness in public settings (50% of the students who had a low level of participation said that the main reason was shyness, and the others did not question so much because they did not have any doubts), these results will lead us to reflect on how to improve their level of participation.

Most students felt that their expectations were overcome (only 2 did not). They all felt motivated to repeat this experience in other courses. When asked about the teaching and learning approach, 5 students agreed that this approach clearly allowed a deeper learning compared with a traditional one (*e.g.* lectures). The others however found that the efficacy of this method may depend on the course (11).

At the end of the experience, almost all of the students (87%) felt that they understood, in general, what is lean management, as well as the challenges of its application in the enterprises' environment (73%). About 53% had a better perception of what is expected from them (as future engineers) by real companies. However, only 33% of the students felt more confident to work in a company, and more than half would have wanted a deeper exposure to specific lean management tools.

In the end of the experience more than 60% of the students found that they were prepared to identify management problems, to analyse and find the causes of inefficiencies, to propose strategies to solve them, to present and discuss these strategies with other experts or peers.

Students' general satisfaction about the UBC project

In general, students found this experience satisfactory (73%) or very satisfactory (27%) and 93% found it essential for their preparation to work as future engineers. The main reasons are related to the possibility of getting to know more closely the challenges of the industrial companies as stated by a student: "A mechanical engineer needs to have sensitivity and management skills in order to contribute with the continuous improvement in the company where he works. We have a critical role on that, and we can't be lazy with the reality that the company lives in, but we must always try to improve its processes and operations" (Student 7, 6th January 2015).

Similarly, 73% of the students thought that this course was undervalued in terms of credits: "It should be, at least, equivalent to the credits of the remaining courses, because it gives us very important tools for the labour market – many of them more important than in other theory-based courses." (Student 2, 20th December 2014). In relation to which visits/talks they liked the most and why, 3 companies were identified as not being that interesting, whereas the others were considered by all the students as very interesting and motivating, either because they presented different contexts of application (diversity) or because the professionals' communication skills were outstanding and their profiles were closely related to the students' field (mechanics).

4.4 Companies experts' profile and motivation for the UBC project

Out of the 13 companies experts involved in the experience, 11 responded to the questionnaire (85%). The majority was male (61%). They were 45 years old, in average, and their position in companies ranged from Nurse Supervisor to CEO. Almost all of them considered the participation in the UBC project as an added value

to their companies (91%), not only because it was a "great opportunity to learn from the interaction with students, making us reflect on our problems and listen to different practical solutions based on research" (Expert 3, 16th January 2015), but also to "improve our performance in problem solving" (Expert 5 and Expert 6, 2nd February 2015) or to "disseminate/open our brand and company to potential workers in the future" (Expert 10, 22nd January, 2015).

4.5 Companies experts' perceptions about the value of UBC project for students

All the companies' experts found the UBC project very positive for students. They pointed out that the link between the academic and the business world "enhances the students' perception of real-world problems, and challenges them to develop practical solutions to overcome them" (Expert 2, 14th January 2015). Also in this sense, this kind of experience can "motivate students to learn and increase their confidence to enter into the labour market" (Expert 5, 2nd February 2015).

4.6 Companies experts' general satisfaction, future expectations and evaluation of the students' proposals

The majority of the experts liked the UBC project and felt useful (66%). Some of them even thought they could have done more activities with the students. All of them stated their availability to keep participating in this kind of projects and also to extend the activities for longer periods of time. The reason for this lies in the fact that although half of the experts (5) received proposals from the students and evaluated them as useful, interesting and viable, the other half (6) did not receive any proposal from the students (due to a mismatch between the number of students' groups and companies). All the experts made suggestions for future UBC project activities such as "research projects and data analysis" (Expert 8, 18th February), "internships with mentors from the companies" (Expert 5, 2nd February 2015) or even "an annual project with more students and classes" (Expert 10, 23rd January 2015).

5 Discussion and Conclusion

This paper contributes with a reflection on the adoption of UBC projects using CBL and PBL approaches. It offers, from the students' and companies' points of view, some insight on how these approaches can enhance learning. Students made a positive appreciation in relation to the CBL and PBL experience and manifested enthusiasm in having similar activities in the future, confirming the findings of Rossano *et al.* (2016) on the benefits of PBL within UBC projects. Not only because they became more familiar with the concepts of lean management, to the point of feeling more confident in finding and presenting their solutions to problems presented by some companies, but also because they got a better understanding of the real companies' challenges and of what is expected from them at the workplace.

At the pedagogical level, like some authors suggest (De Putter-Smits *et al.*, 2013), it was possible to identify some key conditions for the experience to succeed, such as trust building between companies and the teacher (which takes time), clear objectives for each intervention (seminars and visits to the companies), the design of learning tasks and the assessment criteria which should promote a higher students' participation (through the development of critical thinking skills such as questioning). It is also important to ensure an adequate number and diversity of visits/talks, as well as the involvement of professionals with good communication skills.

Also, the experts' perceptions were assessed. All of them recognized the experience as an added value both for students and for companies, considering the possibility to keep developing this kind of projects within a larger period of time - deepening the interaction between students and companies in the problem-solving process. Clearly, the experts were enthusiastic and open to establish a closer partnership in order to strengthen the cooperation and implement/apply the students' practical proposals in their companies.

6 Limitations and Future Work

We presented the preliminary findings of a UBC project implemented with local/national business companies and engineering students. In the future, it would be interesting to run this experience in deeper collaboration between all the actors, improving this approach through a better alignment of companies' real needs and the expected learning outcomes, assessing its impact in the development and acquisition of cognitive and soft-skills by the students. Also, it would be interesting to confront the presented results with the analysis of the students' cognitive outcomes (Toyota A3 systematic problem solving sheet).

7 References

Andrews, J., & Higson, H. (2008). Graduate employability,'soft skills' versus 'hard'business knowledge: A European study. Higher education in Europe, 33(4), 411-422.

Baaken, T., Kiel, B., & Kliewe, T. (2015). Real World Projects with Companies Supporting Competence Development in Higher Education. International Journal of Higher Education, 4(3), p129.

Dan, M. C. (2013). Why should university and business cooperate? A discussion of advantages and disadvantages. International Journal of Economic Practices and Theories, 3(1), 67-74.

De Putter-Smits, L. G. A., Taconis, R., & Jochems, W. M. G. (2013). Mapping context-based learning environments: The construction of and instrument.Learning Environments Research, 16(3), pp. 437-462.

European Commission (2013). Report to the European Commission on Improving the quality of teaching and learning in Europe's higher education institutions. June 2013. Luxembourg: Publications Office of the European Union.

European Commission (2014). Measuring the Impact of University-Business Cooperation. Final Report. Luxembourg: Publications Office of the European Union.

Forsyth, D. (2009). Group dynamics. Cengage Learning.

Jackson, D. (2014). Testing a model of undergraduate competence in employability skills and its implications for stakeholders. Journal of Education and Work, 27(2), 220-242.

Kelley, T. e Kellam, N. (2009). A Theorical Framework to Guide the Re-Engineering of Technology Education.Journal of Technology Education, 20 (2), 37-49.

OECD (2015). OECD Skills Outlook 2015: Youth, Skills and Employability. OECD Publishing.

Plewa, C., & Quester, P. (2008). A dyadic study of "champions" in university-industry relationships. Asia Pacific Journal of Marketing and Logistics, 20(2), 211-226.

Quintana, C. D. D., Mora, J. G., Pérez, P. J., & Vila, L. E. (2016). Enhancing The Development Of Competencies: the role of UBC. European Journal of Education, 51(1), 10-24.

Rose, D. (2012).Context-Based Learning. Em N. Seel (Ed.), Encyclopedia of the Sciences of Learning (pp. 799-802). New York, NY: Springer.

Rossano, S., Meerman, A., Kesting, T., & Baaken, T. (2016). The Relevance of Problem-based Learning for Policy Development in University-Business Cooperation. European Journal of Education, 51(1), 40-55.

Shook, J. (2009). Toyota's secret: The A3 report. MIT Sloan Management Re-view, 50 (4), 30-33.

University-Business Cooperation Forum (2014). Universities, Businesses & Co.: together we can; strategic inter-sectoral partnerships for economic and social change and growth. Rome, 2-3 October 2014.

Yin, R. K. (2013). Case study research: Design and methods. Sage publications.

Analysis and Diagnosis of a Hand Tools Production System

Ana Martins[1], António Gonçalves[1], Filipa Barros[1], Inês Vilas Boas[1], José Rodrigues[1], Pedro Araújo[1], Rui Baía[1], Tiago Pereira[1], Vasco Areias[1], Rui M. Lima[2]

[1] Integrated Master of Industrial Engineering and Management, School of Engineering, University of Minho, Campus of Azurém, Guimarães, Portugal
[2] Department of Production and Systems, School of Engineering, University of Minho, Campus of Azurém, Guimarães, Portugal

Email: ana_pmartins@live.com.pt; antoniocvbg@gmail.com; marianabarros1994@gmail.com; ines.martinezvb@gmail.com; ze_braga_pedro@hotmail.com; pedroaraujo_94@hotmail.com; rui.baia94@gmail.com; tmiguelpereira@hotmail.com; vascoareias9@gmail.com; rml@dps.uminho.pt

Abstract

Engineers must have a set of professional competences, which includes sound technical knowledge and the ability to solve engineering problems, integrated with a set of transversal competences, which must mobilized for managing projects, working in teams and communicate with the others effectively. The development of these sets of competences can be supported by projects in interaction with companies. This article reports the work developed by a group of students on the Integrated Project of the 4th year of Industrial Engineering and Management of the University of Minho. The main objective of this work is to describe the type of project that a group of students can develop in interaction with an industrial company, and reflect about the main results that this project have for the development of their competences and for the company. This is a descriptive paper based upon on reports and the experience of the students. The target of the project was the diagnosis and analysis of a production system in an industrial environment. The company chosen to develop this project is a multinational and pioneer company on the manufacturing of hand tools. The content of this article will mainly cover the internal supplier of materials (Mizusumashi), namely the standardization of the Mizusumashi route and the improvement of the components` warehouse (materials organization and visual management). The suggested modifications can result in a 30% decrease of the time wasted in the warehouse, a 20% decrease of the time it takes the Mizusumashi to complete a full route, reaching the 45 minutes the company requested. The students were able to fulfil the project milestones and integrate the company culture in their weekly visits, during the 15 weeks of the project. Furthermore, the company showed to be very satisfied with their behaviour and performance.

Keywords: Active Learning; Project-Based Learning; Engineering Education; Industrial Engineering and Management

1 Introduction

Nowadays the higher education system is on an adaptation and transition phase regarding the student's position during their learning process. The usual teaching methodologies, in which the student plays a passive role makes it hard to develop important competences required in the professional world. The goal of the higher education system is to form professionals capable of facing the challenges proposed by the society and in order to succeed in those challenges a change should occur in the education process. With this same goal, innovative teaching and learning methodologies are being developed in University of Minho on the Industrial Engineering and Management degree. These methodologies have as main feature the focus on the students learning, giving them an active role in the process. One of the main methodologies used is Project Based Learning, in which a problem related to the professional reality is tackled by a team of students during a semester that solve that problem integrating several areas of knowledge (Barrows & Tamblyn, 1980; Powell & Weenk, 2003; Graaff, 2007). Project-Based Learning approaches were introduced in the Industrial Engineering and in Management degree in 2005 (Lima, Carvalho, Flores, & Hattum-Janssen, 2007), being present in the first and fourth years. The focus of the project developed in the first semester of the fourth year is the interaction between companies and students in order to develop a real project (Lima, et al., 2014).

The main objective of this work is to describe and reflect on the project of analysis and diagnosis of a hand tools production system developed by a group of students of the fourth year of the Industrial Engineering and Management degree of University of Minho. This description can make a contribution for understanding the type of project that can be developed with companies, and the analysis of the results obtained by the students

will show what can be the main contributions for the company. Additionally, the analysis of the results will contribute for evaluating the results for the formation of the students as future engineers.

In addition to the development of technical skills that helped in the process of resolution of the company's above-mentioned problems, were further developed transversal competences such as communication, teamwork , time management, planning tasks , goal setting , critical thinking and methodology of work that will be more detailed in this article.

The first part of the article will consist in a brief background of the interaction of the group - company and the appropriate work. The second part will cover the technical skills used to solve the project. The third part will focus on the analysis of the results in an integrated dichotomous perspective of the technical competences that allowed to solve the problem proposed combined with the transversal competences acquired during the project.

2 Scope

Engineering, and in particular the industrial engineering field, is known for its comprehensiveness and breadth in several areas, which require a wide range of attributes: from technical and technological competence to the management of people integration system. These attributes are increasingly supported by employers (Lima, Mesquita, & Rocha, 2013) and universities and they can be achieved with alternative teaching methods in which students can solve complex challenges under the professional's reality light (UNESCO, 2010).

During semester 7 (out of 10) of the studies' cycle of the Industrial Engineering and Management degree of the University of Minho, the 4th year students are challenged to develop and broaden their technical competencies via a project approach, under the umbrella of Project-Based Learning. The students' projects are undertaken in partnership with several industrial companies. It intends to act as the vehicle for interactively put in practice the theory learnt in the different courses and for learning those contents in a deeper way. Simultaneously, it is an opportunity for the students to develop solutions for the partner companies' issues and learn to deal with the companies in a professional way. In this sense, this project provides the opportunity to develop a closer contact with the industrial reality and it allows the students to experience the difficulties and barriers found in the professional world.

The project mentioned in this paper resulted from a work developed by a team of 9 students throughout 15 weeks, from the end of September 2015 to the middle of January 2016. There was a total of 48 students divided in 6 different teams, each with their respective company. In this work reported in this paper, the team was in direct contact with a multinational company and pioneer in the manual tooling field and in which it was conducted the analysis and diagnosis of its production system. The analysis of the production system focused in important industrial engineering areas, in particular applying and integrating areas of knowledge related to the courses offered in semester 7, processes of production management, ergonomics, simulation and production system organization. During 15 weeks, the group worked on multiple study areas, however, this paper will focus on the Mizusumashi route, its development and the internal gains it achieved.

The symbiosis between the project team and the company was fundamental to the project's success and it stood out for the close and active working relationship between the two parties. This interaction was possible especially due to the weekly visits of the project team to the company from which several meetings were organized with the senior management team, including the Chief Operating Officer and engineers from Production and Logistics. The project team usually met the management team in the morning to clarify some doubts, to request documentation and to share the milestones set for the day. Another meeting was held once the morning shift was finished in order to discuss the results of the work carried out and to define goals for the following sessions. Another important factor to improve the relationship with the company was the persistence of the Chief Operating Officer in having frequent communication between the company and the project team via weekly feedback reports of the work carried out.

3 Mizusumashi

In this section will be approached the methods used by the students that provided improvements in intern supply system. Although this methodology is directly connected with the development of technical skills, other competences were developed too and will be explained with more detail in section four.

3.1 Analysis and diagnosis

The analysis and diagnosis of the production system when in contact with the organization enabled the identification of a set of opportunities for improvement such as the weak factory's internal supply system. This supply system consists of a logistics train known as Mizusumashi and which is responsible for the supply of materials to the different production cells. Its main advantage is the concentration of the non-productive time (motion and transport) in one single operator (Droste & Deuse, 2011; Alnahhal, Ridwan, & Noche, 2014; Nomura & Takakuwa, 2006).

After recording data for 5 weeks, it was noted a high variability in the Mizusumashi route's duration. The causes of this variability were related to the lack of a standard route and of a standard sequence of tasks to undertake. It was concluded that during its route, the Mizusumashi was spending a big portion of time in the components warehouse sector. This was due to the poor parts organization and to the lack of visual management in the warehouse. These factors contributed to the fact that only an operator with a significant level of experience would be able to undertake this task in a reasonable time.

3.2 Suggestions of improvement

While the project was being develop, some ideas emerged in order to improve the company's results. One of those problems was the Mizusumashi route. Usually one lap would take 56 minutes, but the company wanted that time reduced to just 45 min. That improvement was done using some visual management in the components warehouse, due to the fact it was the section were the Mizusumashi took the longest amount of time. This visual management was created with a more equal distribution of the components with the criteria being the necessity of their supply. Labels were created to identify the boxes of each component with the product picture, the hall identification and the shelf were it was stored.

Other methods were important to make enhancements like applying the standard work method to the entire route and using the standard worksheets as complement. With the application of the standard worksheets in each supply section, the intention was to make the Mizusumashi comply with the established timetable assuring a reduction of the supply time. The results of these improvements are summarized in Table 1.

Table 1. Actual average time and planned results with the suggested changes in route of the Mizusumashi

	Actual Average Time (min)	Planned Average Time (min)
Component's Warehouse	14	10
Total Supply Time	50	38.5
Total Transportation Time	7	7
Total Route Time	56	45

3.2.1 Standard Work

The Standard Work is a Lean tool, whose goal is to create a pattern of the work that should be followed by the operators, reducing variability in the process and increasing productivity (Arnheiter & Maleyeff, 2006; Dennis, 2007). Due to the absence of standard work in the Mizusumashi tasks, was decided to apply this tool in order to achieve the goals stipulated by the company. In order to be able to apply this tool, the team needed to develop an intensive process of time measuring and observation of the Mizusumashi route and tasks. In order to be able to define the standard work, the team measured the average time of each task of material handling and transportation of materials, of the operator of the Mizusumashi. Considering the time measurements and the observations, it was possible to discuss the best solutions with operators and managers of the company.

3.2.2 Standard Worksheet

The standard worksheet is a Lean tool for visual representation of the standard work. "The standard worksheet is one of the main steps to achieve Lean production, it allows a graphical view of the workstation, the operator route and the necessary amount of WIP to keep the production process balanced" (Surekha, Gowda, & Kulkarni, 2013). The worksheets developed by the team have a table with a description of the each task and the expected time. Furthermore, it should represent graphically the route of the operator in each production section.

3.2.3 ABC analysis

The ABC analysis is an inventory categorization technique. The ABC (Sanders, 2014) analysis provides a mechanism for identifying items that will have a significant impact on the inventory, while also providing a mechanism for identifying different categories of stock that will require different management and controls. This way the use of this tool was a huge help to create a better stowage of the components in the components warehouse and as a consequence an optimization of the operations done in that area. According to the ABC analysis, 20% of the items represent 80% of the overall consumption value and the 80% items left only represent 20% of the overall consumption. The items classified with an A will receive special attention when stored. Figure 1 represents the study that was developed for identification of different classes of components, using the ABC classification

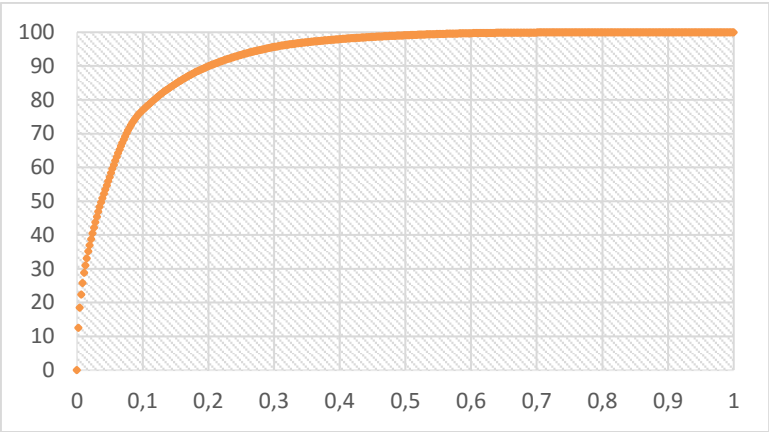


Figure 1. Components warehouse ABC analysis's graphic

4 Technical Results

The Project-Based Learning turned out to be a highly defying challenge capable of allying the technical knowledge of the Industrial engineering and management as well some other soft skills. This project was the first real contact of the group with the industrial world and, as such, it took a preponderant role in the preparation and reduction of the possible impact that could be felt when the transition from the academic to professional reality occurs.

The previously presented methods and tools were used with the main goal of solving the problems found at the company, allowing the students to acquire technical skills useful for the professional future. At first, it was necessary to acknowledge the need of a task standardization in an industrial world, as well as the importance of visual management and organization, from the production planning and control to the basic processes and operations. The technical competences were developed along the projects' 15 weeks through the constant analysis of the company's internal supply system.

The first step into the company's internal supply system analysis consisted on the observation of the different routes the "Mizusumashi" would take and the respective measurement of the total route time, time spent on each section and time it took to gather the required materials.

On a second stage, the establishment of a new, the most adequate, course for the Mizusumashi was the primary focus. The standard times for the different operations and sections were also determined. Once a more detailed study of the records was concluded it was easily observed that the lack of standardization theory was strongly corroborated. It was perceived that a time reduction from 56 to 45 minutes was, not only possible but viable once the warehouse's organization was optimized. This optimization was achieved by reorganizing the articles present in the warehouse in a more logical way following and ABC analysis regarding the articles rotation, as well as an improvement to the labelling system present in the racks. Figure 2 represents a visual image of the new organization of the warehouse, with the identification proposed for the rows and the routes of the Mizusumashi. Additionally, it is possible to see the proposed identification for the components positions.

Figure 2. Reorganization of the Warehouse, including new routes and a visual management system

The last stage of the standardization process consisted in standardizing the operations within each area by resorting to Standard Worksheets (Surekha, Gowda, & Kulkarni, 2013) that would be posted in each cell. Figure 3 shows an example of the visual illustration used in the worksheets. The main purpose was guaranteeing that the Mizusumashi would carry out the established times minimizing the operation times within each section and, as a result, minimizing the total route time. Some simulations were ran while adopting the new organization and labels and the results showed a gain, in some instances, of nearly 40%. With these improvements it is estimated a considerable reduction of the wasted time by the Mizusumashi on the components' warehouse and thus, improving the existing route.

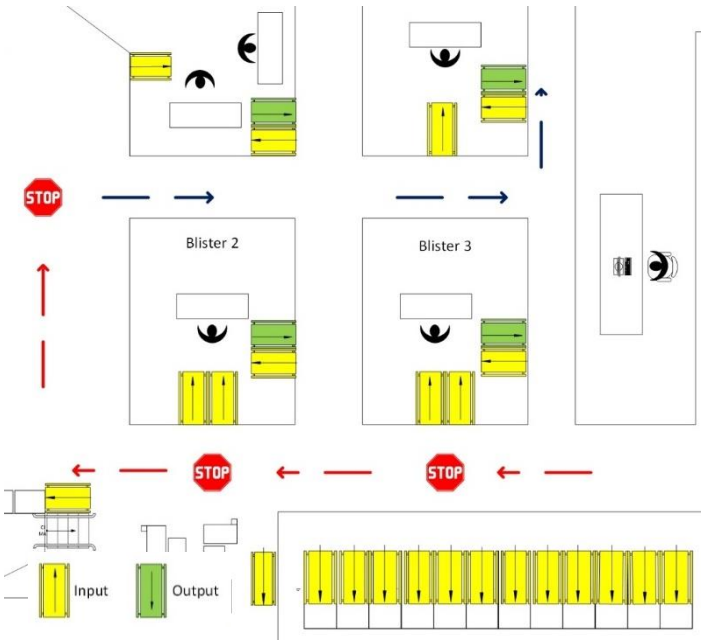


Figure 3. Worksheet example - visual illustration of routes of the Mizusumashi and the operator

5 Discussion

There are multiple examples of soft skills developed by students, one that was quickly highlighted was communication. This was promoted via acquaintanceship with, not only the elements of the group but with the company's employees. These exchange of ideas and discussion about the different subjects grappled during the project's lifespan lead to a broader acceptance of different viewpoints and contrary opinions. A healthy communication between the group's members also lead a better and improved method of teamwork since the management of time, tasks' division and an easier definition of the methodology to be used was imperial and learnt. The company's availability and kindness was enormous as the group was granted almost total freedom one day per week, or more if the group found it necessary. This freedom lead to a better and healthier development as it was possible to identify multiple improvement opportunities and, perhaps one of the key factors, the communication not only with the higher ups on the hierarchy but with the operators. As such, it was possible to hear the operators' opinion and find and confirm some of the identified problems with their help. The interactions with the company's multiple hierarchy levels helped the group feel ingrained within the company instead of an unknown and estranged member.

A fair share of the problems encountered, as well as the solution for the same problems, were not subjects directly taught at classes so, another soft skill the group had to develop was the ability to search and find answers to these problems on the various sources available, strengthening attributes such as creativity, proactivity and dynamism.

The interpretation of all the gathered information and its applicability to the encountered problems was possible with both the help from the company's management and the teachers involved. The group was frequently faced with distinct and sometimes clashing opinions on the same topic so it was required to absorb and analyse all this information while trying to come up with the best and most viable solution to the problems at hand. This process was responsible for the strengthening of some skills such as synthesis ability, critical analysis and decision making. The dichotomy observed between the theory taught at university and the industrial experience and reality, mainly the difficulties that occur when trying to apply some theoretical concepts from the industrial management field. It is also noteworthy that, not only is the knowledge and investigation important, but it is also crucial that these other transversal competences, such as communication and these professional experiences suffer improvements in order to solve multiple problems such as the ones found in this project.

6 Conclusion

The purpose of this article is to present how the work performed by the group, for the Integrated Project in Industrial Engineering and Management, on the first semester of the academic year 2015/2016, benefited and helped the group in learning technical and soft skills.

This way, as soon as some problems that occur in the company were identified, the group proceeded to investigate some possible solutions that, besides helping the learning and consolidation of the subjects taught in classes, namely the ABC analysis, Standard Work and standard worksheets, allowed, and in a certain way obliged, the simultaneous development of some soft skills, especially the ability to self-teach ourselves some technics and subjects we wouldn't learn in classes. Because of that, it was needed to search new technics to solve these issues encouraging creativity and proactivity. On the other hand it also allowed the group to vastly improve the communication skills seeing that it was required to talk with both the higher ups of the company, such as the production manager, and the operators on the shop floor.

Furthermore, due to the massive influx of clashing information and ideas, it was also possible the development of synthesis capability, critical analysis and decision making skills.

7 References

Alnahhal, M., Ridwan, A., & Noche, B. (2014). In-plant milk run decision problems., (pp. 85 - 92). Duisburg, Germany.

Aquere, A. L., Mesquita, D., Lima, R. M., Monteiro, S. B., & Zindel, M. (2012?). Coordination of Student Teams focused on Project Management Processes. International Journal of Engineering Education.

Arnheiter, E. D., & Maleyeff, J. (2006). The integration of lean management and Six Sigma.

Barrows, H. S., & Tamblyn, R. M. (1980). Problem-based learning. An approach to medical education. New York: Springer Publishing Company. Retrieved Fevereiro 2016

Dennis, P. (2007). Lean Production Simplified, Second Edition: A Plain-Language Guide to the World's Most Powerful Production System. New York: Productivity Press.

Droste, M., & Deuse, J. (2011). A Planning Approach for In-plant Milk Run Processes to Optimize Material Provision in Assembly Systems. (pp. 2-5). Montreal, Canada: Reconfigurable and Virtual Production (CARV2011).

Graaff, E. &. (2007). Management of change – implementation of Problem based and Project based learning in Engineering.

Lima, R. M., Carvalho, D., Flores, M. A., & Hattum-Janssen, N. v. (2007). A case study on project led education in engineering: Students' and teachers' perceptions. European Journal of Engineering Education, 32(3), 337-347.

Lima, R. M., Dinis-Carvalho, J., Campos, L. C., Mesquita, D., Sousa, R. M., & Alves, A. (2014). Projects with the Industry for the Development of Professional Competences in Industrial Engineering and Management. In N. v. Hattum-Janssen, R. M. Lima, D. Carvalho, S. Fernandes, R. M. Sousa, F. Moreira, . . . D. Mesquita (Ed.), Project Approaches in Engineering Education (PAEE'2014). Medellin, Colombia: University of Minho.

Lima, R. M., Mesquita, D., & Rocha, C. (2013). Professionals' Demands for Production Engineering: Analysing Areas of Professional Practice and Transversal Competences. International Conference on Production Research (ICPR 22), (pp. 352a[1-7]). Foz do Iguassu, Brazil.

Nomura, J., & Takakuwa, S. (2006). Optimization of a Number of Containers for Assembly Lines: The Fixed-Course Pick-Up System. (pp. 155-166). Japan: Nagoya University, Graduate School of Economics and Bussiness Administration. Retrieved Dezembro 10, 2015, from http://ijsimm.com/Full_Papers/Fulltext2006/text5-4_155-166.pdf

Powell, P. C., & Weenk, W. (2003). Project-Led Engineering Education. Lemma.

Sanders, N. (2014). The Definitive Guide to Manufacturing and Service Operations. In N. Sanders, The Definitive Guide to Manufacturing and Service Operations (p. 192). Pearson FT.

Surekha, S., Gowda, R. V., & Kulkarni, M. (2013, Abril). STANDARDIZED WORK: AN IMPORTANT PRINCIPLE IMPLEMENTED IN THE MANUFACTURING INDUSTRY. International Jounal of Management Research and Business Strategy. Retrieved Novembro 2015

UNESCO. (2010). Engineering: Issues, Challenges and Opportunities for Development. Paris, France: United Nations Educational, Scientific and Cultural Organization. Retrieved 10 06, 2012, from http://unesdoc.unesco.org/images/0018/001897/189753e.pdf

A Student Team Project in Real Context: The Team View

Francisca Ribeiro[1], João Nobre[1], Liliana Silva[1], José Dinis-Carvalho[2]

[1] Integrated Master in Industrial Engineering and Management, University of Minho
[2] Department of Production and Systems, School of Engineering, University of Minho, Campus of Azurém, Guimarães, Portugal

Email: francisca.sousa.ribeiro@gmail.com, joaoandrenobre@gmail.com, liliana.ds.silva@gmail.com, dinis@dps.uminho.pt

Abstract

In the Industrial Engineering and Management Integrated Master course the projects in real industrial context are assumed to play a crucial role in the development of key technical and professional skills in students. In the 7th semester of this integrated master course the students are involved in a large real context project integrating many different subjects covered in 5 different curricular units. Student teams must analyze and diagnose a production unit in a company, identify improving opportunities, design solutions and implement them if possible. These experiences are very demanding to students since many different uncontrollable variables are influencing their performance as team and as individuals. In this article the students will describe the experience from different perspectives, such as: personal interaction, group and project management, technical challenges, communication issues, as well as the challenges in meeting teachers and company staff expectations.

Keywords: Projects; real industry context; teamwork.

1 Introduction

As the market develops, a change in organizational paradigms occurs. At present, the need to process and act based on ever more updated information in order to maintain high competitiveness in the market, leads to the need of more skilled human resources, capable of acting accordingly in immediate and unexpected situations.

Dias (2011) states that the modern professionals must embody the ability to quickly make decisions, outline new strategies, motivate and inspire team workers, use new technologies and find out what customers desire. Still according to the same author, they also must be bold without being reckless, be focused on the development of human potential and their skills and seek to educate and inform to be tuned and aligned to the constant changes. Therefore, training more autonomous, innovative and able to respond to the demanding market requirements professionals is required. This leads to a challenge to the universities, since they have to seek new ways of training their students to these new market demands and so the need to link the theoretical knowledge provided by the universities with its real industrial application is increasingly higher. In this point of view, new approaches are being adopted by universities to deal with this problem, such as the application of projects that connect the universities and their students with the industry. These projects present improvement opportunities both to the teaching models of the universities and to the companies' structures, since they are presented with the opportunities of improving some part of their structure through the work performed by the students in their facilities. These projects also represent a significant advantage to the students that take part of them, because they generate the opportunity to these future professionals to observe how things work and act in real industrial context.

This article intends to present the point of view of a team of students of the Industrial Engineering and Management Integrated Master course of Minho University that participated on a project in real industrial context in a company. Students will describe how they perceived the project …

The company's name will not be mentioned in this article being only referred as the company. In the next chapter, an explanation of how the project we have participated in works and how we have organized ourselves to respond to its requirements is presented. In the 3rd chapter, a brief exposition of the work we have accomplished is made and, in the 4th chapter, our opinions about what are the positive and least positive aspects of our interaction with our professors and the curricular units involved in the project and with the

company where the project took place and, an analysis on what went well and what went least well in our interaction as team members is presented.

2 Project Context

The project in which this article is based on is developed in real industrial context. A company along with the faculty presents a problem related to its production system that must be studied and some improvements or some possible solutions must be presented. During the evolution of the project students must develop the learning skills listed on the six curricular units directly involved in the project as well as other professional skills more linked to the real context project work (

Figure 1). These curricular units included in the seventh semester of the Integrated Master in Industrial Engineering and Management of Minho University which are: (i) Manufacturing Systems Organization II, (ii) Integrated Production Management, (iii) Production Information Systems, (iv) Ergonomic Study of Workstations, (v) Simulation and (vi) Integrated Project in Industrial Engineering and Management II. Note that the last curricular unit mentioned is the result of the interaction between all the others and the company (

Figure 1).

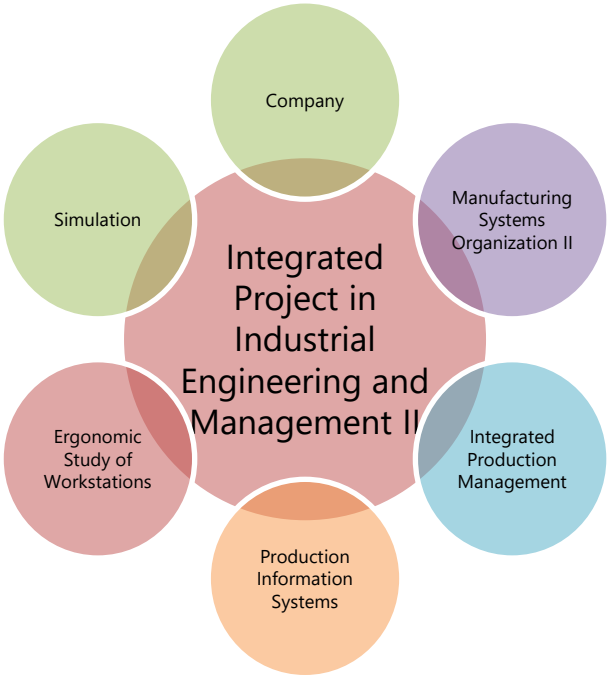


Figure 1 - Illustration of the interdisciplinary relationship between curricular units and the company.

During this project students should characterize and diagnose the existing production system and evaluate its performance, identify waste, identify and model planning processes and production control, partially analyse how the implemented systems meet the functional requirements and the production system information and, create simulation models of the production system. Furthermore, students should also characterize workstations in the ergonomic point of view and their physical environment, and identify possible alternative actions and expected results.

The project is divided in three stages (Figure 2): (i) company exploration/recognition, (ii) analysis and diagnosis of the production system and (iii) improvement proposals; each stage's end was characterized by a milestone.

