PAEE ALE 2019

11th International Symposium on Project Approaches in Engineering Education

16th Active Learning in Engineering Education

JUNE 10 TO 12, 2019 - HAMMAMET.TUNISIA

WORKSHOPS PANELS PRESENTATIONS

PREPARING TEACHERS AND STUDENTS FOR CHALLENGING TIMES IN ENGINEERING EDUCATION

PAEE/ALE'2019 — PROCEEDINGS

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ALE

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http://paee.dps.uminho.pt/

http://www.ale-net.org/

This is a digital edition.

WELCOME TO PAEE/ALE'2019

Dear Participants,

Welcome to PAEE/ALE'2019, the 11th International Symposium on Project Approaches in Engineering Education (PAEE) and 16th Active Learning in Engineering Education Workshop (ALE). Educating engineers that will shape our future is an important and challenging task. After all, we are currently preparing future professionals for jobs and technologies that do not yet exist, in order to solve problems that we still do not know that are problems.

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.

In 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. Participants carried out a variety of activities, including workshops, hands-on and debate sessions, industry panels, interactive poster, paper and keynote sessions, and student project awards. This year PAEE and ALE continue to join forces to create opportunities for learning and networking of Engineering Education professionals who are dedicated to Active Learning. The present events are being hosted by ESPRIT School of Engineering in Tunisia.

The theme of this year's conference - Preparing Teachers and Students for Challenging Times in Engineering Education – calls attention to the fact that Engineering Educators and Engineering Students need to develop new skills and attitudes required by the 21st century challenges. Engineering Educators must have an active role as mentors and therefore need training to plan learning environments that will lead students to learning outcomes (i.e., conceptual, procedural, and attitudinal content) established in the courses and their respective programmes. Students need to become more active and masters of their own learning. The option for active learning strategies and methods breaks the paradigm of traditional teaching, emphasizing the students' own responsibility for their learning and, at the same time, promoting the awareness of the teachers about the permanent need for continuing education. May this event give us the 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 Hammamet.

Lamjed Bettaieb

Kaouther Akrout

Rui M. Lima

Valquíria Villas-Boas

(Chairs of the PAEE/ALE'2019)

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PAEE/ALE'2019 Invited Speakers

PAEE/ALE'2019 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:

- Denis Bédard (Université de Sherbrooke, Canada)
- Kristina Edström (KTH Royal Institute of Technology, Sweden)
- Erik De Graaff (Aalborg University, Denmark)
- Edmundo Tovar (Universidad Politécnica de Madrid, Madrid)

DENIS BÉDARD

Short bio

Denis Bédard is a professor in the Department of Pedagogy at the Université de Sherbrooke, Canada. Pr. Bédard received a Ph.D. in Educational Psychology from McGill University in 1993. He has been an active researcher in the field of higher education teaching and learning, more specifically in the role of context on knowledge acquisition. He earned the «*Glen L. Martin Best Paper Award*» of the *American Society for Engineering Education* in 1997. Dr. Denis Bédard published several articles on the impact of pedagogical and curricular innovation on students and teachers. In 2009, he co-wrote a book entitled "Innover dans l'enseignement supérieur" published at the "Presses Universitaires de France". One of his latest papers will appear in *The Wiley Handbook of Problem-Based Learning* (2018): "PBL in Medical Education: A Case Study at the Université de Sherbrooke". He is currently the director of the Microprogramme de 3ème cycle en pédagogie de l'enseignement supérieur (MPES) at the Université de Sherbrooke.

KRISTINA EDSTRÖM

Short bio

Kristina Edström (kristina@kth.se) is Associate Professor in Engineering Education Development at KTH Royal Institute of Technology. Since 1997, she led and participated in educational development activities at KTH, in Sweden and all over the world. She serves on the international CDIO Council and leads the research track in the annual international CDIO conference. She was awarded the KTH Prize for *Outstanding Achievements in Education* in 2004 and was elected lifetime honorary member of the KTH Student Union in 2009. Kristina holds a M.Sc. in Engineering from Chalmers, and a PhD in Technology and Learning from KTH. Her research takes a critical perspective on the why, what and how of engineering education development. In 2018, she was appointed Editor-in-Chief of the European Journal of Engineering Education.

ERIK DE GRAAFF

Short bio

Erik de Graaff (PhD) is a trained psychologist. He has been working in educational research and development for about 40 years. After stepping back from professorship, he is currently honorary professor (*adjugeret*) at the Aalborg Centre for Problem-Based Learning in Engineering Science and Sustainability under the auspices of UNESCO. Throughout his career, he contributed to the promotion of knowledge and understanding of higher engineering education with numerous publications and through active participation in professional organizations such as SEFI, IGIP, IFEES and ALE. In the course of his career, he published over 200 articles and papers and presented more than 70 keynotes and invited lecturers on various topics related to PBL in higher education. He was Editor-in-Chief of the European Journal of Engineering Education for 10 years (2008 – 2018).

EDMUNDO TOVAR

Short bio

Edmundo Tovar, received the computer engineering degree and Ph.D. degree in informatics from the Madrid Technical University (Universidad Politécnica de Madrid, UPM). He is currently with the UPM as a Professor of information technology in enterprise. He has servedas an elected member of the Board of Directors of the Open Education Consortium (2009–2013), Executive Director of the OCW Office of the UPM (2008–2012), and Executive Director of the Open Education Office at UPM (2013-2016).

Member of the IEEE Education Society Board of Governors (2005–2012) he is currently President elect (2019–2020) and President (2021-2022). He leads an Innovation Group in technologies applied to Open Education and he is Editor of the Information Technology / Information Systems Editorial Board of MERLOT.

PAEE/ALE'2019 Round Table : Engineering Education Research

During the past decades, the interest in Engineering Education (EE) and Engineering Education Research (EER) has been increasing all around the world. Nevertheless, educators and researchers in engineering schools that dedicate their time to this field of applied research often find themselves in a reverse flow with the most accepted and traditional career paths. Considering that engineering educators are practitioners of EE and sometimes also researchers in EER subfields, this panel aims to discuss the state of the art with respect to EE and EER in higher education and its role in higher education institutions (HEI).

The members of this panel and the audience will discuss the fundamental issues about Engineering Education Research (EER), and the best approaches for developing this field in engineering schools.

- Denis Bédard, Université de Sherbrooke
- Kristina Edström, KTH Royal Institute of Technology
- Erik De Graaff, Aalborg University
- Edmundo Tovar, Universidad Politécnica de Madrid

PAEE/ALE’2019 Programme

	MONDAY, 10 June		TUESDAY, 11 June		WEDNESDAY, 12 June
9:00-9:30	Opening Ceremony	9:00-10:30	**Keynote** Kristina Edstrom Engineering education: ideals, approaches and communities	9:00-10:30	**Keynote** Erik De Graaf How to stimulate independent Life-long Learners
9:30-11:00	**Keynote** Denis Bédard Innovating in higher education: a new Space for learning and teaching	10:30-11:00	Break	10:30-11:00	Break
11:00-11:30	Break	11:00-11:30	**Keynote** Edmundo Tovar Extended use of Curricula guidelines to improve the learning process in Open Education	11:00-12:30	**Paper Session** **PS.C**
11:30-13:00	**HandsON** HO.A	11:30-13:00	**Student Paper Session** ST	12:30-13:00	Closing Ceremony
13:00-14:30	Lunch				
14:30-16:00	**HandsON** HO.B	14:30-16:00	**Round Table** Education Engineering Research		
16:00-16:30	Break	16:00-16:30	Break		
16:30-18:00	**Paper Session** PS.A	16:30-18:00	**Paper Session** PS.B		
		19:40	Symposium Dinner		

PAEE/ALE'2019 Paper Sessions, Hands-On Sessions and Students Sessions

Hands-On/Workshops : HO.A

Session	Language	#	Presenter	Authors	Title
HOA	English	2	Miguel Romá	Miguel Romá	Impulse response and transfer function. Touch them to understand them
	English	3	Elisabeth Saalman	Elisabeth Saalman	Teaching Portfolio Workshop
	English	35	Meriem Chichti	Meriem Chichti and Kaouther Louati	Assessing group and individual work in a collaborative project
	French	132	Ikram Bouhassine / Sameh Ben Ammar	Ikram Bouhassine, Sameh Ben Ammar and Afef Belaid	La ludopédagogie : comment animer un cours par les jeux pédagogiques

Hands-On/Workshops : HO.B

Session	Language	#	Presenter	Authors	Title
HOB	English	38	Maroua Douiri and Zied Alaya	Zied Alaya and Maroua Douiri	Moodle and peer review for better learning
	English	96	Diana Mesquita	Diana Mesquita	What I hope students will remember from my course in ten years?
	English	128	Anabela Alves	Anabela Carvalho Alves, Celina P. Leão and Andre Uebe-Mansur	Competencies driven by Lean Education: system-thinking, sustainability and ethics
	English	133	Valquíria Villas-Boas	Valquiria Villas-Boas	The "Empty Square" Activity

PAPER SESSIONS: PS.A

Session	Language	#	Presenter	Authors	Title
PS.A1	Portuguese	92	Ronan Cruz Amoras	Ari Melo Mariano, Patrício Esteban Ramírez-Correa, Maíra Rocha Santos, Alberto Ayaviri-Panozo, Ana Carla B. Reis and Ronan Cruz Amoras	Grau de inclusão das metodologias ativas: Um estudo por meio dos estilos de aprendizagem de Felder-Silverman.
	Portuguese	104	Maíra Rocha Santos	Mara Lúcia Castilho, Ari Melo Mariano and Maíra Rocha Santos	Metodologias Ativas: uma proposta de etapas práticas para construção de instrumento de avaliação integrada às Diretrizes Curriculares Nacionais.
	Portuguese	65	Camila Marinho Avelino da Silva	Lucas dos Santos Althoff, Patrícia Milhomem, Camila Marinho Avelino da Silva and Ana Carla Bittencourt Reis	Utilização de recursos de aprendizagem ativa na capacitação de equipe de projeto de pesquisa multidisciplinar
	Portuguese	23	André Luiz Aquere	Yuri Cerqueira and André Luiz Aquere	A Utilização de Rubric na Avaliação da Aprendizagem do Design de Moda
PS.A2	Spanish	16	María Del Carmen González Cortés	María Del Carmen González Cortés, Margarita Portilla Pineda, Javier Ramírez Angulo and Enrique González Cortez	Educando en valores en cursos de química para ingenieros.
	Spanish	31	Margarita Portilla Pineda	Margarita Portilla Pineda, María Del Carmen González Cortés, Javier Ramirez Angulo and Andrés Ramírez Portilla	Análisis de proyectos como una herramienta para identificar el Desarrollo Sustentable en las carreras de ingeniería. Estudio de caso.
	Spanish	120	Jesús Escalante Euán	Jesús Escalante Euán, Carlos G. Cantón, Alan García Lira, Jorge Santos Flores and Ileana Monsreal Barrera	IDENTIFICACIÓN DE COMPETENCIAS EMPRENDEDORAS A TRAVÉS DEL ANÁLISIS DE GRUPOS
	Spanish	103	Camila Marinho Avelino da Silva	Alberto Ayaviri-Panozo, Ari Melo Mariano, Maíra Rocha Santos, David de Almeida Moysés, Ronan Cruz Amoras and Everaldo Junior	Visión Emprendedora de las Universidades en América Latina en la Formación de los Ingenieros
	Spanish	113	María Felipa Cañas Cano	María Felipa Cañas Cano and Elizabeth Calderon Garcia	Competencias ingenieriles en una sociedad cambiante
PS.A3	English	84	Nadia Ajailia	Nadia Ajailia, Hafedh Benabdelghania, Mohamed Ali Bouakline, Majdi Gharbi, Fadoua Guezzi, Mohamed Kort and Mourad Zeraï	Competences based curricula (Case Study)
	English	6	Tertia Jordaan	Tertia Jordaan and Marietjie Havenga	The SETH Academy: Enhancing Learners' Mathematical Competence for Engineering Challenges in Higher Education
	English	43	Angelo Eduardo Battistini Marques	Cesareo De La Rosa Siqueira and Carlos Eduardo Fontes	Engaging Engineering Students – a Success History
	English	26	Carola Hernandez	Francisco Buitrago, Carola Hernandez, Silvia Restrepo and Giovanna Danies	Boosting 21st Century Competences through Computational Thinking and Student Centered Strategies
PS.A4	English	131	Pedro Miguel Faria	Isabel Araújo and Pedro Miguel Faria	Potentialities of Using an Online Platform to Learn Mathematics in Engineering
	English	37	Maroua Douiri and Zied Alaya	Maroua Douiri and Zied Alaya	The implementation of the peer evaluation and its impact in a programming course / L'implémentation de l'évaluation par paire et son influence dans un cours de programmation
	English	40	Anderson Assis Morais	Walter Nagai, Rui M. Lima, Diana Mesquita and Anderson A. Morais	Peer and team assessment: strategies and applications in Engineering courses
	English	100	Salah bousbia	Salah Bousbia and Dhouha Arfaoui	Engaging Engineering Students Within and Beyond the Classroom-Flexim case study
PS.A5	English	29	Faouzi Kammoun	Faouzi Kamoun and Sami Sifi	Fostering Intelligible English Pronunciation as a Means to Revamp Technical Oral Presentations in Engineering Education: A Case Study
	English	42	Rui M. Sousa	Rui M. Lima, Diana Mesquita, Rui Sousa, M. Teresa T. Monteiro and Jorge S. Cunha	Curriculum Analysis Process: analysing fourteen Industrial Engineering programs
	English	59	João Mello	Ana Carla B. Reis, Ari Melo Mariano, João M. Silva, Ronan C. Amoras and David De Almeida Moysés	Proposal of collaborative interaction in an engineering discipline with an active approach based on problems and projects
	English	5	Marietjie Havenga	Marietjie Havenga and Hannes du Toit	Integrating Diverse Team Capabilities as Part of Problem-Based Learning in a First-Year Engineering Course

STUDENT PAPER SESSIONS : ST

Session	Language	#	Presenter	Authors	Title
ST1	English	14	Video conf	Natan Labarrère Mendes, Natália Rocha Vinhal, Alezandre Vaz Dias Albuquerque, Igor Saraiva Mendes Barcelos and Andre Luiz Aquere	PBL in teaching Project Management: Mais que Já Civil
	English	27	Kerlla de Souza Luz	Kerlla de Souza Luz Prates, Sanderson César Macêdo Barbalho and Mylène Christine Queiroz de Farias	Analysis of Learning Assessment Role using active methodologies in "KAA" perspective.
	English	28	Kerlla de Souza Luz	Kerlla de Souza Luz Prates, Sanderson César Macêdo Barbalho, Sônia Marise Salles Carvalho and Mylène Christine Queiroz de Farias	A New Strategy for Fostering Engineering Students' Entrepreneurial Skills in the School of Entrepreneurs at the University of Brasília
	English	56	Carola Gómez Medina	Carola Gómez Medina and Carola Hernández	Teacher role tensions in the transition to project-oriented curriculum
ST2	English	89	Jéssica Basílio Machado	Jéssica B. Machado, Carolina De M. Machado, Amanda C. C. De Araújo, Moacyr A. D. Figueiredo, Ana C. S. M. Campos, João Meyer and Marco N. Mossi	Aplicação da Abordagem Project Based Learning na seleção de maquinas de uma empresa da Industria Textil
	English	74	Video conf	Alberto Bumba, Ana Sousa, Carlos Silva, Catarina Barros, Costa Ferreira, Pedro Campos and Rui M. Lima	Students' first hand experience on the development of competences: solving interdisciplinary industry problems
	English	76	Maria Paula Reis	Maria P. G. Reis, Thais R. De Oliveira, Raquel M. Braga, Mariana S. Abreu, Enzo G. Oliveira, Moacyr A. D. Figueiredo, Lívia C. Figueiredo, Paula Mossi and Marco N. Mossi	Application of Project Based Learning Approach at process analysis and improvement of a Textile In
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PAEE/ALE'2019 Submissions

The PAEE/ALE'2019, a joint organization between the International Symposium on Project Approaches in Engineering Education (PAEE'2019) and the Active Learning in Engineering Education Workshop (ALE'2019), has three type of submissions in up to three languages (English, Portuguese and Spanish):

- **Hands-on and 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/ALE'2019 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 template. Accepted contributions were invited to make a presentation at the symposium.

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PAEE/ALE'2019 List of Submissions

PAEE/ALE'2019 FULL PAPERS SUBMISSIONS (ENGLISH)

Submissions accepted for the PAEE/ALE'2019 papers sessions in English.

Integrating Diverse Team Capabilities as Part of Problem-Based Learning in a First-Year Engineering Course

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Abstract

Working in teams is an important feature of problem-based learning where students are required to address real-world problems and challenges. The aim of this research was to report on the integration of diverse team capabilities as part of problem-based learning in a first-year engineering course. An interpretivist approach was followed to understand participants' experiences, and a qualitative methodology was employed. The population consisted of one cohort comprising 378 students in a compulsory engineering course. This course enables students to obtain essential skills in the first year while the application thereof is performed in the second year when engineering students design and develop a project. Some activities involved in the first year are cooperative learning and team building, conducting meetings, self- and peer assessment, communication and writing skills, project feasibility analysis and project management, technical drawings and workshop practice. Participating students were also required to apply their knowledge and skills in the planning of a community uplifting project and to apply multifactor decision-making to compare three projects by using the analytical hierarchy process. The main challenge however was to work in diverse teams. Members differed in terms of personality, gender, language, culture and their responsibility towards academic work. Data collection involved students' reflection reports, which they submitted at the end of the first year to reflect on their experiences with problem-based learning and team collaboration. The data was manually analysed and certain themes emerged. Results indicated that, although members were initially not used to working in teams, they managed diversity in several ways. A model was compiled as based on the findings to integrate diverse capabilities within a problem-based learning context.

Keywords: Diverse teams; Engineering Course; First-year Students; Problem-Based Learning.

1 Introduction

According to the International Engineering Alliance (IEA) (2017, p. 1, 2), the essential purpose of engineering education is to build a knowledge base and attributes to enable a graduate to continue with the learning process and develop numerous capabilities as required for 'independent practice'. Engineering students need to engage in 'independent and life-long learning in the broadest context of technological change' (IEA, 2017, p. 11). As a result, the role of higher education is to prepare these students for professional practice and aid in the development of the required skills from the first year onwards.

Problem-based learning (PBL) is an instructional student-centred pedagogy where the student or learner is actively involved in and contributes meaningfully to develop a viable solution to an ill-structured problem (Savery, 2015). PBL requires students to work in collaboration while addressing a problem with no clear solution. Hirshfield and Koretsky (2018) stipulate that the open-ended nature of PBL as teaching–learning approach encourage students to teach themselves and one another, and to enable them to become self-directed learners. Moreover, the authors emphasise that PBL is team-based, and such teamwork 'reflects the social structure of engineering work in practice … [and] can improve industry-relevant skills' such as social skills, communication and conflict management (Hirshfield & Koretsky, 2018, n.p.). Solving authentic problems, however, is a challenge as first-year students do not necessarily use PBL, as they were mainly taught in schools where teachers used the traditional way of teaching by focusing on rote learning and memorisation.

During the previous three years, all engineering first-year students at our university worked on real-world problem-based projects within teams. Although the lecturers assisted students in teamwork, problem-based learning and project management among others, they realised that this was a rather overwhelming task for first-year students. One of the main concerns was that the students experienced challenges to work together in diverse teams on problem-based projects. As a result, the curriculum was modified to enable engineering students to obtain essential skills in the first year, while the application of their knowledge and skills was performed in the second year when they had to design and develop a project. The aim of this research was to report on the integration of diverse team capabilities as part of PBL to provide opportunities for essential skill development in the first-year engineering course.

This paper is organised as follows: the context and related work is given, followed by a report on the empirical research, the results and discussion as well as the conclusion.

2 Context and Related Work

2.1 Problem-based learning

Educational practices should be implemented to create meaningful experiences where students need to cooperate in solving problems in uncertain and ill-defined contexts. Engineering graduates are required to deal with an array of problems in broader contexts, which require innovative and practical competencies (Lima et al., 2017). PBL is a well-known method of instruction in engineering, and involves active learning. It is team-based, and encourages the development of self-directed learning (Havenga, 2016; Hirshfield & Koretsky, 2018). Principles that underpin PBL involve that students engage with the problem, and they need to accept responsibility for bringing along various capabilities to the team. Information should be integrated from various resources, collaboration is essential and problem simulations should be unstructured and allow for investigation (Savery, 2015). The nature of problems provides a focal point for PBL. Jonassen, Strobel, and Lee (2006), and Jonassen and Hung (2015) distinguish among the following types (or characteristics) of engineering problems (categorised by the author):

- Structured-ness of problems: ill-structured problems include aggregates of well-structured problems, and such problems have multiple, often conflicting goals
- Knowledge of problems: engineers rely primarily on experiential knowledge, and engineering problems often encounter unanticipated problems
- Representation of problems: engineers use multiple forms of problem representation
- Solving of problems: ill-structured problems are solved in many different ways
- Success in problem solving: success is rarely measured by engineering standards; most constraints are non-engineering
- Team involvement: problem-solving knowledge is distributed among team members; most problems require extensive collaboration and communication

2.2 Working together in diverse teams

Team diversity in a social grouping involves the degree to which members differ within a group (Shemla & Wegge, 2018). Working in teams brings together students who are cognitively diverse and also differ in terms of gender, culture and personality, among others. Such diversity brings challenges to team dynamics. Hirshfield and Koretsky (2018) refer to gender, status (academic capability) and team interaction in engineering. They argue that the difference in personality, academic capability, race or gender could lead to poor team interaction and that it might result in an underperforming team. For example, women are more likely to assume a non-technical role to be the secretary of the team. In terms of academic diversity, it is also noted that some members are confident and trusted by their peers while others may be disregarded, and it is less likely that the latter group will participate in team activities (Hirshfield & Koretsky, 2018). Vigier and Spencer-Oatey (2018) portray that language-disparate and cultural diverse groups experience various challenges. However, most people need to work together as a team and share information as part of job requirements (Savery, 2015).

2.3 Integrating diverse team capabilities

Working together in teams requires cross-pollination of individual members and team capabilities to model real-world problems in PBL. Johnsson (2017) is of the opinion that high-performing teams perform best when they are diverse. The challenge in a diverse team is to enable all members to participate in team activities and assigned tasks. On this note, Shemla and Wegge (2018) argue that diverse teams have a pool of capabilities and task-related information available at their disposal and provide for the elaboration thereof. Their study indicated that 'high collective team identification' and the association between objective and perceived team diversity is essential in terms of the benefits involved in diverse teams (Shemla & Wegge, 2018, p. 1, 18, 19).

Mayo, Kakarika, Mainemelis and Deuschel (2017) highlight group boundaries (open or closed) and a diversity mind-set (members' representation regarding their diversity and its effect on group performance) as two meta-dimensions regarding the nature of team diversity. For example, members' minds may be set on a continuum of cooperative to adversarial teamwork. Cooperative learning is an active method of learning where students work together by emphasising each member's responsibility, commitment and ownership within the team (Johnson & Johnson, 2013). Thus, cooperative learning provides a structure for equal responsibilities in a team. Another view of integrating diverse capabilities is that team rules are an intervening mechanism for bridging language differences in a team to enhance effective communication and members' contribution toward the team (Vigier & Spencer-Oatey, 2018).

As emerged from this subsection, the following characteristics may influence effective work in diverse teams: high-performing teams perform best when they are diverse; diverse teams have a pool of capabilities available at their disposal; high collective team identification is essential regarding the benefits involved in diverse teams; group boundaries and a diversity mind-set influence team diversity, and the use of team rules may enhance effective working in diverse teams. Since the intention of this research was to report on the integration of diverse team capabilities in PBL, the research question was the following: How can first-year students integrate diverse team capabilities to aid in skill development in a PBL engineering course?

3 Empirical Research

This section outlines the research context as well as details about the participating students. An interpretivist approach was followed to understand participants' PBL experiences in diverse teams and a qualitative methodology was employed.

3.1 Course structure and team activities

This compulsory course enables students to obtain essential skills in the first year while the application thereof is performed in the second year when engineering students design and develop a community project. Lecturers provided facilitation regarding cooperative learning and team building, conducting meetings, assessment, engineering economy, communication and writing skills, project feasibility analysis and project management, technical drawings, and safety and workshop practice. Members were required to complete class assignments within their teams after a particular topic had been discussed. In addition, they assessed each other regarding each member's participation. A 9-point assessment scale was used to assess self as well as peers. Students needed to motivate the mark they had assigned to one another. Engineering students were also required to apply their skills and address real-life scenarios as follows:

- The planning of a community uplifting project (e.g. low-cost housing). The above topics are interwoven as follows: use the elements of project management to plan a real life township community upliftment project, apply engineering economy, develop a business model to find sponsorship for improving the living conditions of the poor, and manage conflict in groups while working on this project. In addition, each team had to develop a work-breakdown structure (WBS) and a Gantt chart.
- Students needed to apply multifactor decision-making to compare three projects by using the analytical hierarchy process (AHP) (the numerical weight was derived for each project). Teams selected their own three projects (e.g. learn the community to start and maintain a crop garden, explore an infrastructure improvement on water, and learn a community grow by taking care of their own chickens (Group 50). Regarding the types of engineering problems (see 2.1), the above community projects are ill-structured real-life problems that emphasise team involvement where problem-solving knowledge is distributed among members requiring extensive collaboration and communication.

3.2 Participants

The population consisted of one cohort comprising 378 students in a compulsory first-year engineering course in 2017. Ethical approval was obtained from the university where the research was conducted, and participants completed the required informed consent form. Before they started working, each team member was required to sign a code of conduct regarding his or her responsibility for particular tasks.

3.2.1 Diversity in personality

Selection of team members was done according to an Enneagram personality test as a typology of nine interrelated personality types (The Enneagram Institute, 2017) regarding an individual's behaviour according to his or her dominant characteristics (e.g. the reformer, helper, achiever, individualist, investigator, loyalist, enthusiast, challenger or peacemaker). Students completed the test, and assessed themselves to be in one of the mentioned categories. A diverse team of six participants was formed according to the random selection of students to be representative of various personality types. The aim was to ensure that students work in diverse teams to resemble engineering contexts. Each team selected a chief executive officer (CEO) themselves – always Member 1. Figure 1 shows members of a diverse team who are working together on a particular task.

Figure 1. Members working together in a diverse team.

3.2.2 Diversity in gender and language

Participants in this cohort were diverse in terms of gender where most of them were male (81%) whereas only 19% were female students (Figure 2, left). Although more female students enrolled for engineering when comparing to numbers of a few years ago, Engineering as field of study is still a male-dominated course.

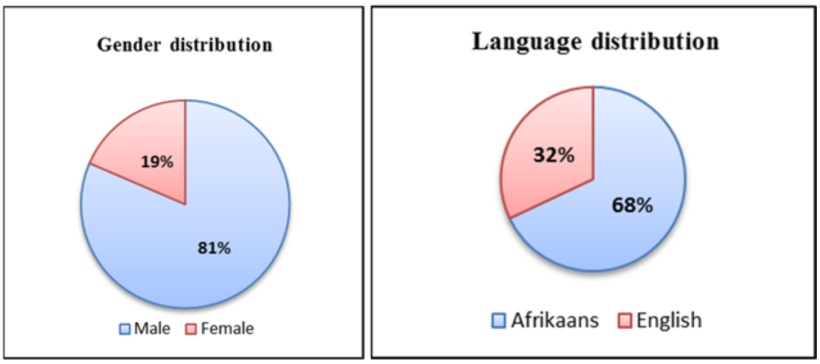

Figure 2: Gender (left) and language diversity (right) of participating students.

Participating students were mainly Afrikaans speakers (68%). While 32% of participants indicated that their language was English (Figure 2, right), more or less 11% of the English students' first languages were typically languages used in particular geographical regions in the country (e.g. Nguni, Venda, Sotho).

3.3 Data collection and analysis

Data collection involved team members' reflection reports, which they submitted at the end of the course to reflect on their experiences with PBL and team work. The data was manually analysed using the approach of Saldaña (2016). Initial coding (open coding) was mainly used to 'reflect deeply on the contents and nuances' of the data (Saldaña, 2016, p. 115).

4 Results and discussion

The results are presented regarding diversity in personality, language and culture, gender as well as variation in responsibility and ownership. The first column of each table outlines the challenges, and the action or procedure on which a team or member decided is mentioned in the second column. Participant numbers (Pnr) are given in brackets in the first column. Note that all direct quotes are reproduced verbatim and unedited (note the right column involves the *same* participants explaining how the issues were addressed). Although students' feedback in Tables 1 to 4 does not indicate the distribution of views of 378 participants, the researchers started with analysis until data saturation was obtained. The researchers continued to investigate the feedback from the remaining groups for additional opinions that could emerge.

4.1 Diverse personalities

Some feedback of students regarding their experiences with diverse personalities is shown in Table 1.

Table 1. Experiences regarding diverse personalities.

Challenge	Resolution
In my team, we were six very different people that were forced to work together. Sometimes all the personalities work; sometimes not. (P10)	It challenged us to think around the problem, how to compromise and find alternative options so that everyone in the group is satisfied.
'Different' was the word that would perfectly describe us from each other. (P100)	We kept to our house rules strictly and everybody agreed to this, which prevented many arguments … and I respect them tremendously.
Conflict must be resolved in effective ways to build and maintain positive relationships. (P102)	The meetings were a very successful step in showing how to organise, communicate and build relationships with random students that later on became very good friends.
[N]ot everyone was participating in the group activities or that activities were misunderstood and done wrong … because of bad group leadership, the inability to keep to the rules and accepting different personalities or opinions. (P36)	[I]t can be solved through acknowledging the problem, and working through it as a team.
[W]e often spent most of our meeting time arguing with each other, the conflict became more regular and intense from time to time. (P190)	[P]ractice professionalism, whereby everyone acts in line with codes of conduct, regardless of what their personal traits are.

4.2 Diversity in language and culture

Some exemplars of diversity in language and culture are outlined in Table 2.

Table 2. Experiences regarding diversity in language and culture.

Challenge	Resolution
Our group had a bit of a language barrier in the beginning of the year and a lot of translation was required. (P37)	[T]owards the end of the year, this problem grew smaller and smaller. Our group understood that it is necessary to stay patient while resolving problems.
In my group, there were many instances where we had arguments that really broke us apart, for example, language and culture. (P83)	[T]hrough many sessions and techniques, we grew from a group who simply wanted to pass the subject to a team who worked together, in spite of our differences, to do what we had to do to reach our goals.
We had a very big communication problem, as one individual said he cannot speak English, and another said he cannot understand Afrikaans. (P30)	We all had to learn how to compromise, especially in our group meetings. As the year passed, it got better.
How to treat other people from different cultural … backgrounds in a professional matter. (P17)	I clearly realised that there were many skills of mine that I really need to improve on. Like I have to improve my English vocabulary.
Language was a potential problem … the group sometimes forgot to speak English, or simply did not realise they were speaking Afrikaans out of excitement. (P97)	I felt that it was my responsibility to bring it back to English whenever this happened, because our English speaker is slightly quieter … we managed it quite well.

4.3 Gender diversity

Only a few examples of gender diversity emerged from the data (Table 3).

Table 3. Experiences regarding gender diversity.

Challenge	Resolution
The group consisted of two girls (including me) and four guys. At first, it was difficult to know which role each person in the group will take up. (P65)	[A]s the weeks and assignments progressed, we came to realise quite quickly who would fulfil which role.
In a mainly male-populated student group … comprised of two female students. One of the female students was elected to be CEO. However, the male students in our group often undermined her authority at the beginning of the year. (P110)	[W]hen the CEO had her authority undermined, a direct, firm and clinical approach to the situation prevented the conflict from getting out of hand and grudges being formed.
There were moments where I felt outvoted because of being the only female in the group … I would sometimes say something that I believed would have a great effect on whatever that is being discussed, and whenever my fellow group mates wouldn't listen. (P179)	I then decided that I will speak my opinion and let my voice be heard …. Our group somehow grew closer in resolving the conflicts because we got a chance to really know one another and understand why someone would feel the way they did concerning a certain issue or matter.

4.4 Variation in responsibility and ownership

Students were required to be responsible for particular tasks within a team (Table 4).

Table 4. Variations in students' responsibility and ownership.

Challenge	Resolution
[B]ut if the competition between two people in a group gets too hefty it will influence the whole group. (P69)	To prevent conflict, the CEO needs to write down each of the group members' responsibilities for a specific task … After the work is dedicated to each of the members, everyone needs to have their work done and handed in before the closure time of the project.
[I]t became noticeable that one certain member was starting to become a weak link, in the sense of missing deadlines as well as not being as prepared as the rest of us. (P108)	[W]e handled it in a very strict, yet sensitive way, as stated in our house rules in the beginning of the course … Thus the entire productivity rate of our group increased which led to shortened, more focused meetings.
[I]t was difficult at first and we learned that sharing the responsibility amongst everyone in the group was not always easy. (P2)	As time went on we learned one another's strengths and weaknesses leading to us actually working very well together and not only that, we learned to work very well under immense pressure.
The module focuses on preparing students for the 'real world' by placing students into situations where high-quality work is demanded with limited time being available … students work in groups, thus preparing them for the challenges all engineers face on a daily basis. (P151)	This teaches each student that they are not only responsible for their own work but also the work that is expected of the group they have been assigned to.

5 Discussion

This section addresses the research question. Working in diverse teams poses various demands. Although numerous challenges are outlined in each of the tables, corresponding ways of addressing these challenges are also suggested. Moreover, students' experiences are associated with some characteristics of diverse teams (section 2), as indicated in square brackets.

- Members learned to organise, communicate and build relationships with their peers who differed in many ways (4.1) [diverse teams have a pool of capabilities available].

- Members grew from a group who wanted to pass the subject to a team who worked together, despite their differences (4.2) [collective team identification is essential concerning the benefits involved in diverse teams].
- Some groups grew closer in resolving the conflicts since they had a chance to really know and understand one another (4.3) [group boundary and diversity mind-set influence team diversity].
- Non-cooperating members were handled in a strict way according to their 'house rules', and as a result, their productivity rate increased (4.4) [the use of team rules enhances effective working in diverse teams].

Integration of diverse team capabilities therefore provided opportunities for essential skill development. Members had to work with each other, regardless of personality, language, cultural or gender differences. Team members learned how to build relationships, take responsibility for tasks and solve problems, address conflict and work according to their house rules. Students developed skills to work cooperatively and give frequent feedback to group members. Team members assisted each other, requested regular feedback and made decisions at focused meetings while the CEO managed the overall operations and responsibilities in diverse teams. Regarding the final assessment of this course, 73 obtained distinctions, 269 passed, 30 failed and six discontinued engineering studies. It is essential that team capabilities be integrated within a team, especially in diverse teams, to strengthen team cooperation and performance in a problem-based context. The findings are integrated and displayed in Figure 3.

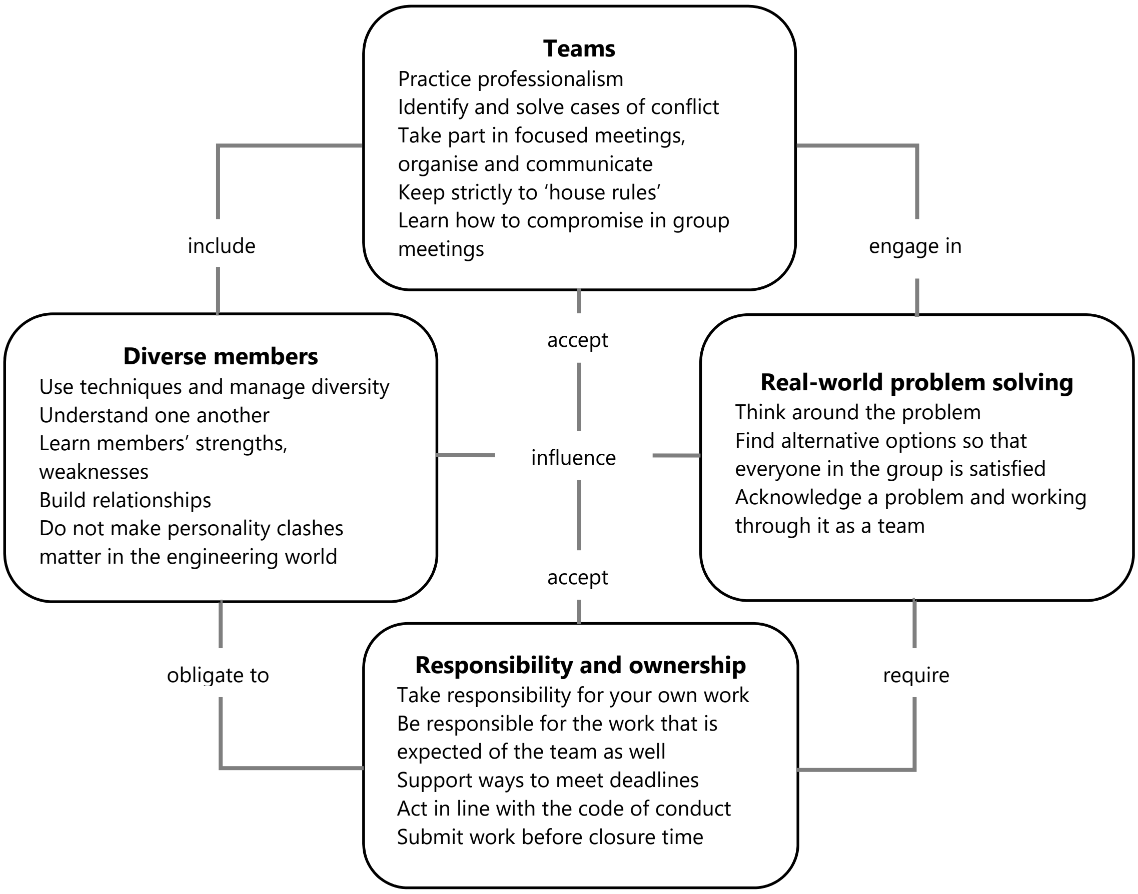

Figure 3: Integrating diverse capabilities as part of PBL in a first-year engineering course.

Particular capabilities, which emerged in the PBL context, were integrated and grouped by using the following headings (themes): Real-world problem solving, Teams, Diverse members, and Responsibility and ownership. Each of the themes (in italics below) are integrated and associated with one another as indicated by the connection lines using descriptive verbs. As part of the focal point of PBL, participating students were required to engage in *real-world problem solving*. Particular capabilities involved that students need to think around the problem, find alternatives, work through a problem and make decisions to the team's satisfaction. *Team* capabilities comprised the following: practice professionalism, identify and solve cases of conflict, take part in focused meetings, keep to 'house rules', and learn how to compromise in group meetings. Although *diverse members* were initially not used to working in teams, they managed diversity in several ways: they used various techniques, understood one another, learned members' strengths and weaknesses, focused on the building of relationships, and managed personality clashes in a professional manner. Similarly, Johnsson (2017) argues that high-performing teams perform best when they are diverse, and have distinctive capabilities and task-related information available at their disposal. Successful teams accept *responsibility and ownership* of numerous tasks. Although some members were not as dedicated as expected and were responsible for a team missing deadlines, the respective teams managed and addressed such challenges and acted accordingly. Teams were required to submit their work online on the student learning environment before closure as electronic time slots were set. Results are in line with the view of Johnson and Johnson (2013) as they emphasise skills such as equal responsibilities, commitment and ownership in a team. Regarding team diversity, a well-known quote of Henry Ford is true: "Coming together is the beginning. Keeping together is progress. Working together is success."

6 Conclusion

The aim of this research was to report on the integration of diverse team capabilities as part of PBL to provide opportunities for essential skill development in the first-year engineering course. Results indicate that first-year engineering students experienced several challenges when working in diverse teams to solve real-world problems. However, they also developed various actions and procedures to address such challenges. Students' diverse team capabilities were integrated in a diagram indicating the associations between the main themes that emerged. These capabilities can be seen as recommendations to assist lecturers further in the successful implementation of diverse teams in engineering contexts. The research opens perspectives on the development of industry-relevant skills, such as the importance of relationships, professionalism, management of team responsibility, and the enhancement of effective work in diverse teams.

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The SETH Academy: enhancing learners' mathematical competence for engineering challenges in higher education

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Abstract

South Africa needs a coordinated strategy to prepare school learners for higher education in the disciplines of Science, Technology, Engineering and Mathematics in particular. Mathematics as a core discipline requires problem-solving knowledge and skills essential to 21st-century demands. However, many secondary school learners do not have the required level of mathematical skills to meet future challenges. The SETH Academy (Science, Engineering, Technology and Health) is an exemplar of such a coordinated strategy. In 2013, SETH was established at the North-West University (NWU) as an initiative of the Faculty of Engineering to prepare school learners for higher education and assist in the training of future engineers as a shortage of such skills threatens the economy. The SETH programme aims to increase the output of engineering graduates, the throughput of students and the number of graduates from previously disadvantaged groups as well as females. The SETH Academy is a university–secondary school community programme in collaboration with industry. As mathematics is a prerequisite for all engineering programmes, SETH strives to promote mathematical competence and learners' active involvement in solving problems. Stakeholders also introduce learners to visit the industry and help them interact with university lecturers. The aim of the research reported here was to investigate SETH learners' active involvement in problem-solving tasks to enhance their mathematical competence for higher education engineering challenges. A quantitative approach was followed. One hundred and four Grade 8 and 9 learners participated. Data collection involved learners' written tests, and these were assessed according to the correctness of their solutions on a scale from zero to three. Data were analysed using statistical methods. Results indicated that the SETH Academy made a noteworthy contribution by enhancing learners' mathematical competence.

Keywords: Active Learning; Engineering; Higher Education; Learners; Mathematical Competence.

1 Introduction

Life in the 21st century demands a contemporary look at mathematics education, and this necessitates the implementation of appropriate pedagogical approaches to assist in knowledge and skill development for future demands. Mishra and Mehta (2017) synthesised essential core abilities for the 21st century as follows: creativity, collaboration, communication, critical and reflective thinking, digital information, and communication technology. Scholars also highlight active learning, collaborative problem-based learning, the development of deep knowledge as well as scientific and engineering practices (Krajcik & Delen, 2017; Matlala & Wessels, 2015). Active learning involves a problem or task where learners have responsibilities in addressing such a problem. Rands and Gansemer-Topf (2017) refer to active learning as a teaching–learning approach or strategy where learners are practically involved in doing some tasks, for example active listening, sharing thoughts, peer questioning and discussing challenging problems in small groups. Furthermore, the authors emphasise that active learning approaches, in comparison to traditional teaching-centred approaches, enhance learning. Consequently, school learners should be prepared for 21st-century demands and challenges in higher education where they are required to construct knowledge actively in engineering and scientific disciplines. Engineering and related subjects embrace integration of scientific fields to focus on "solving pressing individual and societal problems" (Krajcik & Delen, 2017, p. 21). The Engineering Council of South Africa (ECSA) system for accreditation of programmes involves 11 exit-level outcomes. Among these are problem solving, investigation, individual and teamwork, and independent learning (ECSA, 2012), which are similar to the essential abilities required for the 21st century.

In South Africa, school learners are largely exposed to traditional teaching approaches. Such approaches tend to enhance rote learning, lead to artificial understanding, are often used for examination coaching, and proved to be unsuccessful in promoting the problem-solving abilities and mathematical competence of learners

(Samuelsson, 2010). Recently, the focus shifted to approaches where learners are actively involved, for example problem solving, problem-based learning, cooperative learning and investigative teaching and learning (Fernando & Marikar, 2017). Such approaches contribute to a higher level of understanding, enhance problem solving and the development of mathematically competent learners since these are prerequisites for learners who intend to become engineers (Domazet, Baranović, & Matić, 2013). However, this change is taking place at a slower rate than desired due to many poor and under-resourced schools with overcrowded classrooms and often underqualified mathematics teachers. Moreover, fewer learners qualify for study at university at the end of Grade 12 due to poor performance in mathematics (DBE, 2016). Candidates who pass mathematics in the final school year also seem to be deficient in fundamental and mathematical competencies that should have been obtained in lower grades (Grades 8–11). As a result, students coming from the schools seem to be underprepared for the formal world of definitions, proof and axioms in mathematics as required in higher education (Benade, 2012). In general, learners struggle to solve real-world (non-routine) mathematical problems. The responsibility to prepare learners adequately for higher education, and for engineering challenges, primarily lies with schools. Rach and Heinze (2017, p. 1343) assert, "specific precursory knowledge related to scientific mathematics and students' abilities to develop adequate learning strategies turn out as main factors for a successful transition phase". Furthermore, Nor, Nambiar, Ismail, and Adam (2018) highlight the redesign of classrooms to emphasise active learning where school learners demonstrate improvement in how they engage in small group interaction. Consequently, the transition from secondary to tertiary mathematics requires progression to advance mathematical thought as well as competent and well-prepared students who enrol for courses, such as engineering (Boesen et al., 2014; Neumann et al., 2015).

To address this challenge, the Faculty of Engineering at the North-West University (NWU) initiated the SETH Academy to prepare school learners for studies in higher education. SETH is a university–secondary school community-based programme, in collaboration with industry, and focuses on secondary school learners with the potential to pursue STEM-related studies (Science, Technology, Engineering and Mathematics), such as engineering. SETH learners are selected during Grade 7 (last year of primary school) and should have scored at least 80% in mathematics and science, achieving a grade average of 80% or more. SETH aims to support talented and gifted learners in developing mathematical competence, problem solving, reading skills and computer skills. The stakeholders in SETH also strive to expose learners to additional activities, such as visits to industry and interaction with university lecturers in the Faculty of Engineering. Although participation in SETH is not free, bursaries are available to less fortunate learners. SETH working sessions are held once a month in the afternoon after school, where learners are involved in problem-solving tasks with the aim to reinforce and develop mathematical knowledge and skills where they actively collaborate. As a result, the purpose of the study reported here was to investigate SETH learners' active involvement in problem-solving tasks to enhance mathematical competence and prepare them for engineering challenges in higher education.

2 Theoretical aspects

Worldwide countries recognise the importance of STEM education and acknowledge the contribution thereof to address real-world challenges. STEM as interdisciplinary field of study involves a learner-centred approach and requires cooperation and the application of higher-order thinking skills to solve authentic problems (Khalil & Osman, 2017). Common STEM practices comprise active learning, problem-based and project-based learning, scientific inquiry as well as engineering design (Fitzallen, 2015). Nevertheless, Fitzallen (2015) accentuates mathematics as an essential component in the interdisciplinary nature of STEM education.

Mathematical thinking is an important contributor to the learning of mathematics and the development of mathematical competence. Mathematical competence entails the ability of an individual to make sense and apply mathematical knowledge and thinking in various contexts and real-life problem situations (Niss, 2011). Although a variety of procedural, factual knowledge and concrete skills are important, these are insufficient to account for mathematical competence (Gilmore et al., 2018).