Figure 2 – The three stages of the project.

2.1 Team's Organization

After the selection of the Company in which the team would develop the project, a spokesperson was chosen amongst the team members to be the one responsible for contacting the faculty or the connections from the Company on behalf of the team.

In order to accomplish the demands of each milestone, the team decided to split tasks by curricular unit among its members to increase productivity. During the course of the project, that division of tasks wasn't really fulfilled, because it was necessary to answer to different tasks from each course unit in different moments and so, if that division was truly maintained some team members would spend much time unable to do anything productive and the team members wouldn't be able to learn more about the subjects from curricular units that were applied in the project.

During the course of the project, the need of a spokesperson became less necessary since tasks splitting lead to the need of getting direct contact with the professors and the connections from the Company according to the theme of each member's task.

2.2 Theoretical background

The team had to use concepts, principles, as well as tools that are part of the subjects covered in the curricular units that support this project based learning case. Only the subjects that support the project pieces presented in the scope of this article will be described below.

2.2.1 Overall Equipment Effectiveness

The Overall Equipment Effectiveness (OEE) (Nakajima, 1998) is an indicator that measures the effective use of critical equipment that for some reason must be used as much as possible. This indicator helps in identifying the causes for capacity loses (Availability, Performance, and Quality) and should be continuously monitored and improved. The main idea of this indicator is that there is a set of constraints preventing you from using the equipment 100% of the time producing good parts. The conventional formula for OEE can be written as follows (Huang, Dismukes, Shi, Su, Wang, Razzak, and Robinson, 2002):

$$OEE = A \times P \times Q$$

Where

A = Availability Efficiency – represents the percentage of scheduled time that the equipment is available to operate. Often referred to as Uptime. It is related to losses that include non-scheduled downtime, break-downs, setup and adjustments, etc.).

P = Performance Efficiency - represents the speed at which the equipment runs as a percentage of its designed speed. Losses related to operate the equipment at a speed lower than the standard speed due to wear of equipment and tools, workers' failures, inappropriate material, etc.).

Q = Quality Efficiency - represents the good units produced as a percentage of the total units produced. It is related to defects.

2.2.2 Ishikawa Diagram

The Ishikawa Diagram or Cause and Effect Diagram, created by Kaoru Ishikawa, is a visualization tool for categorizing the potential causes of a problem in order to identify its root causes (Bamford et al, 2005). It was developed to determine and break down the main causes of a problem, by dividing them into categories, such as: (i) Machinery, (ii) Method, (iii) Maintenance, (iv) Personnel, (v) Product and (vi) Equipment. The Cause and

Effect Diagram was described by Ishikawa as a diagram that "can easily be understood by those on the shop floor" and "can be prepared showing assignable causes, different types of defects, etc" (Ishikawa, 2012).

The Cause and Effect Diagram is part of the Seven Basic Quality Tools (Tague, 2005) first emphasized by Ishikawa, which the remaining ones are Pareto Analysis, Check Sheets, Control Charts, Histograms, Scatter Diagrams and Flow Charts.

2.2.3 SMED – Single Minute Exchange of Die

The setup or changeover time is a variable playing an important role when the same equipment is used to produce different parts. The higher the changeover time the larger must be the batch in order to dilute the cost of the setup. So in order to reduce the batch size, so important in lean environments (Womack and Jones, 1996) a method was created under the TPS development (Ohno, 1988) called SMED (Shingo, 1985). SMED stands for Single Minute Exchange of Die which can be translated into fast tool change on a digit minute and proposes that the setups are performed within 10 minutes, which is a possible time to be achieved from the rationalization of the tasks performed by the machine operator.

The implementation of SMED starts with a preliminary stage consisting in a previous analysis in order to clearly understand the changeover process, identifying all the setup operations involved. The video recording of a changeover occurrence is very useful, as some characteristics of the setup operations can be easily obtained (e.g. duration and necessary resources). Usually, informal meetings with the involved workers are also necessary to clarify other aspects/characteristics (e.g. technical details and eventual existence of precedence relations). After this preliminary stage, three more stages are necessary to implement SMED: 1) separation of internal and external setup operations, 2) conversion of internal into external setup operations, and, 3) rationalization of all the setup operations. Unlike the external operations, the internal ones can only be executed if the production equipment is stopped, and, thus, it is obvious the importance of the transformation of internal into external setup operations (stage 2). In some cases stage 3 may become complex, but its execution is determinant to achieve relevant setup time reduction. An extensive list of techniques/tools that can be used in each stage can be found in Shingo (1985) as well as in PPDT (1996).

3 Diagnoses and improving opportunities

The company where this project took place produces furniture parts in three different production areas: BOF (Board on Frame), PFF (Pigment Furniture Factory) e Warehouse. The PFF was the production area where the team had to pay more attention. One of the main challenges proposed by the company was related to the large number of defects existing in a specific part of this PFF area, the spray lines. The non-conformed products need rework, which decreases productivity and further induce an increase costs. Therefore, the team started to analyse the overall process including the internal logistics and then decided to focus on the painting area, more precisely in the spray line 14.

3.1 Production Planning and Control

In order to have an overview on how the production was managed the team decided to study the production planning and control (PPC) activities. At the Master Production Scheduling level, named as Master Plan by the Company, the demand for 52 weeks is assumed and then an effort is made to create a reasonable even production schedule (production leveling). For example, in case the demand is superior than the maximum production capacity of the factory, it is necessary to distribute this excess of demand for the nearer weeks with low demand. Because of that, the company produces for immediate delivery and stock. The next stage, named as Production Plan, what is necessary to produce is balanced with the stock existences, the work in progress and the delayed production. As in the previous stage, it may also be necessary to level the quantity to produce without forgetting the priorities since the delayed products are more important than the production to stock.

Last but not least, it comes the weekly plan which determines for every production line/machine the order to produce including the product's name and code, the start time, duration and the time to finish that production order. Given the magnitude of the factory, this stage of PPC requires three employees responsible for different family products. While products of different families can share production lines/machines, people in charge of

this plan need to work together and maintain a good level of communication so that everything works the best way. At the PPC level the team detected that the Company dependence to this people since they work based on personal experience and no document stating the priority rules to launch weekly production orders exist. The team decided to create a standard set aspects that must be taken in consideration by week planners. To do so the team had to interview different people with experience in this planning in order to establish a proposal of a set of aspects to be considered during the development of a week plan (Figure 3).

Figure 3 – Standard to create the week plan for spray lines.

Setups and color sequences are important because the setup time depends on the sequence of colors. As an example, the setup time from grey to white is higher than from white to grey. It is still necessary to know the interval between setups and the time spent on it without forgetting priorities like delivery deadline. Although the company produce for immediate delivery is also obliged to produce for stock, result of leveling. But when it comes to priorities is more important to produce for immediate delivery than for stock without forgetting that there are jobs in delays these should be considered as the delivery thereof. Since there are conveyors along the line it is important to consider the dimensions of the parts in order to reduce transport.

3.2 Description of the spray line 14 production system

The company evaluate its performance by financial and non-financial indicators. The financial indicator evaluates the production costs and the non-financial evaluates efficiency, absenteeism, overtime, breakdowns, scrap and rework. The team calculated the OEE (Overall Equipment Efficiency) indicator, a non-financial indicator, which aimed to measure the operating performance of the machinery.

An overview of the spray line 14 is shown in Figure 4 where main processes and route is represented. After the loading of parts into the spay line, operation performed automatically without human intervention, comes the sander process, which performs the smoothing of the surface of the parts that come from the machining in order to remove surface irregularities. After this, parts are subjected to an extraction process to remove dust in order to reduce impurities. Subsequently, the process takes place in a painting box in which the parts are subjected to application of base layers (first topcoat layer which reduces and equalizes the absorption surface and also gives some colour to the substrate) and a top (the last layer of paint that by having more additives provides the colour, desired strength and brightness), by spray.

At the end of this operation, the parts are sent to a hot air oven for drying. Here takes place the formation of a rigid layer of ink on the surface which can occur in a hot air curing oven with ultraviolet lamps (UV) or in a curing oven with infrared lamps (IR). Finally, they pass through a cooler and then they go through a quality control and automatically unloaded from the line.

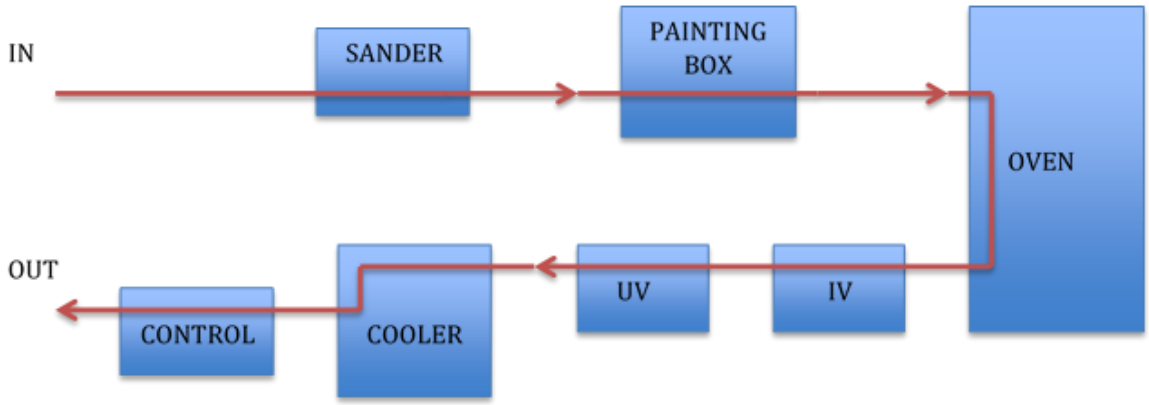


Figure 4 – Overview of the spray line 14.

3.3 OEE – Overall Equipment Efficiency

Table 1 presents the performance indicators of spray line 14 measured on October 2015 whose OEE value was 41,58%.

Table 1 - OEE for spray line 14 on October 2015.

Performance measures	Average
Availability (%)	66,81
Performance (%)	65,61
Quality (%)	94,36
OEE (%)	**41,58**

Through the OEE results, the team concluded that the factors that contribute to the decrease of OEE are mainly availability and performance. The performance is affected by failures in the processing speed of the machines and by operators' inefficiency while the availability is affected by breakdowns, and setups. Despite the defects in October did not significantly affect the performance of the line, they were responsible for the low availability, since the high frequency of occurrence led the company to invest in preventive maintenance and planned stops. The team also investigated, for October 2015, the time spent in cleaning the painting box and realized it was the one that most influenced the reduction of availability. The evaluation of the time spent in cleaning the box was assessed by SMED application mentioned in chapter 3.2.3.

3.4 SMED – Single Minute Exchange of Die

The cleaning of the painting box occupies lots of producing time, which led the team to apply the SMED (Single Minute Exchange of Die) method in order to reduce this time. Although the main objective of the SMED method is to reduce the changeover time, in this project this method is used to reduce the setup time as well as to reduce the maintenance time of the line and allow more time for the production of parts.

By knowing the operations which the cleaning of the painting box includes, their observation and timing was performed. Since all the activities were internal, the team evaluated the possibility of changing the activities to external, one by one. It was possible to change one of the activities to reduce the cleaning time in six minutes, meaning a gain of 6,9% of time. In addition, also in order to reduce the time spent on internal activities, it was suggested to put two operators in the execution of another activity which was being performed by only one operator, which would allow a decrease of about thirteen minutes, corresponding to a percentage gain of

14.9% of time. In conclusion, with SMED application, it was possible to obtain a reduction of nineteen minutes, which is about 21.8% of the time spent in the painting box's cleaning.

3.5 Quality

The items' quality is one of the most important indicators for the Company as it is related to the performance of the production system and customer satisfaction. The nonconforming occurrences massively disturb the production, in one hand, because it's required to stop the manufacture for corrective and preventive maintenance and, in the other hand, because it causes over processing due to the rework of defective parts.

To determine which defects were the most representative, the team developed an ABC analysis to the occurrences on October 2015. In category A are the impurities, broken/fissured parts and, deep marks and scratches. However, impurities and deep marks and scratches do not need to go to scrap, unlike broken/fissured parts. Those defects provide the option of reworking the parts because, although it doesn't add value to the product, it allows the parts to re-enter the system and, in a way, they don't become a total waste.

Thereby, the costs involved were analysed. It is known that the Company has spent, in October 2015, about €106.100 in rework and €20.000 in scrap which means a total of approximately €126.000. Of this total, the impurities are those that entail more costs.

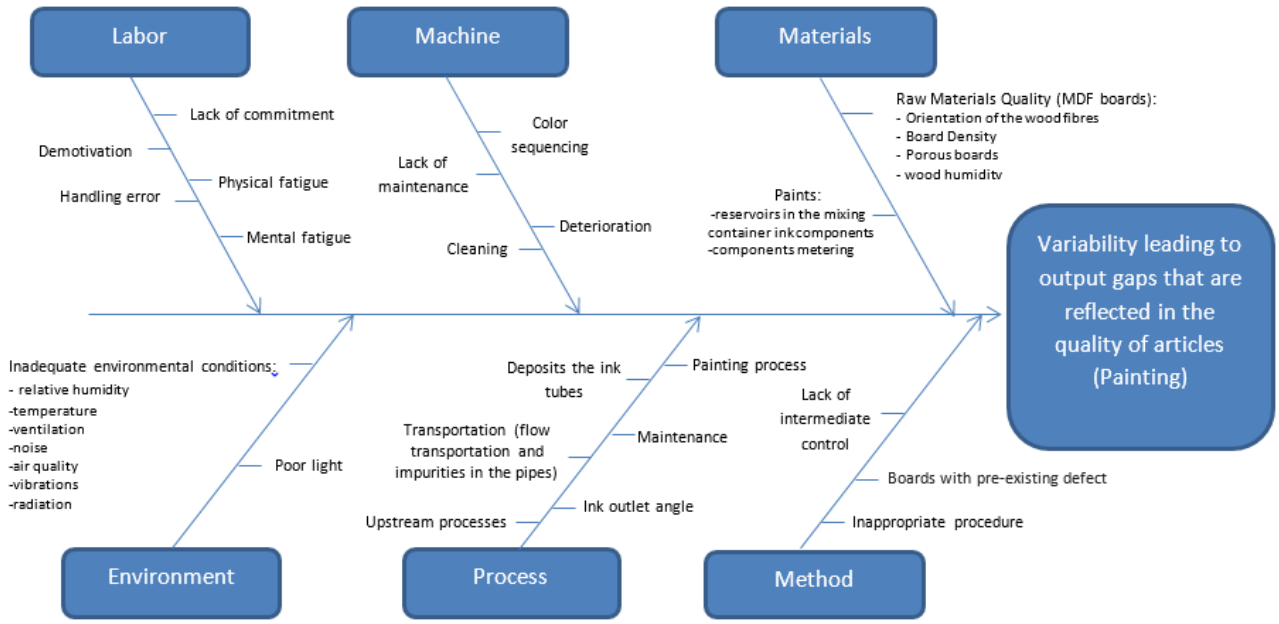


Figure 5 - Ishikawa diagram of the variability in the spray line 14.

In conclusion, the impurities are the most substantial type of defects, not only by its frequency of occurrence but also by the ignorance of the causes that originate this defects. Thus, the team conducted a brainstorming on possible causes for variability in the production of spray line 14, which was represented by the Ishikawa Diagram presented in Figure 5, where a large possibility of causes, however inconclusive, due to lack of data on that subject are suggested.

4 Interactions between different parties

4.1 Interaction with the University and professors

The professors' role in the execution of this project was a very significant factor mostly because they were the ones who established contact with the companies and enabled the realization of this project.

The interaction between the team and its professors provided some benefits such as the support provided by the professors during the course of the project and their ability to promote the project since they established contacts with major international companies.

However, sometimes there was a lack of communication with the Company in establishing the problems that were to be analysed by the team in which it was possible to apply knowledge obtained in the course units (since that was required to this project). A negative point was that the professors required the delivery of work related to their course units and so much time was spent doing that instead of spending that time working on the problems that the Company really need the team's study.

4.2 Interaction with the Company

In general, the team's relationship with the Company was very positive despite some difficulties felt in the beginning. From the team's point of view, this interaction was one of the most important parts of the project.

An advantage of this interaction was the possibility to deal with real industrial context. Furthermore, it allowed the establishment of professional contacts, important for the team members' future, and, since this interaction took place along five months, some professional experience was obtained.

The difficulty of transforming theoretical knowledge into practice was one of the disadvantages identified by the team because as students the team lacks professional experience.

In the beginning of this project there were some difficulties in scheduling meetings and even professors involved in the project felt some gaps in communication with the Company, because it was the first time that the Company was involved in this kind of project and so it wasn't aware of how the project was supposed to run. This led to loss of time by the team due to the Company's reluctance in providing data.

A team's suggestion for future projects in a company is the establishment of an advisor that should guide the students during the project's development. This should facilitate the exchange of data and give the students a view of an engineer's life.

4.3 Interaction with the team and between the team members

The relationship between team members was another of the most important aspect of this project. It provided the opportunity to improve the team members' soft skills, such as communication ability, problem solving and time management. Despite the existence of leaders and followers, it was managed to cooperate in order to achieve the best possible result. This project also allowed the distribution of tasks which lead to its quicker execution and, therefore, to a greater productivity. Lastly, the discussion of ideas made the project run successfully.

In a least positive side of this project were the interaction difficulties between some team members, because in some cases it was the first time a member was working with others which lead to some problems. Another difficult point was the schedules conciliation since the members live far from each other and that made it difficult to schedule meetings. Also, the failure to meet the stipulated tasks by some team members lead to excessive workload for the others. It should also be mentioned that some unjustified absences by some members in the meetings turned out to be an obstacle since the work plan had to be changed to adapt to this situations.

5 Conclusion

This article reports a real context project work carried out by a team of student in a company under a PBL (Project Based Learning) platform. This team of students on their 7th semester of the integrated master course in industrial engineering and management, identified improvements opportunities in the assigned company and designed effective solutions to perform the required improvements. Among other interventions that are not mentioned in this article they analysed the OEE indicator and in order to improve it they applied the SMED method to reduce the painting box's cleaning of about 21.8%, they identified improving opportunities in the PPC system and managed to diagnose sources of quality problems. In terms of the PBL experience the students

pointed out the importance of the project in terms of the provided interaction with company´s reality and all benefits that come with it. On the other hand they also pointed out the difficulty in managing that interaction, especially in a company that was the first time involved in this type of PBL integration. Students also mentioned the important soft or professional skills developed during this project and the difficulties they felt in managing the project, their interactions with colleagues as well as the time management difficulties. Finally the students also recognized the classic dilemma between the syllabus and the project technical needs that almost impossible to match completely.

6 References

Bamford, D., Greatbanks, R. (2005) "The use of quality management tools and techniques: a study of application in everyday situations", International Journal of Quality & Reliability Management: Vol. 22 No. 4.

Dias, L. G. (2011). O Mercado de Trabalho Contemporâneo: a necessidade de formar e informar. Fundação Aprender.

Huang, S. H., Dismukes, J. P., Shi, J., Su, Q., Wang, G., Razzak, M. A., Robinson, D. E. (202). Manufacturing System Modelling for Productivity Improvement. Journal of Manufacturing System. Vol. 21, nº4, 11 pgs., 2002.

Ishikawa, Kaoru (2012). *Introduction to Quality Contro*. Springer Netherlands.

Nakajima, S. (1998). *Introduction to TPM: Total Productive Maintenance*. Cambridge, MA: Productivity.

Ohno, T. (1988). *Toyota Production System: Beyond large-scale production*, Productivity Press, Portland, Oregon.

PPDT, Productivity Press Development Team. (1996). *Quick Changeover for Operators*, Portland, Oregon, Productivity Press.

Sousa, R., Lima, R., Carvalho, D. and Alves, A. (2009). An industrial application of resource constrained scheduling for quick changeover: Proceedings of IEEE International Conference on Industrial, p. 189-193.

Shingo, S. (1985). *A Revolution in Manufacturing: The SMED System*. Portland, Oregon: Productivity Press.

Tague, N. (2005) "The Quality Toolbox", Second Edition, ASQ Quality Press, page 15.

Womack, J.P., Jones, D.T. (1996). *Lean Thinking: Banish Waste and Create Wealth in Your Corporation*. Free Press, New York

Different structures of projects in engineering: the perspective of freshmen students

Francisco Ramires[1], Mariana Martins[1], Miguel Cunha[2], Anabela C. Alves[3]

[1] Integrated Master of Industrial Engineering and Management, Department of Production and Systems, School of Engineering, University of Minho, Campus of Azurém, Guimarães, Portugal
[2] Integrated Master of Mechanical Engineering, Department of Mechanical Engineering, Faculty of Engineering of the University of Porto, Porto, Portugal
[3] Centro ALGORITMI, Department of Production and Systems, School of Engineering, University of Minho, Campus of Azurém, Guimarães, Portugal

Email: fdsramires@gmail.com; msocm97@gmail.com; mnbcunha@gmail.com; anabela@dps.uminho.pt

Abstract

This article emphasizes the difference between a Project-Based Learning (PBL) interdisciplinary project developed in the Industrial Engineering and Management of University of Minho and a transversal course to all engineering programs called "Projeto FEUP" implemented in the Faculty of Engineering of the University of Porto (FEUP). It clarifies three different points of view, from three different freshmen students, about the importance of the implementation of projects as learning/teaching methodologies in universities and the impact that this would have in the reinforcement of the links with the professional world. In one hand, the Integrated Master Degree on Industrial Engineering and Management, from the Department of Production and Systems of University of Minho – Portugal, requires the development of a teamwork project in the first semester of the first year, which consists in the application of an active methodology of learning multidisciplinary contents of engineering courses of the semester using the PBL methodology. On the other hand, all engineering courses in the Faculty of Engineering of the University of Porto include a course designated "Project FEUP", that was conceived to promote a complete integration of the newcomers; a familiarization with FEUP facilities and the services its students are allowed to use and to adapt more easily to the academic environment. This paper aims to highlight the differences of these two project approaches that are very different in contents, context and objectives from the point of view of the students involved that are three authors of this paper. At the same time, the paper authors discuss their opinion about the different project structures and the gains/advantages obtained with both. Main results of this discussion is the awareness for PBL methodology as a dynamic and revolutionary form of learning that empowers the students where they are able to develop not only technical, but also soft skills such as teamwork, among others.

Keywords: Active Learning; Engineering Education; Project-Based Learning; Soft skills; Interdisciplinary Project.

1 Introduction

The globalized market creates some challenges to Education, particularly, Engineering Education which educates professionals for the world and future decision-makers. This education continues demanding solid competences in technical or "hard" contents but, to face these challenges, it is also needed strong competences in transversal "soft" skills such as communication, creative and critical thinking, system-thinking, pro-active spirit, project management, among others. This means that learning approaches which promotes these kind of competences, better prepare the students for these real world challenges. Active learning methodologies have been discussed as approaches that have what is needed to promote these competences because involve the students in their own learning (Prince, 2004).

Projects approaches and, in particular, Project-Based Learning (PBL) methodology are considered active learning methodologies because they engage the students in the learning process (de Graaff & Kolmos, 2007). Implementing this kind of methodology is not an easy process and depends much on teachers will because it involves changing their normal practices, curricula and programs. This change is needed and even recommended by the High Level Group on the Modernization of Higher Education (2013) to introduce and promote cross-, trans- and interdisciplinary approaches to teaching and learning, in order to help students develop their breadth of understanding and entrepreneurial and innovative mind-sets.

Few universities are doing this, but, fortunately, in the University of Minho (UMinho) this effort has been made. In the particular case of Integrated Master of Industrial Engineering and Management (IEM) of Department of Production and Systems, PBL has been implemented since 2004_2005 (Lima, Carvalho, Flores, & Van Hattum-Janssen, 2007; Alves, Moreira, Sousa, & Lima, 2009; Alves et al., 2012; Fernandes, Mesquita, Flores, & Lima, 2014). The PBL model implemented is the model of Powell & Weenk (2003) that was implemented by a group of IEM teachers after training workshops with Professor Powell promoted by the UMinho rectory. This implementation has been a dynamic process as the teachers involved are always searching continuous improvement by researching in a continuous action-research cycle (Alves & Leão, 2015). After each semester, teachers organized a workshop to have feedback from students and teachers involved. This provided many important progresses in the PBL model (Alves et al., 2014) and an understanding of challenges and difficulties of teachers in this process that becomes a facilitator in a student-centered teaching (Alves et al., 2015; Alves et al., 2016).

To know better this PBL model and responding to a call of an IEM teacher and PAEE organizer, the authors of this paper, as students of different universities, wanted to compare the project implemented in IEM program of UMinho developed in the course Integrated Project of Industrial Engineering and Management in the first year, first semester (IPIEM1) and in the FEUP in the course "Projeto FEUP". So, it was proposed this paper to explain the differences between these two types of project approaches that are very different in purpose, content and objectives. This paper continues the effort of research in the PBL model implemented in IEM program launching a new perspective about this, the perspective of the main stakeholders, the students. In order to do this, the papers authors raises some important questions that were prepared in order to obtain the responses of the comparison.

The paper is divided in five sections. After this first introduction where the objectives are presented, the second section presents the research methodology. The third section introduces and describes the study context. The fourth section presents the main part of the paper: the comparison between the projects structures. The conclusions are shown in the fifth section.

2 Research methodology

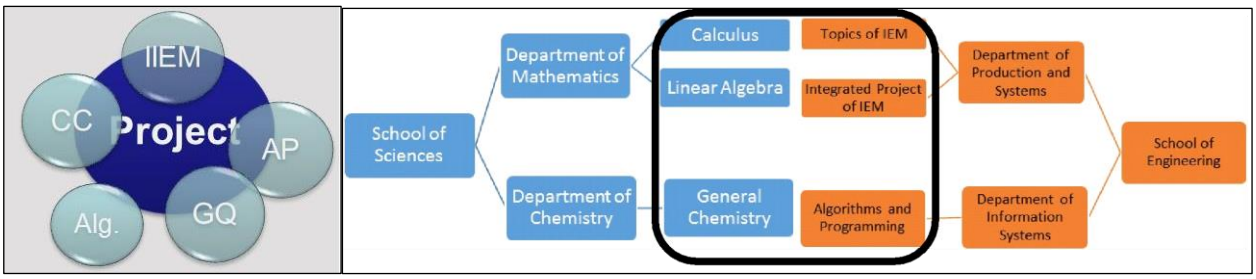
To achieve the objective proposed for this paper, some questions were raised by the paper authors in order to be answered and to have the results of the comparison of the project structures. It was intended to know how different these projects are, difficulties felt in each, learning and competences acquired. As so, the main research questions were:

- What differences exist between IPIEM11 and FEUP project?
- What difficulties and/or challenges were felt in each?
- What were the personal and professional gains?
- What competences do you considered that were developed in each project? Are they improved?
- Are these projects structures benefit the students which learning level and attention are reduced?
- Is it possible to apply the PBL model to all programs?
- What are the differences felt during the transition from a project semester to a traditional classes semester? How this change was reflected in the learning?
- Do you liked the experience of being integrated in a project approach?

To answer these questions, the papers´ authors consult the documents provided by teachers such as "project guide" in the case of IPIEM11, the reports and presentations produced during the project and the experience acquired in the project. Also, in the case of "Projeto FEUP" (PFEUP), the base for the information was the experience of the realization of the project, associated with the report and the presentation. It is important to notice that three authors of this paper are the students who were involved in the projects developed and they are from both universities (two from IEM of UMinho and one from Mechanical Engineering of FEUP) so they were reporting their experiences, perceptions and feelings. So, they defined the questions according to their need in explaining the differences between IPIEM1 and PFEUP they experienced and only for a particular year as they were not involved in different years.

3 Study context

The PBL in IEM program is operationalized in Integrated Project of Industrial Engineering and Management I (IPIEM1) course of the first year, first semester (IEM11_PBL). In this integrated project, students are exposed to an introduction to engineering, concepts of industry and management strategies. Accordingly to these peculiar characteristics, the courses integrated in the project (IPIEM1) are Linear Algebra (Alg.), General Chemistry (GQ), Calculus (CC), Introduction (Topics) to Industrial Engineering and Management (IIEM) and Algorithms and Programming (AP) (Figure 1a). These courses are from different schools and departments (Figure 1b).



a) b)

Figure 1. a) PBL model of IEM11 (IEM11_PBL); b) Schools and departments involved in the IPIEM1 (Alves & Leão, 2015).

This semester is developed with a close approach to the project and it includes the effort from teachers and students (teams with nine elements), and the cooperation between both. IPIEM1 is a course with an active methodology of learning in IEM being an independent course that lasts the entire semester (from September to January). As it is considered an important course, with its strong practical component, IPIEM1 has the same amount of European Credit Transfer System (ECTS) of other curricular units like Algebra or Programming.

In the beginning of the semester, teachers provide useful tools (e.g. documents, bibliography and workshops) for teamwork learning. Teachers prepare a PBL guide that explains the project theme, the specific objectives, the learning outcomes for each course, the assessment methodology of each course, the milestones and resources students can use (teachers' contacts, communication tools, among others). Examples of contents of workshops are: teamwork tools and solve-problems tools, Powerpoint use and to make presentations, to prepare Word documents, how to make references and use reference systems.

Normally, the teachers organize six teams of nine elements each and a tutor is allocated to each team. The teams also have a room project with a space for the teamwork that they can use whenever they need (they have a key of the room). Each year the project is different but teachers select a theme that felt will attract and motivate the teams and, at the same time, deal with a contemporary issue always related with sustainability (Colombo, Alves, Hattum-Janssen, & Moreira, 2014; Colombo, Moreira, & Alves, 2015; Moreira, Mesquita, & van Hattum-Janssen, 2011). The main objective of the project is to allow students to contact, right after the beginning of their university life, with the harsh reality of the world of work that is governed by the resolution of problems that require multidisciplinary knowledge applicable in different situations.

In the FEUP project, the students are organized in groups of three or four elements of each program, randomly, and must develop a theoretical thesis whose theme is defined by the tutor teacher. The main objective of the project is to make the students work as a team while sharing ideas, debating and making decisions as a whole, the same way they will be doing once they enter the labor market. By the end of the project, students should have a report on the given theme, a presentation and a poster on the same subject. This course has the duration of six weeks and is divided in two phases: the first one consists on a week of intensive formation, with presentations related to: public speaking; documentation copyright and the process of making a public presentation. After this first week, the second phase is more practical since it is related to the report preparation. During this phase, students attend a class weekly with the tutor teacher and two monitor students whose help is to aid and advise the students during the report preparation.

The theme is related to the program of students of the groups and in some courses it is integrated in the introductory course of the program. The main objective of the integration of the project in the introductory

course is to incite the interest and the motivation of the students on the tasks of the project since these are related to themes of their interest.

4 Comparison of the projects

This section presents the IPIEM1 vs FEUP project comparing the two structures, which is centered in the following topics: objective, model of execution, importance, ECTS, infrastructures, team dimension, skills developed, duration and courses integrated. After this comparison, a discussion is followed.

4.1 IPIEM1 vs FEUP Project

Both curricular units have the designation of project, although the term is the same, the way the word is interpreted is different, starting by the objective of each curricular unit. While IPIEM1 objective is to integrate contents of the courses of first year, first semester in a project, coordinate and monitor the development of the reports and to assess the application of the theoretical topics in the context of the project; the objective of FEUP Project is to provide students with the ability to make public presentations, inform the alumnus of the educational services available at FEUP and create awareness of the importance of copyright and trustworthy sources of information.

Another major difference between the two courses sites on the number of ECTS associated to each project: - IPIEM1 has the value 6 ECTS and FEUP Project has the value of 1,5 ECTS. This difference can be related to the importance of each course has in the program and that is evident in the difference between durations of both unit, being that IPIEM1, just like the other courses of the program, lasts an entire semester, while Project FEUP only lasts 6 weeks, because FEUP Project is an introductory course whose objective is to promote the integration of the students in an independent way from the other courses, whereas IPIEM1 project is the result of a multidisciplinary work, which complements the assessment of each unit has. The importance of the IPIEM1 in the program of IEM is also portrayed in the fact that each team had its own working space, where the team gathered and developed the project. On the other hand, at FEUP students had no space attributed for their meetings. Table 1 synthetizes the main characteristics of each project.

Table 1. Characterization of IPIEM1 vs FEUP Project

Characteristics	IPIEM1	FEUP Project
ECTS	6	1,5
Duration	One semester (Sept.-Jan.)	6 weeks
Integrated Curricular Units	5	1
Competences to apply	Technical and transversal (soft)	Transversal
Milestones	6	4
Team dimension	9	4/5
Tutor role	Monitoring, guiding and reporting to teachers team progress of the teams	Monitoring
Infrastructure	Project meeting room	No associated infrastructure

The skills developed during the elaboration of the project is the point where both curricular units are closer since both aim to develop soft skills, simulate real life challenges while promoting the creation of bonds inside teams.

Nevertheless, IPIEM1, by the team dimension, period involved and the project challenges, allows the development of essential skills for the practice of good engineering, time and conflict management, teamwork, argumentation, efficient communication (written and oral), decision making and, at the same time, builds a spirit of creativity and initiative in the students, which is essential in a world marked by fast shifts and accelerated rhythm of the industry. It has a strong practical component, because it forces students to use their learning from the traditional way to create a product and its productive system. Therefore, students have one common mission: pursuit knowledge, scientific rigor, and determination in order to demonstrate the

acquisition of scientific or technical skills enhanced in the course units, to produce solid and eminently practical products / production systems solutions.

To exemplify, this year's project theme was a solar oven. Students had to create the mission, objectives, final products, strategies to maintain the motivation to create a concise and strong basis between team members. After, the team was assessed in several oral presentations and various reports (ones were specifying the structure of the production system and other were related with which curricular unit). Thus, it should be highlighted the proximity created between students and their future as Industrial and Management Engineers. It is important to refer that students attended a class weekly, with teachers from other courses, in order to solve problems about that specific discipline. To exemplify: it was suggested, from the Programming teacher, that students should develop a code to create a program to the non-real solar oven enterprise. If students had doubts on succeeding in this challenge, this class provided the information and explained the doubts students had. So, students took challenges and difficulties, not as a barrier, but as an opportunity to learn more.

Briefly, IPIEM1 consists on a methodology that emphasizes teamwork, solves interdisciplinary problems, articulates theory / practice environments. The realization of this project culminates with the presentation of a solution to a real situation related to professional practice (an efficient productive system, in this case). Therefore, the success of the project is dependent on the quality, management, motivation, dedication and dynamic attitude from students, as the reinforcement and consolidation given by teachers.

4.2 Discussion

This section presents a discussion divided by the main research questions referred in section three. This discussion is based on the experience of the papers authors for the academic year (2015_2016) they were involved and developed the project. At the same time, IEM students and authors of this paper also experienced the second semester without project, allowing them to compare the two semesters.