Frameworks for mathematical competence include the Danish Competence Development and Mathematics Learning (KOM) project comprising eight mathematical competencies – problem tackling, mathematical thinking, representation, symbol and formalism, communication, aids and tools, reasoning and modelling –

(Niss & Højgaard, 2011), the Programme for International Student Assessment (PISA) (OECD, 2016), and the Trends in International Mathematics and Science Study (TIMSS) (Mullis, Martin, Foy, & Hooper, 2016). The last two frameworks enable researchers to recognise, identify and classify the level of competency for a specific learner. Nevertheless, it is compulsory to adhere to the South African Mathematics curriculum as a policy document for all national schools. This curriculum is based on four cognitive levels of thinking according to increasing levels of complexity, namely knowledge, routine procedures, complex procedures and problem solving (DBE, 2011). *Knowledge* comprises the application of mathematical facts, correct formulas, straight recall and the appropriate use of vocabulary. Examples of such problems for Grade 8 are the following: name two properties of a square; and determine the area of a circle with a diameter of 10 cm when the formula is given. On the second level, *routine procedures* entail the identification and use of suitable formulas, execution of well-known procedures, usage of simple calculations and the application thereof in multiple steps. For example, solve for y if y – 6 = 9. *Complex procedures* on the third level require conceptual understanding and involve no obvious way to address the solution to the problem. Solving such problems require complex calculations and higher-order reasoning. Examples are the following: use a paper cutting activity to show that the interior angles of a triangle are supplementary; and calculate the following: a car travels at a constant speed (60 km in 30 minutes). How far, by travelling at the same speed, will the car travel in 1 hour 15 minutes? *Problem solving*, the fourth and highest level of mathematical thinking refers to non-routine (open) and unseen problems, higher-order processes and understanding where the learners should break down the problem into its components. An example is: the sum of three consecutive numbers is 87. Find the three numbers (DBE, 2011). Metacognition (thinking about one's own thinking) plays an important role in mathematical thinking, competency and problem solving as well. Metacognitive strategies include planning, monitoring, evaluation and reflection and these are of importance when solving mathematics problems. Learners who can monitor their thinking regularly and adapt it when required, become effective problem-solvers (Van de Walle, Karp, & Bay-Williams, 2015). Hence, learners need to be actively involved in managing their thinking processes when solving mathematics problems.

School learners need to view situations mathematically, solve a problem with no clear answer, and be actively involved in the proses to address a problem (OECD, 2016; Schoenfeld, 2014). When learners are actively involved and thinking about what they are doing, active learning may lead to the enhancement of higher-order cognitive activities, such as analysis, synthesis and evaluation (Jacobs, Vakalisa, & Gawe, 2016). These skills are essential prerequisites for developing mathematical competence and preparedness for higher education. Nor et al. (2018, p. 19) stipulate that classrooms making provision for active learning enable learners to work collaboratively "through problems, apply concepts, analyse results and draw on their own conclusions which lead to increased motivation … able to transfer what they have learned into new situations, courses, and beyond".

Although problem solving and active learning is not the standard practice in South African classrooms (Matlala & Wessels, 2015), teachers increasingly attempt to implement active ways of mathematical learning as they realise the value of it. Teachers assist learners to plan their solutions, make good decisions, and to monitor, evaluate and reflect on their problem-solving attempts (Smith & Morgan, 2016). In the next section, the authors report on SETH learners' active involvement in problem-solving tasks to enhance their mathematical competence for future engineering challenges.

3 Research Methodology

Although an embedded mixed research design was utilised (Almalki, 2016), the emphasis in this paper is only on the quantitative aspects of the study.

3.1 Participants and SETH activities

At the project school, there were 305 Grade 8 and 9 learners; the focus of this research, however, was only on the SETH learners (N = 104) in these grades. There were three cohorts, two Grade 8 cohorts, namely 8(1) and 8(2), and one Grade 9 cohort. Due to circumstances, the two different cohorts in Grade 8 did not start at the same time with the SETH classes. Ethical clearance was obtained from the university and all ethical requirements were addressed (e.g. the learners gave informed assent).

Learners follow the school curriculum during school hours but have a weekly afternoon session at the university where they participate in enrichment activities, such as laboratory experiments and practical activities, and they go on excursions from time to time. Mathematics class sessions are held once a month at the project school. Learners collaborated in small groups of three to four where they worked together and reflected on their attempts to solve problems. Initially, the SETH learners completed worksheets with routine types of problems, for example, simplifying algebraic expressions. However, the approach was revised. Two mathematics teachers in collaboration with a university lecturer compiled open-ended, non-routine problems. The intention was to provide opportunities for SETH learners to improve their problem-solving skills and to assist them in solving such problems. Learners' active participation in problem solving involved the following:

- they had to read the problem a few times to make sure that they understood what was being given, what was needed and then had to plan a solution;
- monitor their thinking during problem solving;
- reflect on their problem-solving abilities and the correctness of their solutions; and
- learn from their peers to solve problems together.

3.2 Data Generation

Data were generated by means of a mathematics test for each grade compiled by the researcher. The Grade 8 cohorts wrote a pre- and post-test within a six-month interval whereas the Grade 9 cohort wrote an additional test (delayed post-test) (cf. sections 4.1 and 4.2). Even though learners worked together on class activities, they completed the tests individually. Note that learners wrote the *same* test two or three times but never received their scripts back after marking. The rationale was to determine the progress of the problem-solving abilities of the groups over time. Although these tests had questions on all four cognitive levels of the mathematics curriculum, only feedback on *problem-solving questions* at level four is presented. Mathematics tests were assessed by using a marking rubric (scores ranging from zero to three) indicating learners' problem-solving efforts and progress towards a correct solution. Each question was compared in terms of learners' performance, i.e. their experiences of the difficulty of the questions and the level of knowledge of the question. Based on these scores, the Statistical Consultation Services at NWU analysed these results. This research was part of a larger study where a comparable procedure to that of the SOM (Study Orientation Questionnaire in Maths) analysis was followed in the statistical analysis of the mathematical competence tests. Cronbach's ∝ determined the reliability, and factor analysis, the validity of each question. Paired t-tests determined the changes in the mathematical competence of the SETH learners from test to test. Two examples of questions are included.

The **cuboid problem** was a *Grade 8 problem-solving* question: The cuboid on the left was initially filled with water (Figure 1). Water was then emptied into the cuboid and the rectangular cylinder on the right in such a way that the height h in both containers (the right cylinder and the cuboid) was equal. Calculate the height h of the water in these two containers (round your answer to one decimal place).

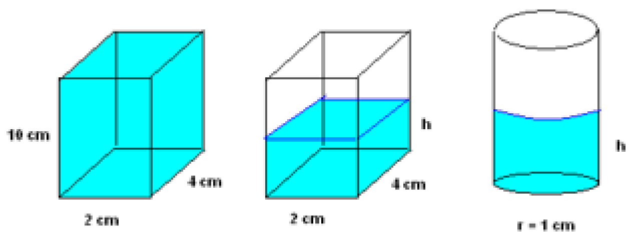

Figure 1: The cuboid problem.

The **box problem** was a *Grade 9 problem-solving question:* Four small squares are cut from the four corners of a rectangular piece of cardboard. The cardboard is then used to make a box. The volume of the box is 60 cm^3. The length is 5 cm and the width is 4 cm. Calculate the original area of the cardboard (before cutting something out).

4 Results and discussion

Firstly, the Grade 8 results are presented followed by the Grade 9 results.

4.1 The Grade 8 test results

The Grade 8 test had nine questions on each of the four cognitive levels (cf. section 2). These learners only completed the pre- and the post-test (and not the delayed post-test as in the case of the Grade 9 learners, see Table 2) due to time constraints. The results are presented in Table 1.

Table 1. Test results of the Grade 8 groups.

Participants	Test	Cronbach's ∝	Mean	Standard deviation	Sig (2-tailed)	Effect size
Grade 8(1)	Pre-test	0.637	12.67	4.82	0.00	0.95
(cohort 1)	Post-test		17.48	5.07		
Grade 8(2)	Pre-test	0.707	7.54	4.01	0.00	0.62
(cohort 2)	Post-test		10.93	5.48		

In the Grade 8 test, the individual questions had low Cronbach's ∝ values (< 0.6) for the two Grade 8 cohorts. These low values could be ascribed to the degree of difficulty experienced by the learners. The test results in terms of the learners' performance grouped the questions differently. However, when all the test questions were considered, the Cronbach's ∝ values were larger than 0.6 (Table 1). The data obtained was therefore regarded as reliable for further investigation.

The Grade 8(1) SETH learners performed better in the post-test, (M = 17.48; SD = 5.07) than in the pre-test (M = 12.67; SD = 4.82) (Table 1). This difference was statistically significant, t (26) = -5.71, p = 0.00 and presented a large-sized effect, d = 0.95. The results indicated practical significance. Moreover, the Grade 8(2) SETH learners also performed better in the post-test (M = 10.93; SD = 5.48) than in the pre-test (M = 7.54; SD = 4.01). This difference was statistically significant, t (40) = -6.15, p = 0.00 with a medium-sized effect, d = 0.62. This was an indication of practical significance.

From the statistical analysis, it appears that the Grade 8 SETH learners had improved their abilities to solve mathematical problems over time. Based on these results, it seemed that their mathematical competence improved from the pre-test to the post-test regarding their ability to solve open-ended, non-routine problems among others.

4.2 The Grade 9 test results

The Grade 9 test had eight questions on each of the four cognitive levels of the Mathematics school curriculum. These participants completed the test three times during the year. The results are displayed in Table 2.

Table 2: Test results of the Grade 9 group.

Test	Cronbach's ∝	Mean	Standard deviation	Sig (2-tailed)	Effect size
Pre-test	0.677	13.52	3.45	0.02	0.35
Post-test	0.670	15.00	4.22		
Delayed post-test	0.694	15.74	3.73	0.00	0.60

Some of the questions in the Grade 9 test had low Cronbach's ∝ values (< 0.6) while others had a Cronbach ∝ of 0.679. The low values could be because the learners' performance grouped the questions into these factors. However, when all the questions were considered, the Cronbach's ∝ values were higher than 0.6. This was the case in the pre-, post- and delayed post-test. The test and data obtained were therefore reliable for further analysis. These SETH learners performed better in the post-test, (M = 15.00; SD = 4.22) than in the pre-test (M = 13.52; SD = 3.45). This difference was statistically significant, t (26) = -2.43, $p = 0.02$ and presented a small-sized effect, d = 0.35. However, this difference was of no practical significance. The Grade 9 SETH learners performed even better in the delayed post-test, (M = 15.74; SD = 3.73) than in the pre-test (M = 13.52; SD = 3.45). This difference was statistically significant, t (26) = -3.57, $p = 0.00$ and presented a medium-sized effect, d = 0.60. This could be an indicator of practical significance.

Based on the statistical evidence, it turned out that the Grade 9 cohort continuously improved on their mathematical competence, from the pre-test to the post-test, and from the pre-test to the delayed post-test. When learners are exposed to suitable mathematics problems, they become actively involved in their thinking processes. Furthermore, their reasoning abilities, communication skills, modelling and representation skills can be enhanced (OECD, 2016).

4.3 Discussion

Both the Grade 8 and 9 SETH learners were actively involved when developing mathematical solutions in small groups during SETH class sessions. Team members also shared their thoughts and discussed challenging problems as mentioned by Rands and Gansemer-Topf (2017). Although the tests were individually done, active involvement and the development of mathematical capabilities during class sessions were evident since the results showed that learners in all three cohorts improved on their mathematical competence – involving questions on all four cognitive levels of the curriculum. In particular, the Grade 8 SETH learners performed better in the post-test than in the pre-test, the difference was statistically significant as well as practically significant. The results of the Grade 8(1) learners indicated a large-sized effect (d = 0.95) whereas 8(2) had a medium-sized effect (d = 0.62). Regarding the Grade 9 learners, they continuously improved on their mathematical competence, namely from the pre-test to the post-test, and from the pre-test to the delayed post-test. Results were statistically significant as well as practically significant. These learners were actively involved in mathematical thinking and skill development. Good problem solvers are mathematically competent learners and seem prepared for engineering courses in higher education (Neumann et al., 2015).

As a result, learners were actively involved in solving mathematical problems in small groups under the supervision of the teachers. They had to come up with their own solutions, took responsibility for their learning within small teams and had investigative attitudes in attempting to solve the problems. Additionally, they learned through discourse, reflection and social interaction. These capabilities are needed to prepare learners efficiently for higher education and specific courses, such as engineering, where mathematics is a requirement. Likewise, problem solving, teamwork and independent learning, developed as part of mathematical competency, are also aligned with the exit-level outcomes of the Engineering Council that students need to develop (cf. section 1).

5 Conclusion

This research investigated learners' active involvement in problem-solving tasks to enhance their mathematical competence for challenges in higher education. Results indicated that the SETH Academy made an important contribution by improving Grade 8 and 9 learners' mathematical knowledge and skills as essential for 21st-century demands. These learners were actively involved in solving problems within small groups. Furthermore, all cohorts improved on their mathematical competence as indicated by the test they wrote. The SETH Academy is an exemplar of a coordinated strategy and important endeavour to prepare secondary school learners for higher education and especially learners who consider a career in engineering.

Limitations of this study are that Grade 8 learners only completed the pre- and the post-test, and not the delayed post-test as in the case of the Grade 9 learners, due to time constraints. Completion of the third test could give an indication of whether Grade 8 learners develop problem-solving skills over a longer period.

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Soft or Hard? That is the Question. The Necessity of Integrating Life Skills in Engineering Education

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Abstract

Today, engineering graduates face a major challenge of successfully placing themselves in a good job position soon after they finish their engineering education. Employers, nowadays, look for graduates who are not only qualified in their own field of study and have excellent technical skills but who also possess special competences that can meet the progressively increasing demands of the employers thus those who can make themselves stand out from the crowd. Soft skills also termed as employability skills or life skills have been defined as 'psychological abilities for adaptive and positive behavior that enable individuals to deal effectively with the demands and challenges of everyday life.'(UNICEF 2015). This paper focuses on the importance of soft skills in today's job market and the necessity to integrate the teaching and practice of "Soft Skills" in engineering courses without sacrificing the specific learning objectives that the syllabus requires. This paper reviews the current literature and compares it with the findings of this research involving 107 engineering students from ESPRIT and academic staff. The primary research uses quantitative and qualitative research methodologies based on an online student survey and interview questions.

Keywords: Soft Skills, Employability, Skills development, engineering education

1 Introduction

Engineering education is witnessing a major change from the past. Emphasis is placed not only on technical knowledge but also on skill and character in an attempt at making education more comprehensive. Engineering education has always been the backbone of the development of any society.

In today's fast-changing world, engineering education prepares graduates to contribute to society through productive and active careers as innovators, decision makers and leaders. Engineering education communities came to realize that graduates need to possess more than excellent technical knowledge in their chosen disciplines, but more importantly need to be better educated in communication skills, teamwork, problem solving, creative thinking, leadership and other 21st century skills.

The term 'soft skills' is often used to describe the development of someone's professional network and interpersonal competences. While it is conventionally easy to measure and evaluate hard skills through mathematics, programming and other engineering courses, the assessment of soft skills has proven to be problematic to engineering educators. A massive shift has been witnessed in the field of engineering education from teaching only hard skills to realizing the need for soft skills in the recent years.

Engineering graduates today are expected to be ready for changing work places in different sectors. Engineering as an education and as a career has always attracted students from all communities in Tunisia. Five years of engineering education offer subjects including technical theory and practical core courses specializing in the chosen field of engineering education. Students acquire an engineering degree and believe that is enough to get through an interview to get a satisfactory job. However, today's world economy, stimulated by rapid technology transfer, progress, globalization and increasing demand of customer's satisfaction, has paved the way towards developing a set of employability skills that need to go along with an extensive range of technical skills. These universal skills make graduate students more employable. Such skills include communicative and interpersonal skills, problem solving, management skills, teamwork, and many more thus maintaining a balance with the core technical skills acquired during engineering education. This balance enhances competition among the new engineering graduates, finally letting the employers choose the best among the lot to work for them.

Chaita describes employability skills as "thinking skills such as logical and analytical reasoning; problem solving; capacity to identify access and manage knowledge and information; personal attributes such as imagination; creativity and intellectual rigor; values such as ethical practice, persistence, integrity and tolerance, problem solving, team working, communication, leadership". (Chaita, 2016, p.11-12). He recommends developing employability skills for a successful career.

Dorsey describes soft skills as a pill which one has to swallow or else face the consequences. He believes employability skills "are often times the area that will determine failure or success for many in the workplace in personal life as well as individual contractor. Some of the most important people in the world are failing, because though they have mastered the hard skills, they can't cope with the world that is fuelled by soft skills." (Dorsey 14).

Why are soft skills so important to keep high level of employability? Because these are the skills that an individual uses to interact with, interpret or inform social and physical settings. Employers look for employees who are not simply able to do the specific job they apply for, but who do it better than others. In other words, soft skills represent the working style of a person (the way in which s/he carries out the assigned tasks. It is the personal style, what I like to call the 'Wow' factor, which makes any person unique and which allows him/her to stand out from the crowd as Engineering graduates end up having the same technical abilities and qualifications after five years of studies i.e the same hard skills.

2 Literature Review

In February 2014, the respected journalist and writer Thomas Friedman published an article in the New York Times entitled "How to Get a Job at Google". In this article, the author refers to an interview in which the senior vice president of people operations for Google noted that they had determined that G.P.A.'s (Grade Point Average) are worthless as a criteria for hiring. The article examines the five hiring attributes that Google has across the company and finishes with an important conclusion: "Beware. Your degree is not a proxy for your ability to do any job. The world only cares about – and pays off on – what you can do with what you know (regardless of how you learned it). And in an age when innovation is increasingly a group endeavor, it also cares about a lot of soft skills – leadership, humility, collaboration, adaptability and loving to learn and re-learn. This will be true no matter where you go to work."

Employers often say that, given the chance between hiring a technologically skilled recruit with lousy people skills and a technology apprentice with a great attitude, they'll take the apprentice every time. Why? Because it's easier to teach technical skills than it is to teach attitude. And 'attitude' is the underlying trait for several key "soft skills," those personal attributes that enable people to work effectively and harmoniously with other people. By contrast, "hard" skills are teachable, often technical, abilities that can be measured and are specific to well-defined tasks like mathematics, writing code in Python or SQL, fluency in Arabic, video editing with Adobe.. But what are the key soft skills employers want?

2.1 The need for teaching and learning in 'soft skills':

When I asked industry representatives what our school, ESPRIT could do to better prepare engineering graduates for the highly- competitive job market, the strong response was to teach them "soft skills" which are necessary in today's work environment. "I can teach them the technical stuff," said one member, "but they need time to learn how to work with other people."

Most of the times the importance of soft skills is ignored and not given adequate attention for engineers. The education that goes in to make an engineer; does not concentrate on the people skills. The curriculum tends to ignore the fact that at the end of the day an engineer would be working in a team, reporting to someone, dealing with work pressure, giving presentations, attending phone calls, sending emails just to specify a few.

In all such situations along with technical skills, personality and character of an individual are going to play an important role.

Twenty years ago, the American Society for Engineering Education (Augustine and Vest,1994) asserted that "engineering education programs must not only teach the fundamentals of engineering theory, experimentation, and practice, but be relevant, attractive, and connected," preparing students for a broad range of careers and lifelong learning. Goldberg (1994) suggested that students spend 80% of their time studying technical subjects but these technical skills developed only constitute 20% of an individual's working day.

Despite this, several later studies highlighted the perception from industry professionals of a soft skills gap within graduates. Kumar and Hsiao (2007) stated that *"Engineers learn soft skills the hard way"* supporting the theory that engineers are continuously entering the market place technically qualified but not sufficiently proficient in soft skills.

There are many examples, however, in the recent literature that the education system is currently too focused on measurable hard skills such as qualifications, certifications etc. which means that soft skill development is often deserted. Findings from a survey study conducted by Sharma (2009) including 50 middle to top level executives in Human Resources found that recruitment managers are not satisfied with the current graduate workforce; believing that the graduates should be better equipped with soft skills as well as hard skills that can become quickly outdated.

2.2 The Educational Gap

One of the challenges in engineering education in Tunisia today is to improve the soft skills of the young engineers and prepare them for the workplace. The modern business world expects, along with hard or technical skills and latest knowledge in developing areas, cool and competent engineers who can work well a heterogeneous workplace. But the reality is that in the increasingly globalized world and the internationalized nature of workplaces, only a few engineering graduates are employable. They need to improve dramatically in the areas of communication, language skills, team work, critical thinking and leadership. The gap between academic education and required skill sets in the job market has been addressed on several occasions especially in IT oriented fields. Problem Based Learning was subject of several academic studies and research. The crucial question is whether academic IT related education fulfills the demands and requirements of the IT industry. Traditional academic syllabus focus more on core skills like mathematics, algorithms and programming. Marginal skills, especially soft skills, are offered mostly in 'optional' courses and are subject to the deliberate selection of the student.

"What we're hearing from employers is that they need a work force that's broadly prepared, that adapts to changing circumstances, that knows how to work in groups and in teams, that can communicate well, and that has problem solving ability." (Mary K. Grant)

3 Methodology

3.1 Research Questions

- How important are 'soft skills'
- Are they perceived as "second class" skills?
- What are the most appropriate methods to promote skills development and where does the responsibility for this lie?
- How effective is the current education system in preparing students for employment?

3.2 Approach

Primary research was conducted through quantitative and qualitative research methodologies as follows:

1. Online Survey Questionnaire that has been sent to ESPRIT Engineering Students by email.

2. Paper surveys handed to ESPRIT engineering students in class.
3. In-depth interviews with teachers from Esprit School of Engineering and undergraduates from ESPRIT.

A small local pilot study was used to sample the survey questionnaire and the resulting online survey questionnaire achieved 107 responses. 100% of the participants were from Esprit School of Engineering. Students from all five years of study were surveyed with the largest constituents being taken from 4th year (34%) who are computer science engineering students. A number of recent graduates also took part. The survey was distributed through social media groups as well.

Eighteen individual structured interviews were carried out as part of the qualitative data collection. The participants are shown in table 1 and represented four different spheres of interest; all have a direct connection with engineering.

A pre-prepared interview script included questions that were divided into groups under the following three sub-headings:

The interviewee's perception of 'soft skills': Which soft skills are most important?

The skills gap: Does it exist? Are soft skills sufficiently emphasized in college? How could the gap be closed?

Teaching and learning soft skills; who has responsibility? What are the most appropriate methods to integrate soft skills in engineering education?

Table 1: Structured Interview Participants

Sample frame	Percent	Details
Academic staff	36%	From Esprit School of Engineering
Undergraduates	44%	Studying computer science engineering, electromechanical and civil engineering in all levels. Mostly 4th year students.

4 *Results*

The following section summarizes the key findings and opinions collected.

4.1 How important are soft skills in engineering education?

While 71% believed hard skills are more important than soft skills in engineering, 92% of the survey population stated that soft skills are also important, which suggests that soft skills support the core of technical knowledge and skills.

82% of participants agreed that hard skills help engineers get to the job interview, but soft skills get them hired. The majority believed soft skills are more connected with a candidate's employability than hard skills which are seen as crucial.

Interviewees stressed that modern day engineers need to work in heterogeneous teams and are often required to collaborate with others on multidisciplinary projects. This puts a very high importance on soft skills to ensure the projects are successfully completed. The ability to report, orally and in writing at a high level of competence was also highlighted because of the ever increasing need for transparency in business.

80% of the survey respondents identified communication (oral, written, body language, listening skills and etiquette) as very important, 72% identified teamwork as very important and 44% identified time management as very important. Communication skills are pillars to many other skills including effective teamwork. The ability for a person to be able to adapt their communication style to the audience and environment is very difficult to master, but is essential in a successful engineer.

4.2 Are 'soft' skills, "second class" skills?

The word 'soft' has several meanings. Soft skills are referred to as soft because they are particularly difficult to quantify. They are more difficult to define and thus to effectively teach by conventional methods such as the lecture and the exam which are most familiar to engineers. Much more innovative learning styles are required to properly engage students in such non- technical subject matters. Unhelpfully too, soft skills are often perceived to be easier than 'hard' skills even though many employers see them as the most valuable skills to have. Soft skills are strongly associated with a person's emotional intelligence. Expressing emotions is, however, unfamiliar to many engineering professors who limit their thoughts to complex technical concepts, and therefore, consideration of such expressions be considered of little significance or perhaps, weak or 'soft'.

The term 'soft' is the opposite of the term 'hard', which also happens to be a synonym for difficult, so the meaning is blurred. A useful analogy was introduced by one of the interviewed ESPRIT academics. He compared soft and hard skills to software and hardware, suggesting that hardware like hard skills is more tangible, visual and easier to understand. A participant for the industry suggested that traditionally an engineer's role was to provide exceptional technical engineering expertise. Today the lines between functions in the hierarchy are much more blurry. Also, another businessperson stressed that with the growth in technology and automation, human soft skills will become more dominant in the future as engineers become ever more commercially aware. This means that engineers need to become more rounded.

4.3 What are the most appropriate methods to promote skills development?

Participants believed that soft skills can be both acquired through application and taught in theory. It was also suggested that the base level ability of an individual's soft skills is an innate ability from birth and developed from a very early age inside the family. This shows the importance of the elementary and secondary education system in developing the younger generations in soft skills.

Demands from employers for graduates with better employability skills has led to the introduction of more practical hands-on activities in the courses and simulated industrial experience. (Arlett et al, 2010). Many of the recruitment professionals along with the students believed that the best way to develop soft skills is through application and experience. The students in particular identified the internships which are part of their degrees as key to their personal and professional development and in preparing them for working life. However, the majority thought that there should be a combination of regular classes and hands-on experiences.

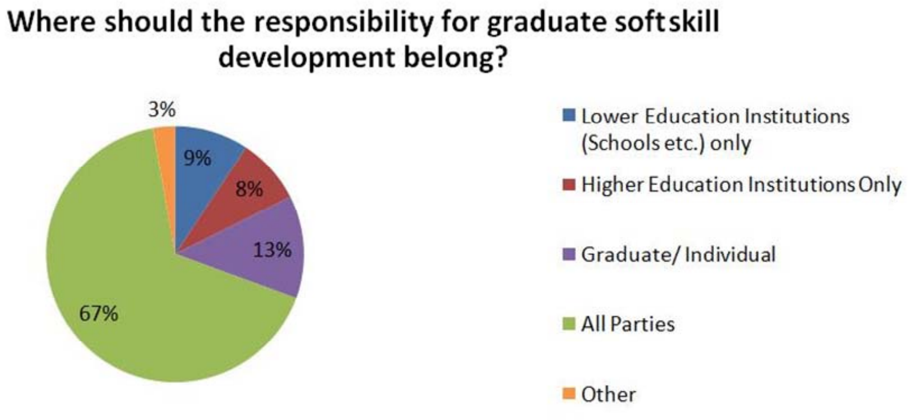
It seems that the environment in which people learn contributes significantly to soft skills acquisition and development. For example, the interviewed professionals reported that students who had attended private schools, where they are usually encouraged to take on responsibility, work on projects in teams and learn to speak in public through clubs and extracurricular activities, were more employable and ready to get their professional careers started.

4.4 Where does the responsibility lie for graduate soft skill development?

Only 8% believed the responsibility for graduate soft skills development should belong with Higher Education institutions alone; 67% of participants believed that the responsibility for soft skill development should lie with different parties (schools, employers and with the student himself). This was fully supported by the qualitative interviews. (The results are shown in Figure 1).

Many participants thought that Universities are here to teach students the specialty being studied and it is the graduates' individual responsibility to develop their own soft skills.

Figure 1: Online survey responses



4.5 How effective is the current higher education system in preparing engineering students for employment?

From the online survey questionnaire, when asked, do you agree that graduates enter employment with a sufficient competence in soft skills, 39% agreed, 36% neutral and 25% disagreed, showing a large spread of beliefs across the student survey population.

In response to the question: do you agree with the statement; Engineering courses include sufficient emphasis on soft skill development? A spread of responses was collected. 40% agreed, 24% were neutral with their opinion and 36% disagreed with the statement. However when asked do you agree that Engineering courses are too focused on teaching hard skills, 60% agreed.

Nevertheless, all interview participants supported the separate survey findings that nowadays, soft skills are not sufficiently emphasized in the university curricula.

The student participants believed that the best way to introduce more soft skill development is to change the method of learning in the technical subjects, rather than directly teach soft skills, which suggests that the adoption of more innovative teaching methods is required. At Esprit School of Engineering, for example, students found team-based work extremely beneficial to learn and develop how to work together and indirectly develop their skills and aptitudes. Students also mentioned that once employed, the hard skills learnt can become quickly outdated, and therefore the Higher Education curricula should try to create a balance between the teaching of soft and hard skills, to produce more rounded and flexible engineers who become more effective employees. From the academic professional perspective, work experience was seen as the main contributor to soft skill development.

5 Conclusions

This research emphasized the importance of soft skills in engineering education, regarding employability and personal development. The traditional perception that soft skills are less important than hard skills identified in the literature was explored. It was widely agreed that this perception exists, however, the present research supports the idea that soft skills are equally important and often undervalued in the modern engineering profession. The online survey questionnaire identified communication as the most important 'soft' skill within engineering. Communication is essential to ensure that students working in teams are collaborating effectively.

The literature identified a graduate soft skills gap but suggested the gap may be closing. On balance the present research did not identify any specific skills shortage. However, given that the majority of participants here were undergraduate students, they are likely to be predisposed not to acknowledge their own weaknesses in employability, or worse, may not be aware of them.

Findings also show that soft skills can be both taught and developed through hands-on experiences and innovative application. Introducing individuals to interpersonal skills from a young age is extremely important to create a strong base to build on throughout their lives.

This research also suggests that soft skills development is a shared responsibility and is developed throughout a lifetime. There is also significant evidence that higher education institutions are currently still deeply focused on technical skills and that they have the main responsibility to ensure graduate employability. Teaching these skills effectively, however, may require a shift in the educational philosophy and the adoption of more innovative teaching methods. Educators may need to adopt non-traditional methods of reporting student progress to adequately capture growth in soft skill development.

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Application of Design Thinking and On-site Customer validation for projects with Engineering freshman students

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Abstract

The course of Integrated Project of Industrial Engineering I (PIEP I) is attended by recently enrolled Industrial Engineering students from the School of Engineering of Lorena at the University of São Paulo (USP), Brazil. The goal of this course is to introduce students to an interdisciplinary engineering project as well as to develop technical and transversal competences. From 2013 to 2017, it was carried out for benefits inside the campus. In 2018 however, the theme of the class project was "Development of Didactic Games", with two modifications implemented in the program design. First, in the middle of the semester, there was the application of Design Thinking tools in order to broaden the search for solutions with effective customer-focus. Second, in the last month of the course, the students were oriented to test the product with potential off-campus customers in order to validate and improve the prototypes previously created. The purpose of this article is to show the impact of these two innovations on the major outcomes of the project. It was found that: (i) the application of Design Thinking led most of the teams to reformulate their projects; and (ii) leaving the school campus for on-site testing of the prototype with potential customers has significantly improved the final product delivery.

Keywords: Engineering Education; Project-Based Learning; Design Thinking; Didactic Games

1 Introduction

Engineering can be considered the technological engine of a country, and many of key issues regarding the development of a region, like competitiveness and productivity, are intrinsically related to the engineering potential of such place. Many factors contribute to making countries more competitive commercially, including as one of the most important being the training of engineers, as they are one of the most important players in technological development. On a broad sense, engineering courses in Brazil are still based on traditional teaching models, in which the teacher is the active agent of knowledge and the student the passive agent. With that in mind, we believe it is necessary to consolidate a new model focused on the student's deep learning to really prepare an engineer for the great challenges of a routine with focus on technological developed.

The Future of Jobs report (World Economic Forum, 2016) points to significant changes in the industrial landscape of the coming years due to the fourth industrial revolution. Therefore, the development of transversal competencies is increasingly relevant, as they will be required in the Engineer's day to day due to the changes in the new era of industrial development. Over a decade ago, for instance, Prince & Felder (2006) already warned that engineering schools needed to change in order to train professionals prepared for this new industrial setting. For this, Mulongo (2013) proposes the adoption of active learning methodologies that allow students to stop being mere spectators of theoretical classes. In addition, according to UNESCO (2010), it is necessary to increase the emphasis of engineering education in a problem-solving approach based on activities relevant to students, such as learning through projects and problems related to real life.

Active learning consists on the application of an educational method that involves the active participation of the students in the learning process. Active learning methodologies thus requires students to do meaningful tasks and critically evaluate what they are doing (Brum, Purcidonio & Ferreira, 2017). The central elements of active learning are the effective participation and engagement of learners in the learning process itself.

The Industrial Engineering course at the School of Engineering of Lorena, at the University of São Paulo (EEL-USP) has sought to differentiate itself from the traditional model with an intense focus on active learning strategies, particularly with an emphasis on Project-Based Learning (PBL). As an example, the course has three specific disciplines based on projects: Integrated Project of Industrial Engineering I, Integrated Project of Industrial Engineering II, and Integrated Project of Industrial Engineering III. In addition, students develop projects in several other disciplines of their curricula that are related to the subject of the discipline, such as Factory Project, Strategic Industrial Management, and Ergonomics, among others. PBL applied at EEL-USP, uses projects based on real problems during the semester in order to develop the knowledge and skills that are passed as theory (Echavarria, 2010) and it is recognized as an effective method to prepare students for their careers after graduation in a higher education course (Jollands & Molyneaux, 2012).

PBL has been growing in engineering education due to its positive impact on the students' learning and engagement (Edström & Kolmos, 2014) who are called to take on the role of protagonists in their learning process. Consequently, the role of the teacher also changes, as the main role ceases to be the bearer of "all" knowledge to assume the role of facilitator of the learning process (English & Kitsantas, 2013), which provides the theoretical basis and important instructions for the process of building a project (Holm, 2011).

Engineering schools that aim at innovation in education usually apply Design Thinking as a methodology that allows students to be agents of innovation who can solve problems with a look of empathy and a holistic vision leading assertive solutions for the client and the market. Olin College, in the United States, for instance, has an innovative experience as it offers engineering education in which its graduates are challenged to solve real problems from the first semester of the course. In this sense, PBL is one of the main teaching strategies used at Olin College and, when combined with Design Thinking, guides its students to the development of projects by stimulating teamwork and innovation (Olin, 2018).

We present herein a case study of Integrated Project in Industrial EngineeringI (PIEP I), a discipline based on PBL. In this course, from 2013 to 2017, the students carried out projects on the school campus itself. In the 2018 class, the project introduced two innovations: the application of Design Thinking tools and the students going off campus to test the prototypes created with potential clients. We noticed along these years that the use of Design Thinking favors a change in the paradigms of traditional teaching of engineering, because it allows to train an engineer to go beyond the domain of technical tools, to be a professional focused in the resolution of problems that are viable from the environmental, technical and financial point of view, and with a strong humanistic bias (Brown, 2009).

2 Study Context

PIEP I is a discipline of the first semester of the EEL-USP Industrial Engineering course. Its purpose is to introduce the entrants into a project anchored in a central theme that is challenging and motivating for students, but broad, in order to allow different solutions to be proposed. From 2013 to 2017, the themes of the projects were: Sustainability of a university campus; Production of Biofuels; Production of drinking water from unconventional sources; Global warming; and Clean Energy Production, respectively. In all these five years, students have carried out projects on the school campus itself.

The discipline was conducted by a team composed of a coordinating instructor, two student monitors, two invited teachers and a psychology professor. This team was responsible for the production and supply of didactic material, administration of theoretical and practical classes, elaboration and analysis of applied questionnaires and monitoring the elaboration and execution of the project.

The theme of the project for the 2018 class was "Production of Didactic Games" with the objective of creating an interactive recreation that would awaken in adolescents and young people the "beauty" of engineering. The target audience for the didactic games was made up of students aged between 14 and 18, who were attending the last years of elementary school II or high school in Brazil.

The PIEP I class consisted of 39 students divided into 7 teams with five or six members. The teams were assembled by the instructor, who separated the students into two groups: (i) five teams were made up of students who were starting an engineering course for the first time; and (ii) two teams only by students who had already partially completed engineering in the past and had switched to Industrial Engineering. Each of the teams had a tutor, a seniro student of the course who had already completed PIEP-I and who volunteered to be part of the class. This tutor student did not need to have technical knowledge of the project theme, since the main function of such tutor was to motivate the team in the search for a solution and facilitate the contact with different stakeholders that could help in the creation of the didactic game.

The course was composed of classroom activities for 15 weeks. In the first class the presentation of the project was made for the students. A Project Guide was given to them, containing a detail and justification for the project theme. The teams were assembled and each of them chose their leader (responsible for leading the group) and secretary (responsible for preparing the meeting minutes). In the second class, each of the teams presented a Conceptual Project that consisted of the first idea of the didactic game that would be created during the semester and received feedback from the instructor and the student monitors.

In the following three classes, general training topics were developed, aiming at the development of technical and transversal skills. The third class was led by a psychology professor on the importance of teamwork and good communication, through oral explanation and dynamics. Students also learned on the upcoming classes about project management basics based on the PMBoK Guide (PMI, 2017): Project Charter, Project Scope, Project Design Framework, and Timeline. They also learned how to visualize the project in Project Model Canvas (PM Canvas, 2017) and on Trello, a tool for task management when working in teams (WPCurve, 2015). In addition, in this fourth class, each of the teams delivered a Research Project, a document with a maximum of five pages that already had a basic detail of the Project of the Didactic Game that would be defined. In the fifth class, each team presented its Research Project and received feedback from teachers and student monitors.

A Design Thinking Workshop was applied in the sixth and seventh class of the course, that is, shortly after the delivery and presentation of the first report (Research Project) and prior to the preparation of the second report, which was later delivered in the ninth class. The application of the Workshop was intended to stimulate creative thinking and to enable teams to re-evaluate projects if they so wished.

In the next two classes (eighth and ninth), the topics covered were aimed at developing technical and transversal skills: analysis of the technical, economic and financial viability of a project; how to draw up meeting minutes and how to make good presentations. In the ninth class, each of the teams delivered the Preliminary Report, which should be a maximum of fifteen pages, containing the project in a structured way. In the tenth class, an oral presentation of the Preliminary Report to a committee of three invited external teachers was made and then feedback was given by these experts. After this feedback from the Preliminary Report, the students were allowed to go on the field testing of their prototype of didactic games they had created. In the eleventh class they were instructed to leave for fieldwork, which they did in the next three weeks. All teams tested two of their prototypes directly with the target audience for whom the game was intended.

Simultaneously with the implementation of the field application to the target public, the next three classes (eleventh to thirteenth) again addressed themes that aimed at the development of technical and transversal competences: (i) - leadership; and (ii) - on scientific writing and consulting the scientific database, using the Web of Science platform, aiming at the final delivery of the students that should be in the form of an academic article to be submitted to the main event of Industrial Engineering in Brazil (ENEGEP).

In the fourteenth class, six senior students from the last years of the course, who are already engaged in the labor market as trainees, presented a testimony about their trajectory in the course, as well as the learning and difficulties they had. The fifteenth and final class of the course consisted of a theoretical presentation of five minutes and in the application of the game for external teachers invited as evaluators.

3 Research Methodology

The research carried out has a qualitative basis and is based on the analysis of content collected from different sources (Bardin, 2001). (i) - Documents used as project support material (Project Guide, teaching materials used in the lectures), as well as the two Reports delivered by the students (Research Project in the fourth class and Preliminary Report in the eighth lesson) and in the article students delivered at the end of the semester; (ii) - Meetings held between the coordination team and the seven tutors, which analyzed the progress of the project activities, as well as evaluating the degree of teamwork and individual behavior of the incoming students; (iii) - At the Design Thinking Workshop stage, a questionnaire was applied in order to evaluate the impact of the activity on the evolution of the project; and (iv) - Previous experiences of the authors with PBL and the perception of behavioral details.

4 Innovations of the 2018 course

Two significant changes were introduced in this class of 2018: (i) the application of Design Thinking tools; and (ii) - students testing their prototypes with off-campus customers.

4.1 Design Thinking

The tool used in the year 2018, Design Thinking (DT), is a methodology of innovation and capacity building for complex challenges, in which traditional processes are not so suitable (Lockwood, 2009). It has a human-focused approach to the search for innovative business solutions (Brown, 2008), as well as to analyze the technical and economic viability of the project by non-designers to solve various problems in different areas (Brown, 2009). The method uses, in addition to empathy, iterative and rapid prototyping, aimed at transforming businesses, processes and systems (Curedale, 2013; Ingle, 2013). In short, a common point among the various authors is that DT is a process of creation of new solutions centered on the human being, and that makes it possible to find a more assertive and innovative solution through experimentation. Glen et al (2015) present a model in which they tried to synthesize several currents of different forms of application of Design Thinking in five distinct phases as shown in Figure 1.

Figure 1: *Design thinking* in five stages, adapted from Glen *et al*. (2015)

A DT Workshop, based on this model of Figure 1, was applied in two consecutive weeks (sixth and seventh class) with a total time of 100 minutes in each of the classes.

4.1.1 Design Thinking workshop

In the first week of this phase (sixth class), the students were divided into seven new teams. The only mandatory rule was that each of these "new" teams could not have two members of the same team on which students had been developing the project since the first class. A detailed schedule of activities, step by step, was prepared as shown in Table 1 and the details are presented in the last column. The times (in minutes) were strictly controlled. For the accomplishment of the steps 3 to 6, each one of the students received a worksheet divided into quadrants. In the first quadrant, each student should record the pertinent information from their interviewee's project (step 3). In the second quadrant, each student should note what were the goals and needs of the interviewee's Project from what it was collected during the interview (step 4). In the third quadrant, each student should draw what in their perception represented the project of their interviewee (step 5). And in the fourth quadrant, each student, after showing the drawing he had done for his interviewee, collected feedback (step 6). It was emphasized that only after the pitch (stage 9) the theoretical part related to the first three phases of the DT (immersion, analysis and synthesis, ideation), that is, the option was to have the students immerse themselves in a intense experience of a certain "creative chaos", to only in the end explain about the "theory" of Design Thinking.

Table 1 - Detail of the application of the DT in the first class

Step	Time (min.)	Activity	Detail
1	15	**Introduction to DT**	General presentation of concepts related to DT and their importance
2	3	**Team formation**	Formation of seven teams
3	8	**Immersion**	Student A interviews student B about the Project being developed at PIEP class (and vice-versa)
4	5	**Analysis and Synthesis**	Student A reflects and synthesizes the objectives and needs of the Project being developed by student B (and vice-versa)
5	8	**Basis Prototyping**	Student A draws a sketch of the Project being developed by Student B (and vice-versa)
6	8	**Solution Validation**	Student A presents the drawing to student B and collects feedback (and vice-versa)
7	10	**Ideation**	The teams formed are gathered, and each of the students talk about the Project being developed by the other student, followed by feedback and brainstorming
8	5	**Structuring**	Teams are structured and talk about a Project remodelling based on the brainstorming ideas
9	15	**Presentation**	Each team presentes the new Project ideas in up to 2 minutes
10	10	**DT Theory**	Presentation of DT theory and the first phases of DT

During the week after the sixth lesson, each of the original teams (those who had been assembled in the first class) met, along with their tutors, to reevaluate the initial project if it so desired. After this evaluation meeting, all students should, during that week, before the next lesson, conduct an interview with someone who was part of the target audience for their team project.
In the second class, the prototyping and testing phase took place with the original teams. A detailed schedule of the activities of this second class, step by step, was elaborated as shown in Table 2.

Table 2 – Details of DT application on the second class

Step	Time (min.)	Activity	Details
1	10	Feedback	The original PIEP I team meet and each of its members shares the feedback of interviews conducted with target audiences
2	5	Initial Pitch	Each team makes a brief pitch (30 seconds) on the "new" Didactic Game if any changes have occurred.
3	30	Prototyping	Each team creates a physical prototype of the Didactic Game from materials (glue, colored paper, toothpick, scissors, newspaper, cardboard, etc.) made available
4	10	Tests	Two members of each team present the Didactic Game to the colleagues of the other teams. There were two rounds of five minutes.
5	5	Evaluation	Each team fills in a spreadsheet with feedback received in the previous phase
6	5	Structuring	Each team decides based on the feedback received on possible improvements in the Learning Game under construction.
7	15	Pitch	Each team should present a final pitch on their Didactic Game.
8	10	DT theory	Presentation of the theory of the last two phases of DT
9	5	Data collection	Students respond to an evaluation form on the DT Workshop

At the end of this second class, 37 of the 39 students in the class answered a questionnaire of six questions using the Likert scale from 1 to 5, in which 1 means totally disagree and 5 means totally agree (Likert, 1932).

Table 3 presents the results in percentage of students for each of the answers from 1 to 5. The last column presents the weighted average of the answers.

Table 3 – Results from the Likert-based questionnaire applied

Question	1	2	3	4	5	Average
The DT classes helped me to carry out a more structured, user-centered project			5.4	43.2	51.4	**4.46**
The **immersion** phase helped in the development of the project		8.1	29.7	35.1	27.0	**3.81**
The **analysis and synthesis** phase helped in the development of the project			13.5	54.1	32.4	**4.19**
The **ideation** phase helped in the development of the project		2.7	18.9	29.7	48.6	**4.24**
The **prototyping** phase helped in the development of the project		2.7	2.7	18.9	75.7	**4.68**
The **testing** phase helped in the development of the project			5.4	10.8	83.8	**4.78**

The results of Table 3 allow us to verify that the prototyping and test phases were the ones that contributed the most to the project and that the immersion phase contributed the least. But overall, all phases had good student approval, and they were able to use the proposed methodology to effectively contribute to the project readjustment or change.

4.1.2 – Project changes

The Workshop was applied at a time that all the teams already had a project conceived, and already knew the product that they were creating and had documented this project in the first report of the discipline. After each of the two classes of the Design Thinking Workshop, an analysis of the design of each of the teams was carried out, in order to verify if any changes had occurred and, if there was change, indicating the degree of impact of these changes that were classified as: No changes; Few changes; Some changes and Complete project change (game). Table 4 summarizes these results.

Table 4: Impact of the Design Thinking (DT) Workshop on the development of the projects

Team A	Status after the first DT class	Status after the second DT class
A	No changes	Some changes
B	Few changes	No changes
C	Some Changes	No changes
D	Complete Change	Few changes
E	Some Changes	No changes
F	Few changes	No changes
G	Some Changes	Few changes

The analysis of Table 4 shows that all projects were influenced in some way by the Design Thinking Workshop, however, the depth of the changes in the projects after the first lesson was much greater than after the second lesson. It is important to highlight that six of the seven teams had decided to change their initial project because of the "creative chaos" they had experienced in the first class.

4.2 On-site Customer validation

The teams between the eleventh class and the fourteenth went to field testing the prototype of didactic games they had created. These tests were carried out in four schools in Lorena: School A (private), School B (private), School C (public) and School D (technical-level public school). These schools were invited and accepted that the teams could test the game with their students.

All teams should do two tests of their prototype directly to the target audience for whom the game was intended. It is important to note that the eight game types were different among themselves. There were board games, RPG (Role Playing Game), and card games. Each of the games had a different dynamic, from the number of players to the estimated time for the game to be held. Table 5 presents the main specifications of each of the games.