4.2.1 Advantages and disadvantages of project implementations against traditional teaching method

The advantages of the implementation of the PBL model in every university are based on the introduction of a learning that is meaningful in students, meaning that they only contact with subjects that have importance and practical use, used to resolve the problems and challenges that mark today's world. It has significant effects on the learner, being that it makes classes more enjoyable and satisfying, encouraging greater understanding and creating lifelong skills, and this increases class attendance, promotes interdisciplinary and encourages students to study more by their own. For the institution, the PBL implementation shows that student learning is a priority, decrease student retention and establishes its role in society as an institution that values knowledge and teaching.

In terms of disadvantages, the implementation of this methodology of learning implies some risks for the university and the teachers. Since from the start of school the learning model is listening the teacher speak, memorize the subjects taught, and do an exam, students do not have sufficient preparation in terms of learning experiences to do a PBL. It also requires a lot of time and takes away study time from another courses possibly compromising the success of students in the course and it creates anxiety, because the learning process is messier. For teachers, it requires a lot of preparation and extra work to do a good PBL for students, and it raises a lot of problems in what to assess and how. In terms of the institution, PBL creates a need in staff development and support, it takes more instructors and it requires a big change in educational philosophy for universities who mostly lecture.

4.2.2 Differences experienced in the transition between project period and traditional classes period

This question does not apply to FEUP project, since the project does not involve other courses. Although, in IPIEM1 after the end of the project, a feeling of relief and peace "starts to run through our body", because of the workload ended, all the presentations, all the weekly tasks that students had to accomplish and reports that had to deliver, all the meetings to discuss ideas, students get a feeling of emptiness when they go to the "traditional" class in the second semester.

The transition from a period with a project, when students a have a sense of purpose in going to class, objectives, and goals to reach for, to a period without project is really a 180 degrees change in every aspect of

a student life. They feel like the motivation vanished, and it is much more difficult to learn certain topics because it is lacking the bridge between theory and reality, something that was accomplished when worked in the project. The learning is no longer a fun process, and it does not excite the students in general anymore, being that there is no longer a seek for knowledge, there is no longer the spirit of search for more and deeper ways to resolve problems, and there is no longer a true interaction between science and practice.

It is also evident that even the professor feels less motivated to teach, because they, like the students, don't have the need to seek for more, for new ways of teaching, and they are not challenged by the students anymore. Where as in the period of the project the teachers learned new ways of teaching, in order to make students realized how they can introduce the theory in the project, in traditional class they stick with a static and standard model of class, where the student is just an exam taker and the teacher is the one who takes the active role in learning.

If teachers maintain traditional notions of students as information recipients, teaching and learning become a pointless game where, instead of connection and engagement, the main challenge for students is to read the teacher's mind while producing a product in which they don't feel invested.

4.2.3 Difficulties and challenges felt during the project

In FEUP project, there were some challenges during the elaboration of the project, that needed to be overcome and that required the dedication and continuous dialog by the group. The main challenge was the time management due to the tight schedules, requiring the ability to work under pressure constantly in a continuous work of improvement. Another aspect that represented a challenge was the debate of ideas that was permanent; the good relationship between the group members was essential to maintain the motivation levels high and constant dedication. In terms of difficulty, the level of the project was adequate to the capabilities of the students despite their inexperience with such type of evaluation.

The IPIEM1 produces a feeling of desire to learn more and to find different and simple ways to resolve the problems that appear, so it creates an entire new environment of learning, creating highly motivated students who seeks more from the teachers, seeking the practical application of the science taught in the classroom.

Paper authors can point out, as disadvantages of the project, the big teams formed with nine elements which creates big challenges in terms of division of work: 1) there are always some team members that work more than others; 2) make ideas clear for everyone, make decisions and communication in meetings to discuss the direction of work; 3) the fact that because there are a lot of members in the team, sometimes it's formed a spirit of "parasitism" in some team members that live from the work of others and do not produce value to the project; 4) the ambiguous model of individual assessment of the students, meaning that there is not established a real and rock-solid structure to evaluate the individual performance of each person in the team because the teachers can only see the work that the team accomplished in periodic discussion sessions, in presentations, reports and with conversation to the students but has never the knowledge of who did what and if the work load was equally divided through the team members; 5) lack of support from some teachers in the execution of some technical tasks; some of the units integrated in the project were not the most appropriate to allow the creation of a viable project that could possibly turn into reality.

4.2.4 Gains in personal and professional terms: competences developed

The impact of having a project like the one in FEUP is quite significant in terms of adaption since the process of integration in a new environment is eased. The fact of having a group of students with similar interests developing a project related to the area they appreciate leads to the creation of social connection with peers. In terms of professional aspects, having this project incites the development of several soft skills such as: time management, due to the tight schedules that are stipulated; team work and dialog, since several opinions have to be considered; and presentation experience since all the reports had to be presented to a jury at the end of the project. Some hard skills were also developed during the elaboration of the reports such as the ability of working with document editing on the cloud, and recognizing and applying the structure of a scientific report.

In IPIEM1, throughout the project, there were many obstacles which when beaten allowed the development and growth of all the people involved, either professionally, with the knowledge acquired from the different

courses integrated in the project but also with the creation of a new perception of the how science can be integrated in a practical term; either personally with the development of skills indispensable to the practice of Engineering like time management, once everything had to be coordinated. At the same, students had exams and assignments for other courses; conflict management with the conflicts that come to surface with divergence between ways of thinking and the feeling of lack of dedication from team colleagues; efficient communication of ideas because teams only have ten minutes to present everything that had worked in, so they must be concise and direct without compromising the content of the presentation; decision making, because teams must have to make decisions every week that could jeopardize the future direction of the team; and, finally, team-work, once integrated a team of nine members with different personalities and totally different work rhythms, which taught to understand everyone's limitations and to use each person skills in the creation of a viable and innovative project.

4.2.5 Variations in the teacher's position on the student learning

This question does not apply to FEUP project since it is not considered a PBL model, therefore, there is no difference in the teaching method. Project-based learning transforms the roles of students and teachers in ways that benefit all. In the IPIEM1, the teacher is the passive piece in the process of learning, giving the students the tools to achieve knowledge, making the learner the one that is active, the one has the responsibility for their own learning by identifying their learning issues and needs.

Throughout the entire project, students were the ones who looked for the information, and asked the questions to the teachers that worked as guides, giving us tools to structure the knowledge acquired from researches made, but there was not a right direction, being that the students had to be the ones that took command of everything they were doing in the project.

4.2.6 Benefits for students whose degree of learning and attention in class is reduced

This question does not apply to FEUP project since it is not considered a PBL model, therefore, there is no significant change in the way students attend classes.

In IPIEM1, when the papers authors start to compare the differences between the period with the project and the period without it, it is evident the modification in students behavior, and it is even more evident the changes that occur in students with a lower level of learning. With the project, because they are inserted in a team of nine elements, being that everyone has different levels of knowledge they have, besides the teacher, other eight members can resort to when they have doubts in a certain topic. Another important fact that must be taken to count, when the differences are analyzed, is the environment, being that the environment, has one of the most important roles in human behavior. In the project, the entire team has one goal, that it is accomplish all tasks presented by the teachers, make good reports and presentations, and finish that project with a good grade, so they have to work together, put each other in the same stage of knowledge and comprehension because the teachers asked everyone periodically questions about each discipline and about the development of the project. So the students with low level of learning were forced, by the environment to learn, to understand, and also to share knowledge with the other team members.

4.2.7 Application of the PBL model to all courses

The challenge with the implementation of the PBL model is that it requires a lot of resources to be put into practice, such as, more work hours and dedication from the teachers, the modification of the way and structure they teach the topics, because they have to mirror the theory into the real world so that the students can apply their knowledge the resolution of the problems in the project; and a lot of bureaucracy to go through to establish a project in just one course of the university.

Although there are a lot of challenges in applying the model of PBL in courses, the gains that the teachers, the university, and the world of work can collect from it are far more great than the risks and difficulties allied with it, so the paper authors strongly believe that the direction of education should be the application of this model not only in university level but also in high school, because it is the best way to prepare students for the resolution of real problems in real life, something that is certain to happen when they start working.

4.2.8 Did you like the experience?

The experience of having a course like FEUP project was a very enriching since it was essential in the adaptation to the academic environment, since it allowed the students to integrate more easily by establishing social relations with new people, to know better the place where they studied and the resources students have available to use in their daily academic routine. On the other hand, learning how to search for information whose reliability is assured and guaranteeing the copyright of the information, was very useful for students since it was a whole new aspect to take in consideration. In conclusion, students considered the experience very useful since it helped to integrate and to acquire more motivation for the rest of the semester.

The Integrated Project of Industrial Engineering and Management of University of Minho, integrated in the first year of the program was an incredible experience once allowed to understand what would be the role of an Industrial and Management Engineer in the world of work, something that cannot be achieved with traditional classes where students are not more than mere exams takers without realizing how our knowledge can be truly applied. Thus, the paper authors believe that the project introduces in the course the "reality" component that is lacking in many universities, reducing the gap between the world of work and the theory that learned throughout the course. In conclusion, papers authors would like to highlight how enriching this experience was, and how much believe that it will help to succeed in the future as engineers.

5 Conclusion

The practice of engineering is in constant need of updates, due to the rapid changing needs of the market and society. In this way, education in engineering strongly needs an update and a transformation in teaching methodology, in order to adapt to the fast shifting world that constantly creates new necessities, new problems where different and ingenious solutions are required.

Even though there are many similarities between Project FEUP and IPIEM1, the paper authors cannot consider the first one as a PBL approach. PBL is an active method of construction of learning based on the model "Learning to Learn", making the learner the active part of the learning process- being the one that seeks for the best ways to learn subjects -, and the professor no more than an advisor that guides the student through the road of learning and shortens the distance between the student and knowledge. There is a distance that separates the two models marked by the no integration of the courses from the program in the project – that is the basis of the PBL -, by the technical nature that dominates the entire project, (the process of learning is more focused in technical aspects than in the development of soft skills). Therefore, there is not a real interaction in Project FEUP between the learner and the environment of the course and does not exists a real contact with day life problems, being only a way to give students soft skills.

To sum up, the paper authors experienced two types of project in the university context and agree that the benefits of having such an experience are unquestionable, because these type of project put students in a position very similar to that they will face in the labor market and it is a preparation that no other unit provides. However, they also agree that the IPIEM1 type of project is the one that is more advantageous to students, since it enables a complete interaction with the course units enabling a broader perspective on the functional way the units are structured. The main characteristic of IPIEM1 is the symbiotic and synergetic relation with all courses, which separates it from the traditional way of learning.

6 References

Alves, A. C., & Leão, C. P. (2015). Action, practice and research in Project-Based Learning in an Industrial Engineering and Management program. In *Proceedings of the ASME 2015 International Mechanical Engineering Congress & Exposition (IMECE2015)*.

Alves, A. C., Moreira, F., Lima, R. M., Sousa, R, M., Carvalho, D., Mesquita, D., ... Van-Hattum-Janssen, N. (2014). Aprendizagem Baseada em Projetos interdisciplinares: análise da implementação em duas estruturas curriculares distintas. In A. Fischer & O. L. de O. M. Heinig (Eds.), *Linguagens em uso nas Engenharias* (Edifurb -.).

Alves, A. C., Moreira, F., Lima, R., Sousa, R., Dinis-Carvalho, J., Mesquita, D., … van Hattum-Janssen, N. (2012). Project Based Learning in First Year, First Semester of Industrial Engineering and Management: Some Results. In *Volume 5: Education and Globalization; General Topics* (Vol. 5, p. 111). ASME. doi: 10.1115/IMECE2012-89046

Alves, A. C., Moreira, F., Sousa, R. M., & Lima, R. M. (2009). Projectos para a aprendizagem na Engenharia e Gestão Industrial. In U. do Minho (Ed.), *Actas do X Congresso Internacional Galego-Português de Psicopedagogia* (pp. 3360–3375). Braga.

Alves, A. C., Sousa, R. M., Fernandes, S., Cardoso, E., Carvalho, M. A., Figueiredo, J., & Pereira, R. M. S. (2015). Teacher's experiences in PBL: implications for practice. *European Journal of Engineering Education*, 1–19. doi:10.1080/03043797.2015.1023782

Alves, A. C., Sousa, R. M., Moreira, F., Carvalho, M. A., Cardoso, E., Pimenta, P., … Mesquita, D. (2016). Managing PBL difficulties in an Industrial Engineering and Management program. *Journal of Industrial Engineering and Management*, *Accepted for publication*.

Colombo, C. R., Alves, A. C., Hattum-Janssen, N. Van, & Moreira, F. (2014). Active Learning Based Sustainability Education: a Case Study. In *Proceedings of Project Approaches in Engineering Education (PAEE2014)* (pp. ID55.1–9). Retrieved from http://repositorium.sdum.uminho.pt/bitstream/1822/30173/1/paee2014_submission_55.pdf

Colombo, C. R., Moreira, F., & Alves, A. C. (2015). Sustainability Education in PBL Education: the case study of IEM. In *Proceedings of the Project Approaches in Engineering Education* (pp. 221–228).

de Graaff, E., & Kolmos, A. (2007). *Management of Change: implementation of Problem-Based and Project-Based Learning in Engineering*. Sense Publishers.

Fernandes, S., Mesquita, D., Flores, M. A., & Lima, R. M. (2014). Engaging students in learning: Findings from a study of project-led education. *European Journal of Engineering Education*, *39*(1), 55–67. doi:10.1080/03043797.2013.833170

High Level Group on the Modernisation of Higher Education. (2013). *Improving the quality of teaching and learning in Europe´s higher education institutions*. doi:10.2766/42468

Moreira, F., Mesquita, D., & van Hattum-Janssen, N. Van. (2011). The importance of the project theme in Project-Based Learning: a study of student and teacher perceptions. In *Proceedings of the 2011 Project Approaches in Engineering Education* (Vol. 53). doi:10.1017/CBO9781107415324.004

Lima, R. M., Carvalho, D., Flores, A., & Van Hattum-Janssen, N. (2007). A case study on project led education in engineering : students ' and teachers ' perceptions. *European Journal of Engineering Education*, *32*(3), 337–347. doi:10.1080/03043790701278599

Powell, P. C., & Weenk, W. (2003). *Project-Led Engineering Education*. Utrecht: Lemma.

Prince, M. (2004). Does active learning work? A review of the research. *Journal of Engineering Education*, *93*(3), 223–231.

EBEC Bridges University-Business skills

Andreia Almeida[1], Mariana Masteling[1], Mariana Sousa[1], Marta Cortesão[1], Rita Faria[1]

[1] Board of European Students of Technology, Porto, Portugal

Email: andreia.almeida@bestporto.org, mariana.masteling@bestporto.org, mariana.sousa@bestporto.org, marta.cortesao@bestporto.org, rita.faria@bestporto.org

Abstract

Nowadays graduates need more than the technical skills they learn in university, being necessary to expose them also to non-technical study areas, increasing their employability by better reaching industry's needs. BEST (Board of European Students of Technology) is a student's organisation present in 96 universities in Europe. One of its main events is EBEC (European BEST Engineering Competition), that provides technology students the chance to compete in a multicultural environment technology competition. But what makes EBEC so special? What are students actually developing by organising this extracurricular activity? This paper presents how BEST Porto members develop their skills and tools to facilitate professional development by being involved in EBEC organisation. An online survey was performed to BEST Porto members: Teamwork (70.6%), work under pressure (67.6%) and problem solving (52.9%) are the three main skills members find to develop the most during EBEC organisation. Problem solving (79.4%), communication (55.9%) and teamwork (52.9%) are the three main skills students' think employers or funders find the most relevant when hiring. From these results we see that the event succeeds in the development of many professional skills, developing its organisers, both as students and as future employees.

Keywords: BEST; Board of European Students of Technology; Education; Engineering Competition; EBEC; Skills; Employability, University-Business.

1 Introduction

University-Business cooperation (UBC) is a trending topic, being tackled in the Europe 2020 strategic plan. Reports from the European Commission have shown good examples of UBC (Healy, Perkmann, Goddard, & Kempton, 2014), however, there is still lack of action to better bridge the university and professional life. Higher Education Institutions (HEIs) play an important role in UBC, but it is the involvement of the three main stakeholders of education that will make UBC develop and benefit society - University, Business and Students.

BEST (Board of European Students of Technology), is a continuously growing, non-governmental, non-profit and non-partisan students' organisation that counts with around 3500 members. Through its activities, BEST reaches more than 1.3 million technology students of 96 Universities in 33 European countries. The main goal of BEST is to develop students, facilitating their contact and involvement with Universities and Companies. To accomplish this, BEST has developed three main services: educational involvement, complementary education and career support. Through these, students' become aware of university and industry's needs, as well their own. This knowledge helps students' with their self-development and helps them to convey their opinions and ideas into innovative solutions (http://www.bestporto.org/).

Graduates need more than just technical skills and theoretical knowledge (Nair, et al., 2009). It is necessary to expose them also to non-technical areas, increasing their employability by better reaching industry's needs (Markes, 2006). The role of non-technical skills (also known as soft skills) in employability and professional development has been recognised (Andrews, & Higson, 2008) - professional skills. If students were to develop the desired skills before graduation, transitioning to the first job would be easier (Markes, 2006). Either by better choosing, or by having a quicker adaptation to the job environment. For this to be able to happen, study programs should be comprised of different set of subjects, and extracurricular activities should be easily recognisable.

In this paper we present the involvement of BEST in the development of professional skills, giving the example of Local BEST Group (LBG) Porto and the development of its members throughout the organisation of EBEC (European BEST Engineering Competition) Project.

2 EBEC Project

EBEC Project it is conducted by students, for students. Teams of students are challenged to solve the tasks that are provided by BEST in 3 different competition levels: local, national/regional, and final round. LBG Porto (Portugal) has been organising the local round of EBEC - EBEC Porto - for 8 years, and last year, in 2015, LBG Porto has organised the final round of EBEC - EBEC final. The overall competition will be hereby called EBEC Project.,

Team Design (TD) and Case Study (CS) are currently the two official categories of the EBEC Project pyramid (Figure 1). TD consists of building a prototype from simple materials subject to restrictions, in order to achieve a particular purpose and CS as the development of a hypothetical solution to a practical situation of a particular problem, or optimizing an existing system, taking into account the information and limitations imposed by the challenge (http://ebec.bestporto.org/ebec-porto/o-que-e).

All the activities developed in BEST, both at a local and international level are subjected to the approval of the associated members, through the Annual Action Plan (AAP). After approval of the AAP and thus, approval of EBEC Project, each LBG decides whether to take part in EBEC Project, or not. In 2105 there were 88 local rounds, 15 national/regional rounds and 1 European Final - organised by LBG Porto.

Figure 1. Scheme of the EBEC project, representing the 83 local rounds (bottom), the 15 National and Regional Rounds (middle), and the European final round (top).

EBEC Project is only possible due to cooperation of supporters, partners and several internal bodies of BEST. Each category - TD and CS is evaluated separately, and students can only participate in one of them. The winners of each round are decided based on several criteria, supervised by a jury which is composed by professors, experts and company representatives. This jury has knowledge about the given task, specific to each of the categories. The winner in each category is invited to attend the next round of the competition. Having companies present in the event, makes each edition unique and ensures that the tasks are oriented to current industry and corporate world problems, promoting the communication between the employers and their future employee (Nguyen, 1998).

Locally, EBEC Porto is a key event, raising the students and university awareness of our organisation, promoting their involvement in extracurricular activities, and helping the financial stability of LBG Porto. EBEC Porto lasts for 3 days, including an opening and closing session and the competition itself which for 24 hours, straight. The event also counts with smaller, extra tasks that involve students from different teams in order to add some fun and create a more relaxed environment, giving the chance to boost creativity, since these tasks do not take part in the evaluation for the official competition). In recent editions we have received more than 300 applicants, making EBEC Porto an important and one of the biggest extra-curricular activities to happen at the

University of Porto. Specially focussed on students from the Engineering and Science Faculties of the University of Porto (FEUP and FCUP), raising awareness of more than 10.000 students of technological fields.

In the academic year of 2013/2014, EBEC Porto has been recognised as a forming unit by the rectorate of the University of Porto, assigning 1,5 ECTS (European Credit Transfer and Accumulation System) to participants and 2 ECTS to organisers, who each reach a set of proposed objectives. But what makes EBEC so special that it has been recognised as a forming unit, not only to the participants, but also to its organisers? What are students actually developing by organising this activity?

2.1 Workflow EBEC Porto

To acknowledge the requirements and needs for the successful organisation of EBEC Porto, a workflow is presented (Figure 2). EBEC Porto's workflow can be accessed in two different organisational perspectives: team and competition. In the team organisational perspective we address from event definition, coordinator and sub-responsibilities election till the report presentation by those involved. In the competition organisational perspective both case study and team design manuals are tested, as well as all tools and materials to be used and safety procedures are recapped.

There is a coordinator, also known, as Main organiser (MO), who is the ultimate responsible for the event. He/she is responsible, with the management of the LBG, to choose his/her Core Team (CT) upon the candidates and together define the strategy for the event. Always in communication with the rest of the LBG throughout Mailing List (ML) and LBG weekly meetings. Spreading out responsibilities allows the creation of a bigger and better event. With people more focused in details and in technical areas.

The first steps concern the creation of the event's booklet, which describes the event, past editions, this year goals as well as the different partnerships type possible. Those partnerships concern different opportunities this event can represent, i.e.: a company is able to be the creator of the TD topic, present its own CS, make a presentation about its work and what they look forward in students. Those partnerships besides providing better opportunities to participating students have the main goal to cover events costs both financially, in materials or refreshments.

In parallel, the TD topic starts to be created, followed by the testing of ideas and prototype creation using materials that will be available to the participants' finalization of the competition manual that includes both guidelines, rules and safety procedures for the competition. CS is also elaborated in cooperation with a company (or by our own, in case, we do not have a company sponsor that years' CS edition) and feasibility is tested in a controlled environment, as it is not possible to replicate a 24hours CS beforehand. This prototyping and testing, allows us, to create a challenge possible to be executed in the available time, with the available materials and tools, as well as, the definition of specifications to ensure the safety and fairness of the tasks required. During the whole process of the event preparation, happening and follow-up there are constant feedback on the CT work throughout meetings (online or in person) or mailing list (ML).

After the event itself occurs, there is still another phase of work to happen. The follow up to the LBG, partners and supporters as well as knowledge transfer (KT) in the form of report writing for next edition. After the new MO is elected, the current MO has the responsibility of sharing is knowledge and improving aspects for the event.

3 Developed Skills during EBEC Porto organisation

To assess the impact of EBEC Project organisation in the professional skills development of BEST Porto members, feedback was gathered continuously by email and weekly meetings between the members. This input represents seven years of EBEC Porto organisation, where the concept has been improved, by changes and adaptations in result of continuous feedback and knowledge management.

An online survey was recently performed to BEST Porto members (Fall 2015) in order to assess what are the most developed skills throughout the organisation of EBEC Project, as well as if these skills are considered

important by them for a future job application. With a total of 68 respondents (51.5% male; 48.5% female), aged 18-24 years, 91.2% were engineering students while the others were students of science.

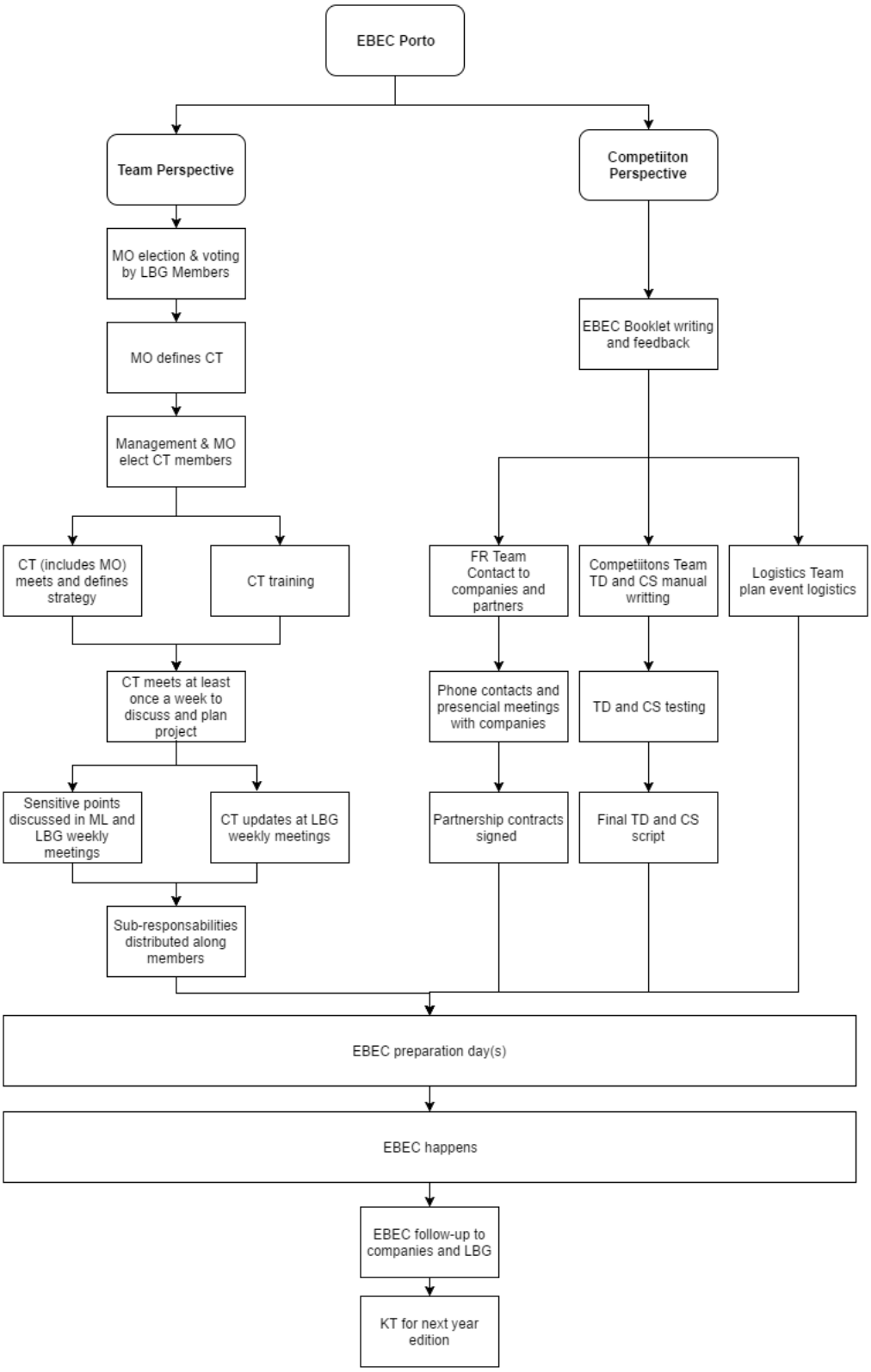


Figure 2. EBEC Porto Workflow. Divided in the organisational as well as the competition point of view. In the first it is described from the MO and CT election, their communication with the LBG and task delegation. On the second the work

of the different teams in order to ensure the content and logistics of the event. MO-Main organiser; CT-Core Team; ML-Mailing List; FR-Fundraising; TD-Team Design; CS-Case Study; KT-Knowledge Transfer.

Of these, 25% were in 2nd year Master/5th year Integrated Master, 23.5% were in 1st year Master/4th year Integrated Master, 19.1% were in 2nd year Bachelor/Integrated Master and 3rd year Bachelor/Integrated Master, 10.3% were in 1st year Bachelor/Integrated Master and, finally, 2.9% considered themselves in another year. Almost half of respondents (41.2%) reported having participated in the organisation of EBEC Project (Figure 1) and 8.8% of respondents reported having participated in EBEC Project both as participant and as organiser in different editions (students can join BEST, after having participating in EBEC, but not vice-versa). The remaining respondents did not participate in EBEC Project as organiser or were participants. Considering the students who participated in the organisation of EBEC Project, when questioned about the soft-skills acquired during the organisation of the event, Teamwork was the most chosen skill (70.6%), followed by work under pressure and problem solving with 67.6% and 52.9%, respectively. On the other hand, the less skills mentioned by the students who participated in the organisation of EBEC Project were Theoretical knowledge (0%), Virtual/online work (2.9%) and university relations (2.9%) (Figure 3).

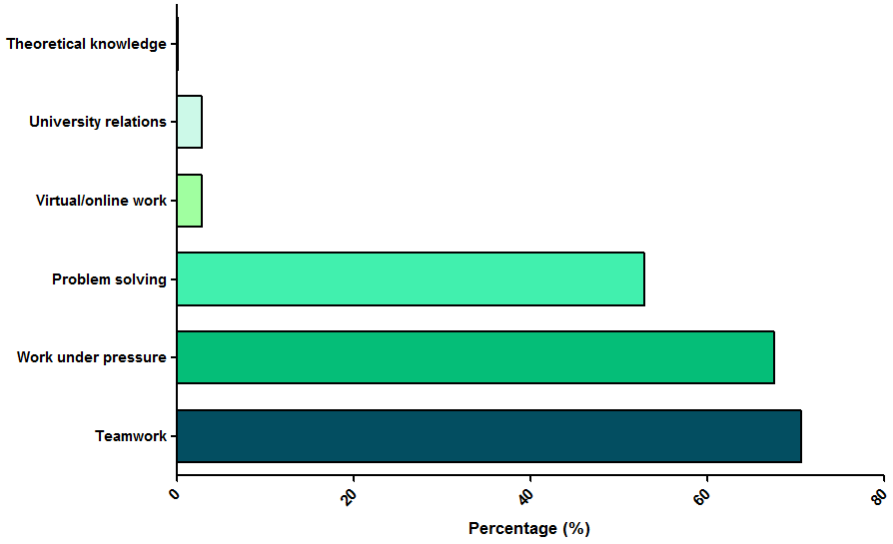


Figure 3. Skills developed the most and least by EBEC Project organisers.

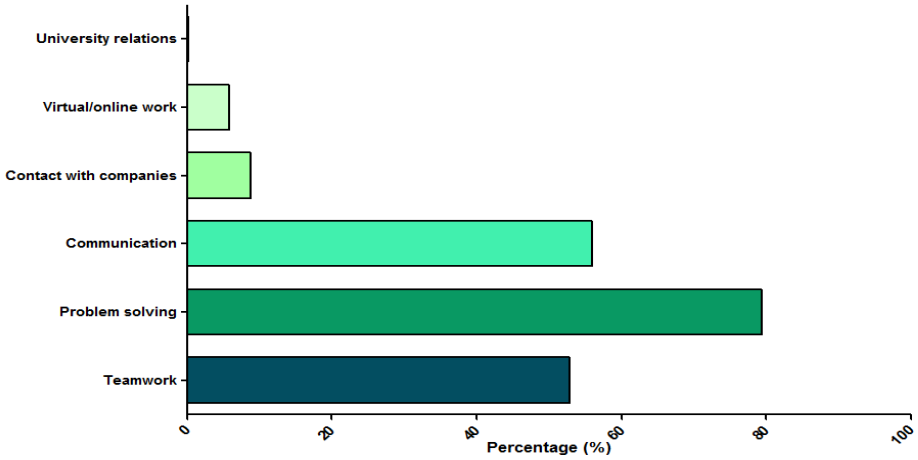


Figure 4. Skills considered the most and least important to employers or funders when hiring for BEST Porto members who have not organised previous editions of EBEC Porto.

When confronted about the importance of the five most mentioned skills to get a job, 78.3% of the organisers consider them very important to get a job; 15% that have some importance, and 6.67% to not be very useful to get a job. Considering BEST Porto members who had not participate in the organisation of EBEC Project, 79.4% of students considered problem solving as the skill most sought employers or funders when hiring; then communication with 55.9% and teamwork with 52.9%. The less mentioned skills were University relations (0%), Virtual/online work (5.9%) and Contact with companies (8.8%) (Figure 4). Results congruent with BEST Porto members who were part of the competition's organisation, however the first considered theoretical knowledge of some importance for companies at time of hiring, being mentioned by 38.2% of participants of EBEC Project (data not shown) who are now BEST Porto members.

4 Discussion

The survey was launched after the first semester recruitment that lead to a high response rate by new members. Consequently 58.8% of the members had neither participate in EBEC as participant or organised. However, 8.8% reported to have had both roles.

Although during EBEC preparation, organisers develop both TD and CS, test TD prototypes and design the evaluation formulas, it seems students do not consider these challenges as theoretical knowledge. Moreover, during the competition itself, theoretical knowledge needs to be applied in order to achieve the winning results, but neither organisers and/or participants have identified theoretical knowledge has been developed during EBEC. Does this mean students find the concept of the theoretical knowledge to be associated with classes only? Perhaps it is the informal, relaxed environment that allows EBEC Project to "escape" the association with theoretical at first sight.

With regards of the skills developed during EBEC Porto, we see that most of the identified ones are considered soft-skills, such as team spirit/teamwork, ability to work under pressure and problem solving (52.9%). Soft-skills have been shown to be important when it comes to employability (Rao, M.S. (2014), thus developing these during EBEC assures one step further in UBC. Students' think employers or funders find problem solving, communication, and team spirit/teamwork relevant when hiring. Interestingly, these three skills have been considered as important from the employers' side as well. It can be shown, for instance, in a study by Burning Glass in 2015, entitled "The Human Factor: The hard time Employers Have Finding Soft Skills" (http://burning-glass.com/wp-content/uploads/Human_Factor_Baseline_Skills_FINAL.pdf) where communication skills were the first baseline skill demanded by the employees, Problem solving was the sixth and teamwork was the 21th.

In the study entitled "Employers' perception of graduate employability, 2010" (more information can be found here: http://ec.europa.eu/public_opinion/flash/fl_304_en.pdf) graduate recruiters find team working, sector-specific skills (or technical skills), communication skills, analytical and problem-solving skills, among others to be the most important. And when searching for what companies expect in newly graduate students: teamwork, problem solving, and communication are the skills most sought by companies such as P&G, and Continental (more information on these companies can be found here: http://pg-fit-tool.com/default.aspx and http://www.continental-corporation.com/www/hr_com_en/themes/students/students_at_continental/). These means students from the University of Porto are not that far out when it comes to assessing the needs of the job market. In fact, Problem solving has been described by an important skill, able to catalyse industrial development (Fink, 2002), which is in agreement with the students' perspective in our research.

5 Conclusion

Soft-skills development plays a crucial role in students' quality of education and adaptability as future professionals. Events that test and enhance those skills in students are lacking. However, EBEC has been proving to be an asset, both for EBEC participants as well as EBEC organisers, as understood by our results. The impact of EBEC and its accreditation as forming unit in students' curricula reflects the conclusion that, in Portugal, the importance of UBC has been recognized, and it has a focus on students.