Table 5: Main Characteristics of each game

Team	Game type	Number of players	Average game time
A	RPG	12	50 min.
B	Board and cards	6	10 min.
C	Board	4	50 min.
D	Cards	2 to 6	15 min.
E	Board and cards	2	50 min.
F	Board	6	35 min.
G	Board	4	20 min.

In the eleventh class, students received detailed instructions from the instructor on how the validation test should take place. The planning of the application was made according to the characteristics of the games as shown in Table 5. In this class, the instructor also gave guidelines on how they should behave during the visits and highlighted essential points for student organization and test application. After that, a group was created in the WhatsApp messaging application with the leader of each of the teams, the teacher and a monitoring student who was the one who administered and monitored the students' trip to the schools.

An agenda was established and on the days of the on-site prototyping, the student monitored the teams to the schools and remained there throughout the application. The on-site prototyping occurred initially by the teams being sent to the classrooms where the application would take place. Initially, the monitor presented the project in a general way to the students and asked for the collaboration of all of them in the activities. Then, the teams presented themselves and began to organize the application of the games according to the specific characteristics of each one of them. After the organization of the room, the teams explained the rules of the games and started the game, helping the students to play. Meanwhile, some team members were responsible for watching the students playing and collecting feedback through informal conversation. It is interesting to note that at this stage, students were able to develop skills such as flexibility and empathy, since they had to manage some unforeseen situations. For instance, in some cases, the number of students present in the room was not what was initially planned, in others the structure of the place was not the most suitable for the type of game. There were cases where the educational level was not compatible with what was expected. For example, at school A team had to adapt the way they played at the time of application so that an international exchange student could participate, even if such student did not speak Portuguese fluently. At school C, some teams had to manage the vast difference in knowledge among students in the same class, creating mechanisms to make everyone comfortable to play in order for them to learn from the tested prototype.

A captivating fact was that during the tests, the teams noticed the excitement of the students of the schools for having a different class with dynamic games and an unexpected class content. Most of them were interested and curious to know how to play the concept that was involved in such activity. Another interesting fact was that high school students, especially in the senior year, always asked about university routine, including the courses and the way the classes were taught. At school B, one of the teachers in a room where the games were being applied, asked the teams to answer questions from the students and talk about college life, encouraging them to pursue that academic path.

After the application, the teams passed on questionnaires to collect feedback and talked to the students about the opinions and points of improvement that they felt needed in the games. Some teams in this process realized that the stipulated time was not appropriate, that some rules were difficult for the target audience they were proposing and that some changes needed to be made.

During this process, teams could see the importance of testing a prototype with the target audience and how this validation was essential to improve the product and really understand what the customer wants and needs are, and how to achieve them. Since a project must have a beginning, middle, and end, the finalization with the client was crucial to the students' full experience. All teams made improvements to the games they were developing from this validation stage.

5 Conclusion

PBL was applied in the group of students of the course of Industrial Engineering of the School of Engineering of Lorena at the University of São Paulo. The theme of the 2018 class project was "Production of Didactic Games". The target audience, i.e., the costumer audience for the products being developed, was composed of students aged 14 to 18 years who were in the final years of middle or high school in Brazil. Two significant changes were introduced in the 2018 class: (i) the implementation of a Design Thinking Workshop and (ii) - the students' journey to test the prototypes with off-campus customers. Both changes had relevant results considering the learning of the students involved in the process. Design Thinking allowed an expansion of the students' ideas, which provided a reassessment of the project ideas initially proposed. EEL students 'contact with middle and high school students improved not only the customer relationship experience, but also the students' view on how to execute a project.

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The importance of partnering with stakeholders to develop projects with second-year Engineering students

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Abstract

The class of Integrated Project of Industrial Engineering II is attended by students of the second year of the Industrial Engineering course at the School of Engineering of Lorena at the University of São Paulo (USP), Brazil. Students enrolled in this class have already taken a project-related course in their first year, developing solutions on-campus. In this second-year course, the students work on specific projects in small and medium-sized off-campus companies, since they are already more mature and have professional experience to act in real situations with greater complexity. The projects are focused on engineering topics with particular emphasis on management. The method for following up the projects is PDCA (Plan, Do, Check, Act). The teams receive support from faculty members, monitor students, and, among others, professionals with experience on the explored topics. This article describes the projects that were carried out by the class of the second semester of 2018. Our purpose here is to detail the course application model highlighting the importance of the partnership with several stakeholders. Finally, the article shows that the deliveries of the projects, as well as the development of technical and transversal competencies by the students, are greatly influenced by the active contribution of different stakeholders, not only in the company but also at the school or with the external partners.

Keywords: Engineering Education; Project-Based Learning; Stakeholders, Partnering.

1 Introduction

During the 21st century, many courses still train engineers through the traditional teaching model, as it has been done for hundreds of years. Such teaching methods focus on the figure of the teacher as the main actor of the teaching-learning process. This could make sense until the advent of the revolution of the dissemination of knowledge in the most different platforms that the emergence of the internet made possible. Currently, traditional methods are being questioned in regards to their efficiency because the student has at its own disposal the knowledge within reach hands quickly. Therefore, the teaching-learning model, which has been in force for hundreds of years, based on the idea of teacher transmission of knowledge, makes little sense nowadays, considering that the demand for transversal skills in engineering students is growing at a fast pace. These competencies can be developed from educational approaches based on active learning methodologies.

The World Economic Forum report (2016), titled "Future of Jobs," points to profound changes in the industrial hiring scenario in the coming years due to the advent of Industry 4.0. The relevance for the development of transversal competencies in professionals is growing, since many of the positions, currently existing, will be redesigned. One only certainty seems to make sense: change seems to be the only permanent thing in the professional career. Moreover, universities need to adapt to this reality to be in tune with this new scenario of the fourth industrial revolution.

This need for change is also discussed in a report on engineering education produced by UNESCO (2010) which emphasizes the importance that engineering curricula to be based on relevant activities for students, among which stands out teaching activities based on projects and problems, and others.

In order to pass from the teaching-learning model based on the idea of the transmission of knowledge to a model based on the development of competences, Project Based Learning (PBL) was adopted in the Industrial Engineering course at the School of Engineering of Lorena at the University of São Paulo (EEL-USP) since 2013. Our focus herein is to demonstrate the importance of the partnership with stakeholders for the development of projects, in particular on PBL-related topics, in a specific discipline of the second year of the Industrial Engineering course.

1.1 Project-Based Learning (PBL)

King (2012) points to the need for rapid changes in engineering education due to different demands: (1) a better understanding of human, cultural and societal conditions; (2) ability to work with public policies, business and government; (3) understanding of the innovation process and contributing factors; (4) ability to work in synergy with people from other areas of science and engineering, as well as with people from other areas of knowledge; and (5) ability to explain technical issues in simple, understandable terms.

Faced with these changes, schools have been seeking novel ways to develop skills in emerging engineering professionals. One of them has been the adoption of active learning methodologies, which allow students to be more than mere spectators in traditional classes (Mulongo, 2013). Among such methods, Project Based Learning (Unesco, 2010), stands as an active learning strategy that consists of developing projects based on real problems in order to train technical and transversal skills on the students themselves (Echavarria, 2010). PBL aims to put the student as the main actor in their learning process. Because of this, the role of the teacher must change, since such participation leaves the position of the holder of all knowledge to that of facilitator of the learning process (English & Kitsantas, 2013). PBL, in addition to enabling students to become responsible for their learning, also promotes the development of transversal competencies, such as teamwork, communication, and leadership, among others (Lu, 2007; Lehmann, 2008).

For Jollands and Molyneaux (2012), the use of PBL in engineering courses is a way of adding value to the student learning process, as well as being recognized as useful in preparing the student's professional career after the engineering training. For Graaff & Kolmos (2007) and Edström & Kolmos (2014), the use of PBL in engineering education generates a positive impact on the student learning and engagement

1.2 PDCA Cycle

The PDCA cycle, also known as the Deming cycle or Shewhart cycle (Strotmann et al., 2017), is a methodology created in the 1930s by an American statistician named Walter A. Shewhart (Silva, Medeiros & Vieira, 2017). However, it was William Edward Deming who in the 1950s began to use and disclose this method as a product quality control tool (Sangpikul, 2017). Since then, PDCA has been standing out as a method for developing process improvements (Maruta, 2012; Sangpikul, 2017), and nowadays it is widely recognized as a logical method aimed at continuous improvement (Sangpikul, 2017; Zhang, 2013). For Darmawan, Hasibuan & Hardi-Purba (2018), the PDCA cycle is a philosophy of continuous process improvement that is already part of the organizational culture of companies. In practice, the PDCA consists of a methodology that unfolds in four stages (Gorenflo & Moran, 2010):

- Plan: To identify improvement opportunities and prioritize them. It is also a step to help defining the real causes of a given problem and propose concrete solutions for its resolution through a plan of action through consistent data.
- Do: Implement the proposed action plan and document information.
- Check: It aims to analyze the results of the actions implemented in the Do phase to verify if there were improvements and if the desired objectives were obtained.
- Act: It aims to develop methods to standardize improvements, whenever goals have been achieved.

To perform these four steps effectively, various quality and productivity management tools are used, such as 5W2H, benchmarking; brainstorming, checklists Failure Mode Analysis and Effects (FMEA), flowchart histograms, Ishikawa diagrams, the Pareto chart, statistical process control (SPC) among others (Silva, Medeiros & Vieira, 2017).

2 Study Context

The EEL-USP Industrial Engineering course was first implemented in 2012. PBL was introduced in 2013 in a model like that used at the University of Minho, Portugal (Lima et al., 2012; Alves et al., 2016).

The course has three specific project disciplines: Integrated Project of Industrial Engineering I (PIEP I) in the first semester; Integrated Project of Industrial Engineering II (PIEP II) in the fourth semester and Integrated Project of Industrial Engineering III (PIEP III) in the seventh semester. The goal of PIEP I is to introduce the entrants of an engineering course into a primary project with a broad and generic theme. For example, in 2017, the theme was "Clean Energy Production," and in 2018 it was "Didactic Game Production." The goal of PIEP II is to place the student on a work situation based on projects related to real problems that are proposed by small/medium companies. PIEP III has an objective like that of PIEP II, but usually with problems of higher technical complexity.

This study focuses on the Integrated Project of Industrial Engineering II (PIEP II) of the Industrial Engineering course of the School of Engineering of Lorena (EEL-USP). The presented case refers to the group of 2018, realized between August and December of the respective year. The coordination of the class was made by the teacher of the discipline and two students monitors.

2.1 Projects

The initial stage of the course takes place before the semester begins. The course instructor prospects projects with companies and collect with each one a document with necessary project information, including a clear definition of the primary contact of the students in the company. In this project definition phase, two or three meetings are held in the companies to align the project with the expected expertise of the students (second year of Engineering course), and the time they will have to carry out the project (4 months). In this group of 2018, eight projects were aligned with seven companies. Table 1 shows the main characteristics of the companies and projects carried out.

Table 1 – Projects developed in PIEP II – 2018

Project	Partner	Products and Services	Project Objective
A	Hospital	Medical care, hospital services	Determine causes of losses in the billing process
B	Hospital	Medical care, hospital services	Improve the financial process
C	Tire retreading industry	Tire retreading of light and heavy vehicles	Reduce energy and fuel costs
D	Business Association	Services to members	Elaborate marketing plan to prospect new associates
E	Special steel painting industry	Painting, cutting and coating of sheets of rolled steel	Reduce setup time for a painting line
F	Automotive Components Industry	Components for brake systems of vehicles	Enhancing Global Equipment Efficiency (GEE)
G	Public school	Elementary, Middle and high school	Propose the creation of environments for classes with active methodologies
H	Special papers industry	Edge ribbons for furniture coverings	Decrease Lead Time in the Maintenance and Supplies area

2.2 Team formation

The class consisted of 45 students, all of them from the Industrial Engineering course. They were divided into eight teams, one for each of the projects, with a maximum of 6 students per team.

Each of the 45 students chose, in order of priority, four projects in which they would like to work at, ordering from the first to the fourth option. Students were allocated at their first option when the number of interested in such project was equal to or less than six students, i.e., the maximum number of members each team could have. When it would be the case that for the same project there were more than six subscribers as the first option, a lottery was made among the subscribers to define who the six members of that team of projects would be. In this first round, about 60% of the students stayed in their first option. Then, for the remaining 40%, the choice was made from the second option until the maximum number of 6 students was reached for each of the project teams. Then, in a third and fourth round, students who had not yet been considered in their first and second options were then placed in the third or fourth option they chose. At the end of this process, six teams were composed of six students, one was composed of five students, and one was composed of four students.

2.3 Project phases, timeline, and activities

The main phases of the project that occur during the semester are presented in table 2.

Table 2 – Project phases and activities

Phase	Week(s)	Classroom Activity	Off-campus Activity
1	1	Project Management lecture	None
2	2	Presentation of Projects; Assembly of teams	None
3	3 to 4	Theoretical reinforcement on themes essential for the realization of the projects	First visit of the teams in the companies
3	5 to 8	Project follow-up meetings	Visits and business meetings in the companies
4	9	Oral presentation of projects	Project evaluation meeting
5	10 to 13	Project follow-up meetings	Visits and business meetings in the companies
6	14	Final instructions on project delivery and evaluation of projects by teams	Visits and business meetings in the companies
7	15	None	Final oral presentation of the project and delivery of the final report to the client

The classroom timetable during the first semester had 14 meetings of the instructor with the students of each group. In the first class, a presentation was made on the importance of projects in the career of an engineer, as well as on the professional attitude that one should have in a company regarding the way of communicating and dressing, since the vast majority of the students was constituted by young people (average age of 19) who would be entering a company for a "professional" activity for the first time. In the second class, the teams were divided. In the third and fourth classes, fundamental concepts of project management, PDCA, process design software and some necessary tools of quality management and production process management were presented. From the fifth to eighth class, the teacher met, alternately, with four teams in each of the classes. In the eighth lesson, the teams delivered the first partial work report. In the ninth class, there was a presentation of all teams with feedback given by the teacher and student monitors. In the thirteenth class, the teams delivered the second partial work report. From the tenth to the thirteenth class, again the teacher met alternately with four teams in each class. In the fourteenth class, the teams evaluated the projects and received instructions on the final presentation of the project to be done in the companies and preparation of the final report that was delivered to the companies.

Parallel to this schedule of activities in the classroom, from the fourth week until the end of the semester all the teams made visits in the companies for the adequate progress of the project. These visits occurred at a frequency demanded by the project in which the team was working on. In the ninth week of the project, the instructor held a working meeting in all companies to evaluate the progress of the project up to that point and, if necessary, carry out a realignment of the project in the last weeks.

2.4 Project Deliveries

During the semester, the teams made four deliveries related to the project. Three of these deliveries consisted of partial reports delivered to the instructor, for which they received written feedback: (i) - a detailed technical analysis by the instructor; and (ii) - on the adequate use of the Portuguese language by the student monitors.

The first delivery was made in the fifth class on two essential elements of project management: Project Charter and Scope, which should contain as much information as is necessary for the proper start of the PDCA planning phase.

The second delivery was made in the eighth class, i.e., about 60 days after the start of the project) and consisted of the first partial report that aimed at the complete description of the first phase of the PDCA: Planning. This report should be subdivided into four parts: problem identification, observation, analysis, and action plan. Therefore, the teams needed to prove that they had already detected the root cause and worked out a complete plan of action to eliminate the root cause. The main tools used in this phase were Brainstorm, check list, histogram and Ishikawa diagram.

The third delivery was made in the thirteenth class, which was about 15 days before the delivery of the final report to the company. In this report, the team should point out that it had applied the entire PDCA Cycle from the first stage (Plan) to the fourth stage (Act). Besides, they should present their earnings and suggestions to the company. This report should have 7 (seven) distinct parts according to the template sent by the teacher. 1) Presentation of the Company; 2) PDCA Step 1: Planning; 3) Step 2 of the PDCA: Implementation; 4) PDCA Step 3: Verification; 5) Step 4 of the PDCA: Act; 6) Earnings Obtained and 7) Suggestions for the Company

Finally, the fourth and last delivery consisted of the final report that was delivered to the company. This report should have a structure similar to the last report given to the teacher. However, each team, after feedback received by the teacher, was free to present this report in a way that it judged to be the most appropriate, considering the profile of the interlocutor (s) in each of the companies.

2.5 Interaction with Stakeholders

The primary external stakeholder of each of the teams was their crucial contact in the company in which the project was carried out. All teams had at least one primary contact in each of the companies. Also, the teams were motivated to seek external support in the project theme, when needed, from diverse stakeholders that could help them. Half of the teams had external stakeholders, among which the following stand out: university professors, professionals working in industries and students from EEL-USP.

3 Results and Discussion

3.1 Project Evolution

All projects evolved according to schedule. The recommendation for the teams was that they had an average frequency of a biweekly visit to the companies. This occurred with six of the teams as shown in table 3.

Table 3 – Frequency of Visit in Companies

Team	A	B	C	D	E	F	G	H
Number of visits to the Company	18	10	8	4	16	21	18	6

The project carried out by the D (Business Association) team did not require a higher visit frequency, since almost all the necessary data were made available on the second visit and because it was a marketing project, the team had an intense interaction with the external clients of this association. On the other hand, in the project carried out by the H (Special Paper Industry) team, one of the team members worked in the company and thus had easy access to obtain data without having to go all the team more frequently in the company.

3.2 PDCA Utilization

The use of the PDCA cycle as a logical method for the development of the projects was essential on the excellent result obtained, especially considering that the teams were formed by students of the fourth semester of the course and that most of them were in their first real-world project in a company. Teams took about half the time of the project in the Planning phase, which ended with the proposal of an action plan (5W2H) detailed by six of the eight teams in the first report delivered in the eighth lesson. The other three phases of the PDCA (Do, Check and Act) were held in the second half of the semester. In short, the use of PDCA was essential to discipline the evolution of projects over the semester

3.3 Report Feedback

Six of the eight teams were able to deliver the planning phase entirely completed until the eighth lesson (delivery of the first partial report). The two teams that failed to do so were due to the complexity of technical information. Already in the second partial report, all the teams were with the third phase of the PDCA (Check) finished. Some were still preparing the consolidation of the project, which would occur from the standardization of some processes done in the fourth stage of the PDCA (Act).

The partial reports delivered in the eighth and thirteenth classes were the subject of careful analysis by the instructor who provided concrete feedback to each of the teams. This feedback proved to be very important to align with the teams the appropriate technical language of management and Industrial Engineering. Some written comments to some of the project teams are as follows:

> You start from three "big" problems. The first problem (inconsistencies) you detail as much as possible. The second (losses), you present only one paragraph dealing with it. Moreover, the third (high lead time) you just point at the beginning of the report and little talk about it. Problems need to be presented and analyzed similarly. (Feedback for team A for the partial report 1)
>
> The report is not following the PDCA model. No action plan (5W2H) with activities, responsible and deadlines were delivered. (Feedback for team F referring to the partial report 1)
>
> Avoid using informal language. You wrote: Paint line employees often change the schedule on their own and do not report the PCP area. A technical terminology should be used, something on the lines of Employees often decide for themselves, schedule changes, and do not inform the PCP. (Feedback for team E for the partial report 2).
>
> The students' Pareto chart is in the wrong sequence. The number of students who spoke about the difficulty of relating to employees was more significant than the number of students who spoke about the lack of commitment. These two items are reversed in the Pareto chart (Feedback for team G referring to partial report 2).

3.4 Interaction with Stakeholders

Two types of stakeholders were considered during the projects: (i) - internal, referring to those involved in the coordination of the discipline (teacher and monitors); and (ii) - external, referring to all types of support not directly related to discipline coordination.

The teacher of the discipline and the monitors are considered "internal" stakeholders, since the contact with the students extrapolates the meetings in the classroom on the regular classtime. During the execution of the projects, it was prevalent for the teacher or the monitors constant monitoring via WhatsApp, especially in the first weeks of projects. Students usually had numerous questions and concerns about their execution and what would be the most appropriate technical tools to use, and follow-up messages on WhatsApp were used as an instant feedback tool.

Concerning the "external" stakeholders, i.e., people who had no direct relationship with the coordination of the PIEP II discipline, all the teams were stimulated to interact with the most diverse players. The external stakeholder with the highest intensity of contact with the teams was the employee of the company that is the permanent point of contact in the company to assist the students during the project. In addition to this employee, in all projects, relevant stakeholders in the companies were also other employees with whom the students interacted to collect information or assist in different analyses during the project. Other external stakeholders were professionals who contributed to projects based on specific technical characteristics. For instance, four teams had the collaboration of stakeholders who were people who did not work in the companies in which the project was carried out.

Project C was carried out in a tire retreading plant. It is important to highlight that some advanced statistical mathematical models were used in order to assess the reduction of fuel expenses, which was something the students had not had formally learned in any of their courses until that moment. The team was assisted by a Statistics professor at EEL-USP, who met several times with them. This instructor was instrumental to the outcome of the project as well as to the students' technical learning about the proper use of advanced statistical mathematical models and basic concepts of operational research. The second theme of this project was the reduction of electricity cost. Initially, the team was assisted by an Electricity professor at EEL-USP that extended to them the general vision on the subject. This instructor then referred them to an expert on the subject of the project. The team had two meetings with this specialist who suggested: (i) - the installation of a capacitor bank in order to raise the power factor of the motors; and (ii) - the painting of the tiles with appropriate paint in order to maximize the energy reflection which provided the reduction of the temperature inside the company, and as a consequence, a sensible reduction in the consumption of the air conditioning. It is important to note that the results obtained in the two work fronts of the C project were only possible due to the valuable contribution of the stakeholders with whom the team interacted.

Project E carried out in the specialty steel painting industry was assisted by an industrial engineer with more than 30 years of career in an automotive industry. He had an initial meeting of about 2 hours with the project team. He then went on to act as a staff consultant whenever he sued for her. Also, aiming for benchmarking, led all team members to visit an industry that had a production line similar to what the team was studying.

Team G worked on a project aimed at implanting a room for active methodologies in a public school. This team counted on the contribution of dozens of external stakeholders. A seminar was held with the teachers of the public school on the subject of active learning methodologies and was attended by two external guests who interacted with the teachers of the school. Besides, many active learning activities were carried out for the students of the school and were led by about 30 students from EEL-USP who volunteer to cooperate with the project.

The H project carried out in the specialty paper industry had Lean Office features. A professional who works in an automotive industry with more than 15 years of experience in the area was extremely relevant to the team. This professional was with the team three times, having even visited the company in which the project was carried out together with the team, which added much value to the project.

The support given by the external stakeholders in these four projects was of fundamental importance to the results obtained and contributed significantly to the development of technical skills in the students related to the project theme itself. One of the most relevant learnings for the course coordination team was the importance of this type of external stakeholder, who acted as a technical consultant for the student team. From this learning, we intend to expand the use of external stakeholders in future classes, considering their significant value added to the project and to the students.

3.5 Development of Transversal Competences

In the fourteenth class, the teams answered some questions that were asked by the teacher. One of these questions was: <u>What are the strengths of the PIEP-II project?</u> The students emphasized that the project allowed active learning due to the need to solve a real problem in a company. They considered it very enriching to have direct contact with the client (teams C, D, E, F, and H) which allowed them to improve professional posture (teams C, E, G, and H). They also emphasized the development of responsibility (teams A and G), interpersonal relationship (Teams A and E) and teamwork (Teams C, D, and H).

4 Conclusion

We presented a case study regarding a class of the Integrated Project of Industrial Engineering II (PIEP-II) of the Industrial Engineering course of the School of Engineering of Lorena (EEL-USP). It details the projects that were carried out by the group highlighting the importance of the partnership with companies and several stakeholders. It shows that the development of technical and transversal competences in students is influenced by the active contribution of different stakeholders, not only in the company but also in the school or with external partners.

The PDCA cycle was used as a logical method for the development of the projects and was essential for the result obtained since it allowed the teams to have a logical sequence of step to be given, which was essential to discipline the evolution of the projects to them during the semester.

The technical skills developed were those directly related to the technical theme of each project. On the other hand, the students developed some transversal competencies, in particular professionalism, responsibility, interpersonal relationship, and teamwork.

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Boosting 21st Century Competences through Computational Thinking and Student Centered Strategies

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Abstract

Traditionally, cognitive skills in mathematics and language have been described as key indicators for success. However, the social, technological, and economic changes that have occurred in the 21st century have made critical thinking, communication, collaboration, and creativity, key competences to face the challenges of a rapidly changing world. In this study, we developed a Computational Thinking curriculum based on student-centered pedagogical strategies to enhance these four competences. This curriculum was designed under the socio-cultural vision of learning, in which individuals interact in communities to build significant knowledge. An embedded mixed-method approach was implemented to evaluate the students' improvements in competence development both in quantitative and qualitative ways. The results indicate an encouraging increase in skills related to the competences of interest strikethrough. Additionally, by designing the curriculum under socio-cultural ideas of education the results show that the students and the teacher were able to form a community to facilitate teaching and learning.

Keywords: Computational Thinking; Active Pedagogical Strategies; Socio-cultural Education, Skills, Competences.

1 Introduction

Several studies regarding *life-learning* and *learning to learn* identify four competences that make a measurable contribution to desirable outcomes in educational achievement, relationships, employment, health and well-being; this applies to all individuals, not only to those in a specific trade, occupation, or walk of life (Ontario Ministry of Education., 2016). These competences are commonly known as the 4Cs, representing Critical thinking, Creativity, Communication and Collaboration (P21 association, 2017). Briefly, critical thinking is defined as the competence that allows solving problems, to critically evaluate information and arguments, and to construct meaningful knowledge that is put into practice. Communication is understood as the mastery of digital, writing and speaking skills in a wide range of audiences. Collaboration is the capacity to team up to work effectively and efficiently, displaying interpersonal and team-related skills through the process. Finally, creativity is described as being able to generate novel ideas as well as showing the necessary skills to put them into practice (Fullan & Langworthy, 2014).

Nevertheless, traditional education based on the teaching and learning of concepts related to specific and traditional disciplines fails in the development of such competences, since the learning process is based on the "transmission" of knowledge from the teacher to the student, being the latter a passive actor in the practice (Roth, 2009). Hence, the development of 21st century competences require more complex, dynamic and high-level schemes of concepts and practice to engage the students in more active roles.

Computational Thinking (CT) is one of the fields with a high potential to develop these competences. Jeannete Wing (2016) defines CT as "*the thought processes involved in formulating problems and their solutions so that the solutions are represented in a form that can be effectively carried out by an information-processing agent*" The concept and definition of CT have been discussed and researched in recent years, particularly because CT can be used as a tool to develop highly complex skills in students ranging from K-12 to bachelors' programs and beyond (Bocconi, Chioccariello, Dettori, Ferrari, & Engelhardt, 2016; Buitrago-Florez et al., 2017; Buitrago-Florez, Danies, Roman, Restrepo, & Hernández, 2018; Curzon & Mcowan, 2017; French Academy of Sciences (FAS), 2013; Qualls & Sherrel, 2010; Wing, 2006). Nevertheless, most strategies have focused on developing these skills in relation to computer programming and digital literacy (Buitrago-Florez et al., 2017) and no pedagogical approach has yet involved the development of these CT skills in the enhancement of the four key competences.

On the other hand, current pedagogical research provides teachers at any stage of education the means to develop competences in an effective manner. Vygotsky's (1978) socio-cultural perspective of education claims that learning is a complex problem that is the product of different activities, contexts and socio-cultural factors involving the learner. Buitrago-Florez et al. (2018), describe the development of the four key competences as a social process in which the learner's path is embedded in activities of individuals in a particular context. Along this path, the student enters in a community of practice as described by Wenger (1998), as a member who gets involved in participation (actively interacting and creating identity in the community) and reification (transforming abstract information into real artifacts), progressively becoming an expert in ideas, values, beliefs, languages, skills and competences (Radford, 2008). Therefore, the learning process can be seen as the travelling of the learner from the periphery to the center of a community of practice, transforming the practitioner into a fully equipped individual who can interact with its society (Hernández, Ravn, & Valero, 2015). This vision of education puts the students at the center of their own active learning process, and teachers as the guides that facilitate the learners' journey (Radford, 2008).

Accordingly, the purpose of this document is to report advanced results from a Computational Thinking course in which the 4C's where evaluated as critical axes of the curriculum implementation under student-centered strategies.

2 Method

2.1 Course Set Up

The entire curriculum was aligned with the student-centered Problem Based Learning (PBL) approach, which allows students to engage in a problem case or scenario to define and truly understand the learning objectives of the activities (Capon & Kuhn, 2004). As stated by Wood (2003), the true benefits of PBL rely on how students are able to appropriate the problem's situation to increase their knowledge, skills and competences, rather than solving de problem *per se*. There are several studies that explain and validate PBL in depth (Capon & Kuhn, 2004; Ribas, 2004, 2009; Wood, 2003), in which the PBL strategy is summarized in seven implementation steps. However, the activities carried out in this course did not fully follow the PBL guidelines but were designed and implemented to integrate the use of the five key skills related to CT in combination with a set of interactions in which students could consciously enhance the skills of critical thinking, creativity, communication and collaboration in problem-based scenarios.

A total of 42 native Spanish-speaking students (19 females, 23 males), between 16 and 18 years old participated voluntarily in the course. Students dedicated 48 class hours (one class hour = 45 minutes), distributed in approximately 10 weeks. During the development of the course students were engaged in three main activities as described as follows:

In the first activity, students attended a lecture in order to become familiarized with CT and competence concepts, as well as with the description of the first PBL exercise. Later, students were given a 720-pieces Lego brick box and instructed to build a 15-20 Lego brick structure. Then, they were told to develop an algorithm, meaning a step by step set of instructions so that another student could build the Lego structure they designed, by using the same set of Lego bricks. Afterwards, students were organized in pairs and started testing the couple's algorithm and to debug it in real time. This implied that if a student found an error in the algorithm, the designer was able to fix it right away. Once all the students were able to build the structures, they were instructed to modify the algorithm so that a blindfolded mate could assemble it, and later they did the same process of testing and debugging in real time. Finally, the students went through a reflection process in which they described the difficulties they had, and how they were able to solve them. They also established a relation between the exercise and the use of CT skills, communication and creativity, which were the learning objectives of the activity. The total time provided for this activity was 12 class hours.

In the second activity, the students teamed-up in groups of three and were given the following problem situation: they had to design, assemble and test a structure able to hold an impact of 300 Newton's force from a handmade catapult, which they had to build as well. Teams were subsequently equipped with the 720-pieces Lego brick box, popsicle sticks, springs, rubber bands, strings, metal balls, cardboard and clay. Later, students brainstormed in their groups about the possible learning objectives of this activity, considering CT skills, concepts, and characteristics of the 4C's. Finally, students fully engaged in the development of the structure. The teacher was in charge of constantly monitoring the activities of the groups and pointing out the exact moments in which the groups displayed critical thinking, creativity, communication and collaboration. At the end of the activity the groups showed their final products to the other students. The total time provided for this activity was 14 class hours.

The third PBL exercise consisted in the construction of a Rube-Goldberg machine, which is a set of deliberately complex contraptions in which a series of devices that perform simple tasks are lined together to produce a domino effect (Rankin, Gooch, & Gooch, 2008). The students were grouped in teams of four and first they dedicated some time to understand the Rube-Goldberg machine, recognize the materials and define the learning objectives as they did in the second exercise. They were given the materials previously used in the activities 1 and 2 and additional supplies like plastic containers, motors, electronic kits, batteries, light bulbs, pulleys, among others. Later, the students brainstormed on the development of the Rube-Goldberg machine and made a sketch before starting the construction process. Subsequently, they fully engaged in the development of the machine for about 12 class hours and the groups showed their machines to the other students at the end of the activity. The teacher monitored the activity making students aware of the moments they exhibit the 4Cs and students developed a new reflection process in which they described difficulties, strategies to solve them, and an association between the activities carried out and the 4Cs. The total time provided for this activity was 20 class hours.

2.2 Data Gathering and Analysis

Since social phenomena are extremely complex, different kinds of methods are needed to understand them in depth (Green, Bouce, & Ahn, 2015). Therefore, this proposal was evaluated by using a mixed-method data analysis, in order to maximize the power of the information collected, as well as to strengthen the overall evaluation. The research design used in this study collected information with open-ended and close-ended approaches, in line with the embedded mixed method strategies described by Cresswell (Cresswell, 2009). Moreover, according to Tashakkori and Teddle (2002) this research was mainly qualitative in nature (QUAL-quan), since it was our purpose to understand the experience of the participants of the course supported by the gathering of quantitative data of a specific point of research (in this case critical thinking). On the one hand, written reflections from students, notes from the field diary of the teacher, and perceptions from a focus group allowed a qualitative analysis of perception for all competences. On the other hand, a pre/post test based on multiple-choice questions implemented to gather information about critical thinking was analyzed quantitatively. The tests comprised CT questions from validated sources such as www.code.org and https://teachinglondoncomputing.org/ to inquire about the use of CT key skills. We decided to use this sort of questions given that these skills are considered fundamental for problem solving, a major characteristic of critical thinking (Curzon & Mcowan, 2017).

Results will be presented with partial analysis of data, comprehending written reflections and entries from the field diary of the teacher as source of qualitative data for all competences, and written reflections developed by students as well as a pre-post test for critical/computational thinking as source of quantitative data. Triangulation of information with the focus group and other additional data will be available in a future publication.

3 Results and Discussion

The aforementioned research design was used to establish whether the curriculum proposed effectively addressed student-learning outcomes and expected perceptions regarding the 4Cs. This section summarizes the analyses of the pre/post tests for critical thinking as well as the qualitative data collected in relation to the four competences.

3.1 Critical Thinking/Problem solving through CT

The information related to problem solving was classified based on the perception of the students regarding their ability to solve problems in the PBL activities throughout the course, in combination with the pre-test/post-test progression analysis. At the beginning of the course, the students struggled with the use of the five key skills related to CT to formulate solutions, reporting that these were abstract for them. Nevertheless, as students developed the problem-based exercises and reflected about their practice, they recognized the usefulness of the CT skills in problem solving.

Data from reflections demonstrate that students were able to identify specific moments in which they used the skills in particular actions in the three PBL exercises (Table 1). Students were able to propose solutions to the PBL activities in terms of basic computational models. This means, students recognized the usefulness of CT skills to propose real solutions, evidencing a connection between their performance and how they elaborate in CT. This is consistent with Wenger (1998), who proposes that learning is a process resulting from participation and reification in specific communities. As students interacted with their peers and the teacher throughout the course, they were able to get involved in a learning community in which the level of expertise and understanding of CT concepts, language, symbols and artifacts increased over time.

Table 1. Categories formed from associations between actions and CT skills in the second reflection. The numbers in parentheses indicate how many students state a specific relationship between a CT skill and an action made during the activities of the course.

CT Skill	Action
Abstraction	• Modifying the instructions of the algorithm so a blindfolded student could be able to assemble the Lego structure (23) • Imagining the instructions for building the Lego structure while blindfolded (14) • Imagining how materials could be used to create the catapult and the Rube-Goldberg machine (18) • Sketching the designs for the Rube-Goldberg machine (12) • Looking for alternatives for issues regarding the assembling of the catapult and the Rube-Goldberg machine (9)
Algorithmic thinking	• Making the step by step in the Lego activity (39) • Debugging and re-thinking the steps of the assembling process of the catapult and the structure (13) • Designing the steps of the Rube-Goldberg machine (25)
Decomposition	• Dividing the assembling of the Lego structure into different groups of actions to facilitate the process while blindfolded (40) • Dividing the assembling of the catapult and the structure into different processes in the second PBL exercise (23) • Subdividing the assembling of each of the steps of the Rube-Goldberg machine into different steps (16)

Debugging	• Fixing errors in real time while another student assembled the Lego structure (35) • Making an auto-evaluation of the instructions for the Lego structure (6) • Testing the resistance of the structure to the impact of the catapult (21) • Testing each of the steps of the Rube-Goldberg machine (7) • Testing the functioning of the Rube-Goldberg machine as a whole (13)
Generalization	• Re-contextualizing instructions from the first algorithm in the second one during the Lego activity (16) • Using ideas from a physics class to build the catapult (18) • Using ideas from the second exercise in the third exercise (16)

Furthermore, quantitative data show a notorious increase in pre-test/post-test performance in CT concepts and skills to solve specific questions. In the pre-test, the average of correct answers over 19 possible marks was 4.19, with a standard deviation of 1.49, a highest score of 7 and a lowest score of 1. In comparison, the post-test results show an average of correct answers of 14.5, with a standard deviation of 3.0, a highest score of 19 and a lowest score of 8. Furthermore, the population showed a normal distribution and the T-test showed a significant difference accordingly with a P-value of 1.7 E^{-25}. These results were somehow expected, since various entries in the field diary of the teacher mention that during the course the students manifested that most of them had struggled with math throughout their school education.

Several studies highlight a strong correlation between performance in math and how students can elaborate in computational thinking. A robust mathematical thinking comes with high levels of abstraction and algorithmic skills that lead to a rapid progression in CT through computer programming courses (Bocconi et al., 2016; Buitrago-Florez et al., 2017; Curzon, Dorling, Ng, Selby, & Woollard, 2014). Nevertheless, traditional teacher-centered education hinders the students' progress in mathematical thinking since participation and reification processes are extremely restricted, resulting in low performance in math skills (Skovsmose & Borba, 2004). Therefore, the results of this study confirm the benefits of including student-centered pedagogical strategies for skill enhancement. As described by Hernández et al. (2015) these strategies effectively allow students to actively participate and reify in a learning community.

3.2 Communication

Analysis from narrative instruments indicate that students recognize that the problem situations they faced throughout the course challenged them due to a lack of of assertive communication. According with entries from the field diary of the teacher, students struggle with complexity of CT language in some situations of dialogue. The teacher expressed however, that students rapidly start to interact with each other by using CT language, expressing situations in terms of abstraction, algorithmic thinking, decomposition, debugging and generalization to be able to listen, transmit and understand ideas from their peers in complex scenarios. This increase in language skills is the result of discussions encouraged by students to clarify, analyze and evaluate their work (Hernández et al., 2015).

Data from reflections allowed us to group into six different where students stated communication was critical to accomplish specific actions throughout the course: (1) converting ideas into a clear set of steps in the Lego exercise, (2) guiding verbally the blindfolded partner to bypass issues in their algorithms, (3) making other students understand different uses for the materials provided, (4) making others understand abstract ideas for solving the problems related to exercise two and three, (5) discussing ideas and reach agreements for assembling structures associated to exercises two and three, and (6) making others understand issues and debugging processes throughout the course. Perspectives enclosed in these actions are a direct product of being part of a problem-based pedagogical strategy. As proposed by Capon and Kuhn (2004), it is not the same a person that studies by listening to the teacher who is in charge of transmitting knowledge than a person that studies by discussing several topics for an extended period of time. Likewise, the constant communication between all members of the learning community formed in this course helped students to improve their mastery in CT symbols and language, encouraging effective communication among the students.

3.3 Collaboration

Since all the exercises were carefully design to be developed by interactions with peers in teams, it was expected that valuable information on collaboration competences would be gathered from the narrative instruments. From the teacher's perspective, students started the course with several issues in effective teamwork, spending a lot of time interacting to take group decisions. However, throughout the progress of the course students successfully developed strategies to make decisions and debug issues regarding teamwork through discussions. Five activities regarding specific moments in which students appreciated the fact that they had to improve their collaboration practices are: (1) taking into account and integrating all ideas proposed to solve a specific situation, (2) dividing big steps into sub activities with assigned roles and subsequently conducting a debugging process by all members of the teams, (3) appreciating different points of view to find errors in the different exercises, (4) helping other members of the team to understand problems and encourage them to propose potential solutions, and (5) collaborating in the assembling process of the structures in exercises two and three. These data show that our problem-based strategy provided scenarios that enabled students to create a community space in which multiple perspectives were considered and discussed, showing an increase in collaborative process skills and respect for others (Ribas, 2004).

In the development of this course the success of the teacher in the guidance process is a result of previous training in student-centered strategies. Problem-based approaches rely on the capacity of the teacher to understand its role as a supervisor. In this approach, a teacher better resembles a person that aids a less experienced member of the community in the integration of knowledge and actions (Hernández et al., 2015). This role is by all means different from being a transmitter of concepts or a project leader.

The teacher also had to intervene in all the groups to provide guidance about the difference between teamwork and group work. At the beginning of the second activity teams tried to divide assignments individually, nonetheless, they understood very soon that by implementing that sort of strategies they would expend too much time and would face several issues in the development of the activities as a whole. This phenomenon can be explained by the enrolment as passive entities that traditional teacher-centered strategies provoke in students (Roth, 2009). Nonetheless, those sorts of perspectives highlights the way in which, in terms of Johnson, Johnson, and Smith (1991), group accountability and responsibility was reliant on individual accountability and responsibility in this course, being the former a necessary principle for cooperative group learning in communities of learning.

3.4 Creativity

Students were very conscious that this competence was ground base in order to develop strategies to solve situations they confronted. Six subcategories were formed given the analysis of the students' perception considering the instants when they stated that creativity surfaced: (1) imagining different uses of Lego bricks to form a structure in the first exercise, (2) imagining ways to explain how to assemble the Lego figure to the blindfolded partner, (3) proposing solutions to issues in real time while the blindfolded partner assembled the Lego structure, (4) imagining non-conventional uses for materials in exercises two and three, (5) proposing, testing and debugging different types of solutions in exercises two and three, and (6) understating the learning objectives facilitate imagining multiple alternative solutions very fast. Consequently, the data allowed us to conclude that our curriculum design triggers elements of newness, innovation and novelty; inasmuch as problem-solving situations derives in tools and techniques that make the process fun, engaging and collaborative and creates a positive experience that helps the adoption of new ideas (Awwang & Ishak, 2008).

Additionally, entries in the filed diary of the teacher mention two interesting phenomena. On the one hand, students constantly expressed their surprise as they came up with innovative solutions. In different dialogues with the teacher they claimed that this sort of situations, in which they had to be creative, were very rare in their everyday curriculum. This idea is undoubtedly a product of traditional education, being the teacher the "transmitter" and the students passive "receptors", thus preventing students to build their own knowledge and depleting creativity as school continues over time (Roth, 2009). On the other hand, students stated that being aware of the learning objectives and understanding explicitly the reasons why they did each of the exercises, allowed them to create solutions and debug more straightforwardly. This is a direct result of interacting with problem-based strategies, in which a central axis of learning is to establish and understand deeply the learning objectives throughout the process (Ribas, 2009)

4 Conclusion

Creating and implementing mixed assessment tools and evaluation strategies that facilitate systems to evaluate performance while hearing students' voices is critical in understanding learning experiences. Results from this study show that the students and the teacher were able to form what we would like to call a "computational thinking learning community", in which the students increase their level of expertise in critical thinking, communication, collaboration and creativity through CT. Evidence showed that most of the students were able to design and implement solutions to the problem situations presented in the course, to associate specific moments in which CT skills were present in their practices, to extrapolate CT benefits to tackle everyday situations and to increase problem-solving performance quantitatively measured. Therefore, by increasing their ability to solve problem situations the students enhanced their critical thinking competence. Furthermore, the students showed and reflect upon skills such as listening, dialoguing, clarity, friendliness, open-mindedness, respect, role assignment, failure response, tolerance, curiosity and imagination. Consequently, we can argue that our curriculum proposal creates a learning environment that effectively boosts 21st century competences of great importance for every individual of a knowledge-based society.

Without the systematic implementation of pedagogical strategies to create a sense of community and identity, students enrolled in traditional teacher-centered classes in schools and universities can easily get a feeling of insignificance and may be discouraged to learn. The efforts described in this study combined a focus on CT concepts with personal development that is very valuable, given that educational systems must pay attention to how the students' individual growth relates to social necessities. We are aware that setting specific expectations that connect negotiation of meaning with key competences is defiant but is a way to respond to the changing demands of a globalized world by preparing students for future challenges. Accordingly, student-centered strategies such as the approach described in this research project could be used as a starting point in schools and universities for CT development, producing an important effect in experience, skills and concepts worth of use to maximize the 4Cs and other competences in later courses in the curriculum.

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Fostering Intelligible English Pronunciation as a Means to Revamp Technical Oral Presentations in Engineering Education: A Case Study

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Abstract

In an era of globalization, English has established itself as the Lingua Franca of engineering education, which led many schools in non-English speaking countries to adopt English as the language of instruction in selected courses or across curricula. This study shares the experience of a fourth year course that has been taught in English in an Engineering school where French is the predominant default language of instruction. The course uses an instructional design that favors active learning and student-centred pedagogies, including student-led workshops and demos and technical oral presentations. This study reports on a specific methodological intervention to address the observation that during the technical oral presentations, mispronunciations rather than French accents were the key factors impeding comprehensibility. At the same time, instructor's intervention to correct students for mispronunciations was deemed disruptive and a potential trigger for lowered confidence and self-esteem. To address this challenge, this study proposes a pronunciation instruction which is based on the identification of 51 words that are related to the discipline and that have been frequently mispronounced during the technical oral presentations. The theoretical underpinning of this intelligible pronunciation instruction is based on cognitive constructivism which aims at empowering students to assume an active role in their experiential learning through inquiry, discovery, and self-evaluation. More precisely, with the assistance of the APKPure "English Pronunciation" mobile app, students can monitor and self-correct their own pronunciation at their own pace and in a private stress-free context. The pronunciation instruction led to noticeable improvement in self-reported student pronunciation, and a better self-awareness about the importance of pronunciation intelligibility in oral communication.

Keywords: Engineering Education; Communication Skills; Pronunciation Instructions; cognitive constructivism; mobile-based learning.

1 Introduction

To address the evolving professional workplace needs in a global environment, the 21st century engineering graduates need to be equipped with a versatile portfolio of competencies that includes not only technical and interdisciplinary proficiencies, but interpersonal skills as well (Hairuzila, Rohani, & Muhammad, 2011). In particular, next generation engineers are required to communicate effectively (Riemer, 2001), as engineers devote nearly 60% of their time communicating at work (Tenopir & King, 2004; Tilli & Trevelyan, 2008). This need has been echoed by many other studies that revealed the dissatisfaction of employers with the level of communicative competencies among engineering graduates (Riemer, 2001). In addition, among its criteria for accrediting engineering technology programs, the Accreditation Board for Engineering and Technology (ABET) stipulates, through student outcome (g), that upon graduation, students should have the "*ability to apply written, oral, and graphical communication in both technical and non-technical environments; and an ability to identify and use appropriate technical literature*" (ABET, 2017). Despite this emphasis, there is a global concern that engineering graduates lack the proper communication skills in general and oral communication competencies in particular (Norback & Hardin, 2005; Kassim & Ali, 2010). This shortcoming can potentially hinder engineering graduates' chances for recruitment, retention and success (Riemer, 2007).