It is important to see students as future graduates, employees and professionals, for they are whom should play an active role in the development of UBC (Galán-Muros, et al., 2013)).

6 References

Nair, C. S., Patil, A., & Mertova, P. (2009). Re-engineering graduate skills – a case study. European Journal of Engineering Education, 34(2), 131-139

Markes, I. (2006). A review of literature on employability skill needs in engineering. European Journal of Engineering Education, 31(6), 637-650

Andrews, J., Higson, H. (2008). Graduate Employability, 'Soft Skills' Versus 'Hard' Business Knowledge: A European Study. Higher Education in Europe. 33(4)

Fink F.K. (2002). Problem-Based Learning in engineering education: a catalyst for regional industrial development. World Transactions on Engineering and Technology Education. 1(1), 29 - 32.

Galán-Muros, V., Davey, T., Meerman, A., Rivero, S.R., Silva, P. (2013). The state of University-Business Cooperation in Portugal. Science-to-Business Marketing Research Centre, apprimo UG and University Industry Innovation Network (UIIN).

Healy, A., Perkmann, M., Goddard, J., Kempton, L. (2014). Measuring the impact of university-business cooperation. Luxembourg: Publications Office of the European Union

Nguyen, D.Q. (1998). The essential skills and attributes of an engineer: A comparative study of academics, industry personnel and engineering students. Global J. of Engng. Educ. 2(1), 65 - 75.

Rao, M.S. (2014). Enhancing employability in engineering and management students through soft skills. Industrial and Commercial Training. 46(1), 42 - 8.

PAEE/ALE'2016 Poster Submissions

Submissions accepted for PAEE/ALE'2016 poster session.

The Global UCPBL network for PBL in Engineering Education Sharing PBL expertise

Erik de Graaff[1]

[1] UCPBL, Department Development and Planning, Aalborg University, Aalborg, Denmark

Email: degraaff@plan.aau.dk

Abstract

The Aalborg Centre for Problem Based Learning in Engineering Science and Sustainability (UCPBL) officially opened in 2014, expanding the range of the UNESCO chair in PBL and Engineering. During the previous decade Anette Kolmos as chair holder initiated several activities promoting international collaboration on PBL, like the international research symposium for PBL (IRSPBL) organised bi-annually since 2008.

The UCPBL aims to contribute to a greener and more democratic society by reflecting on the role engineers and scientists play and what kind of education they need. In this change-process the kind of change in mind set that is required of teachers with the introduction of PBL is helpful. The UCPBL established a Global Network task force in order to coordinate activities like research symposia, workshops, open access resources, webinars, an international online master programmes for staff development (MPBL) and participation in various projects. The presentation aims to highlight the strategic plans for the future development of the Global Network for PBL in Engineering Education.

Keywords: Problem Based learning; Project Based Learning; Global network; Knowledge sharing.

1 The Shifting paradigm of Higher Education

From kindergarten to university the traditional concept of teaching emphasizes transfer of information from the teacher to the student. The teacher is in charge and directs the study activities of the students. A key characteristic of Problem Based Learning (PBL) is the paradigm shift from teaching to learning (De Graaff and Kolmos, 2007). Students are expected to develop skills as self-directed learners (De Graaff et al, 2015).

Al lot has happened since the introduction of PBL at the medical school in McMaster University in Canada by the end of the seventies of the last century. The McMaster philosophy grounded in a vision on the medical profession, aiming to train doctors with a holistic view on their patients (Neufeld and Barrows, 1974). Discussion of patient cases in small groups allowed students to develop their own professional knowledge base. The method of the Seven Jump was developed in Maastricht to help students organise their own learning process. The role of the teacher changed to that of a facilitator of the learning process, in Maastricht labelled 'tutor' (Schmidt, 1983).

Roughly in the same time frame the Aalborg model of Project based learning was developed in Denmark (Kjærsdam and Enemark, 1994). The model is used in all study domains at Aalborg University. However, the Aalborg model has in particular been successful in engineering. Starting in year one students are set to collaborate in small teams, like engineers often have to do in practice. Their supervisor acts as a coach who helps them to find the right track when necessary (Kolmos et al, 2004).

Following the success of both the McMaster-Maastricht as well as the Aalborg model an increasing number of higher education institutes around the world chose to implement one or another variety of Problem Based Learning. As a result the variety of PBL models at presents is innumerable.

The process of changing into a PBL curriculum is difficult (De Graaff and Kolmos, 2007). The organisation needs to adjust to a different programme structure and the teachers have to make a mental shift adapting to their new role.

2 Expertise on PBL at the Aalborg Centre

The Aalborg Centre for Problem Based Learning in Engineering Sciences and Sustainability, including the UNESCO Chair in Problem Based Learning (UCPBL) is known around the world for its accomplishments in supporting the development of Problem Based Learning. The Aalborg Centre is established as a Category 2

Centre approved by the General Conference of UNESCO in November 2013. The official opening was May 26 2014.

Figure 1. Rector Per Michael Johansen at the opening of the Aalborg Centre.

The overall goal of the Centre is to facilitate that universities play an active role in providing sustainable technological innovations by educating engineers and scientists that are able to participate in and contribute to the development of sustainable solution to the existing societal challenges (Aalborg Centre, 2014). To underline these principles the mission of the centre emphasizes the following points:

1. to create a global society of practitioners, researchers, experts and institutions within the field of Problem Based and Project Based Learning (PBL) in Engineering and Science Education and Sustainability from developing and developed economies
2. to establish international research and doctoral training on PBL and sustainability in Engineering and Science Education
3. to provide global formal education and training for academic staff and students and to disseminate and exchange knowledge and support among society members in terms of how to change engineering and science education for sustainable development at the national, regional and international levels
4. outreach to institutions and schools for attracting students to engineering and science and give HE institutions and governments open access to a body of knowledge, education, training and other resources in order to facilitate PBL and other resources in order to facilitate PBL and Sustainability in Engineering and Science Education.

3 Activities and Scope of the UCPBL

The activities of the UCPBL aim to combine research, education and development in three areas:

1. problem based and project based learning in engineering and science education
2. engineering education research within engineering sciences and
3. education for sustainable development

The activities of the Centre connect university activities to activities in private and public organisations for sustainable technological innovation (see figure 1 below). Besides that the work of the Centre also reflects the UNESCO priorities, like a focus on Africa and gender.

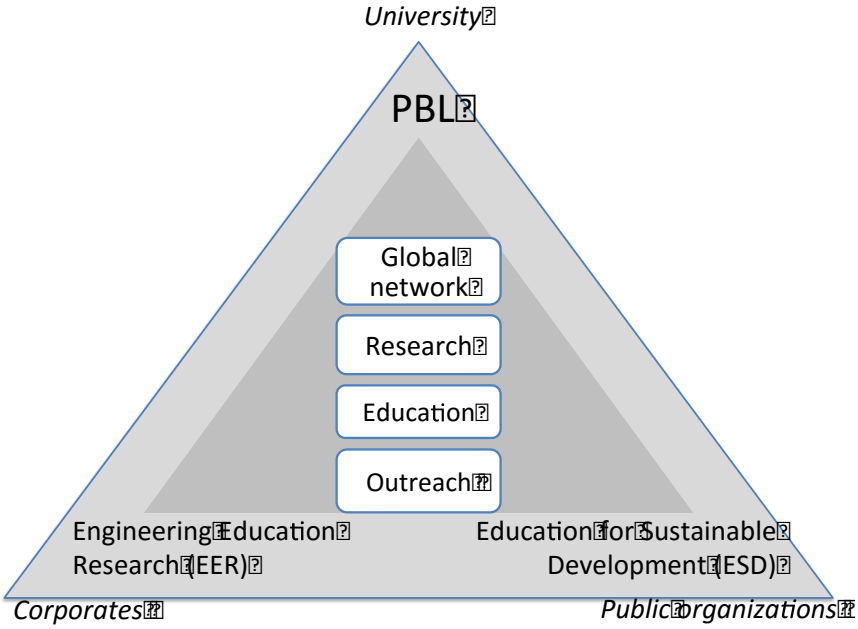


Figure 2. Scope of the UCPBL.

3.1 Research programme and PhD training

In line with the academic tradition, the UCPBL has developed a research programme mirroring the major areas of expertise that are represented in the centre: Implementation of PBL / Management of Change, Evaluation and Assessment, Collaboration with Industry, Science education, Gender studies. Research methodology is a topic of special interest. Exploiting expertise in qualitative as well as in quantitative research methods a mixed methods approach to research is utilized in several studies. Also the benefits of Design Based Research are highlighted.

Within the context of the research programme, the UCPBL offers a comprehensive PhD education on Problem and Project Based Learning. The specific scope of the training at UCPBL is to educate PhD candidates that will be able to do research independently and have knowledge and skills on transforming education. Falling under Danish legislation the PhD training at UCPBL is organised as part of the Doctoral program in Planning and Development. The PhD training consists of two main elements: working on a research project, supervised by one or two members of the academic staff, and following a number of PhD courses according to the Doctoral School Program in order to acquire the necessary competences.

The time schedule for a fulltime PhD research project is three years. The PhD thesis can be a monograph or a collection of articles with a short covering report. The PhD degree is awarded after the PhD candidate publicly defends a thesis reporting an academic research project carried out independently by the candidate. The UCPBL PhD training aims to prepare international PhD students for a career in research, development and teaching in higher education in the private and in the public sector. However, it is possible to arrange a part-time study plan and to work partly at a distance.

3.2 Education and Training

Members of the UCPBL contribute to teaching in the Bachelor and Master programmes of Aalborg University in their own disciplines. Besides that members of the group are for many years active in training first year students in PBL and group skills. The UCPBL also offers an online master program; a formal degree based Master Programme in Problem Based Learning in Engineering and Science (MPBL).

Over the years the UCPBL at Aalborg University has build extensive expertise in working with PBL in engineering education. The centre offers a series of workshops to share this knowledge with interested parties from around the world. Besides the Visitors workshop that introduces the basics of the Aalborg PBL model there is a number

advanced workshops that are dealing with a specific aspect of implementing PBL. On demand it is possible to run a 2-5 day workshop on site incorporating selected elements of these workshops.

Figure 3. An exercise with LEGO in a PBL workshop.

3.3 Global network and outreach

The UCPBL contributes to capacity building in engineering education in countries around the world and participates in educational design and implementation of innovation of teaching and learning in a great number of engineering schools. For many years our colleagues around the world like to come and visit Aalborg, to see in person what it is really like. To meet this demand the UCPBL offers a visitors workshop two time a year, one in Spring and one in the Fall. Both the institutes where we run workshops and the visitors to Aalborg are added to our Global network.

In order to promote research on PBL in 2008 the initiative was taken organise an International Research Symposium on PBL (IRSPBL) in Aalborg. Since then the symposium has grown into a bi-annual event. Co-organising with local hosts the IRSPBL has been held in Melbourne, Australia, Coventry - UK, Kuala Lumpur-Malaysia and San Sebastian – Spain. The next event is planned for Bogota – Colombia in 2017.

The UCPBL supports activities where the university can be a resource for the community. Strategies for developing outreach activities regional as well as internationally will be based on open access to resources.

4 Beyond Problem Based Learning

Aalborg University is founded on the principle that a University has an important function in contributing to society. First of all the university achieves this goal by training highly qualified professionals. However, these days an academic professional must prepare for a career of life long learning (De Graaff & Ravesteijn, 2001). In that respect a bonus advantage of PBL is that students acquire self-directed learning skills.

More and more often the comment is heard that if PBL was 'invented in the end of the sixties' it can no longer be called an innovation. The history of PBL even shows that the principles on which this pedagogy is based are even older. So what will happen to PBL in the future?

One important aspect to which the UCPBL makes a significant contribution is that our ideas on teaching and learning in the future will be more research based than they were last century (Van der Vleuten, 1997). In the future we will be able to differentiate characteristics of PBL that are suitable for specific professional training programmes, or to vary in order to align different cultural context.

Expanding the core element of self-directed learning will result in a fundamental shift in the tasks of university staff. Rather than transferring knowledge the teachers should concern themselves with the management of the ever-increasing professional knowledgebase and organising how students can access the data. As teaching

becomes less important they should be able to spend more time on research and community oriented activities.

5 References

Aalborg Centre (2014). Aalborg Centre for Problem Based Learning in Engineering Science and Sustainability under the auspices of UNESCO. Available at: http://www.ucpbl.net.

De Graaff, Erik; Holgaard, Jette Egelund; Bøgelund, Pia; Spliid, Claus Christian Monrad (2015). When Students take the lead. In: (Re)Discovering University Autonomy: The Global Market Paradox of Stakeholder and Educational Values in Higher Education. Romeo Turcan (ed.). Palgrave Macmillan, 2015.

De Graaff, E. and Kolmos, A. (2003): Characteristics of problem based learning, International Journal of Engineering Education, vol. 17, no. 5, pp. 657-662.

Piaget, Jean (1971) Psychology and Epistemology. The Viking Press Inc. New York. 157 p.

De Graaff, Erik and Kolmos, Anette (2007). Management of change implementation of problem-based and project-based learning in engineering. Netherlands: Sense Publishers. 221 p.

De Graaff, Erik & Wim Ravesteijn (2001) Training Complete Engineers: Global Enterprise and Engineering Education. European Journal of Engineering Education Vol. 26, No. 4, 419-427.

Kjærsdam, Finn, Enemark, Stig: The Aalborg Experiment. Aalborg. Aalborg University Press. 1994

Kolmos, A., Fink. F. K. and Krogh, L. (Eds.) (2004). The Aalborg PBL model – Progress, diversity and challenges. Aalborg: Aalborg University Press.

Neufeld, V.R. and Barrows H.S. (1974). The McMaster philosophy: an approach to medical education. Journal of Medical Education, 49: 1040-1050.

Schmidt, H. G. (1983). Problem-based learning: Rationale and description, Medical Education, 17, 11-16.

Vleuten, C. P.M. van der (1997) De intuïtie voorbij [Beyond intuition] Tijdschrift voor Hoger Onderwijs, 15.1. p. 34-46.

The perception of students on Projects and Workshops with emphasis in Civil Engineering, offered on initial series of a Engineering course

Nathally Dias[1]; Octavio Mattasoglio Neto[1]

Mauá Engineering School, Mauá Institute of Technology, São Caetano do Sul, 09580-900, Brazil

Email: nathallyd3@gmail.com; omattasoglio@maua.br

Abstract

This study aims to evaluate the performance of the Projects and Special Activities (PAEs) related to Civil Engineering area, offered to students of the first series of a School of Engineering Brazil. In this school were introduced Projects and Workshops in the new course curriculum from 2015. In this context, these Project and Workshops entered the course syllabus, primarily in order to provide the student with tools to active participation from the first contact the chosen engineering, once the current job market values professionals who have proactivity, leadership, ability to work in teams, among others. The detailed study of the perception of students ranges from the submission of PAEs to completion, through methodology, resources used, evaluation of teachers and students, among others, crucial points to evaluate the performance of implementing the activities, of the student point of view. A questionnaire answered spontaneously and randomly by students who performed the SAPs offered was used. The purpose of the analysis is to establish guidelines to strengthen these projects and workshops for the next, ensuring feedback on quality and educational excellence, within the structural parameters of the Project Based Learning (PBL).

Keywords: Curricular change; Learning by project; Students perceptions.

A percepção dos estudantes sobre Projetos e Oficinas com ênfase em Engenharia Civil, oferecidas na série inicial de um curso de Engenharia

Nathally Dias[1]; Octavio Mattasoglio Neto[1]

[1]Mauá Engineering School, Mauá Institute of Technology, São Caetano do Sul, 09580-900, Brazil

Email: nathallyd3@gmail.com; omattasoglio@maua.br

Resumo

Este trabalho tem por objetivo avaliar o desempenho dos Projetos e Atividades Especiais (PAEs) voltados para a área de Engenharia Civil oferecidos aos estudantes da primeira série de uma Escola de Engenharia do Brasil. Nessa escola foram introduzidos Projetos e Oficinas no novo currículo do curso, a partir de 2015. Nesse âmbito as PAES, entraram no plano de ensino do curso com o propósito de, primordialmente, proporcionar ao aluno ferramentas que busquem a sua participação ativa desde seu primeiro contato com a área de engenharia escolhida, uma vez que o mercado de trabalho atual valoriza profissionais que tenham como diferencial características como proatividade, liderança, capacidade de trabalho em equipe, dentre outras. O estudo detalhado da percepção dos estudantes abrange desde a apresentação das PAEs até a sua conclusão, passando por metodologia, recursos didáticos utilizados, avaliação pessoal e recomendações finais, pontos cruciais para avaliar o desempenho da aplicação das atividades do ponto de vista estudantil. Foi utilizado um questionário, respondido espontaneamente e de forma aleatória pelos estudantes que realizaram as diversas PAEs oferecidas. A finalidade da análise é estabelecer diretrizes para fortalecer esses Projetos e Oficinas para os próximos anos, visando a qualidade e excelência de ensino dentro dos parâmetros estruturais do *Project Based Learning (PBL)*, que valoriza a autonomia, participação ativa e a busca do conhecimento pelos estudantes.

Palavras-chave: Mudança curricular; Ensino por projetos; Percepções dos estudantes.

1 Introdução

Em agosto de 2013, foi proposta pela reitoria de uma escola de engenharia do Brasil, uma nova ambientação didática com fundamentos do *Project Based Learning* (PBL), buscando fomentar no aluno a proatividade, o trabalho em equipe, comunicação e a facilidade na busca de solução de problema, adjetivos muito procurados pelo mercado de trabalho atual (Mesquita, Lima & Flores, 2014). O PBL foi inserido na grade curricular dos ingressantes da 1ª série em janeiro de 2015, a partir da implementação de Projetos e Atividades Especiais (PAEs), que consistem em cerca de 40 atividades relacionadas aos diferentes ramos de engenharia ministrados pelos professores da escola. As PAEs, em geral, também pretendem envolver os estudantes no contexto da área de engenharia inicialmente escolhida, visto que disponibilizam aos alunos ferramentas tanto conceituais quanto tecnológicas que geram motivação e interesse pelos diferentes aspectos da Engenharia desde a primeira série de curso. Essa disciplina oferece maior liberdade ao aluno, pois ele próprio pode escolher algumas entre diversas oficinas e projetos para realizar ao longo do ano letivo. Para auxiliar nessa escolha foi criada a figura de Tutor da turma, uma espécie de mentor do estudante, que oferece à turma orientação especializada, além de acompanhar o primeiro ano da sua vida acadêmica.

Como 2015 foi o primeiro ano após a implementação da metodologia que tem como base aspectos do PBL, é importante se ter um feedback das respostas dos alunos que participaram dessas atividades (PAES) voltadas para a área de engenharia civil, a fim de debater acerca dos benefícios da aplicação e desenvolvimento da sistematização ativa dentro da universidade e, posteriormente, analisar tópicos que possam ser melhorados ou mesmo eliminados da proposta. O objetivo deste trabalho é, então, realizar uma análise dos dados coletados e se ter uma avaliação na percepção dos estudantes, sobre as PAES com conteúdos de Engenharia Civil que foram oferecidas aos alunos do 1º ano do curso de Engenharia.

Neste trabalho, foi considerado o referencial de Fernandes, Lima e Flores (2009) que utilizam o modelo Contexto, Entrada, Processo e Produto, para analisar a tomada de decisão num currículo. Também foi

considerado os trabalhos de Kolmos (1996) e Kolmos e De Graaff (2007), que tratam da classificação dos projetos aplicados ao trabalho no PBL e sobrea a mudança curricular para o PBL, respectivamente.

Este trabalho é parte de um trabalho maior de avaliação da Reforma Curricular (Mattasoglio Neto, Lima & Mesquita, 2014) pela qual passa essa escola de engenharia, e o recorte que aqui se apresenta representa uma pesquisa de Iniciação Científica.

2 Metodologia

O principal objetivo deste trabalho é analisar e avaliar a percepção de estudantes sobre os projetos e oficinas introduzidos no ciclo básico de um curso de engenharia. Para isso foram analisados questionários com questões abertas e fechadas, respondidas pelos estudantes ao final do curso.

2.1 Contexto de estudo

A escola em foco oferece nove diferentes cursos de engenharia e faz parte de um Centro Universitário Tecnológico, que também possui cursos de Administração de Empresas e Design do Produto. No âmbito de reforma curricular que se está realizando atualmente na escola, foram propostas as PAES – Projetos e atividades especiais, que têm como objeto temas relativos às engenharias oferecidas na universidade, mas também, conteúdos de matemática, ciências, tecnologia em geral e temas transversais, uma vez que o objetivo das PAES é oferecer aos estudantes conhecimentos, habilidades e mesmo contribuir para a formação de atitudes dentro de um cenário no qual o estudante participe ativamente, sendo o protagonista dos trabalhos propostos e, também, dando a ele a oportunidade de escolher aquelas atividades das quais pretende participar.

De um total de quase 100 atividades propostas, cinco estão diretamente relacionadas à Engenharia Civil abaixo classificadas em três diferentes ramos:

Tabela 1 - Oficinas, Projetos e Práticas de Engenharia relativas à Engenharia Civil, oferecidas aos estudantes do 1º período.

Tipo de atividade	Título
Oficinas	Newton em equilíbrio (PRO415)
Práticas de Engenharia	Competição de ponte de espaguete (PRO702); Aerodinâmica das construções (PRO703); Cidade sustentável (PRO705).
Projetos de Engenharia	Projeto de galpão industrial e sua viabilidade (PRO105); Hidrovia Tietê Paraná (PRO109).

As atividades foram oferecidas em diferentes horários, em períodos de 2 horas por semana, usualmente após o horário das aulas, para os alunos do 1º ano do curso de engenharia. Cada estudante deveria cursar ao longo do ano, um Projeto, uma Prática de Engenharia e uma Oficina, e mais uma Prática de Engenharia ou uma Oficina. Isso significa que, ao longo do ano, cada estudante deveria cursar uma média de 5 horas relativas às PAES, por exemplo, 4 horas no 1o semestre e 6 horas no 2o semestre.

2.2 Coleta e análise dos dados

Ao final do ano de 2015 o Tutor disponibilizou aos alunos um questionário com questões abertas e fechadas (Lüdke & André, 1986), relativas à aplicação e desenvolvimento das PAES, o qual foi usado como objeto de estudo para este trabalho. Os questionários apresentam um total de 24 questões, que foram tabuladas e analisadas para compor este trabalho. A síntese dos dados obtidos sobre a percepção que têm de cada uma das Oficinas, Projetos e Práticas de Engenharia, que estão apresentadas a seguir.

3 Dados e resultados

Os dados estão divididos em tópicos de modo a garantir uma melhor compreensão, são eles: Caracterização geral da amostra; avaliação do processo – competências transversais, estratégias de ensino e avaliação no

processo e; considerações gerais sobre as PAEs. Para essa análise, tem-se como referência o trabalho de Fernandes, Lima e Flores (2012) e os trabalhos de Lima, Flores e Hattum-Janssen (2007) e ainda de Lima et al, (2012), ambos relativos ao PBL.

3.1 Caracterização geral da amostra

Os dados da caracterização da amostra são divididos em gênero, período e opção por habilitação do estudante. As Tabelas 2 e 3 trazem a caracterização da amostra para a opção Oficinas, Práticas de Engenharia e Projetos, por Sexo, Período e Curso de origem dos estudantes que realizaram Projetos e Oficinas da área de Engenharia Civil.

Tabela 2 - Opção pelas atividades por gênero e por período

	Masculino	Feminino	Diurno	Noturno
Oficinas	83%	17%	85%	15%
Práticas de Engenharia	71%	29%	78%	22%
Projetos	70%	30%	87%	13%
Total	75%	15%	83%	17%

De acordo com os dados pode-se notar a predominância do sexo masculino em relação ao feminino, fato marcante da desigualdade de sexo observada no mercado de trabalho para essa área de atuação. A diferença entre os períodos pode ser justificada porque algumas atividades são oferecidas com maior número de vagas e diversidade de horários no período diurno, o que representa uma limitação de opção aos alunos do período noturno.

Tabela 3 - Opção pelas atividades de engenharia civil por habilitação escolhida pelo estudante

	Oficinas	Práticas de Engenharia	Projetos	Total
Civil	**31%**	**57%**	**87%**	**66%**
Alimentos	8%	4%	3%	3%
Computação	0%	2%	1%	1%
Controle e Automação	15%	0%	3%	3%
Elétrica	8%	4%	3%	3%
Mecânica	8%	7%	5%	5%
Química	23%	9%	7%	7%
Produção	15%	17%	12%	12%

Conforme esperado, as atividades oferecidas foram mais procuradas pelos alunos do curso de Engenharia Civil, visto que seu conteúdo engloba métodos e aplicações utilizados nessa área profissional. Por sua vez, observa-se que os alunos que têm interesse em outras habilitações, não realizaram uma procura grande pelos Projetos e Oficinas relacionados à Engenharia Civil.

A Tabela 4 traz a justificativa do estudante para a escolha da atividade realizada nos Projetos, Oficinas e Práticas de Engenharia.

Tabela 4 - Opção pelas atividades por habilitação escolhida

	Oficinas	**Práticas de Engenharia**	**Projetos**
Ajudar na escolha de uma área de engenharia	0%	18%	26%
Aprofundar os conhecimentos na área de engenharia que escolhi	15%	**33%**	**58%**
Buscar conhecimento específico de algum conteúdo que necessito/quero ter	**39%**	17%	10%
Desenvolver habilidades transversais (Liderança, empreendedorismo, trabalho em equipe, etc.)	8%	6%	3%
Horário foi favorável	**38%**	**26%**	3%
Sugestão do tutor	0%	0%	0%

Grande parte dos alunos que cursaram as atividades com conteúdo específico de Engenharia Civil não tinham grandes dúvidas a respeito de sua escolha, mas sim buscaram uma forma de aprimorar o conhecimento para nessa área de atuação já no primeiro ano de curso. É interessante notar que o tutor não exerceu influência na opção dos estudantes. Pode-se notar também que houve uma grande parcela dos alunos que ainda optam pela comodidade, escolhendo uma atividade que possui o horário favorável à sua rotina.

3.2 Avaliação do processo na percepção dos estudantes

3.2.1 Competências transversais

Os estudantes apontam que diferentes competências transversais foram alcançadas nas mais diferentes atividades propostas, Tabela 5. Em destaque estão aquelas que tiveram mais pontuação no total de atividades.

Tabela 5 - Competências transversais desenvolvidas

	Oficinas	Práticas de Engenharia	Projetos	Todos
Competências de comunicação	0%	**12%**	7%	19%
Capacidade para lidar com o imprevisto	7%	12%	**14%**	33%
Competências de trabalho em equipe	**21%**	15%	25%	**61%**
Capacidade para resolver problemas	**36%**	19%	14%	**69%**
Competências de liderança	0%	3%	**4%**	7%
Capacidade para inovar	**29%**	10%	7%	**46%**
Competências de organização e planejamento	0%	13%	**20%**	33%
Ética professional	**7%**	4%	3%	14%
Capacidade para tomar decisões	0%	**7%**	4%	11%
Domínio de línguas estrangeiras	0%	**1%**	0%	1%
Empreendedorismo	0%	**4%**	0%	4%

Em geral, as atividades conseguiram desenvolver competências que dificilmente são fomentadas em outros cursos - tais como capacidade de inovar e lidar com o imprevisto - alguns dos aspectos base da metodologia PBL, que busca o desenvolvimento da proatividade estudantil na universidade. O que se nota é que a Capacidade para resolver problemas, Competências para o trabalho em equipe e Capacidade para inovar foram, nesta ordem, as competências transversais que mais desenvolvidas nas PAEs. Já o domínio de Línguas estrangeira, Empreendedorismo e Competências de Liderança, foram, nesta ordem as que menos foram desenvolvidas nas PAEs.

3.2.2 Estratégias utilizadas nas atividades

A Tabela 6 apresenta as práticas predominantes utilizadas nas Oficinas, Práticas de Engenharia e Projetos.

Tabela 6 - Práticas predominantes nas Oficinas, Práticas de Engenharia e Projetos.

	Oficinas	Práticas de Engenharia	Projetos	Todos
Aulas Expositivas	0%	15%	22%	37%
Aulas de resolução de exercícios	17%	4%	3%	24%
Laboratórios/Aulas práticas	18%	11%	11%	**40%**
Seminários	0%	9%	5%	14%
Estudo de caso	9%	7%	13%	29%
Tarefas individuais	18%	7%	3%	28%
Tarefas em grupos	9%	15%	18%	**42%**
Jogos	0%	13%	1%	14%
Projetos individuais	9%	6%	1%	16%
Projetos em equipe	18%	13%	23%	**54%**

Outro aspecto fundamental para a eficácia do curso é o desenvolvimento de atividades dinâmicas, que não se restringe ao método de transmitir informação apenas por aulas expositivas, mas por um conjunto de ferramentas que se mesclam em individuais, em grupos, teóricas e práticas.

Quanto às estratégias utilizadas nas PAEs, Projetos em equipes, Tarefas em grupo e Aulas práticas em laboratório são as mais utilizadas, nesta ordem. O uso dessas estratégias se justifica pela aplicação prática de conceitos do PBL, visto que atividades práticas e em equipes são técnicas para desenvolver a autonomia do estudante e prepará-lo para o mercado de trabalho, no qual a capacidade de trabalhar em equipe é altamente valorizada.

3.2.3 Avaliação nas Oficinas, Práticas de Engenharia e Projetos

A Tabela 7 apresenta as práticas predominantes utilizadas nas Oficinas, Práticas de Engenharia e Projetos.

Tabela 7 - Instrumentos de avaliação utilizados nas Oficinas, Práticas de Engenharia e Projetos

	Oficinas	Práticas de Engenharia	Projetos
Teste/Prova	0%	1%	0%
Seminário sobre trabalhos realizados	**34%**	**39%**	**33%**
Apenas presença nas atividades	**33%**	3%	4%
Relatório de atividades ou experimentos	0%	24%	19%
Protótipos	**33%**	15%	14%
Participação no trabalho em equipe	0%	17%	20%

Como também observado na Tabela 7, os instrumentos de avaliação não se restringem apenas à uma avaliação teórica final, mas sim no desenvolvimento de diferentes atividades e competências ao longo do curso. Também se pode observar a avaliação pela presença, tópico a ser melhorado tendo em vista que apenas a presença não avalia o desempenho do aluno frente à atividade aplicada.

3.3 Considerações gerais dos alunos a respeito das PAES

A Tabela 8 traz dados qualitativos sobre as opiniões relevantes dos estudantes sobre as Oficinas, Práticas de Engenharia e Projetos.

Tabela 8 – Pontos positivos e pontos negativos nas *opiniões pessoais dos alunos sobre as atividades*

Oficinas	Práticas de Engenharia	Projetos
Pontos Positivos		
• **(PRO415)**: Aperfeiçoamento da habilidade em resolver problemas e criatividade; Foi utilizada como ferramenta de auxílio para os estudos de física I.	• **(PRO702):** Desenvolveu a pro atividade e o planejamento prévio; Ferramenta de auxílio para as matérias do 1º ano • **(PRO 705):** Houve aplicação prática do conhecimento adquirido ao longo da PAE na área de civil. Apresentou aos alunos noções básicas de sustentabilidade e planejamento urbano; Foi abordada de uma forma descontraída; Desenvolveu habilidades em lidar com imprevistos. • **(PRO703):** Ajudou os alunos a entender um pouco mais sobre a engenharia civil; Proporcionou conhecimento de diferentes habilidades e ferramentas utilizadas em civil como estruturas, execução de maquete e estudo de vento;	• **(PRO105):** Aprofundou conhecimentos, comunicação com a equipe e desenvolveu habilidades transversais; Colocou o aluno em contato com a engenharia civil, tanto na parte prática quanto teórica (como por exemplo, calcular a pressão de vento na edificação, utilizar termos técnicos e elaborar um projeto de galpão desde a escolha do local, orçamento e até realização da maquete); Auxiliou na matéria de física I; Apresentou aos alunos imprevistos que acontece na realidade profissional. • **(PRO109):** Desenvolveu o empreendedorismo e o planejamento; Abordou conhecimentos técnicos principalmente na área de engenharia civil.

	Teve retorno positivo quanto ao planejamento da disciplina.	
Pontos negativos		
• **(PRO415):** Monótona; Não atendeu as expectativas dos alunos em esclarecer a funcionalidade dos aprendizados na realidade de um engenheiro civil.	• **(PRO702):** A avaliação do aluno foi precária; • **(PRO705):** O planejamento de atividades não foi bem efetuado; Teve pouco espaço físico para a realização das atividades. • **(PRO703):** Muitos alunos se queixaram do excesso de trabalhos.	• **(PRO105):** Os alunos queriam que correlacionassem mais as matérias do 1º ano com a aplicação prática na engenharia civil; • **(PRO109):** A PAE não foi de acordo com o cronograma previamente apresentado.

4 Considerações finais

Este trabalho teve como objetivo analisar a avaliação na percepção dos estudantes, sobre as PAES com conteúdos de Engenharia Civil que foram oferecidas aos alunos do 1º ano do curso de Engenharia. De acordo com os resultados podemos afirmar que a ideia inicial de explorar na universidade o trabalho por metodologias ativas, traduzidas na forma do Project Based Learning (PBL), e o maior contato entre o aluno da primeira série e a área de engenharia civil, foi bem desenvolvida e executada. Esse resultado também se deve ao fato de tanto os professores como estudantes, se engajarem a trabalhar com sistematização ativa de aprendizagem. Os dados indicam que os estudantes consideram que o trabalho promoveu maturidade e liberdade participativa, dando a ele a liberdade de escolha do caminho que seria seguido.

Há predominância de atividades em equipes nas PAEs, e os estudantes percebem que a capacidade para resolver problemas, competências para o trabalho em equipe e capacidade para inovar são as que mais são trabalhadas.

A finalização deste trabalho pode dar subsídios para promover a melhoraria de aspectos tanto relativos à aplicação da atividade para os próximos anos, visto que analisamos dados referentes ao olhar do estudante perante a nova estruturação da matriz curricular. Para a Escola de Engenharia Mauá, esse material pode ser útil para que outros cursos possam também promover mudanças sólidas na sua diretriz metodológica.

Para a proposta de reforma curricular ser realmente eficaz será necessário que coordenadores e responsáveis pelo desenvolvimento do curso estejam disponíveis para amadurecer o método de aplicação dos Projetos e Oficinas a fim de melhorar aspectos didáticos e organizacionais das atividades.

Agradecimentos: Aos estudantes que responderam o questionário possibilitando que fosse realizado esse levantamento.