Among the most prominent oral communicative competences sought by employers is the ability to professionally deliver technical oral presentations, as these are frequently practiced communicative events (Bhattacharyya, 2011; Salbiah & Dubois, 2002). To be effective, a technical oral presentation must demonstrate proficiency not only in its content but also in the way it is delivered (Stapa, Murad, & Ahmed, 2014). The 21st century employers expect their engineers to have the skills and confidence to make effective presentations when interacting with customers, suppliers, business partners, colleagues and the broader community at large. Beder (2000) went even further, suggesting that oral communication and technical presentation skills may be considered as the biggest single factor in shaping students career success or failure. Inadequate oral presentation skills acquired during engineering education might conceal the technical competency of the professional engineer and can create a negative perception about one's credibility (Riemer, 2007). In the Malaysian context, Radzuan & Kaur (2011) reported that most engineering students perceive technical oral presentations as daunting tasks that are often associated with anxiety-inducing experiences.

In an era of globalization, English has established itself as the Lingua Franca (ELF) (i.e. " a vehicular language spoken by people who do not share a native language" (Mauranen, 2003)) of the international practice of engineering, suggesting that it more useful today than any other language due its sweeping adoption and diffusion (Brand & Yakovleva, 2014). English has also proven itself as the dominant language in academia, transitioning from the language of publications towards the language of instructions as well (Björkman, 2008). For instance, in Europe, the introduction of English as a language of instruction has paved the way towards better graduate employability and more effective academic mobility and student exchange programs, which are among the key objectives of the Bologna Declaration (Björkman, 2008). Despite the many raised concerns over the adoption of English as the second language of instruction (e.g. a threat to the local native language and national identity, an additional linguistic barrier against comprehension, etc.), English proficiency is perceived today as a key success factor in the engineering profession (Björkman, 2008). This leads us to question whether engineering programs that are being delivered in English as a foreign language meet the expectations of the globalized labor market in terms of oral communication skills.

Among the key requirements for effective oral communication during technical presentations is intelligible English pronunciation that enables engineering students to produce sounds and utter words in an understandable manner to their audiences (Gilakjani, 2016; Hismanoglu, 2006; Otlowski, 1998). However, intelligible English pronunciation for non-native English speaking students is the aspect of language that is most difficult to attain (Deterding, 2013; Jenkins, 2000; Fraser, 2000). Thir (2016) observed that mispronunciation is the main cause of communication breakdowns and misunderstanding in ELF interactions. Although some students have the capability to "pick up" pronunciation effectively, for most, it requires special training (Fraser, 2000). Unfortunately, in most engineering schools, intelligible English pronunciation instructions have often been neglected in the English language-teaching (Gilakjani, 2016; Harmer 2007).

This study shares the experience of a specific methodological intervention to improve intelligible English pronunciation among students enrolled in a fourth-year engineering course. In particular, it focuses on the outcomes of the technical oral presentations that revealed that mispronunciation was a key factor that impeded comprehensibility. The research shares the experience of a pronunciation instruction initiative whose theoretical underpinning is rooted in cognitive constructivism whereby students are empowered to become more responsible of their experiential learning through inquiry, discovery and self-evaluation. Our research highlights the need to incorporate intelligible pronunciation instructions not only into communications classes but also into senior engineering classes where technical oral presentations are used as assessment instruments.

The remaining of this paper is organized as follows: Section 2 presents a brief literature review and highlights the research contribution. Section 3 outlines our research method. In section 4, we present and discuss the main research findings. Section 5 outlines the implications of this study, while section 6 discusses the main limitations of this contribution and outlines some directions for future research.

2 Literature Review and Research Contribution

Rajprasit et al. (2014) argued that English language proficiency really matters in the global economy. The authors conducted an empirical study that showed that Thai novice engineers lacked the proper oral communication skills required by the workplace in a globalized world. Several studies, across different countries (see for e.g. (McCroskey & McCroskey, 1988), (Su, 2005), (Taillefer, 2007)), have investigated the perceived level of proficiency of non-native English-speaking students towards their ability to communicate properly in ELF via self-rating interventions. The results tend to lead to the same conclusion that the level of perceived oral communication proficiency is not up to the expectations of the workplace.

Eichhorn et.al (2010), Riemer (2001) and Radzuan & Kaur (2011) argued that engineering curricula should not solely rely on general education courses to promote students' oral communication skills. Teaching oral communication skills should be embedded in the Engineering courses through students' oral presentations.

In a study that investigated the interplay between accented speech and speech comprehensibility among non-native English students, Trofimovich & Isaacs (2012) found that comprehensibility, which is a pre-requisite for successful communication, is linked to grammar and vocabulary and can be reached in an accented speech. Their research suggests that producing a comprehensible oral presentation goes beyond the accent (i.e. the way sounds, syllables and words are pronounced).

A survey conducted among 235 engineering students in Malaysia reported that the top three areas of difficulties encountered when delivering technical oral presentation are (1) inadequate knowledge of presentation skills, (2) low confidence level, and (3) poor command of the English language (Stapa, Murad, & Ahmad, 2014).

Osipova, Gnedkova, & Ushakov (2016) recognized the importance of Mobile Assisted Language Learning (MALL) technology for Lifelong Learning. The authors proposed a mobile learning model to teach students English articulation phonetics. According to Nikbakt (2011), the use of Computer Assisted Pronunciation Teaching (CAPT) technologies promises to pave the way towards new innovative pronunciation instruction methods.

Riemer (2001) argued that oral communication can be considered a learnable skill that can be fine-tuned, provided that proper pedagogical interventions are put in place. Brand & Yakovleva (2014) suggested that English oral communication skills can be refined through many strategies including class discussions and practicing spoken English. Gilakjani (2016) suggested that instructors should encourage learners to monitor and practice their own pronunciation inside and outside the classroom. This emphasis on increasing pronunciation awareness and autonomy among students through self-correcting and self-monitoring was also highlighted by Kenworthy (1987) and Morley (1991).

This study was conducted to explore these opportunities with the intention to guide engineering students enhance their technical oral presentation skills. More precisely, within the particular context of this case study, this research attempts to address the following questions:

- What are the specific challenges faced by engineering students in delivering effective technical oral presentations in English as a foreign language?
- What initiatives can be put in place to address some of these challenges?

To address these questions, this contribution reports on a methodological intelligible English pronunciation instruction that is rooted in the cognitive constructivism theory and that integrates Mobile-Assisted Language Learning (MALL) to promote self-evaluation, flexibility, accessibility and interactivity (Liu, Tan, & Chu, 2009), while circumventing time and place barriers (Miangah & Nezarat, 2012). Further, while some of the above-mentioned studies helped in guiding this research, the experience reported herein is unique in the sense that (1) it is integrated in the teaching of a senior engineering course and (2) it leads itself to a better contextualization towards real-life situations by shedding light on the mispronunciation of those English terms that are closely related to the students' engineering discipline and hence to their future career.

3 Methods

This study was conducted in an Engineering school where French is the predominant default language of instruction, with English representing the third language for learners. More precisely, the research emanated from deep reflections following the assessment reviews of the course "Virtualization & Security". This is a 4^{th} year senior course that has been taught in English for the past 4 years to engineering students in the Network Infrastructure and Data Security (NIDS) specialization track. The course uses an instructional design that favors active learning and student-centered pedagogies, including problem-based learning, three student-led workshops and demos, two student debates, two Jeopardy games, and four technical oral presentations. We have strived to embed several class activities to artificially simulate authentic professional contexts in the classroom by requesting students to undertake some activities of practitioners. This study focuses on the technical oral presentations which constitute one of the many workplace-related oral communicative events.

The general framework that guided this study is illustrated in figure 1 and is further elaborated below.

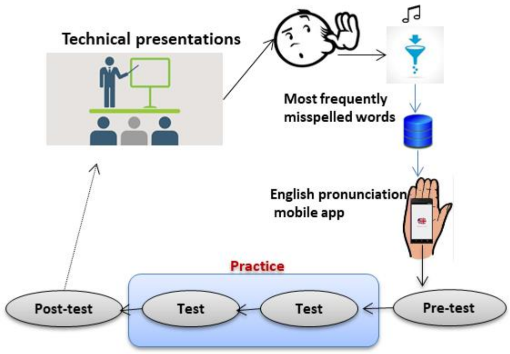

Figure 1. General Framework

The intervention described herein took place during the Fall 2018 semester and it involved 44 students registered in two sections of the same "*Virtualization & Security*" course. During the technical oral presentations, it was observed that mispronunciation rather than the prevailing foreign (French) accent was the major obstacle impeding comprehensibility. In fact, in our case, we came to realize that accentedness or the strength of the accent (Yates, 2002) did not hinder intelligibility. On the other hand, mispronunciation (i.e. the act or habit of pronouncing a word in a nonstandard or incorrect way) made it difficult to understand what some students said. We conjecture that some words were mispronounced because (1) the associated sounds do not exist in the students' second (French) language, (2) students did not learn to pronounce them in English, (3) students learned faulty pronunciation habits from fellow students, or (4) inter-lingual errors occurred when the pronounced letters correspond to different sounds in French.

During the early stages of experimentation (2015-2017), we noted that our intervention to correct students for mispronunciations was a double-edged sword: On one hand, it generated timely feedback to students to correct their pronunciation errors, which was appreciated by some students, in accordance with the findings in (Ancker, 2000). On the other hand, the interruption was deemed disruptive to the smooth flow of the presentations and a potential trigger for lowered confidence and self-esteem among students.

In our case, we were confronted with the challenge of how to proceed with teaching intelligible pronunciation when we lack the time and associated skills. The theoretical underpinning of this pronunciation instruction is based on the notion of "*Cognitive Constructivism*" (Piaget, 1952), a prominent constructivism theory in engineering education that aims to empower students to take a more active role in their experiential learning through inquiry, self-discovery and self-evaluation. In particular, cognitive constructivism is a learner-centered learning theory that suggests that the teacher plays the role of a facilitator of active knowledge-building process while learners monitor, and evaluate their own learning and cognition in a meaningful context. In this instruction, our goal was not to teach students English pronunciation per se, but rather to facilitate their learning pronunciation of terms that are related to their engineering discipline.

Guided by the earlier work of Wrembel (2002) and Gilakjani (2016), this English pronunciation instruction aimed to guide students to achieve "intelligible pronunciation" or comfortable intelligibility (Scovel, 1988), rather than native-like pronunciation in an effort to boost their self-confidence and functional communicability. The intent was to use a mobile app to train students not only to learn different sounds and sound features but also to develop their English speaking skills, in accordance with the recommendation of Harmer (2007). Intelligible pronunciation is a realistic goal for most learners and it enables students to develop spoken English that is easy to understand by their audience while maintaining their foreign accent.

During the technical oral presentations, we took notes of the most recurring mispronounced words. An initial set of 72 words was initially identified. We have then ranked these words in terms of frequency of occurrence and kept only the top 51 most frequently reported words, so as not to overwhelm students with a long list of mispronounced words. The final list is illustrated in figure 2 where the mispronounced words are reported according to their frequency of occurrence: from left to right; top to bottom.

w1-w13	Architecture	Scalable	Configure	Schedule	Infrastructure	Status	Feature	Plugin	Distributed	Robust	Scalability	Migrate	Engine
w14-w26	Virtualization	Comparison	Proprietary	Multiple	Allowed	Authorized	Gigabyte	Machine	Valid	Schedule	Analysis	Null	Relying
w27-w39	Accurately	Recovery	Vulnerability	Resource	Gathering	Stability	Execute	Manage	Adobe	Dynamic	Source	Hypervisor	Microsoft
w40-w51	Consider	Citrix	Multitenancy	Certified	Heterogeneous	Resiliency	Node	Properties	Credentials	Provisioning	Present	Speculative	

Figure 2. The 51 Most Mispronounced Words

Among the many available English pronunciation mobile apps, we opted for the APKPure "English *Pronunciation az-20* Apps" (Figure 3), available from Google Play App Store^{TM}, as it has many features including (1) online and offline modes of operation, (2) support for British and American English, (3) ability to customize the speech rate to fit the user's preferred learning style, (4) ability to adjust the pitch, and (5) ability to save and revisit the entered words at any time.

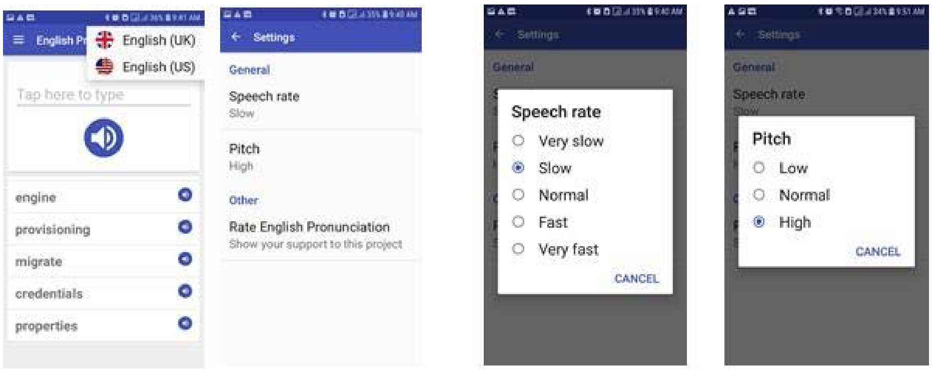

Figure 3. English Pronunciation az-20 Apps (APKPure, 2018)

With the assistance of this mobile app, students can monitor and self-correct their own pronunciation at their own pace and practice their pronunciation skills in a private stress-free context. Learners can type a word and tap on the speaker icon to listen to the pronunciation sound. All entered words are saved and can subsequently be revisited for further practice. This stress-free feedback mechanism of self-correcting and self-monitoring was instrumental in promoting the students' autonomy and communicative self-confidence in EFL. Further, the usage of a mobile app as the learning instrument for the English pronunciation training was driven by the fact that the usage of mobile learning assisted technologies was found to be an effective tool in stimulating learners' motivation and engagement and in boosting their study performance (Jou et. al, 2016). The mobile app enables students to select either American or British English. Although earlier research (e.g. (Kolokdaragh, 2010)) suggested that teachers should familiarize students to both American and British English pronunciations, we opted to focus on American English for simplicity and due to its higher relevance as a global language.

Being aware of the fact that students will not apply their best efforts to an instruction/assessment that does not count (Schneider, 2002), we embedded the pronunciation instruction in the assessment of the final workshop. Students were evaluated not on the basis of their performance in this pronunciation instruction but rather on their participation. We have articulated the instructions of the pronunciation exercise, conducted several demos to showcase the features of the mobile app, clarified via examples what is meant by intelligible pronunciation, and requested students to:

- Take the pre-test and report their self-evaluated result
- Conduct several training tests
- Take a post-test and report their self-evaluated result

4 Research Findings and Discussions

A total of 40 students participated in our pronunciation intervention, yielding an acceptable response rate of 91%. As may be seen in figure 4, the pre-test results showed that the eight words {*schedule*, *recovery*, *proprietary*, *heterogeneous*, *speculative*, *robust*, *resiliency* and *scalability*} were reported as being most challenging in terms of intelligible pronunciation with a mispronunciation rate above 40%. The post-test results showed noticeable improvements in students' self-reported scores with a mispronunciation rate below 5% across all the 51 selected words.

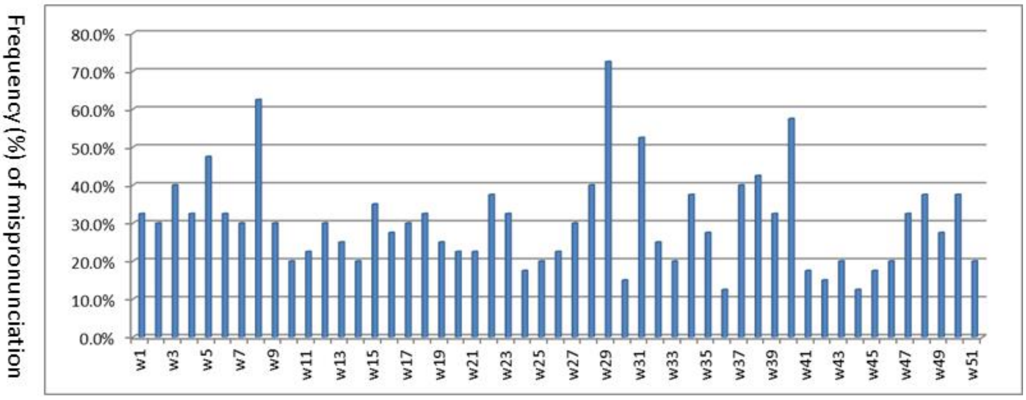

Figure 4. Pronunciation Instructions' Self-evaluated Results (Pre-Test)

We also conducted short focus-group sessions with students to discuss their perception towards this intervention. Overall, the received feedback was very positive and it suggested that the intervention succeeded to a certain extent in fostering a better self-awareness among students about the importance of pronunciation intelligibility in oral communication. Overall, we observed that most students showed a very positive attitude towards the usage of the mobile app. Students were also requested to provide written comments about their experience. The received feedback was positive. Samples of students' written feedback included the following:

- *"I found the pronunciation exercise interesting and useful".*
- *"I'd like to say that the technical words that you have chosen are so important in our field and career. So many thanks for your effort to improve our knowledge and English pronunciation".*
- *"Thank you for this assignment. I will use the app for future presentations"*
- *"I enjoyed using the app and learned to improve my English pronunciation."*

5 Implications and Conclusions

In the realm of engineering education, intelligible English pronunciation instructions can contribute towards increasing the graduates' self-confidence, enlarging their social interactions, and generating more positive perceptions towards their credibility and abilities. This study reported on a successful pronunciation instruction that aimed to enhance learners'' ability to enhance their technical oral presentation skills. By promoting intelligible pronunciation, it is hoped that the reported experience can instigate other engineering schools to develop innovative approaches to help students enhance their pronunciation habits in English as a foreign language and hence improve their technical oral communication skills while building a more positive self-image of themselves as speakers of English as a foreign language. We also hope that the pronunciation instruction reported herein will further stimulate the debate between engineering pedagogy, language proficiency and the usage of mobile-assisted learning technologies.

Our study reconfirms that English intelligible pronunciation is a core component of communication competence and hence it should be an integral part of engineering curricula and not the sole focus of general education courses. This study also suggests that English pronunciation instructions in engineering programs should be contextualized by shifting their focus from generic linguistic competence towards more discipline-specific competence (i.e. in the language of the planned engineering profession).

6 Limitations and Further Studies

As most empirical research, this study has its own limitations. First, it involves an intervention in a single course, during a particular semester and involving a relatively small sample of 44 students. It would be interesting to generalize this study to include additional senior courses within the same discipline and enlarge the data base of identified misspelled words. A longitudinal study involving the same sample of students but across a longer period would offer better insights about the outcomes of this intervention and will address the limitation of our reliance on self-reported results.

The usage of mobile automatic speech recognition software (ASR) is another area of future consideration that is worth pursuing. ASR can potentially provide learners with immediate visual feedback on their performance.

Finally, inspired from the "Situated Learning" theory (Lave & Wenger, 1990), which posits that learning is embedded within authentic activity, context, and culture, we plan to invite professional engineers to attend the oral technical presentations and act as the targeted audience. This will enable students to learn and refine their technical presentation skills by interacting with their "community of practice" (Lave & Wenger, 1990).

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Fiftyone Years of Teaching in Engineering and Technology, A look back and a look forward, and some Advice

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Abstract

When this Professor stepped into the first classroom in 1968 after being a Design Engineer in Industry for nearly eight years, who would have thought that a lifetime of teaching followed in just about all areas of Electrical Engineering Technology, Electrical and Computer Engineering, and as an Adjunct in Night school classes. From the most basic courses and Laboratory Exercises to course areas in Satellite Communications Systems, Optoelectronics, and Switching and Power Electronics, the span of courses touches all areas of the Electrical Engineering spectrum. By introducing MatLab into just about all courses presently taught, the sequence of innovation continues. In 1968 the computation tool was the sliderule and it took an hour to find the complex loop currents to a third order mesh equation, today with MatLab it takes five minutes. Just about all equipment then was tube based, now we look at very large scale integrated systems and Integrated Circuits based on Nanotechnology. What a ride it has been over the last fifty years to be part of a very exciting Engineering education, that never stood still, advanced at sometimes dizzying levels, and gave generations of young Engineers the possibility of a life that is and has been mine. It would be nice to keep on going forever, but the day will come in the near future when it is time to say good bye to being an Engineering Educator. Are there some dark clouds lurking in the future of Engineering Education? The one that has captured many students complete time and interest is the so called "Smart Phone"? Students that have great abilities will spend inordinate amounts of time with the new toy and as has been seen lately, will flunk out. This Professor is known to dismiss students from class for using the " Wonderful Engineering Invention"! in class.

Keywords: Lifetime of Teaching, Electrical Engineering, Electrical Engineering Technology, MatLab

1 Introduction

Since the timeline extends for over half a century, where one is dealing with the information from the nineteen sixties to the information that is happening now, several main time periods will be examined. In the 1960's Engineering education was not much different than it had been for the last hundred years. Due to inventions in the 1940's and 1950's and the cold war and the space race, the push for much more advanced technology and computer capability was fundamentally changing Engineering education. The tool for all calculations was the slide rule and in some cases a mainframe computer and the absolutely necessary CRC hand book, but nobody could imagine the changes that were ahead.

2 The early years (60's and 70's)

The slide rule was the computing device for students and faculty and instruction to freshmen on how to use it was performed on a super big rule that was hung in front of a classroom and could be manipulated just like the one students used for their work. Fortran was the computing language for programming, but all the information had to be entered on punch cards and handed to the mainframe computer center with a turnaround time of about eight hours. If one mistake was made on the punch cards, another eight hours was needed to get the results back from the computer center.

Figure 1. The IBM 360 Computer Center

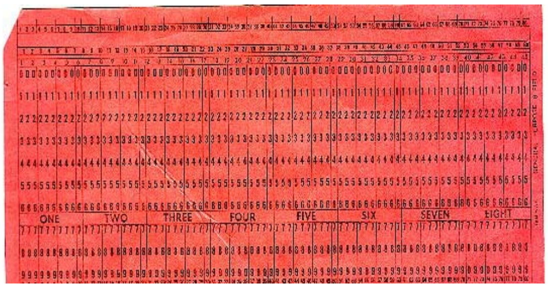

Figure 2. Punch Card used for Batch Processing

In 1972 Hewlett Packard introduced the HP-35 calculator, which was followed by the HP-45 calculator. Although quite expensive initially, it doomed the slide rule, and by the end of the decade manufacturers of slide rules, like Pickett, Keuffel&Esser, and Aristo had gone out of business.

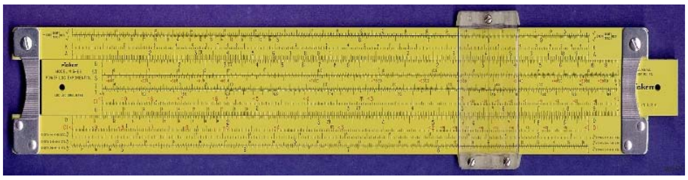

Figure 3. A Pickett Slide Rule

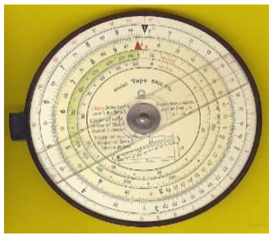

Figure 4. A round Slide Rule

Why was it possible to create devices like the calculator and smaller computers that were instantly available and could fit into just a corner of the laboratory and could be programmed with languages like Basic and C. The transistor and the integrated circuit were replacing bulky tube type equipment which also meant that computer centers did not need the elaborate cooling necessary in the past. Millions of young people were enjoying their Transistor radios, which were usually imported from Japan. In 1977 another milestone was reached when Apple introduced the first useful Personal Computer at the West Coast Computer Fair in 1977. The development of the Winchester Hard Drive by IBM and better display technology contributed to this first personal computer. Of course that development has never stopped and now it can be just about the size of a wristwatch.