5 Referências

Fernandes, S., Flores, M. A., & Lima, R. M. (2012, 26-27 July 2012). A Aprendizagem baseada em Projetos Interdisciplinares no Ensino Superior: implicações ao nível do trabalho docente. Paper presented at the International Symposium on Project Approaches in Engineering Education (PAEE'2012): Organizing and Managing Project Based Learning Challenges, São Paulo - Brasil, 227-236.

Kolmos, A. (1996). Reflections on Project Work and Problem-based. Learning. In: European Journal of Engineering education, vol. 21, no. 2, 1996. P. 141-148.

Kolmos, A. and De Graaff, E. (2007) Processing of changing to PBL. In: Kolmos, A., De Graaff, E. (2007) Management of change: Implementation of problem-based and project-based learning in engineering. 2007. p. 31-43. Rotterdan: Sense Publisers.

Lima, R. M., Carvalho, D., Flores, M. A., & van Hattum-Janssen, N. (2007). A case study on project led education in engineering: students' and teachers' perceptions. *European Journal of Engineering Education, 32*(3), 337 - 347.

Lima, R. M., Carvalho, D., Souza, R. M. A. da S. e, Alves, A., Moreira, F., Mesquita, D., Fernandes, S. (2012) A Project management framework for planning and executing interdisciplinary learning projects in engineering education.

In: Project approaches to learning in engineering education. (2012) Campos, L. C. de, Dirani, E. A. T., Manrique, A. L. and Hattun-Janssen, N. van. Rotterdan: Sense Publisers.

Lüdke, M., André, M. E. D. A. (1986) Pesquisa em Educação: Abordagens Qualitativas. São Paulo: EPU, 1986.

Mattasoglio Neto, O; Lima, R; Mesquita, D. (2015) Project-Based Learning approach for engineering curriculum design: the faculty perceptions of an engineering school. Proceedings, Workshop in Project Approach in Engineering Education. 2015.

Mesquita, D., Lima, R. M., & Flores, M. A. (2013) *Developing professional competencies through projects in interaction with companies: A study in Industrial Engineering and Management Master Degree*. Paper presented at the Fifth International Symposium on Project Approaches in Engineering Education, PAEE'2013. Eindhoven, The Netherlands.

Sesoko, V. M. & Mattasoglio Neto, O; (2015) Mapeamento de curso de Engenharia Civil quanto ao desenvolvimento de Projetos e Atividades Ativas. Anais: Congresso Brasileiro de Educação em Engenharia. São Bernardo do Campo, 2015.

Air pollutants and adverse health effects as the subject of the seminars using the new pedagogical approach – case teaching implementation example

Jozef S. Pastuszka[1], Krzysztof Pikoń[1], Monika Czop [1]

[1] Faculty of Power and Environmental Engineering Silesian University of Technology, Gliwice, Poland

Email: jozef.pastuszka@polsl.pl, krzysztof.pikon@polsl.pl, monika.czop@polsl.pl

Abstract

In this paper an example of the new pedagogical approach used in the seminar for the KIC Innoenergy students of technical university is presented. The approach is focused on learning by doing and project based learning with some elements of case teaching. The aim of the seminar is to analyze the case-study of the subject of air pollutants and related adverse health effects, as well as, to prepare appropriate information for decision-makers and for the exposed people, using the rule of the risk communication. This seminar example is based on real life case described in previously published scientific paper which is used as a pre-reading material. The didactic process is based on discussion and brainstorming. The classes are organized in seminar style. In the beginning of the seminar a general discussion about the published data is initiated. Next, the problems of data analysis and the real meaning of problems are discussed. Further discussion is directed towards environmental and economic issues. The social perspective is presented as well.

In the next stage students are engaged in building various scenarios improving the health situation of people living in affected areas. They try to select the best but realistic solution (i.e. solution reducing the health risk and being economically and technically possible) presenting both positive and negative features of each solution. Finally, the preparation of brief information and recommendation for the decision-makers and for the exposed population is provided.

The case described in the manuscript could serve as a good example of case teaching implementation in engineering courses focused on acquiring practical knowledge and skills including the soft ones.

Keywords: active learning, case teaching method, engineering courses

1 Introduction

KIC InnoEnergy masters programs combine the technical skills needed in energy engineering with studying at top European universities, as well as offering courses in entrepreneurship and business. Each of KIC InnoEnergy's programs include 'added value' activities that cannot be found in any other program, such as summer schools, study visits, guest lectures and internships with the leading names in European energy. KIC InnoEnergy has the ambition to be the leading engine in pedagogy by implementing changes in teaching methods and creating new tools for teachers.

It is well known that in the teaching process, the active participation of students, even during the lectures, is very important (Bonwell 1991, Sivan 2000). It could increase the retention rate of knowledge significantly. Therefore, the interaction between the teacher and students is strongly recommended. One of the ways to make the teaching of the environmental health more attractive is the common analysis of the selected case-studies. Such case-studies should be correlated with the specific part /parts of the planned course and give students the opportunity for deep understanding of the theoretical knowledge and to give them the introduction to the new theoretical/general information.

In this paper innovative teaching process and modern way of presentation human health effects due to exposure to air pollutants is presented. Asking the students, during the "classical" lectures, some short, unexpected questions we found that only 30-60 percent of students absorbed the new knowledge. Therefore, we decided to reorganize the course according to the repeating cycle: two hours of lecture during one week and two hours of seminar during the second week. Meanwhile students were obligated to read some research paper or/and to prepare their own presentation.

2 The Case Teaching implementation example

During the teaching of the exposure to traffic-related aerosol near busy roads the analysis of the case-study has taken place. The preparation of the appropriate information for the decision-makers and for exposed people using the rule of the risk communication was implemented.

The aim of this seminar was to assess the influence of airborne particles and benzo(a)pyrene (BaP) on the human health, as well as, the role of the traffic in the exposure to these air pollutants.

Students were asked to refresh their knowledge on the issue brought up previously during the lectures and from the additional pre-reading materials which were indicated in some part delivered to students. Some part of information was prepared to be presented by teacher during the classes when the case was performed.

This seminar example is based on the real sample described in paper entitled: "Assessment of exposure to traffic-related aerosol and to particle-associated Polycyclic Aromatic Hydrocarbons (PAHs), in Gliwice, Upper Silesia, Poland" (Grynkiewicz-Bylina et al., 2005). Using journal publications as a source of information for case building seems to be attractive due to fact that they are usually well structured and are often based on real issues. Sometimes theoretical research could be used as well. But it could change the general character of the case – which according to its definition should be rather real then theoretical.

The teaching process was divided into 5 steps including the home work of students, preparing themselves for the classes, the main teaching and finally the last conclusions which include answer to the main question. During process students must formulate the problem, make value judgements as well as elaborate the proposal of the solution. This make the whole process very close to the challenge driven education approach.

2.1 Step 1 – presentation of the idea

Students were obligated to read (at home) the obtained copies of this paper. Next, two students referred shortly the published data indicating the most significant results. This is important to activate students and refresh their knowledge what is essential for proper performance of the case.

The results of the pilot study of exposure to the airborne particles and PAHs close to a busy street in Gliwice in the spring season are presented. Traffic density in the investigated street between 9 a.m. and 6 p.m. was 1400 vehicles per hour. It was found that average daily concentration of particulate matter 10 µm or less in diameter (PM10) increases by 40 µg/m^3 in the street canyon in relation to places in a distance of 100 m from the road, what for inhabitants who live in this street means the increase of risk of respiratory diseases by ten percent. An average concentration of total PAHs near the street was 191.56 ng/m^3 (in the spring season and without rain) and was over 1.5 times higher than at the point 100 m distant from the street, what confirms, that exhaust gases emission on busy streets elevate the exposure to the total PAHs. However, it does not concern Benzo(a)pyrene (BaP), which main emission sources seem to be industrial and municipal emitters. Exposure to BaP concerns not only the persons who live close to the busy streets, but bigger population of inhabitants in the city.

2.2 Step 2 – general discussion

In step 2 the general discussion on the published data was started. Students tried to compare these data with the results obtained in different cities. Material was deliver by teacher and found by students according to thematic guidance suggested in pre-reading.

In this step lecturer stimulated the discussion asking question about some important problems, especially, the following:

1. What is the essence and real meaning of analysis of traffic density that was provided? (Fig. 1)
2. What concentration levels of PM10 have been found near the road and 100 m away from the road? (Table 1);
3. Which conclusions can be obtained from the analysis of the Polycyclic Aromatic Hydrocarbons (PAHs) levels? (Table 2)

In first question students found that the pattern of the traffic density, shown of Fig. 1, as a function of time is unusual. Instead of two peaks typically appearing in the traffic density in cities, in this case for most of the day the traffic density remains at the same, very high level of 1400 cars/hour with the high contribution of trucks what indicates that the analyzed road was used as the transit way in these years.

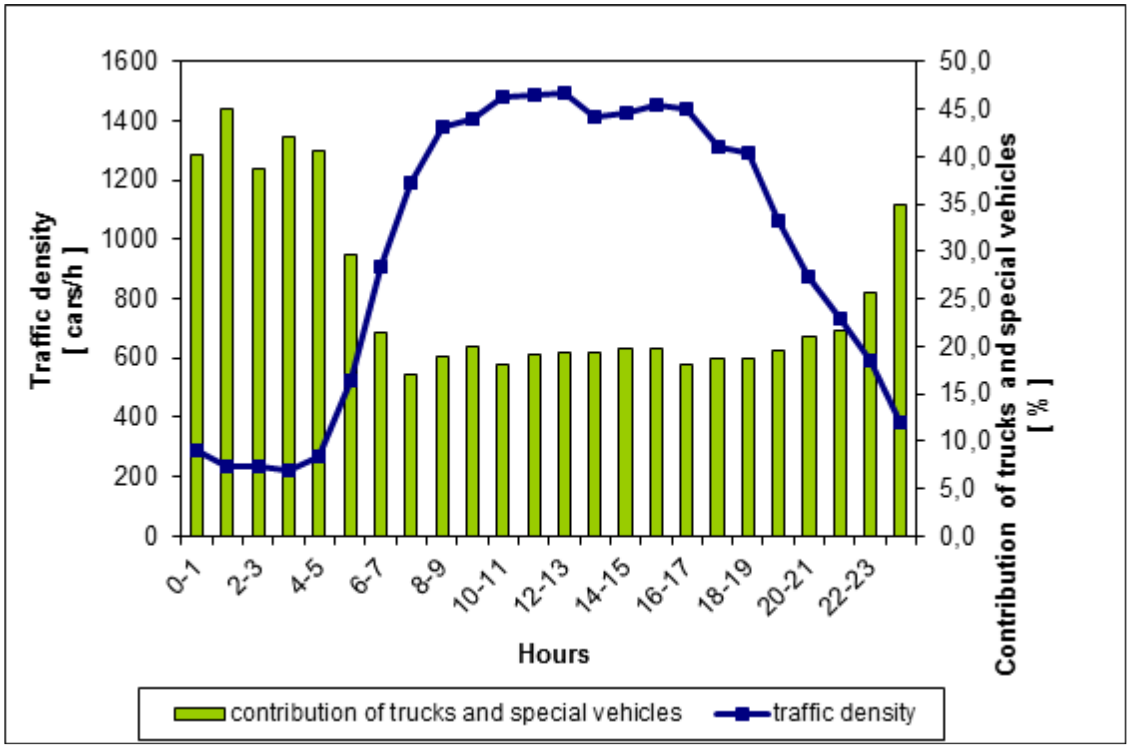


Fig 1. 24 hours traffic density (from: Grynkiewicz-Bylina et al., 2005)

Table 1. Average PM10 concentration on the studied area (Grynkiewicz-Bylina et al., 2005).

Measurement place	PM10 concentration [μg/m³]								
	24 hours			Day			Night		
	average	δn	N	average	δn	N	average	δn	n
street canyon	94.0	33.0	16	125.5	47.5	4	69.0	12.4	6
street canyon – rain	41.9	10.3	6	61.5	9,5	4	40.6	9.2	4
100 m from the road	54.0	15.9	16	42.3	3.8	4	50.2	14.0	4

Table 2. Average concentration of PAHs contained in airborne particles in the studied area (Grynkiewicz-Bylina et al., 2005).

Measurement place	PAHs concentration [ng/m³] day and night			PAHs/PM10 [%]
	Average	δn	N	
street canyon	191.56	102.8	7	0.15
street canyon – rain	141.36	12.0	4	0.29
100 m from the road	118.44	45.2	4	0.28

Classical approach to the aerosol data leads to the conclusion that the PM10 levels are very high (table 1), exceeding the national standard in both, the street canyon and 100 meter from the road. However, students are informed that all the new available data indicate that airborne particles are nonthreshold pollutants (without threshold dose).

Students conclude that these concentration levels are very high compared to different cities. Besides, they know from the paper that the level of benzo(a)pyrene (BaP) was in this area about 5 ng/m^3 in the air (Table 2).

2.3 Step 3 – prognosis of impact

In step 3 the prognosis of the adverse health effects was prepared. This prognosis should answer the question: What does this result mean for the inhabitants living near the street?

It was strongly documented that the increase of concentration of PM10 by 10 µg/m^3 causes the 2 – 6 % increase of respiratory tract illnesses, including asthma. Students immediately find that the daily average of PM10 concentration increases by 40 µg/m^3 in relation to sites 100 m from the road. For inhabitants living in this street, that implies, after simple calculations, about a 10 percent increase of respiratory incidents.

It can be also found that BaP exposure generates cancer risk. It was estimated that the risk of cancer diseases, in the studied area, associated with inhalation of aerosol particles containing BaP is 10-4, but persons living near the investigated street have higher cancer risk of 10-3 order.

2.4 Step 4 – health effects determination

In step 4 scenarios of the improvement of the health of the exposed population are prepared and discussed. In this part of the seminar students discussed various scenarios improving the health situation of people living near the street and the selection of the best but on the other hand, realistic solution (i.e. solution reducing the health risk and being economically and technically possible). After the presentation of all the proposals the lecturer together with the students selected two best scenarios.

2.5 Step 5 – summing up

In the last step the extensive discussion on the obtained result is performed. Finally, students prepared the brief information about the environmental situation which was previously discussed and about its consequences for human health. In addition students are asked to formulate the final recommendation for the decision-makers in order to reduce environmental impact in specific area. This step is very important. It is part of creative work for student.

3 Conclusion

The new pedagogical approach using the case teaching example can be recognized as a success. During analysis of the case study students were very active and enjoined the classes. In order to measure the level of student's satisfaction the special survey was launched. The reference round was conducted in the group of students in previous year when the new pedagogical approach was not implemented. After completion of classes with new pedagogy the survey was launched as well. Results of both surveys revealed that level of satisfaction of student rose form 60% to 85%.

They were not only effectively trained in the application of their knowledge (environmental health field) but they also absorbed some new information very effectively and quickly extended their knowledge on this subject, what was documented by the exams.

The example indicates that the published articles in scientific journals could be the good source of material for cases. Especially when case is built by the author of the manuscript. This is due to fact that usually scientific journals articles volume is restricted to a few pages. This is not enough to deliver all necessary information for 2-3 hours teaching. The published manuscript could be treated as a pre-reading material for students. The condensed and limited content could rise questions during the classes – which is excellent for case teaching.

Example shows that case teaching could be the part of challenge driven education approach and include elements of project based learning and learning by doing. The whole process could be based on learning pyramid to deliver the best results.

Acknowledgement

This paper has been developed as a part of KIC Innoenergy activity in Clean Fossil and Alternative Fuels Energy MSc program (KIC).

4 References

Bonwell, C. and Eison, J., Active Learning: Creating Excitement in the Classroom AEHE-ERIC Higher Education Report No. 1, Washington, D.C., Jossey-Bass, ISBN 1-878380-08-7, 1991.

Sivan A, Wong Leung R, Woon C. and Kember D., An Implementation of Active Learning and its Effect on the Quality of Students, Learning Innovations in Education and Training International, Vol. 37, No 4, pp. 381-389, 2000.

Grynkiewicz-Bylina B., Rakwic B., and Pastuszka J.S., Assessment of exposure to traffic-related aerosol and to particle-associated PAHs, in Gliwice, Upper Silesia, Poland" by and published in Polish Journal of Environmental Studies 14 (2005) 117-123

KIC Innoenergy Msc programs - information available in the Internet (access 5.06.2015): http://www.kic-innoenergy.com/education/master-school/clean-fossil-and-alternative-fuels-energy/

AeroUnisal team - A successful case of a PBL

Dário Tomaz da Silva[1], Gabriella Maria Alves[1], Mayara Silva Mantovani[1], Nicholas Henrique Delfino dos Santos[1], Midori Yoshikawa Pitanga[1], José Lourenço Júnior[1]

[1] School of Engineering, Salesian University Centre of Sao Paulo, Campus of Lorena, Sao Paulo, Brazil

Email: tomaz.dario@yahoo.com, gabriella.marialves@hotmail.com, mayarasmantovani@gmail.com, nicholas.delf@gmail.com, midori.pitanga@lo.unisal.br, lourencojr.jose@gmail.com

Abstract

Learning through projects is important to engage students to problems and conflicts that will be relevant in their professional life. The AeroDesign project is a worldwide competition where students develop an aircraft controlled by radio and loaded with a specified type of cargo. This article will present the learning experience of Aerounisal Project. About fifteen students of different Engineering courses such as Electrical, Civil, Computer, Mechanical, Industrial and Electronics are acting together since 2012. Despite the fact that the University (UNISAL) does not offer a course of Aeronautical Engineering and most of these academic courses began in 2011, Aerounisal Project has faced these challenges. Students assess the aerodynamics to determine the airfoil profile and the best set of wing and empennage to determine the best set of propeller and engine. They also evaluate weight and structure to determine the shape of the fuselage and the materials to be used in the construction of the aircraft to carry a maximum load with minimum structural weight. Stability and control will determine the stability parameter of the aircraft to be easily controlled and with a good stability and electronics will determine electronic components that have to be used. In AeroDesign project, engineering students of UNISAL develop teamwork, where they learn to be proactive and manage interpersonal differences. Overall, the effort of each member has been essential to allow the team to develop faster. Aerounisal took it first plane in same year that group's founding, different of most Brazilian teams that have set-up time of up to five years. The Aerounisal project is a success because of the diversity of engineering knowledge involved through its members, showing its progress every year at SAE Brazil AeroDesign competition, achieving the excellent thirty-first place among sixty-nine experienced teams of South America. The main factors for this result was the dedication and independent studies of each member, the partnerships with researchers from different areas and all perseverance of the team.

Keywords: PBL, SAE AeroDesign, Engineering Education.

1 Introduction

The learning is a continuous process and by nature is interdisciplinary.

In today's world, every professional should be dynamic and able to interact quickly and clearly, seeking the best solution in a short time. In this way during the formation of future engineers is necessary that the undergraduate learn to deal with future situations of the day by day of a factory.

Learning through projects has the ability to engage students with issues and conflicts that will be relevant in your professional life.

The project-based learning is the result of complex tasks based on challenging questions or problems. These projects involve the students in some steps: design, problem solving and decision making or activities research; important fact of the PBL is the opportunity that the student have to of work independently for a time determined taking this produce a realistic presentation of the theory learned (Jones, Rasmussen, & Moffitt, 1997; Thomas, Mergendoller & Michaelson, 2001). The culmination of the project is the report summarizing the procedure used to produce the product and display the result (Prince, & Felder,2006) in the case of the Aerounisal the highlight of the project is, beyond the report, the flight of the projected aircraft. In the Aerounisal the students go through the steps mentioned above, in design stage the students forge the shape of the aircraft; the problem solving is an assessment of the possible faults and also your corrections; the decision-making stage is continuous and happens all the time from the design stage until problem solving.

Learning "with the project is a training that prepares students for the real world through an active process that teaches critical thinking, problem solving, teamwork, negotiation skills, consensus building, technology and

responsibility to own learning" (Sole, & Schrader, 2008). In the Aerounisal, students should be able to conduct tasks, deciding on actions, time management and interpersonal relationships, plan activities, adapt and anticipate actions, as these actions are necessary to solve the problems.

2 AeroUnisal

The Aerounisal project started in 2012 with a group of seven students; where in its conception had as purpose only the competition. During the project development students realized the need for learning in different areas and the importance of connection of ideas, having interdisciplinarity. In this way, the project that in the beginning had as goal participate of the competition, has become a way of dynamic learning in the academic life of its members, because through it the students put in practice inside of a real project with real goals, all the theory they have learned.

The focus of the project developed by engineering students is to build a controlled radio aircraft capable of carrying a load. However, to build such object is necessary that students go through several steps, because a well-designed aircraft must meet the parameters of aerodynamic, performance, electronic, structural construction and stability and control.

In this way the project was divided into five parts in order to analyse each parameter separately, but within the limits of other parameters.

Figure 1. Team and aircraft of competition 2015

2.1 Aerodynamic Analysis

In aerodynamic analysis the team develops three or two airfoils, one to be used in the wing and the other two for the use in the empennage (vertical and horizontal stabilizer, and these profiles may be identical or not). If the team not develop a new profile, they must choose an existing one.

This analysis is also done for the sizing of the wing and the empennage and their geometric shapes besides the aerodynamic analysis of the fuselage, in order to estimate the coefficient of drag and plot the graph of the aircraft drag polar or observe the flow of air around the aircraft as shown in Figure 2 (Anderson,1991; Kroes, & Rardon, 1998).

To comply with the aerodynamic analysis the students must acquire or have knowledge of calculus, physics, fluid mechanics and strength of materials.

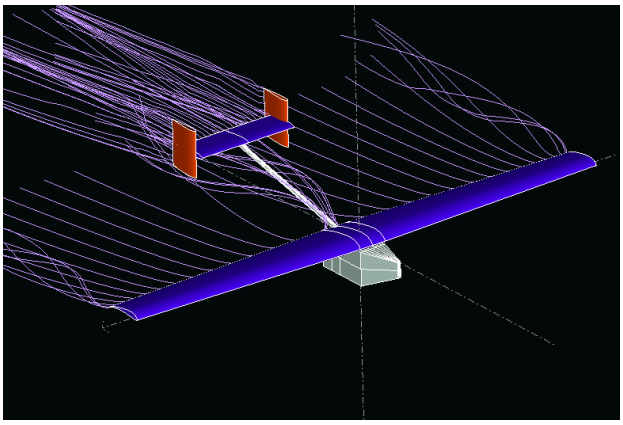


Figure 2. Software used for aerodynamic analysis

2.2 Performance Analysis

At this point, the project team selects the best set of powerplant; the engine must be tested and analyzed with a propeller in order to demonstrate the operational advantages and disadvantages of each propeller configuration and assembly of the engine. The tests are performed on a table (Figure 3) and the analysis is done in software.

With the results the student can interpret and describe operational aircraft information such as maximum take-off weight and required runway length, rate of climb, descent rate, cruise speed, landing conditions including the length of runway to land, besides the density and altitude analysed through graphics and in function of the flight altitude is made a payload graph (Anderson,1991; Kroes, & Rardon, 1998).

In this analysis the student must have or acquire knowledge in calculus, physics and fluid mechanics.

Figure 3. Engine tests table

2.3 Electronic and Structural Analysis

The electronic analysis is performed to optimize the selection of servo motors and the aircraft battery, consequently the team can choose better the components to hold a high-level competition. To accomplish this effectively analysis the student must have or acquire knowledge of basic electricity, electronics analogical and digital (Kroes, & Rardon, 1998)

An aircraft must be dimensioned, for this the structural analysis is done. In this analysis is performed the dimensioning of the wing, fuselage, tail and of the landing gear (Anderson,1991).

To achieve a good structural performance, an analysis is made of possible materials that can be used in the aircraft. After the selection of materials, proper calculations are done to dimension each part of the AeroDesign, so the entire aircraft structure can be able to support the action of the forces that acts on it. In addition it is

made the diagram of internal forces, the distribution of support along the spar of the airfoils and the criteria of strength landing gear. Then with the theoretical results in hands an analysis / simulation in a specific software is carried to ensure that the theoretical sizing is near of the reality. In Figure 4 is possible to observe a structural test of the fuselage of the 2015 competition.

This analysis requires of the student knowledge of mechanics of solids, strength of materials, calculus, physics and theory of structures.

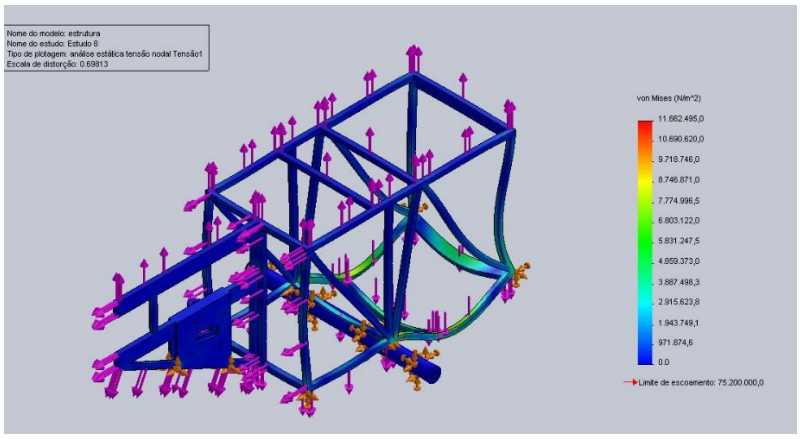


Figure 4. Structural analysis software

2.4 Stability and Control Analysis

Stability and control is an analysis divided in two situations: static and dynamic. To be dynamically stable an aircraft must be statically stable (Ly, 1997). Therefore, first is carried the static analysis. Dynamic analysis is complex and difficult to be done, for this is used software support.

At the beginning of the stability activities the student determines the aircraft's centre of gravity as well as the ride from the centre to the conditions of maximum load and minimum load (Nelson, 1998).

Every analysis of stability, whether static or dynamic, is made in three directions: longitudinal, directional and lateral (Ly, 1997; Nelson, 1998).

The results are shown in graphs and by interpreting these graphs, it is possible to determine if the aircraft is stable or not. An example is shown in Figure 5, where is shown the response time for the Dutch roll movement with satisfactory results.

In this analysis the student must have or acquire knowledge in calculus, physics, signals and linear systems, non-linear signals and modern control systems.

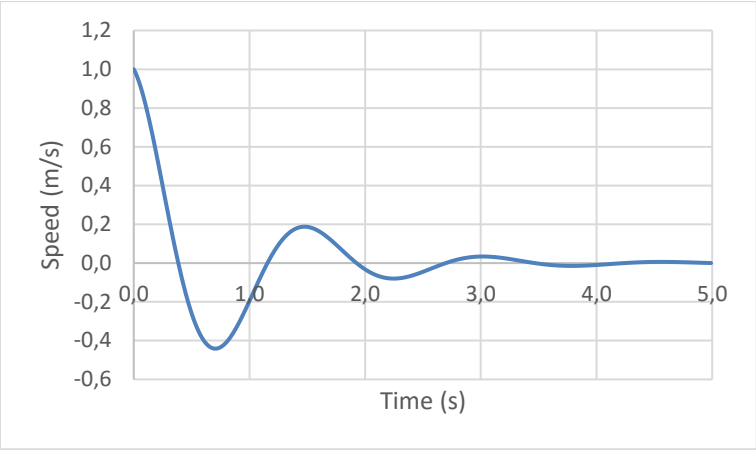


Figure 5. Analysis of Dutch roll response time

3 Progress within the Competition

The Aerounisal team has been evolving their performance in the competition every year, it can be noted when comparing the performance of Aerounisal with other teams that started their participation at the same time, that is in 2012 or 2013.

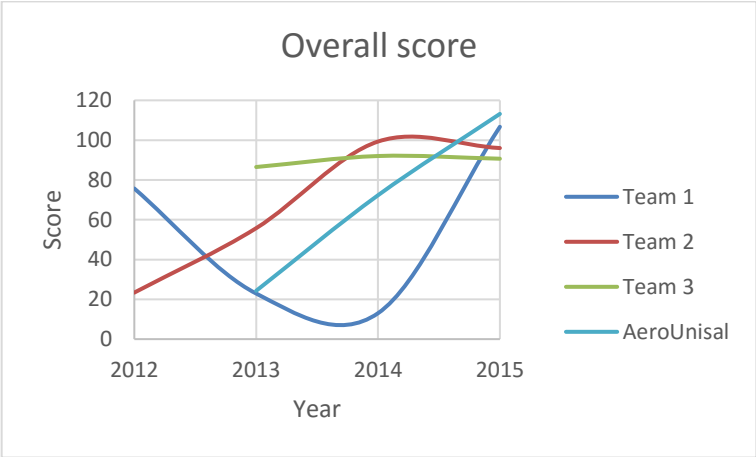


Figure 6. Comparison of overall score

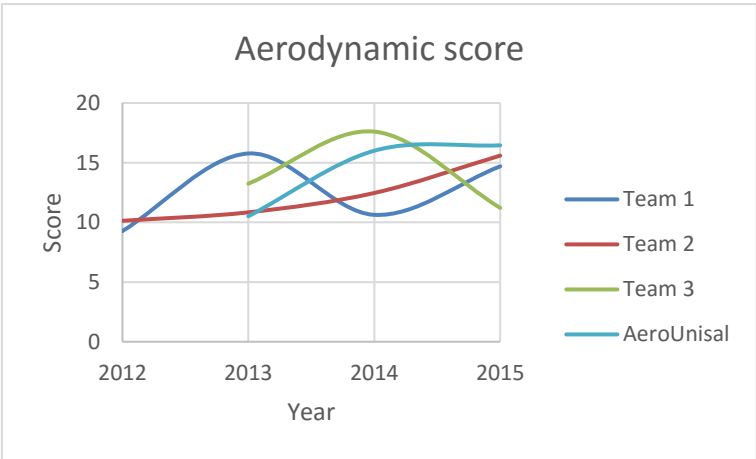


Figure 7. Comparison of aerodynamic score

Aerounisal team managed to have its performance increasing and constant, unlike other teams. As can see in the graph shown in Figure 6.

Another important aspect that should be pointed out, is the performance in aerodynamic studies. Of the three analyzed teams, two have courses of aeronautical engineering at their college, what results an advantage because they have a much larger knowledge in this area and teachers with such training that they can appeal. Nevertheless, Aerounisal showed a performance near or at times superior than these teams. We check this in Figure 7.

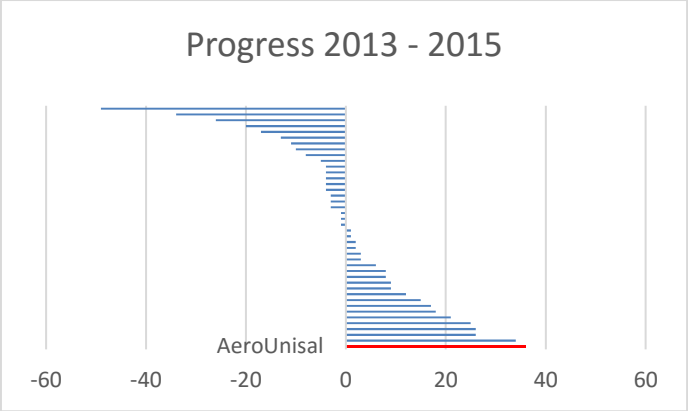


Figure 8. Comparison of progress in the classification

Looking the classification of the teams that participated during the three last years and comparing the progress of each team on a graph as shown in Figure 8, it is possible to observe that Aerounisal has advanced a total of 36 positions, being the best in this analysis.

4 Result

The Aerounisal results in the learning process are clear and objective.

According with the figures 6, 7 and 8 the students in the project had an evolution in the competition and this improvement is a result of knowledge gained from the project through the practice and developments in the search for optimizing increasingly AeroDesign.

Similarly, there was an increase in yield and academic performance, as it was said before each project area is linked to some disciplines, and what was learned from the project was also used in the classroom to facilitate the student's understanding of the given matter.

As an example, in fluid mechanics students learn about flow, and to determine the type of flow these students must calculate the Reynolds number, but he does not see the flow and do not understand the differences between laminar flow and turbulent, because they don't see them.

On the other hand, the student who participates in the Aerounisal beyond to understand the theory also makes assays, both in software as in made wings, and so it has the vision in the practice of what is each type of flow and the which causes changes beyond see a real application of what is learned. The same applies to many other disciplines.

5 Conclusion

The Aerounisal is a project that, as shown, requires that students be responsible, mature to deal with interpersonal differences and dedicated to learn and improve their knowledge in different areas and know inter-relate them in order to achieve the objectives of the team, which is the construction of a controlled radio aircraft. Thus the Aerounisal is an interdisciplinary project helping the learning of university students.

Project Basic Learning is not only efficient but also effective, which makes of it a valuable tool in training professionals increasingly well prepared and qualified to the job market, because their vision are fully adjusted in how to deal with projects and people, since from the beginning they learn to interrelate the knowledge acquired.

6 References

B. F. Jones, C. M. Rasmussen, and M. C. Moffitt, Real-life problem solving: A collaborative approach to interdisciplinary learning. Washington,DC:American Psychological Association, 1997.

J. W. Thomas, J. R. Mergendoller and A. Michaelson, Project-based learning: A handbook for middle and highschool teachers, Novato, CA: The Buck Institute for Education, 2001.

M. J. Prince and R. M. Felder, Inductive Teaching and Learning Methods: Definitions, Comparisons, and Research Bases. Journal of Engineering Education, 95(2), 2006, pp. 123–138.

J. Sole and D. Schrader, Getting real: The Philadelphia story. Designing for the Future of Learning. RetrievedMay19, 2008, from ttp://DesignShare.com, 2007.

Anderson, J. D. Fundamentals of Aerodynamics. 2ª Ed, McGraw-Hill, Inc. New York 1991.

Kroes, M. J., & Rardon, R. J., Aircraft Basic Science. 7ª Ed, McGraw-Hill, Inc. New York 1998.

Ly, Ui-Loi. Stability and Control of Flight Vehicle, University of Washington. Seattle 1997.

Nelson, R. C., Flight Stability an Automatic Control, 2ª Ed, McGraw-Hill, Inc. New York 1998.

Strengthening competences of engineering graduates through supplementary actions - experience gained

Jacek Kalina[1]

[1] Department of Energy and Environmental Engineering

Email: jacek.kalina@polsl.pl

Abstract

The paper presents results and conclusions from a 3.5 year educational project carried out at the Faculty of Energy and Engineering of the Silesian University of Technology which could be the basis for pedagogical evolution activities in KIC InnoEnergy programme carried out at the University. The project titled "Competent mechanical engineers for the energy sector" was financed by the Polish National Centre for Research and Development within the Human Capital Operational Programme (HCOP). The project responded the challenges posed by the programme. The main objective was to increase the number of graduates of the first degree full-time Mechanical Engineering course, specialised in issues of the energy sector and increase their professional competence and competitiveness in the labour market. The objective was planned to be achieved by enhancing the attractiveness of university studies and extending the teaching offer beyond the basic course curriculum. The project was composed of sixteen supplementary actions such as scholarship programme, remedial classes, internships in industrial plants, seminars, specialised trainings, participation in fairs and conferences, lectures provided by specialists from industry, best scientific paper competition and project based learning. The ambitious target was set that assumed 45 students out of 55 starting the course would completed it within the standard time of 3.5 years. The results show that the target was not met and project performance was much under expectations. In the paper the main problems are being identified and discussed. There are also presented results of project evaluation made by students within midterm and final questionnaires

Keywords: Engineering Education; Building Competence, Evolution of Teaching Methods

1 Introduction

Engineering education in Poland and many other countries is based mainly on traditional methods. First two years are devoted to basic sciences elementary courses such as mathematics, physics, chemistry, mechanics, thermodynamics, heat transfer etc. Most of the subjects are taught using chalk and black board. The students are exposed to the vast amount of theory that is presented to them in a passive way. As a mismatches exist between common learning styles of engineering students and traditional teaching styles of engineering professors, students do poorly on tests, get discouraged about the courses and in some cases drop out of school (Felder & Silverman, 1988). The highest number of students resign from the technical studies within first and second semester. What is more, the feedback from the industry shows that the graduates lack skills and competences that are required at the current labour market. As the key attributes of the engineering graduate employers indicate: good communication skills, problem solving ability, learning ability, creativity, critical thinking and adaptability to diversified working environment. The pure knowledge and hard competences are not so much valued anymore.

It was observed in Poland that technical studies were gradually losing interest of the candidates (Grotkowska, Gajderowicz, Wincenciak & Wolińska, 2014). Central Statistical Office of Poland revealed that percentage of graduates from public engineering schools dropped from 6.24% in 2007, to 5.74% in 2010. In the same time the demand of the economy for skilled engineers remained high, what could be concluded from the number of available job offers.

In order to prevent the unfavourable trends in 2008 the Ministry of Science and Higher Education of Poland initiated the programme of the ordered courses. The programme was aimed at increasing the number of students in the fields of strategic importance for the development of the economy. Within the programme universities offered scholarships to students and organised educational projects that were supplementary (but

not obligatory) to the main course of study. Different educational projects were financed at different public and private universities.

In this paper performance of one of such projects is discussed. It brought interesting results and conclusions that are now being used to structure curriculum of the Master course titled Clean Coal Technologies that is offered by Silesian University of Technology within the framework of the European Institute of Innovation Technology (EiT) and InnoEnergy Knowledge and Innovation Community (KIC) aiming at finding and promoting innovative solutions in the field of sustainable production and use of energy. Students attending the course benefit from added value activities such as summer schools, winter ateliers, study visits and lectures from industry experts. Similarly to the programme of the ordered courses the EIT KIC programme is an example of evolution of didactics in engineering education.

2 Project description

The project titled "Competent mechanical engineers for the energy sector" responded the challenges posed by the programme of ordered courses. The main problem addressed by the project was small number of graduates of the first degree full-time Mechanical Engineering course at the Department of Energy and Environmental Engineering. In the academic year 2009/2010 the number of students enrolled in the course was 50, in 2010/2011 it was 20 and in the year 2011/2012 it was 32. The ambitious target was set that assumed 45 students out of 55 starting the course in 2012 would completed it within the standard time of 3.5 years.

The project was launched as a parallel to the primary course of study and therefore participation in particular actions was not obligatory. The project was composed of sixteen supplementary actions presented in table 1. Within each action there were different numbers of specific tasks.

Table 1. Supplementary actions in the project "Competent mechanical engineers for the energy sector"

Action no.	Action name	Number of tasks	Semester at which the action took place
1	Remedial courses on mathematics, physics and informatics	3	1
2	Motivating scholarships for 50% of students	-	1 to 7
3	Three month paid internships in industrial plants	10	4
4	Paid internships in research and development centres	1	4
5	Specialised trainings on topics agreed with industrial partners	3	6, 7
6	Lectures provided by specialists from industry	3	4, 5, 6
7	Visits in industrial plants connected with seminars	2	5, 6
8	Participation in industry fairs	2	1, 5
9	Participation in thematic conference	1	7
10	Four semester course "Organisation and Management in Industry"	1	4 to 7
11	Specialised training titled "Environmental impact assessment of investments in the energy sector" (obligatory action)	1	6
12	Seminar with industry titled "Shaping professional competence in mechanical engineering for the energy sector"	1	2
13	Summer school "Computer aided design of machinery and devices"	1	2
14	Workshops "The use of advanced computer programs for engineering analysis"	3	5, 6, 7
15	Competition for scientific paper written by student	1	6
16	Student grants for individual projects	3	3 to 6

Almost all of the first semester students of Mechanical engineering course signed the declaration of participation. However, in particular actions less students took part. What was surprising that actions such as internships (Nos. 3 and 4), workshops (No. 14), student competition (No. 15) and individual projects (No. 16) appeared not to attract students. It was difficult to find 13 candidates for the three month summer internships

in industry (although students were paid salary). Workshops were attended by 30 - 50 % of project participants. In student competition only 3 students submitted papers. They obviously took places 1, 2 and 3 and won prizes. The first prize was participation in the international conference ECOS 2015. Second and third place were awarded participation in national conferences.

Within the programme of individual grants the students were supposed to create groups and work on a project defined by academic teachers. Students were offered six topics for projects. The budget was for three projects. Each group received 30 000 PLN (7500 EUR) to perform research. Additionally students were supposed to prepare scientific paper that could be presented at a conference. Each group was assigned a supervisor. Initially 11 students in three groups took part in the action. However during the course of studies one group was totally reformed. The students who initially started the project appeared to be passive. Most of them resigned from the studies at all. At the end of sixth semester three projects were completed and the final number of participants was seven. However these seven students prepared 8 good quality papers that were presented at Numerical Heat Transfer 2015, Eurotherm Seminar No. 109, 3rd Polish Congress of Mechanics and 21st International Conference on Computer Methods in Mechanics, VI International Congress on Combustion Engines and International SDEWES 2015 Conference in Dubrovnik. Some of these paper were invited to renown scientific journals.

It seems that students were mostly interested in actions that were attractive and not demanding their work in additional time. Trips were the most attended events. They were organised within actions no. 7, 8, 9 and 13. Students expressed also high interest in specialised trainings provided by external companies. After each training the students were given certificate of completion and competences. As it is a valued paper in the labour market the students were encouraged to take part in trainings. However in the action no. 11, that was also the training but not directly connected with the profession (but set as obligatory by the Ministry), only 26 out of 34 project participants appeared.

The most critical issue of the project was the number of participants. The projects was designed for 55 participants and it was assumed that 45 of them would finish the main course of studies within 3,5 years of project duration. However after first semester the number of students decreased to 42. It was obvious that the target would not me met. The final numbers of students that completed the course was 34. Flow of students within the project is illustrated in Fig. 1. The highest number of participants left the project just after exam sessions in second and fifth semester. These were students that either had to repeat the semester or left the university at all. In the same time new students, that repeated semester from the previous year were joining the project. Nevertheless the net balance of participants was negative.

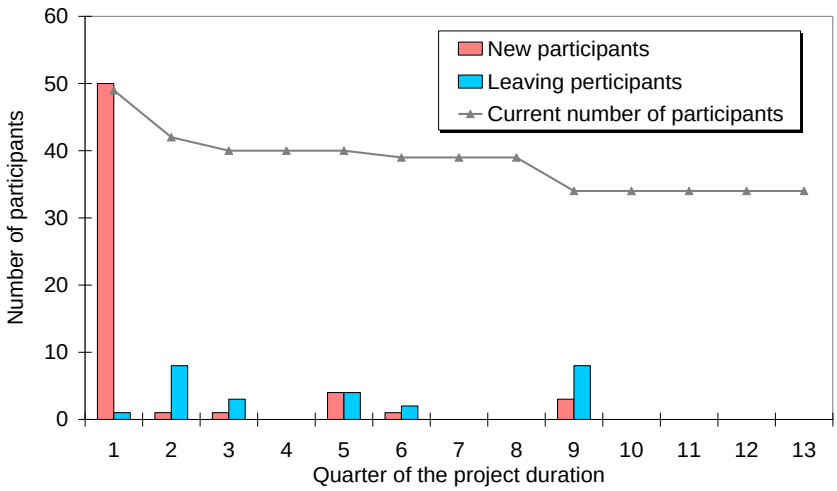


Figure 1. Flow of participants within the project

3 Project evaluation by participants

In order to create changes in education the universities have to have feedback from students. In the country scale a research was performed by the PSDB company on the order of the Ministry of Science and Higher Education (Grotkowska, Gajderowicz, Wincenciak & Wolińska, 2014). It appeared that the programme met the target. Technical disciplines were promoted. The most popular discipline in the country in 2014 was informatics. Mechanical engineering was on the fifth place. What appeared to very interesting, only 33% of the respondents within the discipline of mechanical engineering said that scholarships influenced the decision on starting the studies. According to the results of research in the country scale 24% of students resigned from studies (Grotkowska, Gajderowicz, Wincenciak & Wolińska, 2014). As the main reasons to break studies the respondents indicated: course was not interesting (44%), course was too demanding (26%), it was not possible to connect studies with work (26%), it was not possible to study two disciplines at the same time (11.3%) and quality was too low and not professional (10.3) (Grotkowska, Gajderowicz, Wincenciak & Wolińska, 2014).

Evaluation of the project itself as well as the particular action was performed. There were questionnaires distributed among the project participants in the middle of the project and at the end. In the final questionnaires we asked student to give us their opinion about the decision they made to study mechanical engineering and to take part in the project. The answer is illustrated in fig. 2 (29 responses).

In table 2 agreement to the sentence "The action meets real needs of students" is expressed. According to students most of the actions planned within the project met their needs. The worst actions were 11, 12 and 15, that were also attended by the lowest number of participants. The actions that met students' needs at most were (highest share of responses "strongly agree" and "agree"): workshops (14), visits in industrial plants (7) seminar with speakers from industry (12) and summer school (13) that was organised in hotel in mountains.

We also asked which of project actions promote direction of education and influence the decision to start studies. Students were supposed to give points from 0 (no influence) to 10 (very strong influence). Answer to this question is presented in fig. 3. The highest importance was attributed to scholarships. This is different result from that presented in (Grotkowska, Gajderowicz, Wincenciak & Wolińska, 2014). The actions of high influence are also internships and specialised trainings with certificates of competences. Individual projects took the sixth place after workshops and participation in conferences.

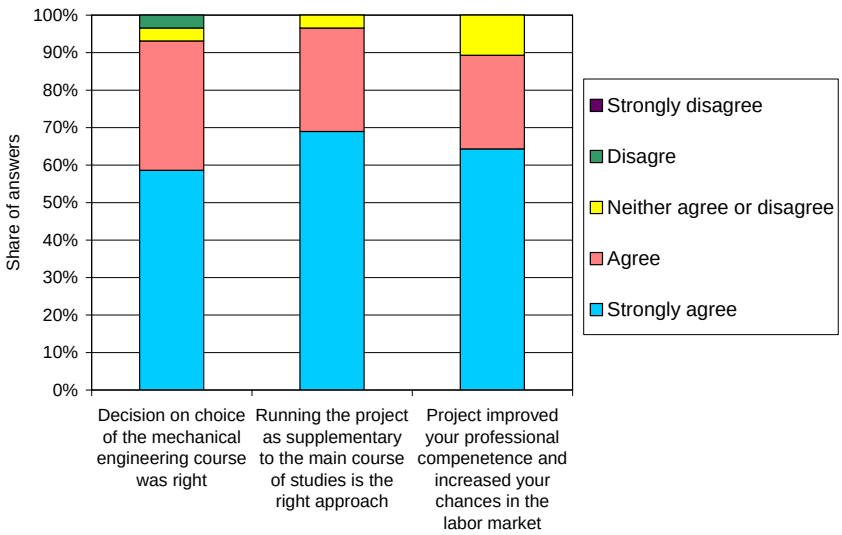


Figure 2. Answers to general questions

Table 2. Agreement to the sentence "The action meets real needs of students"

Action no.	Action name	Number of questionairs returned	Strongly agree	Agree	Neither agree or disagree	Disagre	Strongly disagree
1a	Remedial courses on informatics	24	20,8%	50,0%	16,7%	12,5%	0,0%
1b	Remedial courses on physics	21	28,6%	42,9%	0,0%	28,6%	0,0%
1c	Remedial courses on mathematics	24	45,8%	41,7%	12,5%	0,0%	0,0%
2	Motivating scholarships for 50% of students	25	44,0%	48,0%	8,0%	0,0%	0,0%
3 and 4	Three month paid internships in industrial plants and R&D centres	22	40,9%	40,9%	13,6%	4,5%	0,0%
5	Specialised trainings on topics agreed with industrial partners	25	32,0%	52,0%	4,0%	12,0%	0,0%
6	Lectures provided by specialists from industry	29	37,5%	70,8%	8,3%	4,2%	0,0%
7	Visits in industrial plants connected with seminars	28	50,0%	46,4%	3,6%	0,0%	0,0%
8	Participation in industry fairs	27	18,5%	63,0%	3,7%	3,7%	11,1%
9	Participation in thematic conference	25	40,0%	40,0%	12,0%	8,0%	0,0%
10	Four semester course "Organisation and Management in Industry"	28	14,3%	28,6%	32,1%	25,0%	0,0%
11	Specialised training titled "Environmental impact assessment of investments in the energy sector" (obligatory action)	25	8,0%	24,0%	24,0%	36,0%	8,0%
12	Seminar with industry titled "Shaping professional competence in mechanical engineering for the energy sector"	32	31,3%	68,8%	0,0%	0,0%	0,0%
13	Summer school "Computer aided design of machinery and devices"	38	29,0%	65,0%	6,0%	0,0%	0,0%
14	Workshops "The use of advanced computer programs for engineering analysis"	28	67,9%	28,6%	3,6%	0,0%	0,0%
15	Competition for scientific paper written by student	25	20,0%	12,0%	24,0%	32,0%	12,0%
16	Student grants for individual projects	21	42,9%	33,3%	19,0%	4,8%	0,0%

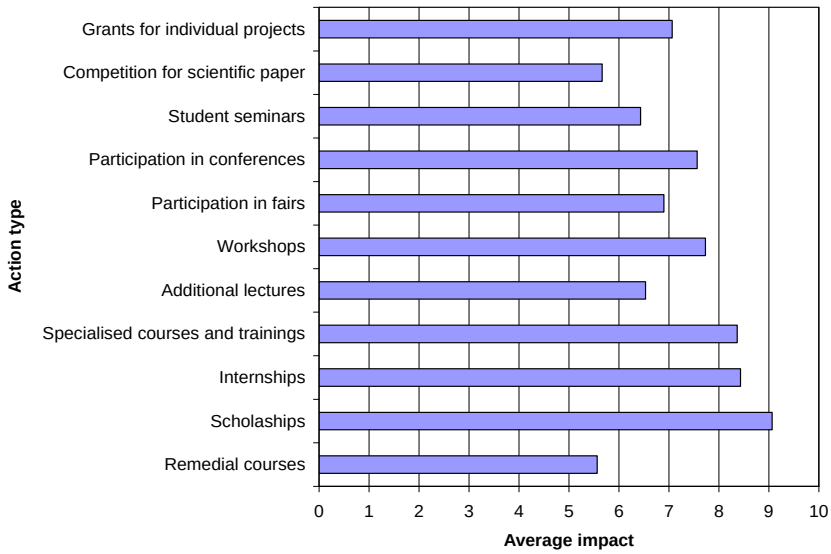


Figure 3. Influence of curriculum components on candidates decision to start the course

Within the project there were three actions that required from students their work input to solve practical tasks. These were specialised trainings, workshops and individual projects. Students were asked to evaluate impact of these actions on building their competences. Answers are given in fig. 4 to 6.

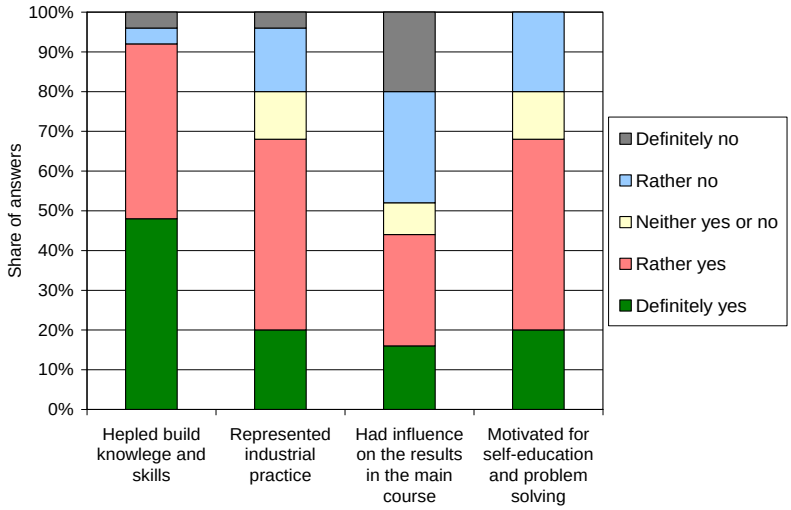


Figure 4. Evaluation of specialised trainings (action 5)

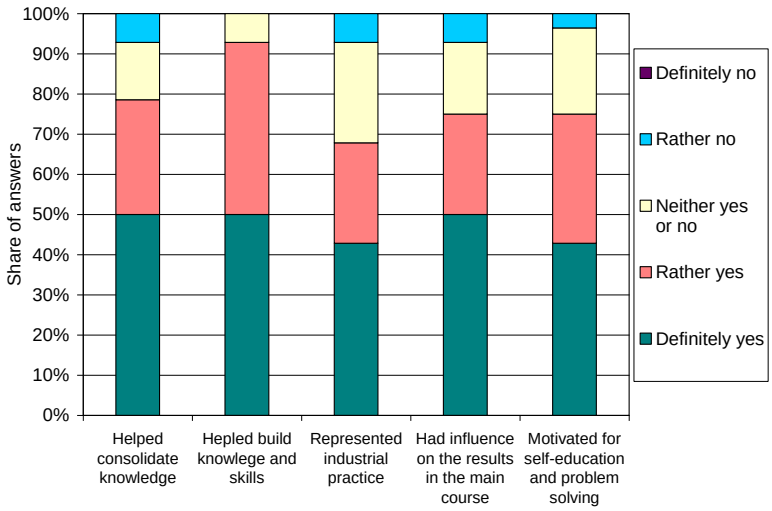


Figure 5. Evaluation of workshops (action 14)

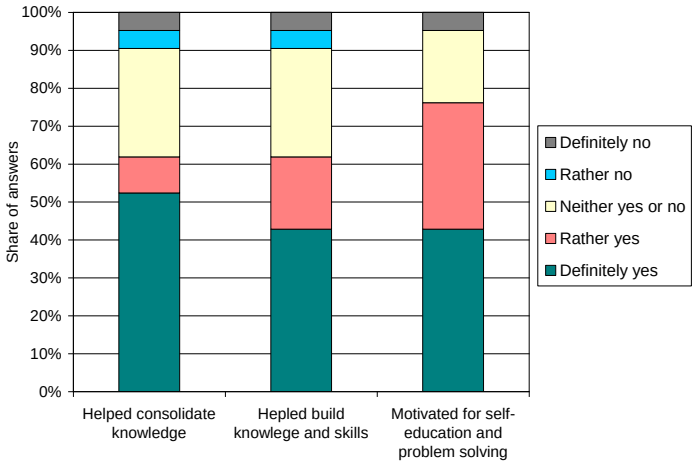


Figure 6. Evaluation of grants for individual projects (action 16)

4 Conclusion

The traditional teaching methods used for training civil engineers are currently being called into question as a result of the new knowledge and skills now required by the labour market (Reyes & Gálvez, 2011). It is well known fact that evolution of traditional teaching methods is required in order to keep up with changes in the real world environment. Universities have to introduce new elements to engineering curricula. It is very important to attract students with engineering courses as well as to offer them a sort of guarantee of the good start in the labour market. Development of the right approach to these issues is not a trivial task. Some researchers say that academics must focus on teaching engineering design practically and staff should undergo practice rather than theory in the classroom (Chandrasekaran, Littlefair & Stojcevski, 2015). The results of our project show that it should be performed in a rather guided way. The workshops and trainings were evaluated by students better than individual projects. It seems that the issue of a prize is also important. The actions where the students obtained some additional benefit such as for instance certificate of competence were the most wanted and well attended.

Our results revealed that actions designed within the project motivated candidates to start the studies in promoted field. On the other side however the motivating factors were not strong enough to keep students within the group. Some of them did not manage to get positive grades and had to repeat the semester or leave the university. The target of the project related to the number of students at the final semester was not met and project performance was much under expectations.

5 References

Felder R. M., Silverman K. L. (1988): Learning and Teaching Styles In Engineering Education. Engr. Education, 78(7), 674–681

Grotkowska G., Gajderowicz T., Wincenciak L., Wolińska I. (2014): Final report from research study: " Evaluation of the quality and effectiveness of support of the ordered fields of studies under sub-measure 4.1.2 of Human Capital Operational Programme" PSDB - Part of the WYG Group. Warsaw, 2014. (in Polilsh) http://www.ncbr.gov.pl/gfx/ncbir/userfiles/_public/fundusze_europejskie/kapital_ludzki/ewaluacja/raport_psdb_final.pdf <access: 29.02.2016>

Reyes E. Gálvez J.C. (2011): Introduction of Innovations into the Traditional Teaching of Construction and Building Materials. Journal of Professional Issues in Engineering Education and Practice. Vol. 137: Issue. 1: Pages. 28-37, DOI: 10.1061/(ASCE)EI.1943-5541.0000033.

Chandrasekaran S., Littlefair G., Stojcevski A. (2015): Learning and Teaching Guidelines for Engineering Students and Staff in Project/Design Based Learning. Proceedings of Seventh International Symposium on Project Approaches in Engineering Education (PAEE'2015) Donostia – San Sebastian, Spain, 6-9 July 2015. ISBN 978-87-7112-305-0.

Acknowledgement

This paper has been developed as a part of KIC InnoEnergy activity in Clean Fossil and Alternative Fuels Energy Msc program.

Raising the students skills through teaching by Cease teaching method - AGH experiences

Karol Sztekler[1], Grzegorz Jodłowski[2], Marta Wójcik[3]

[1] Faculty of Energy and Fuels, Department of Thermal and Fluid Flow Machines, AGH University of Science and Technology, Krakow, Poland
[2] Faculty of Energy and Fuels, Department of Technology of Fuels, AGH University of Science and Technology, Krakow, Poland
[3] Faculty of Energy and Fuels, Department of Technology of Fuels, AGH University of Science and Technology, Krakow, Poland

Email: sztekler@agh.edu.pl, jodlowsk@agh.edu.pl, mwojcik@agh.edu.pl

Abstract

The development of modern information technology makes gain the necessary information from the engineering point of view becomes increasingly easier. Hence, it seems that the teaching approach should be changed where the teacher shows the way to choose from a huge amount of information the content that is reliable and useful in further work. The traditional system of teaching in many cases seems to be no effective and imparting knowledge on the basis of the rule "student hears the teacher says" stand to be insufficient in terms of knowledge transfer and the student development. In such conditions Students have a limited capacity for self-troubleshooting and indeed this is not possible because the teacher is focused on the knowledge transfer without dialogue between the students, so this very important cognitive element will be disrupted. One of the most effective teaching methods is learning through case. This method of teaching through case allows for the involvement of all students in the thought process and activates them in such a way that the assimilation of complex engineering special issues is easier.

At the AGH University of Science and Technology at the Faculty of Energy and Fuels, master studies MSc KIC Clean Fossil and Alternative Fuels Energy KIC InnoEnergy was introduced to the project "Advanced coal technologies", case "Boiler Modernization in Power Plant" associated with the modernization of the boiler to reduce its negative impacts in the environment. Students through analyzing the real case will be able to answer the following questions: What kind of modernization is the most environmentally and economically efficient? ; What scenario (modernization or building of new one) is more optimal in economic and environmental terms? ; What is the emission reduction scale possible to be reached by new technologies in existing fossil fuels boilers implementing and modernization? The article presents the procedure proposed by the author to draw up technical case, how to prepare this type of any particular case to make it clear to students, problems when writing case. Teaching through case studies seems to be one of the most effective methods of knowledge transmitting but to implement this solution in other areas of science can be very difficult due to the nature and degree of complexity and data availability.

Keywords: Case teaching, Engineering Education.

1 Introduction

In the process of teaching at the universities should look for ever more efficient methodological knowledge transfer which would involve the students in the course of discussing a certain area of knowledge. Currently, in most cases, the transfer of knowledge is done at the level of "professor says a student listens" and his participation in the lectures is minimal. One of the methods of activating student and a completely different way of teaching is learning through case study. Case study, is often understood as a method of teaching especially popular in teaching in the fields of economics universities. It is a method of teaching or presentation, it consists in analysing the descriptions of selected, specific events of the field of science. It is based on the analysis of a single case, containing a detailed description thereof, which allows to draw conclusions about the causes and results of its course. For the first time it has been used in the XIX and early XX century. Through American business schools' special role in the popularization of this method have Harvard University and University Northwest. In the XIX century, the Faculty of Law (Law School) at Harvard University used method for solving the case study (case study method) in order to verify that the knowledge delivered on lectures, students are able to use the solving constructed examples that show the real problems decision resulting in

legal practice. The knowledge gained by analysing the case of a better understanding of the phenomena related to the phenomenon analysed - and based on this, to improve the real action.

In the case study, based on real experience management in real organizations had best prepare future managers to work in their profession by enabling the improvement of management skills in a safe environment. Analysing cases develops the ability of critical and creative thinking, learn to see problems in their complex context, think in terms of sequences of the consequences of decisions and consider problems multilaterally. Analysis of the case is as important as its content. Case discussed with the group can realize that there is no "only correct" solutions, absolute rules that can be used in every situation, there is also the situation completely "specific", which does not apply in any way experience and established theories.

Case method introduces realism to the seminar room and allows to integrate practical knowledge (based on real events) with theoretical knowledge and shows the dependencies between them. Case Studies allows students to build confidence in their skills, develop decision-making skills, communication and cooperation in a competitive environment. Lectures and discussions are no longer the most effective teaching methods. Traditional education generally presents a problem and indicates the methodology used to reach a meaningful conclusion. The current method, it does not show how to discover, identify and define the problem or how to meet the challenges posed by the environment.

Case study method is increasingly being used in education. It has long been commonly used technique for very different learning tasks, especially in the universities where its teaches future doctors and lawyers. This method is widely used in other American universities. For example, the business school at the University in Fairfield, reformed its education programs, so that in place of individual long-term courses in management, marketing, production, finance and information systems, the student selects only one course. This course is built with cases which describe each of the previously mentioned disciplines, presenting them in a specific manner. As a result, students are starting to realize with relationship in various fields and begin to think in broader categories, asking questions and seeking solutions. Case study is also used in the development of critical thinking in interactive language courses, courses expanding horizons of students, and even in technical courses and philosophical. According to a Studien studies (2005b), the case study method is the most effective method of teaching, that develops practical skills. It allows to look at the different situations, (not only business) from cultural and economic perspective, opening their minds by offering the possibility of solving problems based on real-life situations. (Voght G.M., 2000; Rippin A., Booth C., Bowie S., Jordan J. 2002; Ż. Bird-Kostecka, 2000)

2 Scope

The main aim of this article is brief presentation of one technical case “Boiler Modernization in Power Plant” implementation at the AGH University of Science and Technology at the Faculty of Energy and Fuels in MSc KIC Clean Fossil and Alternative Fuels Energy KIC InnoEnergy. The article presents the procedure proposed by the author to draw up technical case, how to prepare this type of any particular case to make it clear to students, problems when writing case and its solution.

2.1 Types of case study method

Heatha says that the following cases can distinguished: the case that contains the event, background, training, the situation, the case and the case of complex decision-making (Heath 2006).

Event Case: This case describes a single event and can be used to illustrate the theory. This case doesn’t require prior preparation by the students (approx. Half a page).

Background Case: This case shall provide the information as stories. In this way the "dry" information turns into interesting reading. As a result, students are more motivated and more involved in the case study. This type of case can be used to examine specific issues related to the analyzed phenomenon.

Exercise Case: This type of case allows the use of a specific technique. It is a good instrument for the implementation of quantitative analysis. This case allows to work with numerical data relating to the real situation in a more interesting way for students.

Situation Case: The main objective is information analysis contained in the case. Students must identify important the relationships between data elements.

Complex Case: Cases complex are usually overloaded by irrelevant information. Students have to deal with the situation where important issues are embedded in a mass of information. Students must separate the important data from the additional or unnecessary. The main purpose case is identification of fundamental problem and important issues in mass of other information.

Decision Case: The students task is to decide what should be done in the circumstances described in the case. Students must prepare a plan of action and present a variety of possible approaches. The most important task of the participants is to make the best decisions.

According to Lundberg there are several types of such cases: iceberg, event, illustration, head, dialogue, application, data, and event prediction.

Iceberg: the iceberg case often don't contain large amounts of data or doesn't have a rigid structure and basically shows only a brief introduction to the situation, which may, but not necessarily require taking any decision.

Event: This type of case, the most detailed description of a single event in the specified time and place.

Case Illustration: cases illustrative describe events or processes using facts, information have strict illustrating structure for a given situation.

Head: This type of case describes the actions, thoughts, feelings and interactions one or more event participants.

Dialogue: This case describes the details of the interaction between two or more people.

Application: This case describes the use of specific management techniques or a situation in which the student may use the earlier learned techniques.

Data: This case contains a large amount of information, including those absolutely irrelevant to the problem or situation.

Event: This case concerns a matter or event that is the subject of public interest. Expected educational outcome is to understand and appreciate the role of the preceding circumstances, contexts and dynamics of this event.

Anticipation: These cases present the information in a structural format (series).

In terms of the scope the cases can be classified into local, regional, national, international and global. When it comes to the length, cases may be short (1-2 pages) or long (10-30 pages or more). However, all of them imitate or mimic real situations, they are verbal representations of reality, and they have a common goal: a complete description of the particular authentic situation with all its complexity, uncertainty and sometimes brutality. McKenna (1999) suggests another classification of cases, dividing them into "Western" or "Harvard" and cases of "life learning" (Life Learning Cases - LLC). Cases of "Western" or "Harvard" are already developed for use in the classes. Students have to be aware of them, and then, generally speaking, approach them in the Harvard style, using "logical investigation" and "discovery process". Otherwise in case of "live learning" teams have to examine project or case. Their task is to build a case scenario when surrounding situation is changing. During their work with the company, students will naturally affect the character of case.

In AGH case, case corresponding to the situation case is prepared this type case in very good way descripts situation during modernization in heating power plant. (Ellet W., 2007; Garvin D.A., 2007; Heath J., 2006; Lundberg C., 2001; McKenna S., 1999)

2.2 Case teaching preparation

Usually analysis of the particular case is, or at least should be located in a broader concept of classes. Questions to ask yourself, what purpose it is intended to introduce case: whether it is to show how choices are made; awareness, which models the behavior of people in specific situations; or, for example, what are the possible strategies for solving of the problems faced by a person, social group or organization. Person sorters educational materials for case has to make a series of decisions on the level of complexity of the material, defined as:

1. complicated information. The more complex information contained in the text, the greater the likelihood that students will require more explanation and that will deal with issues for the marginal case. However, it may happen, and so that the task of the case is to be the acquisition by students of skills like sorting, evaluating and structuring information.

2. The complexity of the content. Too multidimensional situations or situations in which you should take into account the advanced knowledge from different disciplines can ascertain when analyzing people of the case are PhD or MSc students.

3. The complexity of the language. Same case must be made language adapted to those who will analyze it. These people should be already familiar with the terminology appearing in the description of a case, unless the purpose is to show case what problems arise when a person involved in a social situation have different understanding of the same concepts.

All of the above work can go down the drain if the leader (moderator) does not have a clear vision of the case use. M. Eugene Gilliom suggests preparing a series of questions based on the following points: clarify and define the key concepts; an explanation of the described events; Evaluation of behaviour; implications (effects, consequences) phenomena presented in the case; The conclusions apply to different circumstances.

There are many conventions of case study writing: one of the most important is the quotation in a case study of the opinions expressed by the person in the video; another convention is to write a case study in the past; next, to exclude's case as a person in a case report; Finally, when writing a case study, the author should avoid placing their own conclusions. Although, as already stated, there are no hard rules to analyze a case, there is a way, or a plan setting out the sequence of actions. The first step is to carefully read the text and reflection on the topic, a problem that was presented. The second step is to assess the information contained in the description of the event, as not all the information in it is relevant and important information may be contained "between the lines". So, you often have to make some assumptions, draw conclusions. Usually, there is a need to organize information so that it is readable and useful. At this stage it is worth to look for examine the accuracy or nature of the relationship between phenomena. In the third step is define the most important problem or problems presented a case report. It is not always easy, because it happens that the observed phenomena are merely symptoms of more fundamental problems. It is good to make a list of problems and define them as closely as possible and relate to each other. Of course, not all problems are equally important - at this point priorities must be chosen. Fourth step is the process of generating thematic solutions. There should be emphasized that the same process of analyzing information and inquiries to the solutions is more important than the actual proposed solutions. Persons analyzing case must present arguments to the validity of the proposed by its decisions. At this stage it is very important to seek a solution of the creative process case.

Step five, the search for the effects of the decision, even before the evaluation of alternative solutions. Here it is important to consider all the possible consequences. At this stage, it is very unlikely that any of the solutions result in further problems. Of course, you have to constantly ask yourselves when to stop looking for the next consequence of the decision. It is clear that not all effects are equally likely.

An evaluation alternative solution occurs in the sixth step. At this stage, shall review the effects of all solutions to the problem. Not all are equally likely. But, not all are equally important. At this point it is important to assign the various events values depending on how they are valid. When this happens, you can already assess the global effect of each of the alternatives and select the most advantageous solution. Finally, a list of solutions with all the arguments for and against these solutions should be done. Analyzing the case should not end at

the decision. With good analysis conclusions should be drawn for a long period. This enables the analysis of the effects of the decision, which was made when solving a case. Based on this analysis, you can make proposals for future decisions, making them from events that may occur. Of course, the starting point is the decision, which was considered as the best. These further steps of the case solving are independent of whether the case is solved individually or in groups (M.E. Gilliom,1977).

2.3 Potential problems during case preparation

Writing a case study is a long-term task that requires careful preparation. Regardless of what type of a case study you want to develop: background, situational, complex or decision-making, we need to obtain adequate, reliable and relevant information. In the process of a case study writing there are many potential problems, especially during the necessary information acquiring. The main question is: how to convince companies to disclose detailed data, knowledge and "know-how" for the internal processes and business activities and technological aspects that may be used to prepare the case. Knowledge is of particular importance for the competitiveness of the company, and its unique combination with practice is a factor that distinguishes your company from its competitors. From the author point of view of, it is important to know what kind of problems can be expected during case study writing, how to prepare for them and how to solve them.

The previously mentioned problems can be divided into four groups, based on the possible ways of solving them (Table 1).

Table 1. Potential problems and possible ways to solve them

Potential problems	Possible solutions
1. Establishment of cooperation with the audited company;	In the methodology of establishing contact and cooperation with the company
2. Very limited contact;	in the methodology of personal interviews and treatment of specific types of information
3. The provision by the company only a very general and / or positive information;	
4. Reluctant to revealing information about interesting and important events;	
5. Treatment information of confidential or of special interest;	
6. The use of secondary data;	in the methodology of development of secondary data
7. Lack of consent from the company to release the final case study;	

The easiest way is to write a case study in collaboration with the company, with which we had previously research contacts, projects or any personal relationships. It is an idea to check among friends and colleagues, or companies with which they work if companies which they are cooperating could be a good host organizations. Usually, companies are more open to collaboration when the author may appeal to personal contacts or earlier cooperation. Another way is to offer to the company some "incentives". It may even be possibility to carry out free analysis, researches or forecasts; promise that any further information will be made available for the company, or even convinced the company that the use of a case study in the teaching process will show your company in the best light. Since the firsts contacts with the company should be taken special care that the whole process is easy for the host. The management of the company has to know what they can expect from our side (type of required information and time range). They also have to know what we are going to include in the proposed case study, and have a guarantee of confidentiality (Heath 2006).

Finally, from the very beginning you need to think about to ensure the right to prepare a case study and its official publication. Approval for undertaking research field should always be sought in the highest levels of the companies management (Heath 2006). Information contained in the case study are intended for public use in the teaching process, so you should take care to keep secrets of the company, and also give the

possibility of company management so they can provide detailed feedback before publication (Ammerman 2010). Authors of the case studies should always decisively acknowledge that developed the study will not be given until the host company will give written agreement (Heath 2006). The author may also suggest signing a contract that ensures confidentiality and outline the intentions of the study. The general rule during the writing a case study is to preserve the objectivity and reliability of the study. Authors must not only accurately assess the quality of secondary information, but also be especially careful in collecting primary data. They have to make sure that data are adequate, accurate, timely and objective (Kotler, Armstrong 2008).

3 AGH Case study method

Currently, teaching procedures through case study at technical universities in Poland and other European universities are not performed because of some problems: the education system is not prepared and bad training of teaching staff. Furthermore, any guidance on how to prepare a technical case study for chosen issue are missing. Nowadays, there are no identified subjects that could be the basis for implementation of teaching by using case study method. KIC InnoEnergy MSc School in cooperation with several universities operate on 7 different programs, among which it can be highlighted the MSc study- MSc EMINE - European Master in Nuclear Energy; MSc RENE – Renewable Energy; MSc SELECT – Environomical Pathways for Sustainable Energy System; MSc SENSE – Smart Electrical Networks and Systems; MSc CFAFE Clean Fossil and Alternative Fuels Energy more info http://www.kic-innoenergy.com/education/master-school/clean-fossil-and-alternative-fuels-energy/; MSc Energy for Smart Cities; MSc ENTECH - Energy Technologies.

Each of these programs has a different range of topics dealing with other technical problems and to each of them should be described certain areas which are base to build a proper case study. For MSc CFAFE prepare and implementation specialization technical case: Boiler Modernization in Power Plant".

Boiler modernization was a relatively straightforward CO_2 abatement strategy. It involved conducting a broad diagnostic evaluation of an existing boiler and then improving its efficiency by replacing old parts with new ones (and possibly more technologically advanced) parts, making repairs, and reducing leakages. Typical elements of boilers modernization included new pressure parts, grid modernization, and installation of automatic boilers, economizers, and dust extraction systems, include replacing old or corroded parts such as the rotary air heater, the superheater coil, combustion chamber walls, pumps, fans and valves, and reducing leakages. Improved efficiency would lead to CO_2 emissions reductions. In the prepared materials for students for the case study, the construction data of the boiler and methods of boilers modernization and retrofit, whose aim was to improve the boiler efficiency are presented. On the basis of available data, the students propose different variants of the boiler modernization and define the benefits they will receive and the problems that arose. After discussing the possible ways of the boiler modernization compared with actually carried out changes in the real object and determined their effect on the reduction of gaseous emissions into the atmosphere. After the course, students gain a deep knowledge of the boilers construction and possible ways of their modernization. Based on the analysis of the case, the student is able to assess how the modernization will reduce emissions from the boiler. Pilot Case study is carried out within the framework of one subject "Advanced coal technologies", the duration of the case is 4 hours. At the case beginning, students become familiar with a given problem, usually related to certain real property or a laboratory model for which solution they use another methods. At the end of the case students prepare a multimedia presentation which will summarize obtained results. The presentation will be presented in front of whole group. That will allow them to give second thoughts about them, discuss it with others. Also it will give other students a chance for criticism or allow noticing of consistency of issues in the framework of a given subject. Obtained results have to be thought through, properly prepared and presented in such way so others student would understand used concepts. Case teaching method is suitable for every subject. Its implementation requires only some administrative decisions and forcing teachers to see given subject from another perspective and to set up a weekly plan in correct way.

4 Conclusion

After the 4 hour classes method case teaching, lecturer observed that compared to the standard model of teaching there was a significant increase in student involvement in implemented subject, students are alive, discuss among themselves, they are more integrated freely exchange views, are more open to discussion and to ask questions. Lecturer in this case is only a guide to the subject and the person who directs the discussions on good track. Lecturers in forming an opinion on the impact of the case teaching's effect on education relied on their experience in conducting classes by the traditional method with the same group of students. In this method, the student involved in the educational process as a partner of the lecturer, not a passive listener, which is involved in the investigation to the theorems, methods, and conclusions pulls out alone. The key in this method is to inspire students to think and search in many directions, rather than focus on one goal. After classes students do not extinguish any surveys or was not conducted any test to verify their acquired knowledge of the finite classes, using case were not conducted any research on this matter and it is another step to develop the theme impact of case methods on the cognitive process of students that will be implemented in the near future and the results of the analysis will be presented in the next article.

5 References

Voght G.M., (2000). New paradigms for U.S. higher education in the twenty-first century. Foreign Language Annals 33: 269–277.

Rippin A., Booth C., Bowie S., Jordan J. (2002). A Complex Case: Using the Case Study Method to Explore Uncertainty and Ambiguity in Undergraduate Business Education, Teaching in Higher Education, vol. 2, nr. 4, 2002, str. 429-441.

Ż. Bird-Kostecka,(2000).Efficiency performing managerial roles, [PhD thesis], Chapter 4 Case Study, or method case study, University of Wroclaw, Wroclaw.

Skudiene V., (2005a). Issues of Evaluation of Management/Business Education: A Survey of Baltic Business Schools. International Journal of Learning 12.

Skudiene V., (2005b). The relationship between teaching methods and educational objectives in management and business administration education. Profesinis rengimas. Tyrimai ir realijos. VDU 10.

Ellet W., (2007). The case study handbook. How to read, discuss and write persuasively about cases. Harvard Business School Press, Boston, Mass.

Garvin D.A., (2007). Teaching Executives and Teaching MBAs: Reflections on the case Method. Academy of Management Learning & Education 6, 3: 364–374.

Heath J., (2006). Teaching and writing case studies. a practical guide. Wyd. 3. ECCH, Cranfield University, UK.

Lundberg C., (2001). Case writing reconsidered. Journal of Management Education 25, 4, August.

McKenna S., (1999). Organisational learning: "live" case studies and the consulting process. Team Performance Management 5, 4: 125–135.

M.E. Gilliom (1977). Practical Methods for the Social Studies, chapter IV, Wadsworth Publishing Company, Inc. Belmont, California

Ammermam Ph., 2010. Establishing contact and cooperation with an organisation. W: P. Barsaukas, A. Pundziene, M. Vadi (red.), Stories told in the classroom. How to write and teach case method. ISM University of Management and Economics, Tartu University, Kaunas, Tartu.

Heath J., 2006. Teaching and writing case studies, a practical guide. Wyd. 3. ECCH, UK.

Hollensen S., 2010. Marketing management. A relationship approach. Pearson Education Limited, Harlow.

Kotler Ph., Armstrong G., 2008. Principles of Marketing. Pearson Prentice Hall, New Jersey.

Toward a more practical Engineering Curriculum (A Sequel)

Klaus Wuersig[1]

[1]Engineering Department, University of Pittsburgh at Bradford, Bradford, PA, USA

Email: wuersig@pitt.edu

Abstract

When students matriculate in the Engineering department at the University of Pittsburgh at Bradford, they will be required to do a Freshmen project as a team member, in the first semester. This usually requires a fair amount of practical knowledge. However is it enough to realize, what are the practical implications in every course area? It is kind of a shock to realize that many students have no idea what a resistor looks like, what happens when a capacitor charges, why Thevenin's Theorem is so powerful, why a digital counter operates as it does and one could go on and on with dozens of other examples. Starting in the fall semester of 2014, teams of 2 or 3 students were required to present to the Professor a practical example of a circuit or theorem discussed in theory. It has to be on a breadboard with its own on board power supply, has to show in certain cases output using LED's, and requires a one or two page explanation of the theory involved. 10% of the semester grade will be dependent on a proper presentation of a practical example and if a presentation is not forthcoming a group of students will forfeit the 10% of their grade.

Well how did this work out? In the first reporting at ICEE 2015, classes that had to perform practical examples were quite small and the results of the 2015 Spring semester could not be included in the report. Yes, a lot was learned over the last 2 semesters. Some student groups would wait until the possible last hour and others would have to forfeit the 10% of the total grade. A much more rigorous timeline had to be adopted and the rules for their team report had to be clarified.

Keywords: practical engineering, student teams, 10% of the grade

1 Introduction

As was pointed out in the abstract several practical exercises are incorporated into the Freshmen Engineering course in the first semester. Teams of students have to design and construct a project of their choosing which has to be approved by the professor. To make sure that the exercise is worthwhile to the students, proper completion of the projects is 25% of the course grade. The whole campus is invited to see what the Freshmen Engineering students have been up to and as can be seen from the two samples of last fall's semester projects, the students put a lot of time and effort into these exercises. Many hours are spent in designing, obtaining parts, building and modifying the project and in some cases starting all over. Practical tools can range from woodworking equipment to welding equipment to machine shop applications. Soldering is quite often necessary and knowledge of small engines and their modifications have to be applied in some cases.

At midterm of semester one each team of students participates in an egg drop contest, where contraptions that will protect an egg are launched from the roof of the Engineering building. Each team of contestants is judged on three categories. Weight of the contraption, number of parts used to protect the egg and the time it takes from the roof to the ground. All of this data is put into an equation and then it will be determined who the best three teams are. Prizes of $150 for first place, $100 for second place and $50 for third place will be awarded. Here again it takes some practical know how to judge what to use for parts, how to minimize weight and how to make sure of a minimum time to reach the ground.

In addition to the aforementioned projects and exercises, the course where all of this takes place includes a laboratory session of an hour and a half each week. Here numerous topics are explored and a laboratory notebook has to be kept. The laboratory exercises could be grouped into three or four different categories. Electrical, Mechanical, Civil and Computer setups are required and involve simple test equipment and parts provided by the instructor. Ohms Law and using a Digital Multi Meter (DMM) gives students the ability to make basic electrical measurement on simple circuits. Another quasi electrical laboratory gives students the ability to understand the basic operation of an oscilloscope and that it is used in different Engineering areas and with

external changes can even be used in the medical field. Students will team up for several laboratory sessions in surveying where they survey parts of the campus and additionally make vertical measurements using a Theodolite. Stress and Strain analysis is done on typical steel and aluminum samples where an analysis is done in one case on computer controlled equipment, while in another case the equipment is manually controlled, and students have to construct graphs of stress versus strain using Excel. A Virtual laboratory shows students that in some cases this might be a preferable method to conduct a laboratory where possibly a hands on way of making measurements could be too dangerous or that the actual equipment that has to be used would be too expensive, and then a virtual laboratory can be a reasonable alternative. [3] These are the two samples of the Freshmen projects mentioned previously and show two completely different approaches to the assignment. One is very high tech with much of the information obtained from the Inter-Net, while the other required welding, Rototiller repair and some ingenious fitting for steering.

Figure 1: The cheap cross country vehicle

Figure 2: The Drone

Figure 3: The Drone in flight

2 The New Practical

Practical Design and Demonstration - 10%

Special Programming - 10%

With all of the effort made in the first semester to give students a background in practical applications it seemed that by the beginning of the sophomore year it was forgotten or at least brushed aside as not being Engineering. When many students in Electrical Engineering classes could not identify resistors or capacitors and did not know what an integrated circuit looked like, it was time to act. As of the fall semester 2014, each syllabus contained one or the other of the above two lines. This meant that students in Linear Circuits I, Digital Logic, Linear Circuits II, Design of Electronic Circuits and a programming course in MatLab, had to conform to the new rule. Students could work in teams of two and with special permission in a team of three. The requirements are quite simple: State what exercise is to be performed. What are the parts and components necessary? Do a sketch of a circuit or a block- diagram. State the theory involved. Get the approval of the Professor. Finish it by the last week of the semester. Demonstrate it to the Professor.

Well how did all of this work out at the end of the 2015 Spring semester and the 2015 Fall semester? In all cases student teams had to be reminded of the time line and in a couple of cases because of their lack of obtaining parts, components, and not finishing before the end of the semester, they lost some points or the total number of points for the exercise. It was obvious that more stringent rules had to be forthcoming and had to be implemented for the fall of 2015.

Table 1: Implementation of the more stringent rules

Rules for obtaining 10% of your semester grade through the submission of a practical exercise related to the material taught during the semester at hand.

A) Week#8 or earlier
Create your team that will submit the Practical. There shall be two students to a team. With permission that can be expanded to three.

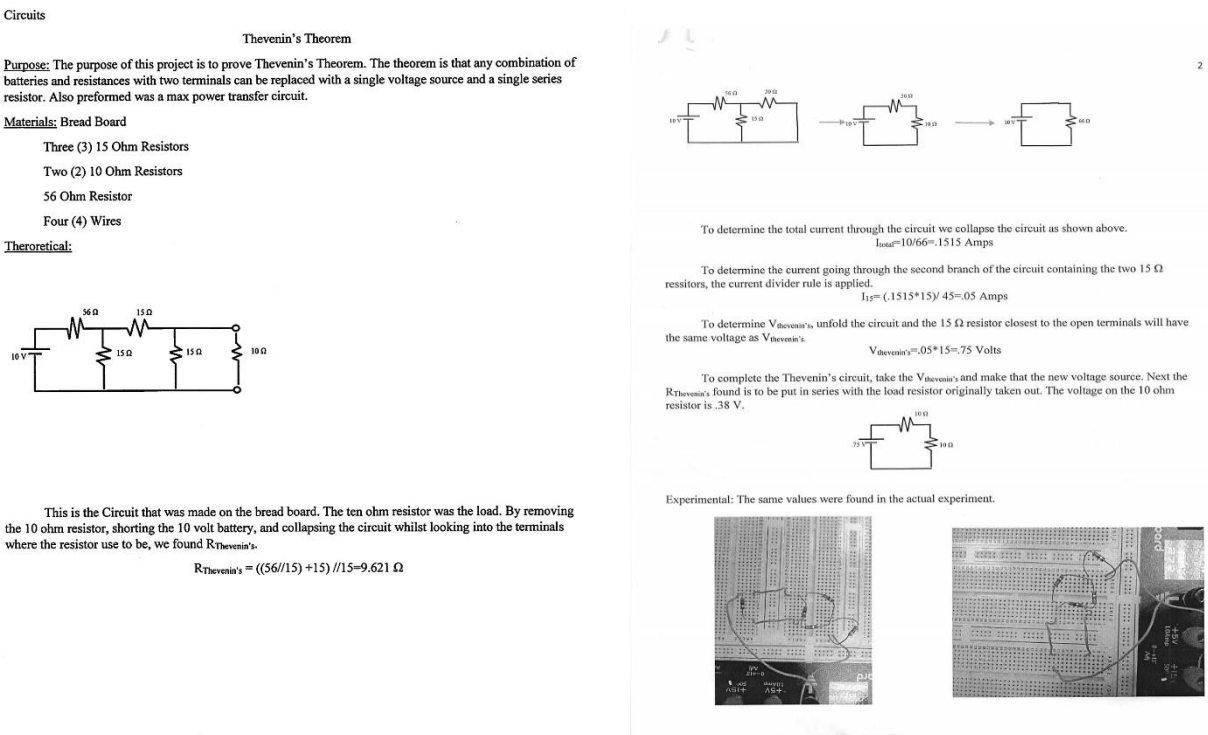
B) Week #9
Research what your proposal will be and if it is feasible.

C) Week #10
Submit your proposal to your Professor and await his response for acceptability.

D) Week#11 and Week #12
Create, build and test your project, do a write up (Wordprocessed) and make sure you understand the theory, the operation of the practical, and how it fits into the course that it is part of.

E) Week #13 and Week #14
Make an appointment with your Professor to do a show and tell and to submit your write up

It seemed to be easier for the students to generate Matlab script files during the 2015 spring semester and then do their show and tell to the whole class and to the Professor than to actually do a physical circuit on a breadboard. Using resistive capacitive circuits with LED's to show charge and discharge was somewhat of a favorite, possibly due to the fact that similar circuits were shown on the Internet. This of course is an area that has to be watched carefully so the presentation is not just a copy.



Circuits

Thevenin's Theorem

Purpose: The purpose of this project is to prove Thevenin's Theorem. The theorem is that any combination of batteries and resistances with two terminals can be replaced with a single voltage source and a single series resistor. Also preformed was a max power transfer circuit.

Materials: Bread Board

Three (3) 15 Ohm Resistors

Two (2) 10 Ohm Resistors

56 Ohm Resistor

Four (4) Wires

Theroretical:

This is the Circuit that was made on the bread board. The ten ohm resistor was the load. By removing the 10 ohm resistor, shorting the 10 volt battery, and collapsing the circuit whilst looking into the terminals where the resistor use to be, we found $R_{Thevenin's}$.

$R_{Thevenin's}$ = ((56//15) +15) //15=9.621 Ω

2

To determine the total current through the circuit we collapse the circuit as shown above.

I_{total}=10/66=.1515 Amps

To determine the current going through the second branch of the circuit containing the two 15 Ω ressitors, the current divider rule is applied.

I_{15}= (.1515*15)/ 45=.05 Amps

To determine $V_{thevenin's}$, unfold the circuit and the 15 Ω resistor closest to the open terminals will have the same voltage as $V_{thevenin's}$.

$V_{thevenin's}$=.05*15=.75 Volts

To complete the Thevenin's circuit, take the $V_{thevenin's}$ and make that the new voltage source. Next the $R_{Thevenin's}$ found is to be put in series with the load resistor originally taken out. The voltage on the 10 ohm resistor is .38 V.

Experimental: The same values were found in the actual experiment.

Figure 4: An Example of an exercise utilizing Thevenins Theorem

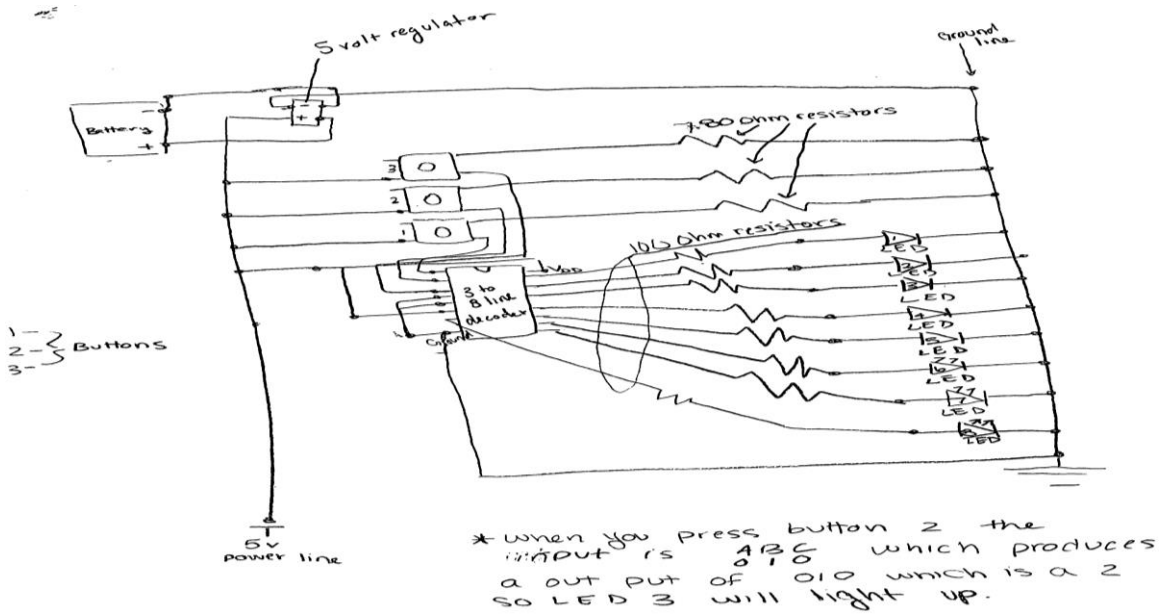


Figure 5: A somewhat rough sketch of a decoder circuit

There were numerous other illustrations of exercises but the above gives a sample of what the general theme of the various projects was. Information for the Electrical Engineering practicals was gleaned from lecture notes and extra sessions with the Professor as well as the books for Basic Electrical Circuits, Digital Logic and Electronics and Circuit Design and MatLab. These books are mentioned in the references.

For the Matlab programming course several changes were initiated for the 2016 Spring Semester. Typical design problems from all Engineering areas were distributed to thirteen design teams at the beginning of week # 9 of the semester. Each team had to do a presentation and use the Matlab publishing criteria to publish the design. It is possible to show a sample of a design because of a resubmit of this paper.

Chapter 2, Problem 59: Lift and Drag of an Airfoil

Published by Natalie [redacted] and Brendan [redacted]

Contents

Define the Values for Velocity

```
V=[0:0.5:150]*(5280/3600); % We must convert from mph to ft/sec.
```

Set the Values for Constants

```
p=0.0022378;
% This is air density at sea level which has units of slug/ft^3.
alpha=10;
%This is the angle between the relative air velocity and the airfoil's
%chord line (measured in degrees).
S=36;
% This is the wing span measured in feet.
```

Define the Lift and Drag Coefficients

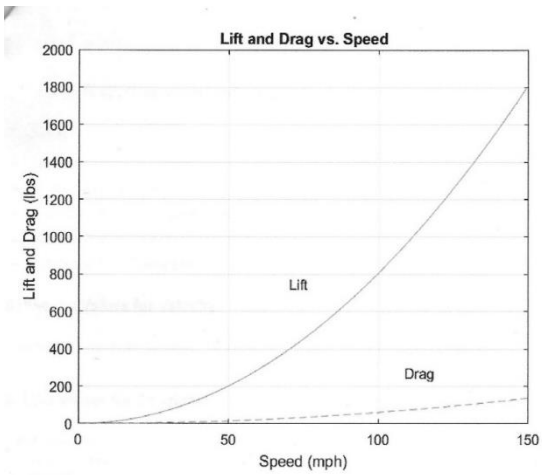
```
Cl=[0.0000475,0.00115,0.0666,0.102];
Cd=[0.00000575,0.000509,0.000181,0.0125];
```

Define the Equations for Lift and Drag

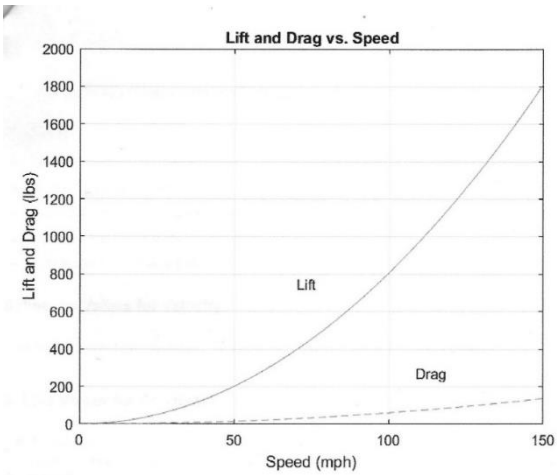
```
L=0.5*p*S*polyval(Cl,alpha).*V.^2;
D=0.5*p*S*polyval(Cd,alpha).*V.^2;
```

Plot Lift and Drag Versus Speed

```
plot(V*(3600/5280),L,V*(3600/5280),D,'--'),title('Lift and Drag vs. Speed'),...
    xlabel('Speed (mph)'),ylabel('Lift and Drag (lbs)'),grid,...
    gtext('Lift'),gtext('Drag')
% Because we want the speed in miles per hour, we must convert back to mph
% from feet per second.
```



Published with MATLAB® R2015b



Published with MATLAB® R2015b

Figure 6: A sample of a published MatLab Program by a Student Team

3 Conclusions

A much clearer picture has evolved after the 2015 spring and fall semester results were tabulated. So far in the programming course participation was at around eighty percent and in the other courses it is over 90 percent. Students that would not participate were in most instances individuals that were leaving the Engineering curriculum due to failing the various courses. Would students in other Engineering disciplines benefit from a similar type of program? Is the **New Practical** a worthwhile endeavor? When the participating teams were asked for input the response was very positive. Many students said that the practical exercises showed them the relevance of the theory. Even though a lot of work goes into this by both, the student teams and the Professor, it is worthwhile and will be continued.

Engineering Technology programs would most likely not have the problems indicated in this paper because most every course has a laboratory attached to it. It is not suggested that Engineering should mimic Technology programs because each has a different mission, but as pointed out in this paper more practicality would not hurt.

It should be mentioned that if one talks about real engineering problems that students would encounter they certainly would be present in industry. The University of Pittsburgh has a very strong Co-op program and over fifty percent of the Engineering students partake of the program, which starts in the junior year. Every year the director of the Co-op program, Maureen Barcic, addresses all Engineering students and coordinates the placement of each student participating in the program. Co-op rotations are between being at the University for one or two semesters and then going for a semester into industry. Here they gain valuable practical experience, make a very good salary and in many cases are hired by the company that they co-op with, after graduation. Student's grades usually improve after being in the program and they mature much quicker due to the responsibility they have shouldered as an engineer in training. For further information contact: wuersig@pitt.edu

4 Acknowledgement

My wife Celeste as always reviewed the paper for misspelled words, sentence structure and general appearance. Finally, the Faculty Development Committee at UPB if they, as they have done in the past, will partially fund this endeavor, should be thanked.

5 References

Alexander and Sadiku, (2014-2016), Fundamentals of Electric Circuits, McGraw-Hill, 5th Edition
Barcic, M., (2014-2016), Director of the Co-op Program, University of Pittsburgh
Mano, M. M., (2014-2016), Digital Design, Prentice Hall, 5th Edition
Neamen, D. D., Microelectronics Circuit Analysis and Design, McGraw-Hill, 4th Edition
Palm III, W. J., A Concise Introduction to MatLab, 1st Edition
Wuersig, K., (2014-2015), " Internal Documents",
Wuersig, K., (2002), "Engineering 11, A new Concept in First Semester Engineering Education", ASEE-SEFI Technical University of Berlin, Berlin Germany
Wuersig, K., (2008), "Should Engineering Freshmen have an Engineering Lab in the First Semester", ICEE 2008, University of Pecs and Budapest, Hungary
Wuersig, K., (2013), "The Evolution of Freshmen Project Experiences due to the Internet", iCEER 2013, Morocco

Mechanical Engineering and PBL methodology in the Federal Institute of Bahia - campus Simões Filho

Esly César Marinho da Silva[1], Claudia Cunha Torres[1], Solange Dias de Santana Alves[1]

[1] Department of Education, Instituto Federal da Bahia, IFBA, Campus of Simões Filho, Brasil

Email: eslymarinho@ifba.edu.br,claudiatorres@ifba.edu.br, solangealves@ifba.edu.br

Abstract

In the face of socio-political, economic and cultural context we live in and the transformation of the contemporary work world, the faculty of the Federal Institute of Bahia (IFBA), campus Simões Filho, after thorough debate proposes a new degree in Mechanical Engineering. The campus is strategically placed in an industrial pole, counting not only with the Aratu Industrial Center (CIA), but also with the Camaçari Petrochemical Complex. However, it is necessary to prepare a professional that meets the specific needs of your area, but also to go beyond them. We present an innovative curriculum proposal at the regional level with the integration of different areas of knowledge through an interdisciplinary methodological approach using problem-based learning (PBL). Thus, we seek to meet the National Curriculum Guidelines for undergraduate courses in engineering that provides that the egress professional have a "generalist, humanist, critical and reflective." The combining technical and scientific training to the ability to interpret the world in which live, act politically with ethics, meeting the demands of society. In addition to specific course knowledge, the learning method based on situations/problem will promote the development of skills and attitudes so important for professionals in the current knowledge society, which will be incorporated into the world of work need to know self-guiding, think critically, solve problems, be analytical, to integrate knowledge and interdisciplinary skills, develop interpersonal skills to work in working groups and finally, seek to continually learn.

Keywords: Mechanical engineering; PBL; Engineering education.

Engenharia Mecânica e Metodologia PBL no Instituto Federal da Bahia – campus Simões Filho

Esly César Marinho da Silva[1], Claudia Cunha Torres[1], Solange Dias de Santana Alves[1]

[1] Department of Education, Instituto Federal da Bahia, IFBA, Campus of Simões Filho, Brasil

Email: eslymarinho@ifba.edu.br,claudiatorres@ifba.edu.br, solangealves@ifba.edu.br

Resumo

Diante do contexto sociopolítico, econômico e cultural que vivemos e das transformações do mundo do trabalho contemporâneo, o corpo docente do Instituto Federal da Bahia (IFBA), campus Simões Filho, após profundo debate propõe um novo curso superior de Engenharia Mecânica. O campus está estrategicamente inserido em um polo industrializado, contando não apenas com o Centro Industrial de Aratu (CIA), mas também com o Polo Petroquímico de Camaçari. Contudo, faz-se necessário preparar um profissional que atenda às necessidades específicas de sua área, mas também que vá além destas. Por isso, apresentamos uma proposta curricular inovadora no âmbito regional com a integração das diversas áreas do conhecimento, por meio de uma proposta metodológica interdisciplinar utilizando a aprendizagem baseada em problemas (PBL). Assim, buscamos atender as Diretrizes Curriculares Nacionais para os cursos de graduação em engenharia que prevê que o profissional egresso tenha uma "formação generalista, humanista, crítica e reflexiva". Ou seja, aliar à formação técnico-científica à capacidade de interpretar o mundo em que vive, agir politicamente com ética, atendendo às demandas da sociedade. Além dos conhecimentos específicos do curso, o método de aprendizagem baseado em situações/problema promoverá o desenvolvimento de habilidades e atitudes tão importantes para os profissionais da atual sociedade do conhecimento, que para serem incorporados ao mundo do trabalho precisam saber se auto-orientar, pensarem criticamente, resolver problemas, serem analíticos, possam integrar conhecimentos e habilidades interdisciplinares, desenvolver habilidades interpessoais para atuarem em grupos de trabalho e por fim, buscarem aprender continuamente.

Palavras-chaves: Engenharia mecânica; PBL; Educação em Engenharia**.**

1 Introdução

As mudanças ocorridas no mundo do trabalho têm apontado para uma nova forma de relação entre a ciência e o trabalho. Neste sentido, a educação superior no Brasil tem alcançado novos patamares na sua demanda, proporcionando novas oportunidades de trabalho nos setores mais modernos da economia antes restringidos a poucos.

Neste período houve uma mobilização do Ministério da Educação e Cultura (MEC) para evitar um "um apagão de engenheiros", movimentando-se no sentido de divulgar a profissão do engenheiro. A partir de 2000, os cursos de engenharia no Brasil aumentaram o número de matrículas em todas as regiões do país. Segundo, o Observatório da Inovação e Competitividade (2013), no ano de 2012, os cursos de engenharia cresceram 391% em relação a 2000, enquanto no curso de Direito o crescimento foi de 173%, o curso de Medicina atingiu 194% e para todo o Brasil o aumento de matrículas para todos os cursos no Brasil foi de 195%.

Outra forma de mensurar o número de engenheiros formados, é relacionando-se a quantidade de graduados para cada 10.000 habitantes do país. Segundo o Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira (INEP), a graduação brasileira, tem superado a proporção de ingressantes para cada dez mil habitantes na maioria das áreas do conhecimento, que é superior à média dos países da Organização para a Cooperação e o Desenvolvimento Econômico (OCDE). De acordo com o Censo realizado pelo INEP em 2012, os destaques foram para às áreas de engenharia, produção e construção. Embora haja um crescimento nestes dados, quando se relaciona a quantidade de alunos graduados em engenharia, o Brasil não apresenta um bom desempenho.

Estas informações são apresentadas a seguir:

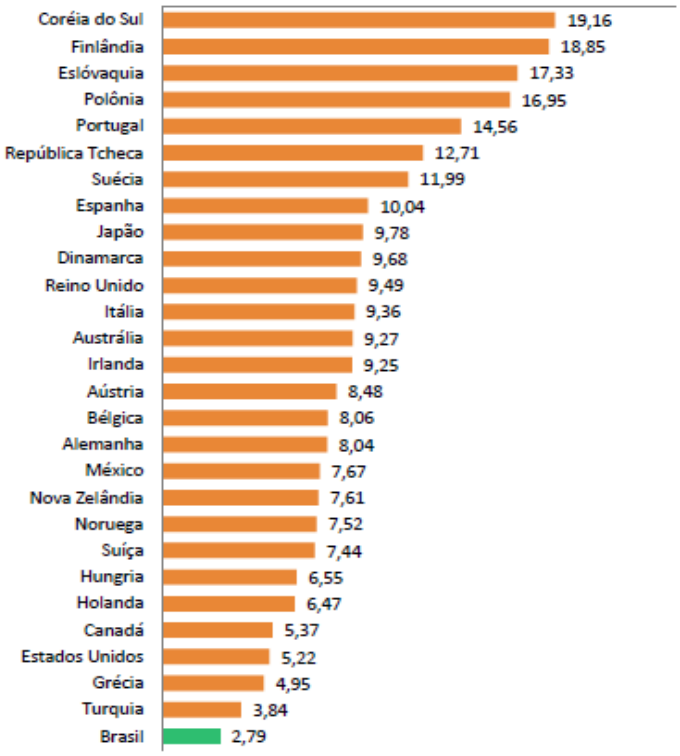


Figura 1. Número de engenheiros graduados por 10.000 habitantes por países no período de 2011 e 2012. (Fonte: OCDE, INEP, Observatório da Inovação e Competitividade, 2013).

Em se tratando de cursos de Engenharia Mecânica, o Instituto Federal da Bahia, na sua proposta de curso, visa atender a expectativa da diversificação industrial que se vislumbra, contribuindo para a formação de profissionais especializados, com grande demanda em nível nacional e regional, onde podemos encontrar um cenário repleto de indústrias de diversos seguimentos: derivados de petróleo e gás, poliuretano, aço, construção civil, alimentos, pneus, petroquímicos, plásticos, automotivo, entre outros.

2 Objetivos

Além dos conteúdos e conhecimentos específicos e necessários para a formação de Engenheiro Mecânico, a proposta que o curso de Engenharia Mecânica do Instituto Federal da Bahia (IFBA), campus Simões Filho, busca é:

- Estimular atitudes ativas nos alunos na busca de soluções para situações/problema ligadas à área de trabalho e do cotidiano.
- Promover o trabalho em equipe, incentivando posturas colaborativas durante todo o processo.
- Proporcionar ambiente respeitoso e satisfatório para que o educando possa desenvolver as habilidades necessárias para a solução dos problemas.
- Construir instrumentos de avaliação da metodologia e autoavaliação do processo de aprendizagem.
- Acompanhar o desempenho individual e de grupo ao longo do projeto/problema, de modo a orientar e mediar as dificuldades.
- Desenvolver a metacognição a partir do reconhecimento das etapas e processos da resolução de problemas, com aplicações em outras esferas da vida.

3 Metodologia Proposta

Os maiores desafios para os cursos universitários, em especial, os cursos de engenharia, são as fortes adaptações do perfil profissional que o mercado está demandando. A resolução de problemas tecnológicos hoje não é mais suficiente, pois, a educação em engenharia deve ser capaz de conhecer as tecnologias, mas também ter a capacidade de compreender e flexibilizar suas atividades, de acordo com o contexto social que o circunda (Carmenado & López, 2015).

Segundo Escrivão Filho e Ribeiro (2007), na educação em engenharia brasileira ainda predominam os currículos tradicionais, a fraca interdisciplinaridade e a integração tardia, quando presente, entre os diferentes componentes curriculares, entre a teoria e a prática e entre o mundo escolar e o mundo profissional.

A metodologia proposta para o curso será o PBL (Problem based Learning), ou seja, a aprendizagem baseada em problemas, e assim, priorizar além da formação teórica técnico científica necessária à formação especifica do engenheiro mecânico, mas que também, favoreça à formação do profissional desejado pelo Conselho Nacional de Educação/Conselho de Ensino Superior Brasileiro (CNE/CES, 2002), que objetiva no contexto de rápida transformação socioeconômica desenvolver determinadas competências e habilidades. Não apenas para cumprir as exigências curriculares ou satisfazer as necessidades do oscilante mundo do trabalho, mas que de fato possibilite ao educando participar efetivamente de seu processo de aprendizagem, agindo e interferindo na construção dos saberes.

Segundo Alves (2015) a implementação do PBL nos diversos currículos proporcionam a contextualização e incorporação de situações da vida real, bem como a interdiciplinaridade de diversos componentes curriculares fundamentais para um discente em formação.

O que vai diferenciar o curso de Engenharia Mecânica do IFBA, campus Simões Filho será a capacidade de formar o Engenheiro Mecânico dentro da nova realidade técnico cientifica e social que se espera e que postula a CNE/CES, 2002. Um profissional nessa "nova realidade" com rápidas transformações tecnológicas (denominada de Revolução tecnológica) que mudou não apenas a forma dos indivíduos se comunicarem, mas também a produção e o mundo dos negócios, que por sua vez reverberam nos mundos do trabalho. A metodologia PBL proporciona ao estudante a responsabilidade e a oportunidade de identificar quais informações são necessárias e como combinar fatos e conhecimentos de diferentes áreas para a resolução dos problemas apresentados (Norrhwood, 2003).

> Uma das áreas particularmente afetadas pelo ritmo acelerado das mudanças é a engenharia, porque abriga grande parte do conhecimento com aplicação tecnológica imediata. Este fenômeno afeta a engenharia, a prática do engenheiro e, consequentemente, o ensino da engenharia, o que pode ser atestado pela grande expansão da base de conhecimento em ciência e tecnologia e pela rápida obsolescência de muito daquilo que é ensinado durante o período de formação profissional. A combinação desses efeitos mais visíveis obriga os engenheiros a continuamente reaprenderem sua profissão. (RIBEIRO, 2005, p.14)

O Método PBL conforme GRAFF e COWDROY (1997) se desenvolveu, diversificou e se propagou por todo o mundo. Nessa ampla variedade de estudos e adaptação a contextos educacionais distintos, o modelo escolhido pelo IFBA Simões Filho para implantar em seu curso de Engenharia Mecânica é o denominado **PBL Híbrido** que é outra forma de organização curricular. Não envolve todo o curso, mas também não fica restrito a apenas uma ou outra disciplina do currículo tradicional.

Nosso modelo estará disposto em 8 módulos que constitui parte central do currículo, nos quais, as situações/problema serão resolvidas com ação interdisciplinar necessária para dar suporte a esse núcleo central.

Nosso projeto de curso prevê ciclos anuais que englobam conteúdos específicos das principais áreas da Engenharia Mecânica, distribuídas da seguinte forma:

1º ciclo – Ciência e Tecnologia dos Materiais;

2º ciclo – Processos de Fabricação;

3º ciclo – Sistemas Termo fluidos;

4º ciclo – Sistemas Mecânicos.

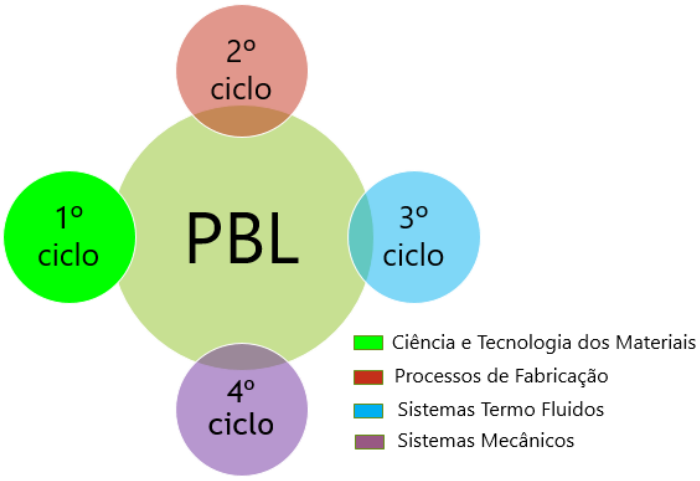


Figura 2. PBL percorrendo as principais áreas da Engenharia Mecânica

Assim, a elaboração do problema estará vinculado ao ciclo anual em curso, no qual, os alunos (as) estarão inseridos.

Partindo do afirmado por Bonwell e Fink (1999) que diz que os educandos motivam-se mais a identificar e pesquisar conceitos e princípios a partir de problemas reais e complexos, tomaremos os ciclos como 'fonte geradora'. Sabemos que essa é a parte mais desafiadora do nosso projeto, por isso que além da pesquisa e apoio na bibliografia especializada existente estamos promovendo a capacitação do corpo docente da Instituição, com cursos sobre Mediação e PBL com profissionais que já atuam na área em questão.

Temos uma estrutura física que possibilita a simulação da prática profissional para que os educandos busquem resolver as situações/problema. O que vai enriquecer ainda mais o programa de ensino, visto que na busca pela 'solução' assuntos complexos em torno do processo vão fazer o educando aprofundar o conteúdo requerido no programa de ensino.

O planejamento do problema além da sua própria criação requer que se estabeleça ainda sua coerência. O que implica definir sua extensão. Nossa pesquisa[6] nos orienta levar em consideração:

Tempo de duração: que não deve ser menos que uma semana, podendo se estender a 6 semanas ou mais. Definimos 30 h/a para o desenvolvimento.

Coleta de dados: as atividades relacionadas ao levantamento de informações e dados tomam um tempo considerável e variado por requerer pesquisas na área de estudo, incluindo-se nesse contexto idas à biblioteca, visitas técnicas, entrevistas etc.

Contato com especialistas: Muitas vezes é necessário o envolvimento com pessoas da área acadêmica e/ou profissional, empresas que possam contribuir com o projeto (situação/problema). Inclusive todo início do semestre será convidado um palestrante para expor sobre a área referente aos ciclos anuais e que correspondem a grandes áreas da Engenharia Mecânica. Isso, no entanto, não será o único contato possível. Com planejamento adequado os grupos poderão contactar com outros especialistas para aprofundar o 'problema'.

Tendo como foco a aprendizagem para a vida buscar-se-á desenvolver habilidades que ultrapassem os conteúdos acadêmicos. Pois é esse o perfil que se pretende para o egresso de Engenharia Mecânica formado pelo IFBA - Simões Filho, que busca atender as necessidades impostas pela comunidade empresarial do século

[6] Conforme Boise State Universty

XXI. Entre elas: habilidades no uso de tecnologias, planejamento, comunicação, pensamento crítico, autogerencia das tarefas e solução de problemas. Para tanto, a metacognição – aprender a aprender – torna-se meta e meio, pois o profissional que conhece a estrutura do próprio pensamento é capaz de tomar decisões com maior eficácia e eficiência. A avaliação será baseada no desempenho durante o processo[7]. Por ser, preferencialmente, problemas 'não estruturados' isso implica a possibilidade de várias soluções significantes. Outro ponto importante é o contexto no qual o problema está inserido.

De maneira geral, a metodologia a ser implantada pretende contribuir com o projeto de nação, com o projeto de desenvolvimento, com a educação do cidadão brasileiro, de modo a integrar a formação geral com a formação específica, a formação política com a formação técnica, a cultura com o trabalho, o humanismo com a ciência, a educação com a qualificação profissional, enfim o desenvolvimento da capacidade de investigação científica como dimensões essenciais à manutenção da autonomia e dos saberes necessários ao permanente exercício das práticas do mundo do trabalho, que se traduzem nas ações de ensino, pesquisa e extensão, que fazem parte dos princípios filosóficos e teórico-metodológicos gerais que norteiam as práticas acadêmicas da nossa instituição, conforme apresentado no projeto pedagógico institucional do IFBA.

4 Considerações Parciais

Percebe-se diante do panorama atual dos cursos superiores em Engenharia a necessidade de formar um novo profissional, voltado para além das novas necessidades do mercado buscando criar uma nova cultura de formação. A formação de engenheiros mecânicos que serão formados no IFBA, campus Simões Filho, terá um perfil voltado para a formação tecnológica, mas também preocupado com as questões sociais (sustentabilidade, atendimento a portadores de alguma deficiência etc.).

Desde o início do curso, os alunos serão submetidos às práticas e pesquisas no campo da engenharia mecânica, utilizando-se a metodologia PBL (Problem based learning). Pretende-se que os alunos conheçam de maneira mais efetiva as principais áreas da engenharia mecânica, tais como: ciências dos materiais, processos de fabricação, termo fluidos, projetos mecânicos, etc. Aliadas com esta metodologia, os alunos trabalharão com planejamentos estratégicos institucionais para vivenciar e solucionar problemas de ordem político-social e levando-se em consideração a inovação tecnológica.

Para alcançar os resultados esperados com o PBL, os docentes estão recebendo formação em mediação da aprendizagem, base para que o professor possa ser provocador, orientador, conduzir sem induzir, garantindo os princípios do PBL.

Por fim, acreditamos que o PBL possa promover uma "aprendizagem sólida" com qualidade, pois o desafio constante em desenvolver a habilidade de pensar criticamente, analisar, discutir, selecionar os recursos de aprendizagem necessários para solucionar os problemas de forma organizada e integrada permite a consolidação de conhecimentos que podem ser acessados e aplicados em sua prática profissional futura. Ao desenvolver a metacognição haverá a chance de conhecer as próprias dificuldades e potencialidades, visando avançar em direção a novas e melhores conquistas.

5 Referências

Alves, C. A. Sousa, R. M., Fernandes, S., Cardoso, E., Carvalho, M. A., Figueiredo, J., & Pereira, R. M. S. (2015). Teacher's experiences in PBL: implications for practice. *European Journal of Engineering Education.* 1-19.

Boise State University. Designing your Project. Disponível em: http://pbl-online.org./online_courses.htm.

Brasil/MEC/CNE/CP. 2002. *Diretrizes Curriculares Nacionais para os Cursos de Engenharia.* Brasília.

Carmenado, I. L. R., López, F. R., Gárcia, C. P. 2015. *Promoting Professional Project Managment Skills in Engineering Higher Education: Project-Based Learning (PBL) Strategy.* International Journal of Engineering Education. 31(1-B). 184-198.

Fonseca, V. 1998. Aprender a aprender: a educabilidade cognitiva. Porto Alegre: Artmed,.

[7] A avaliação durante o processo poderá ser diagnóstica, formativa e somativa tendo em vista o percurso individual e coletivo dos integrantes dos grupos.

Filho, E., Ribeiro, L. R. C. 2007. *Aprendizagem baseada em problemas (PBL): uma experiência no ensino de engenharia sob a ótica dos alunos.* Revista Ciências Humanas. 3(3), 346-360.

GRAAFF, E; COWDROY, R. 1997. *Theory and Practice of Educational Innovation through Introduction of Problem-Based Learning in Architecture*, International Journal of Engineering Education, Great Britain: TEMPUS Publications, 13(3), 166-174.

Instituto Nacional de Estudos e Pesquisas, 2013. *Observatório da Inovação e Competitividade*.

Manrique, A. L, Dirani, E. T., Campos, L. C. 2010. *PBL em um curso de Engenharia Biomédica: a experiência da PUC-SP.* São Paulo.

Mills J. & Treagust D. 2003. *Engineering Education is problem based or Project based learning the answer?* Australian Journal of Engineering Education.

Northwood, M. D., Northwood, D. O., Northwood, M. G. 2003. *Global Journal of Engineering Education.* 7(2), 157-164.

Olsson, A., Nilsson F., Hellstrom, D. 2009. *Group assessment challenges in Project-based-learning: Perceptions from students in higher engineering courses.* LTH 2-3.

Portilho, E. 2009. Como Se Aprende? Estratégias, Estilos e Metacognição. Como se aprende?. Rio de Janeiro: Wak. 164p.

Projeto Pedagógico Institucional do IFBA. 2013. Salvador, Bahia, Brasil.

Ribeiro, L. R. C. 2005. *A aprendizagem baseada em problemas (PBL): Uma implementação na educação em engenharia na voz dos autores.* Tese de doutorado. UFSC.

Ribeiro, L. R. C. 2008. *Electrical Engineering Students Evaluate Problem-Based Learning (PBL).* International Journal of Electrical Engineering Education.

Souza, A. Depresbiteris, L. Machado, O. 2004. A mediação como princípio educacional – bases teóricas de Reuven Feuerstein. São Paulo, Editora Senac, 2004.

A Study on Characteristics of Architectural Working Space for Group Work - Analysis of Characteristics of Table Layouts in Group Work-

Chihiro. Morimoto[1], Hikari Mitsuta[1], Sadayuki. Shimoda[1] and Setsuko. Isoda[1]

[1] Department of Architecture and Civil Engineering, National Institute of Technology, Kumamoto College, Yatsushiro Campus, Japan

Email: ap5537mori@g.kumamoto-nct.ac.jp, ac1593mits@g.kumamoto-nct.ac.jp, shimo@kumamoto-nct.ac.jp, isodas@kumamoto-nct.ac.jp

Abstract

The objective of this paper is to clarify characteristics of layouts with movable tables for students' group work and active learning in our architectural design room of Department of Architectural and Civil Engineering (AC), National Institute of Technology (NIT), Kumamoto College.

In universities' and our NIT colleges' architectural design room in Japan, drawing boards are regularly arranged in general. Our architectural design room was a such layout before October 2013.

Recent years, in our almost architectural design classes, students do not work individual, they address to an architectural subject by a group. Groups are formed by five to six members. They go to a field survey, they discuss about the problems and they make efforts to design higher quality works. Thus they address active learning by group works. So a table layouts is one of the most important elements for group works i.e. active learning.

With the improvement construction of our department building as a turning point, we provided a large space architectural design room placed movable tables, movable chairs and movable white boards equipped with casters. From this, our students have been able to do their suitable layout with tables, chairs and white boards for their group works.

The primary methods for this study are two ways. The first is to record fixed point of observation our architectural design room by digital camera for a semester. The second is a questionnaires survey concerning students' usability of layout of Tables.

As the major results of investigations, table layouts types are classified six types for group works. As results of questionnaire, an I-type and an Island-type are the most easy to use for group works. And as designing process is advance, table layouts become to combine several layout types.

Keywords: Active Learning; Engineering Education; Architectural Design; Group Work; Movable Table Layout

1 Introduction

Recent years, in our almost architectural design classes, students do not work individual, they address to an architectural subject by a group. A students' group is formed by five to six members. Students go to field survey by their groups. They meet real life complex problems, and are required to solve them. They discuss about the problems and they make efforts to design innovative solutions. Thus they address active learning by group works as in Figure1~3. So a Table layout is one of the most important elements for group works i.e. active learning.

Figure 1. Group work in the architectural design room at Department of AC, NIT, Kumamoto

Figure 2. Group work using white board

Figure 3. Presentation in the architectural design room at Department of AC, NIT, Kumamoto

Figure 4. Group work at AAU

In universities' and our NIT colleges' architectural design room in Japan, drawing boards are regularly arranged in general as in Figure 1. Our architectural design room was such layout before October, 2013 as in Figure 6.

With the improvement construction of our department building as a turning point, we provided a large space architectural design room placed movable tables, movable chairs and movable white boards equipped with casters as in Figure7~8. From this, our students have been able to do their suitable layout with Tables, chairs and white boards for their group works. In Japan, there are very few cases of such space for group work. In Aalborg University (AAU), students address projects by a group. Many group work spaces are provided as in Figure4.

We recorded fixed point observation of our architectural design room by digital camera for a semester and conducted a questionnaire on students.

The objective of this paper is to clarify characteristics of table layouts with movable tables equipped with casters for students' group work and active learning in our architectural design room.

Figure 5. Architectural design room at Department of Architecture, NIT, Miyakonojyo College

Figure 6. Our old architectural design room (2012)

Figure 7. New architectural design room (2014)

Figure 8. New architectural design room (2014)

2 Methods

2.1 Objectives of Investigation

Objectives of this investigation are the 4th and 5th architectural students. In the first semester, the 4th students are fifteen people, and the 5th students are nineteen people. The students belong to the four studios (I-Studio, K-Studio, M-Studio, S-Studio). An each studio is composed of eight to nine students. And also, in the studio, students separate into two groups.

The spaces where each studio occupies are shown in the Figure 9.

Movable tables, movable chars and movable white board are subjects of our study. But, in this report a main subject makes a movable tables layouts.

The table size is shown in Figure 10.

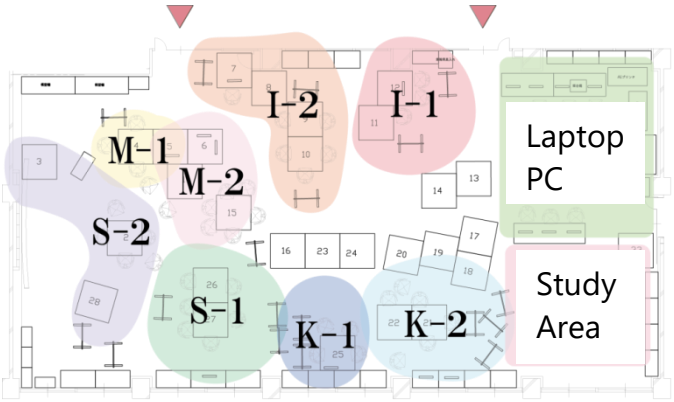


Figure 9. The area where each studio occupies in the architectural design room

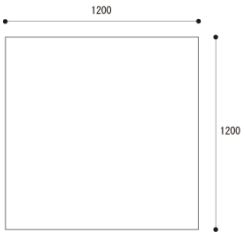


Figure 10. Size of a Table of the subject of this study

2.2 Observation Period

An observation period is April 9th to September 4th, 2014.

2.3 Investigation Flow Chart

An investigation flow chart is shown in Figure11.

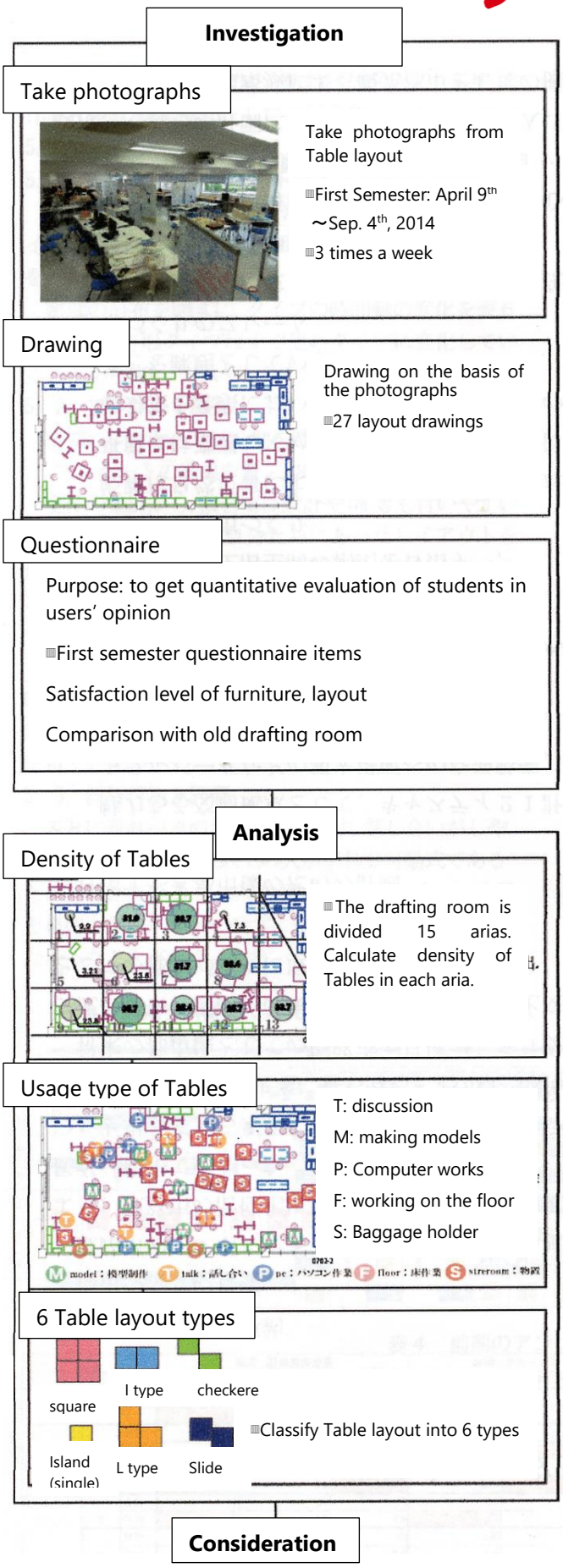


Figure 11. Investigation Flow Chart

3 Result

3.1 Photographic Recording

1246 photographs were recorded by digital camera as in Figure 12.

May 21, 2014 July 21, 2014 July 26, 2014

Figure 12. Samples of a Photographic recording

3.2 Drawings

Twenty eight drawings of table layouts were drafted on basis of a photographic recording as in Figure 13.

April 9, 2014 May 21, 2014 July 2, 2014

Figure13. Drawings of Table layouts

3.3 Students' Questionnaire

We have conducted a questionnaire survey on students about new design room with in movable tables, chairs and white boards equipped with casters. The Linkert Scale and the Questionnaire Items are shown in the Table1, Table2. Most students feel favourable for the new design room as in Table3.

Table 1. The Linkert Scale

very usefull	5
usefull	4
somewhat not usefull	2
not useful	1

Table 2. The Questionnaire Items

Q1: New Design Room	
(1)	Are you think good for those movable tables,chairs and white board use?
(2)	Are you think convienient for those movable tables,chairs and white board use?
(3)	Can you use well those movable tables,chairs and white board?
Q2: Group Work	
(1)	Can you make a suitable table layout for your group work?
(2)	Is the space suitable for design work?
(3)	Is the space suitable for group work?
Q3: Comparison with old design room	
(1)	Was the old design room easy to use?
(2)	Was the old design room suitable for design work?
(3)	Was the old design room suitable for group work?
(4)	Do you want to use it again?

Table 3. Results of Questionnaire

Qestion			New Design Room						Old Design Room			
			Q1: New Design Room			Q2: Group Work			Q3: Comparison with old design room			
			Movable	Usability	Master how to use	Making table layout	Good for design work	Good for group work	Usability	Good for design work	Good for group work	Want to use again
Total	Total		156	149	121	112	133	147	112	124	106	76
	Average		4.9	4.7	3.8	3.5	4.2	4.6	3.6	3.9	3.4	2.4
Studio	I	Total	18	17	13	10	17	17	10	13	10	7
		Average	4.5	4.3	3.3	2.5	4.3	4.3	2.5	3.3	2.5	1.8
	K	Total	35	31	23	28	31	32	24	26	26	21
		Average	5.0	4.5	3.4	3.8	4.4	4.5	3.6	3.9	3.9	2.8
	S	Total	24	24	23	21	22	24	19	23	18	10
		Average	4.8	4.8	4.6	4.2	4.4	4.8	3.8	4.6	4.5	2.0
	W	Total	25	23	18	20	21	23	14	18	14	10
		Average	4.7	4.4	3.4	3.3	4.1	4.4	3.6	4.3	3.9	3.0
School Year	5th year	Total	82	71	56	56	68	76	56	64	53	38
		Average	4.8	4.4	3.3	3.3	4.0	4.5	3.5	3.8	3.1	2.2
	4th year	Total	74	73	65	56	65	71	56	60	53	38
		Average	4.9	4.9	4.3	3.7	4.3	4.7	3.7	4.0	3.8	2.5
										Above 4.0		Under 3.0

3.4 Density of Tables

The new drafting room is divided 15 arias by grid as in the Figure 14. The density of movable tables is calculated in each aria. The average of it in the first semester is shown in Figure14. The area 3 is the highest density. On the other hand, the area1 and area4 have low density because these areas have an entrance.

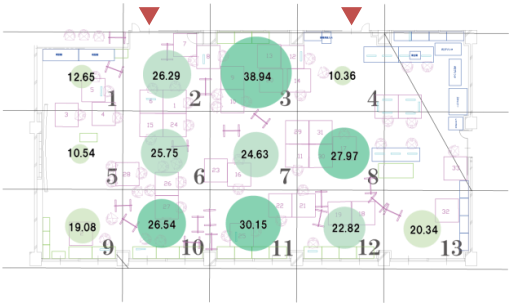


Figure 14. Density of Tables

3.5 Usage Type of Tables in the Design Working

In order to clarify usage of tables in students' design working, five types as follows are observed.

T Discussion M Making models P Computer works S Baggage holder F Working on the floor

The usage type of tables is shown in Figure 15.

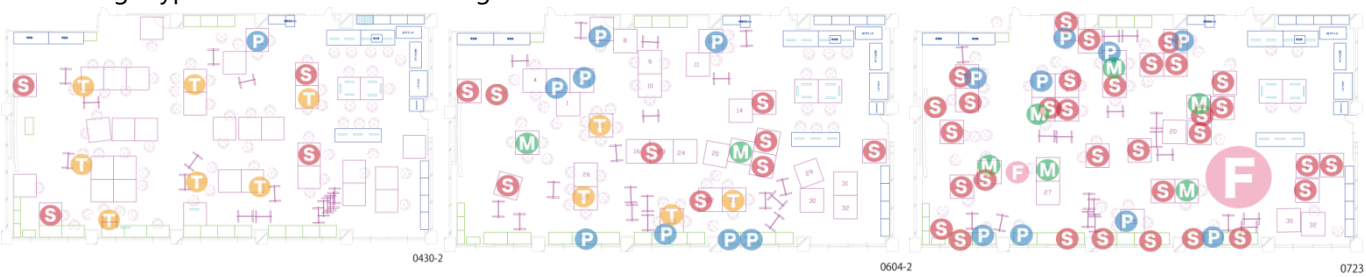
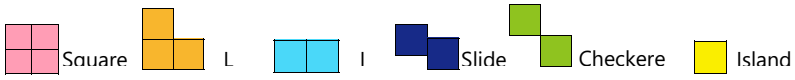


Figure 15. Plotting of Usage Type of Tables

3.6 Classification of Types of Table Layout

Table layouts can be classified into the following six types.



3.7 Relevance with Layout Types and Usage Types of Table

Relevance with layout types and usage types of tables are shown in Table4.

Table 4. Relevance with Layout Types and Usage Types of Table

Layout type / Usage type	Square	L	I	Slide	Checkered	Island	Total	%
Discussion	1	0	38	4	8	11	**62**	20%
Making models	9	1	19	3	2	21	**55**	18%
Computer working	12	1	23	28	11	27	**102**	33%
Baggage holder	12	2	30	14	9	27	**94**	30%
Total	**34**	**4**	**110**	**49**	**30**	**86**	**313**	100%
%	11%	1%	35%	16%	10%	27%	100%	

As in Table4, an I type is table layouts the most frequently used. The next is an Island type. On the other hand, a L type is minimum used. Computer working is the most frequently table usage type. The next is Baggage holder.

An I type is often used to discuss and baggage holder. Especially, almost of "discussion" is done using an I type. An I type is used in every usage.

An Island type is used in every usage too. A Slide type is used mainly in Computer working. Computer working is the most frequently used in Slide type. Discussion is almost not done in a Square type and a L type. Making model is almost not done in a L type, a Slide type and a Checkered type.

3.8 Characteristics of Type of Tables Layout in Individual Studios

Types of table layouts and usage types in individual studios are shown in Table5. I-1 studio uses all six types of tables layouts. M-2 studio uses four types and K-1 studio and S-1 studio use three types. In a questionnaire, S studio students answer that their table layouts type is suitable to their group work. On the other hand, I-1 studio students answer that their table layouts type is not suitable to their group work. A studio of small in number of Table layouts types has a tendency to highly estimate for their group works.

Table 5. Relevance with Layout Types and Usage Types of Table in individual studio

Studio (evaluation group work)							
I-1 (2.5)	Discussion			2	1	2	1
	Making Model	2	1	2	2		2
	Computer	4	1	3	7	4	
	Baggage	4	2	6	5	2	2
I-2 (3.0)	Discussion			7		6	
	Making Model			4		2	
	Computer			1	17	7	
	Baggage			2	8	7	
K-1 (3.75)	Discussion						5
	Making Model			5	1		3
	Computer						14
	Baggage			4	1		3
K-2 (4.0)	Discussion			7			
	Making Model			1			
	Computer						
	Baggage			10			
S-1 (4.0)	Discussion			4	1		
	Making Model			3			2
	Computer			1			5
	Baggage			2			
S-2 (4.3)	Discussion						3
	Making Model						7
	Computer						
	Baggage						14
M-1 (4.3)	Discussion			15	2		1
	Making Model			4			
	Computer			14	4		
	Baggage			4			
M-2 (2.6)	Discussion	1		3			1
	Making Model	7					7
	Computer	8		4			8
	Baggage	8		2			8
Total	Discussion	1	0	38	4	8	11
	Making Model	9	1	19	3	2	21
	Computer	12	1	23	28	11	27
	Baggage	12	2	30	14	9	27
		34	4	110	49	30	86

3.9 Change of type of Table layout of the time base

Changes of type of table layouts in each studio group are shown in Fifure16. As architectural design process advancing, a number of using type of table layouts is tending to increase.

As architectural design process advancing, a number of using type of table layouts is tending to increase.

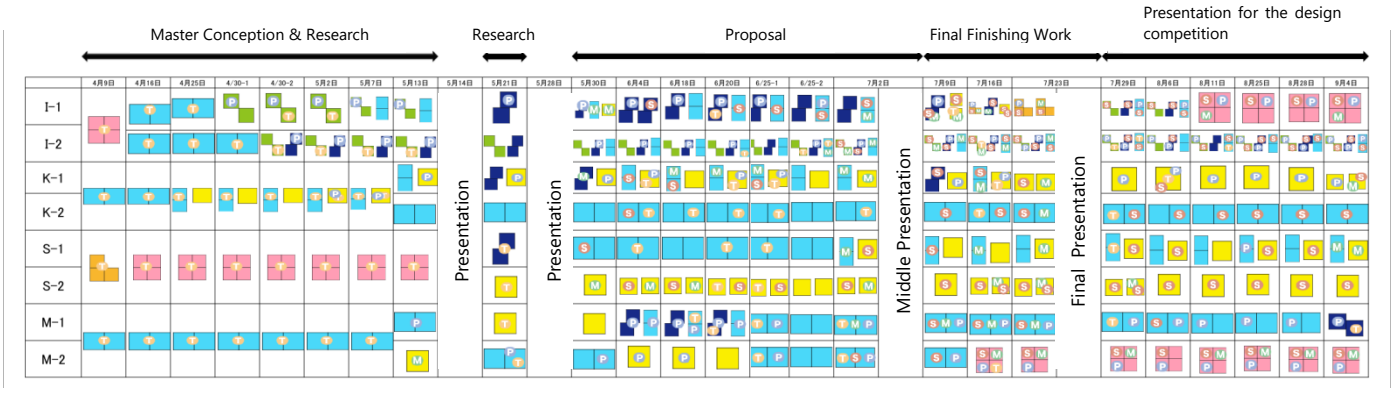


Figure 16. The change of type of Table layout in each studio group

4 Conclusion

The following properties became clear after studying the observation results.

1. Students answer that it is very useful to be able to change table layouts easily when it is necessary for their group work
2. Table layouts can be classified into six types based on observation results.
3. An I type is a Table layout most frequently used, next is an Island type.
4. Especially, almost of "discussion" is done using an I type.
5. An I type is used all usage of design work.
6. A L type is the minimum used.
7. Making models is done using an Island type, an I type, and a Square type, and almost not using a L type, a Slide type and a Checkered type.
8. A studio of small in number of table layouts types has a tendency to highly estimate for their group works.
9. As architectural design process advancing, a number of using type of table layouts is tending to increase.

5 References

Masaji Imai, Mitsunari Akamatsu, Takayuki Nakai, and Shinya Uenishi, A STUDY ON CLASSROOM'S LAYOUT IN COMBINED CLASSES : A case study on practical use of the learning space, Journal of Architecture and Planning, Architectural Institute of Japan, No. 535, pp107-113, 2000.9 (in Japanese)