Figure 5. Figure 6. Figure 7.

The sizes of the above show the advance of using transistors and integrated circuits were Figure 5 show the Hp-35 calculator, Figure 6 the Apple Personal Computer, and Figure 7 an HP Lab. Computer.

Engineering departments at Universities and Colleges had to make some decisions on what courses to teach. Up to this point everything was usually portrayed as analog, which of course is the real world. However with solid state devices like transistors and integrated circuits operating in the 1 and 0 world, courses like Digital Logic, Computer Basics and Computer Architecture and Microprocessors, as well as numerous programming courses, had to be taught. Especially in the Electrical Engineering area the demand for these courses was so great, that some courses like Electrical Machines and Power Systems and High Frequency Domain courses had to be scrapped. Eventually the Electrical area split into Electrical Engineering and Computer Engineering.

Another phenomena, was the greater presence of females in the various Engineering fields. From the early 1970's on, there was a real push to have more females in all of the Engineering disciplines and the result was, that about 20% of all Engineering students were females.

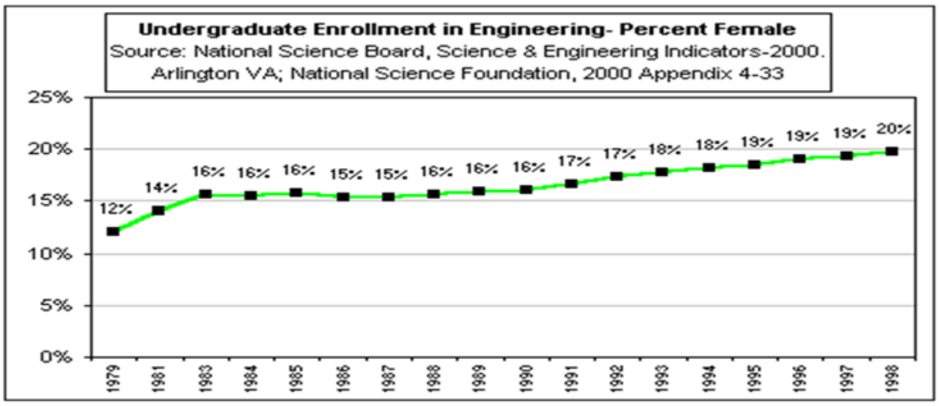

Figure 8. Women in Engineering Disciplines 1979-1999

3 The Internet Years (The 80's and 90's)

The innovations and the progress made in the 1970's led to an explosion of products in the 1980's. Especially the personal computer was very much in demand and nearly a dozen companies were trying to outdo each other in trying to get a piece of this lucrative pie. Clock speeds and RAM were constantly increasing so that by the mid 1990's clock speeds were at 120MHz and RAM was up to 16Mb. We can laugh now at these figures, with all of these in the Giga range. The Apple II computer had a clock speed of 1 MHz and a RAM of 4KB.

In 1962 the Advanced Research Projects Agency was launched , also known as ARPA. This was the forerunner of the Internet. In 1968 it had 4 host computers. In 1993 it would be known as www (The world wide web) with 2026000 host computers and looking at the graph below one can see the most phenomenal rise in the host computers.

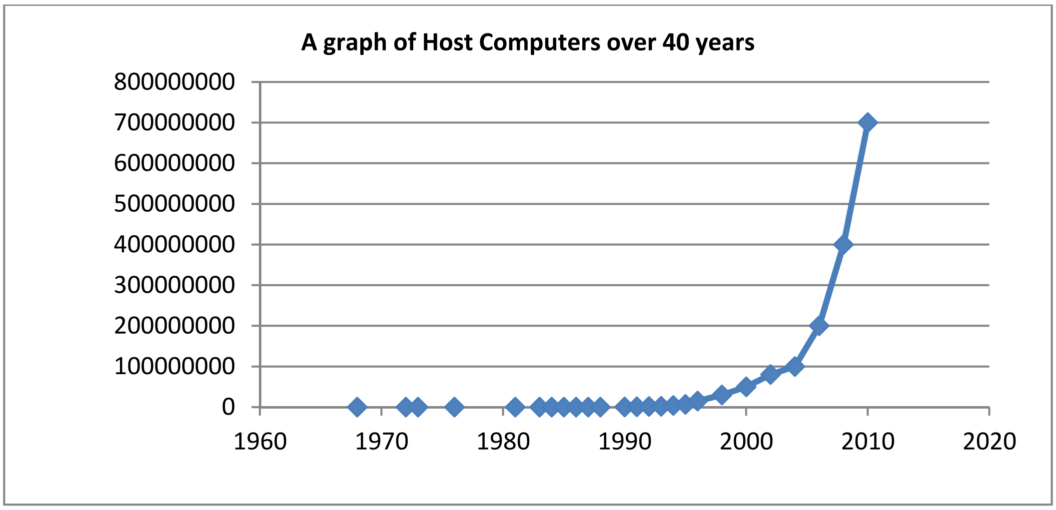

Figure 9. The rise of host computers over the years

Another development that has and will affect Engineering Education much more in the future is Nanotechnology. Richard P. Feynman's famous speech " There is Plenty of Room at the Bottom" at Cal Tech in 1959, laid the groundwork for Nanotechnology, but it was not until the developments of the Scanning Tunneling Microscope in 1981 and the Atomic Force Microscope in 1985 that it now is possible to look at and develop structures at 10^{-9} meters and do extensive research of nanoparticles and nanostructures. New Integrated Circuit devices with 40 nanometer dimensions made it possible to develop the newest smartphones. Hundreds of products use this technology and every major University has a Nanotechnology program.

Recognizing the importance of this new technology, the Federal Government created the National Nanotechnology Initiative in 2001 and in 2008 the NNI budget was 1.5 billion.

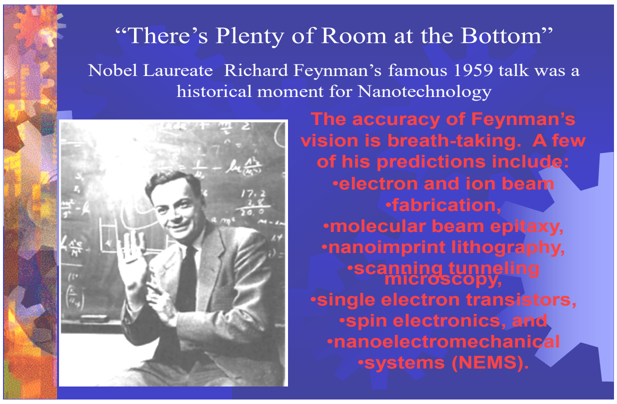

Figure 10. Richard Feynman's famous talk

Figure 11. The Author working with the ATM

4 The Present (2000 to Now)

If one were to put a general stamp on the 1st decade of the new century it would be one of cell phone overload and mass expression masquerading as individualized expression. How else would it have been possible to have a worldwide network like Facebook (Which did not exist before 2004), to go from nothing to 400,000,000 subscribers in six years. With Wireless available throughout the world, with very few exceptions, one can be as close to home and E-Mail information, as is possible. The same thing can be said about the cell phone, which has changed from a phone to a sophisticated small computer. Can your student's text someone on the outside for the answers to your exam? Do we have to put a Faraday cage around each classroom?

Are we at the second decade of the new century at the limit of technology or are we moving just as fast as we have done in the past. Engineers can never sit still, they will always explore they will always find new and hopefully better ways. Are we with the invasion of privacy at the threshold of 1984? These are questions that have to be asked and are concerns of the author.

When it comes to advice the following might be helpful to someone starting out as an Engineering Educator or someone that might like to listen to what an old timer has to say about a life time of teaching in the most exciting area that one can think of.

Do not constantly make references to something that happened more than 20 years ago. Most students were not even born then and to them it is ancient history

When one uses application programs like Excel or high level programs like MatLab it is easy to just use the program and not go back to the basics on how a problem was solved originally. It is very important to lay out the mathematical concepts that are even the basis for the program solution. Lets look at an example that shows the application of a simple mesh problem when it is solved by Matlab or when it is solved by determinants.

Using the Format Method of writing complex Mesh equations

$$(4-j5)I1 - (1+j0)I2 = (5-j5)$$

$$-(1+j0)I1 + (3+j3)I2 = (-10+j5)$$

Amatrix = [(4-5i),-(1-0i);-(1+0i),(3+3i)]; Bvector=[(5-5i);(-10+5i)];

Then the answer with Matlab is achieved by simply the following: For I1 and I2 then = Amatrix\Bvector

$$\text{For } I1 = \frac{\begin{vmatrix} (5-5i) & -(1+0i) \\ (-10+5i) & (3+3i) \end{vmatrix}}{\begin{vmatrix} (4-5i) & -(1+0i) \\ -(1+0i) & (3+3i) \end{vmatrix}} \qquad \text{For } I2 = \frac{\begin{vmatrix} (4-5i) & (5-5i) \\ -(1+0i) & (-10+5i) \end{vmatrix}}{\begin{vmatrix} (4-5i) & -(1+0i) \\ -(1+0i) & (3+3i) \end{vmatrix}}$$

The above set up for determinant solution then will be for I1 =((5-5i)*(3+3i))-((-10+5i)*-(1+0i)) divided by ((4-5i)*(3+3i))-(-(1+0i)*-(1+0i)) and very similar for the solution of I2. It is somewhat obvious which solution set up is simpler, but how the mathematical set up was achieved, is important for the basic understanding of a problem.

Another piece of advice is the continued stressing of the basic principles and laws that Engineers live by in their respective disciplines. It is helpful for not just the basic courses but constantly reminds students that when they attempt more advanced courses they can rely on those basic principles.

Finally keep up on all of the new advances that are happening overall in Engineering and specifically in your discipline. Try to get students involved in their Engineering Society and help them realize that invaluable advice and networking can result from being a member in one of the Societies.

5 Conclusions

Looking at the timeline as a template for Engineering Education and courses that have been and are taught by this Professor from when he first stepped into a classroom. Initially they were Laboratory courses and use Linear circuits courses followed by courses in High Frequency Communications, like TV Circuit Theory, Radio Frequency Theory, Microwave Theory, Satellite Communication Systems.

Replacing the bulky linear power supplies with switching power supplies, and to do this, much work was done with forward and flyback converters. The course area was Switching and Power Electronics using power FET's. On a working Sabbatical for University Technology Malaysia courses in Digital Signal Processing, Optoelectronics and Microwave Engineering were developed and provided to the local faculty. From 1998 to 2000 a new University called Zayed University in Dubai, UAE was developed by many expats including this Professor. It was a University for young women and the subject to teach was for several of the expats, Computer Technology. At present courses in Digital Logic, Linear Circuits, Design of Electronic Circuits, Programming with MatLab and C++ and Introduction to Engineering Analysis are taught.

MatLab, which is a powerful Engineering based language is injected into nearly every course which especially in Linear Circuits II, reduces calculation time significantly.

It has been an honor, a privilege and a joy to be an Engineer and an Engineering Educator. What a ride it has been from the time in 1968 when as a young Engineer the transition from Industry to Academia was made. The Engineer is an old man now but will always be curious, always seek new knowledge and never forget that trip from the slide rule to the 60 Gig flash drive.

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The implementation of the peer assessment and its impact in a programming course

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Abstract

The adoption of an active evaluation approach “the peer assessment” in a C ++ Object-Oriented Programming course, a module taught to 2nd year students from their computer engineering courses, was applied in our school ESPRIT - School of Engineering. The course is taught in a classical way with several practice work and we have chosen two chapters to be done in an active way. In both sequences, the students had online course materials with a home work to submit each time. We opted for peer assessment as a method of assessment for the submitted work. We used the activity "Workshop" in Moodle to submit the home work and peer assessment. In this article, we will discuss the implementation of this activity, its impact on the learner and some recommendations to avoid some risks and have better future results.

Keywords: Peer Assessment, Moodle Workshop, Object-Oriented Programming C ++, Engineering Education.

1 Introduction

For several years now, many courses have been transformed in ESPRIT to an active learning approach. The course "Object-Oriented Programming C++" (OOP C++) was with a traditional approach that is based on lecture. The course is taught in a classical way with several practice exercises. The course is for 2nd year common core of software engineering curricula. Since the academic year 2017/2018, we have begun to use peer assessment in the course as formative assessment.

The students who participated in this study are familiar with active learning approaches such as Project Based Learning (Alaya, Chemek , Khodjet El Khil, Ben Aissa, & Marzouk, 2016), Problem Based Learning (Alaya, Khodjet El Khil, & Bettaib, Active Learning for Freshmen Students in a Software Engineering Education, 2015), flipped classroom (Khodjet El Khil, Alaya, & Bettaib, 2016) and Team Based Learning (Louati, Bettaib, & Derbel, 2014) in their first year. These approaches were applied in different courses such as procedural programming, first year project and mathematics. In the second year, many courses are using one of the mentioned active learning approaches, but the OOP C++ was based only on lecture and practical exercises.

To make the OOP C++ course more active, teachers have chosen two chapters: "Exceptions" and "Files" to be done as e-learning courses without a face to face lecture. At the end of the chapter, students must submit a home work and then evaluate five works of other students according to a well-defined criteria grid. Students don’t have prior experience with peer assessment neither e-learning in previous courses of their first year.

Peer assessment is defined by Topping as: « Peer assessment is an arrangement for learners to consider and specify the level, value, or quality of a product or performance of other equal-status learners » (Topping K. , 2009). Topping demonstrate in the same source that even if a peer assessor has less skill at assessment he can produce an assessment of equal reliability and validity to that of a teacher because the learner has more time in which to do it (Topping K. , 2009).

The peer assessment method has many advantages. It allows learners to practice their knowledge and learn from the mistakes of their colleagues. It also transforms the assessment into a real pedagogical activity. (Rey & Feyfant, 2014; Bouzidi & Jaillet, 2007)

To achieve a peer assessment activity, Topping specified 17 criteria (Topping K. , 1998). Sarah Gielen has resumed and completed K. J. Topping criteria into 4 « clusters » (Gielen, 2007) in this Table 1.

Table 1. Gielen(2007) typology of peer assessment

Cluster (van den Berg, Admiral, & Pilot, 2006b)	Variable	Range of Variation
Cluster I **The function of PA as an assessment instrument**	Curriculum area/subject	All
	Objectives	Of staff and/or students? Time saving or cognitive/affective gains?
	Focus	Quantitative/summative or qualitative/formative or both?
	Product/Output	Tests/marks/grades or writing or oral presentations or other skilled behaviors?
	Relation to staff assessment	Substitutional or supplementary?
	Official weight	Contributing to assess the final official grade or not?
Cluster II **Interaction between peers**	Directionality	One-way, reciprocal, mutual?
	Privacy	Anonymous/confidential/public?
	Contact	Distance or face to face?
Cluster III **Composition and feedback group**	Year	Same or cross year of study?
	Ability	Same or cross ability?
	Constellation Assessors	Individuals or pairs or groups?
	Constellation Assessed	Individuals or pairs or groups?
	Place	In/out of class?
	Time	Class time/free time/informally?
Cluster IV **Requirement & award**	Requirement	Compulsory or voluntary for assessors/ees?
	Reward	Course credits or other incentives or reinforcement for participants

The teachers prepared the PA (Peer Assessment) activity according to the 17 K. J. Topping criteria. In the next paragraph we will describe the course then we will describe our approach and how it was implemented. At the end, we will analyze the results and finish with conclusion.

2 Description of the course

The course name is Object-Oriented Programming C++ (OOP C++). It is a 4 credits course with three hours face to face lecture per week during the semester. The semester is over 14 weeks.

This course is intended for 2nd year common core software engineering students during the first semester of the academic year. These were 415 students divided into 13 cohorts.

The course purpose is to know the concepts of the Object-Oriented Programming approach and how to apply them in C++ programming language. Students don't have prior knowledge about this programming approach neither C++. These are the main chapters in the course:

- Objects and classes
- Encapsulation
- Inheritance
- Polymorphism
- Operator overload
- Containers
- Files manipulation in C++
- Exceptions

Teachers have prepared a Moodle space for the course where learners can find for each chapter some resources and a quiz to do. They have also added a discussion forum and useful links.

3 Description of the approach

In this paragraph, we will describe our strategy which was applied to implement the peer assessment procedure step by step. Only the two chapters "Exceptions" and "Files" was studied in 100% online with a home work to submit.

We have set up this activity as a Moodle workshop with a deadline for submission. For the work evaluation, a grid with detailed evaluation criteria was prepared. The scores were included as 10% of the continuous control average.

Students get two weeks to finish the online chapter and submit the home work into Moodle workshop activity. Then teachers used Moodle to generate the peer assessment assignment with this configuration:

- Only students who submitted a work will get an assessment.
- Each student will get five evaluations to do.
- The evaluation is anonymous.
- Assessors and assesses must be from different cohorts.

If a student doesn't finish the evaluation, he will get zero as a final score of the workshop.

Kim, Ryu pointed a risk of PA: « cognitive gap between students can affect the success of this practice; good students do not accept to be evaluated by weak students » (Kim & Ryu, 2013). To avoid this risk of acceptance, four decisions were made: (i) teachers configured the activity under Moodle to be anonymous, (ii) the assessors and the assesses are note from the same cohort, (iii) the teachers verified the assessment results before it was published, (iv) students could ask for verification if they are not satisfied with the final score.

According to Bouzidi and Jaillet: « Peer assessment can be trusted if applied to exams referring to exact science field and if marked by at least four peers » (Bouzidi & Jaillet, 2009). That's why teachers verified manually that every submitted work was affected by Moodle to at least five students. In a previous experience in the Academic Year 2017/2018, we configured Moodle workshop in a way that every work will be assessed by five students, but many students did not receive any work to assess.

Hsu pointed another risk of Peer Assessment (PA): "Weak students need a clearly established grid to be able to take advantages of peer assessment" (Hsu, 2016). Since the home work is C++ program, students were going to run a program and test it if it works correctly, the establishment of a clear grid for the evaluation was easy.

The deadline to achieve the evaluation was three days. After that, teachers verified that assessments were well done and alter scores if necessary. Finally, the results are published to the students.

4 Results

4.1 Method

This study was conducted at the beginning of the second semester of the academic year 2018/2019. Quantitative measures were applied. A total of 415 second year students enrolled in this 4-credits first semester module participated in the study. We asked the students to give us their feedback using a paper survey. The survey was anonymous.

We received 312 responses from 415 registered students which is ~75% of participation rate. We used Google Sheets to analyze the responses.

4.2 Scholar Results

In Tunisia, our learners are evaluated with scores between 0 and 20. To validate a module, a student must obtain at least 8. The module average is calculated as follows:

Final Average = 40% Continues Control (CC) + 60% Final exam

The scores of the workshops are 10% of the Continues Control grade.

We have compiled some scholar results with final average details in Figure 1 and the participation rate in the peer assessment activities in Table 2.

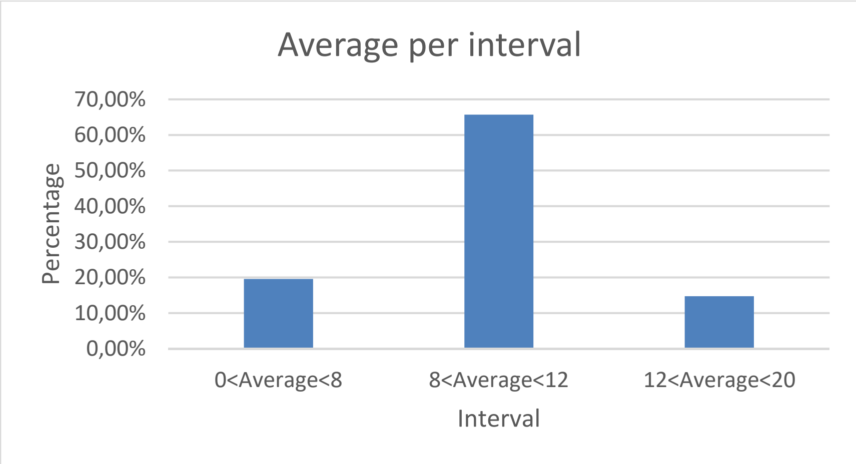

Figure 1:Final Average of the module

Figure 1 shows the number of students per interval of their averages in 2018-2019. From this figure we can conclude that about 79% of students validated this course with is like other years.

Table 2: Results of participation

Legend	Exception	Files
Workshop submission on Moodle	78%	80%
Students who did the workshop evaluation	78%	67%
Students who validate the workshop	72%	70%

Table 2 shows the percentage of learners who submitted their work on Moodle. As we can see 78% of students submitted their work and fill out the workshop Exception on Moodle and 80% submitted the files workshop.

Table 2 shows also the number of students who evaluated the submissions assigned to them. 78% of students completed the assessment phase of the exception's workshop and 67% completed the assignment of the files workshop. It shows also the number of students that validated their workshop (Exception and File) and they obtain at least 10/20. Finally, 72% of students validated the workshop of exception and 70% of students validate the files workshop.

As we can see in Table 2, all of the participants who submitted the home work completed the activity with the peer assessment part. However, in the second workshop there was more students who submitted the home work and less students who completed the activity with the peer assessment. Teachers said that this is because it was at the end of the semester and students was more focused to achieve their projects.

4.3 Survey Results

The survey was 14 questions long about this experience and an open question. Questions with responses are listed here in four tables Table 3: Peer Assessment, Table 4: Review of students who submitted and evaluated the Exception's Workshop, Table 5: Review of students who submitted and evaluated the File's Workshop and Table 6. Overall Satisfaction.

As we can see in Table 3, about 51% are satisfied by the deadline and said that it was enough to submit their final work. Only 48% said that the deadline was enough to evaluate the work, 16% are satisfied by the course materials disposed on Moodle and 43% say that the rules and steps of the workshops have been clearly explained by their tutor.

Table 3: Peer Assessment

Question	Totally Disagree	Disagree	No opinion	Agree	Fully Agree
The deadline was enough to submit the home work	12,83%	15,71%	20,20%	38,47%	11,86%
The deadline was enough to evaluate the work	16,35%	17,95%	16,67%	37,5%	9,94%
The evaluation instructions were clear	19,56%	19,88%	21,80%	26,61%	9,30%
Course materials provided on Moodle were relevant	33,02%	27,89%	21,16%	12,18%	3,85%
The rules and steps of the workshops have been clearly explained by your tutor	22,76%	11,86%	20,52%	30,77%	11,86%

Among the feedback of some students, we can list some comments extracted from our survey:

"As a student, we must have more instructions, clear and useful course materials on Moodle "

"More improve the course materials on Moodle"

"Dispose more clear videos with explanation, more explanations from my tutor"

Since we had this year new hired teachers, we can understand the different opinion shared by several students. For the next year, we planned to work on several points to improve this experience. We propose to plan more trainings to the new tutors, have some videos on Moodle to explain each phase in the peer assessment activity. We should also improve the course materials disposed on Moodle and how to explain every steps and rules of each workshop and give more details about the process.

Table 4: Review of students who submitted and evaluated the Exception's Workshop

Questions	Percentage
No, I didn't answer the question about exceptions in the exam	21,89%
I think that 1hour 30min isn't enough to finish the exam	20%

In the other hand, we find in Table 4 that among 21% of students who couldn't answer the question about exceptions in the exam, 20% from them say that it was fault of time that they could not finish this part.

Table 5: Review of students who submitted and evaluated the File's Workshop

Questions	Percentage
No, I didn't answer the question about files in the exam?	25,11%
I think that 1hour 30min isn't enough to finish the exam	18%

And in another part, we find in Table 5 that among 25% of the students who didn't answer the question about files in the exam, 18% from them say that it was fault of time.

We can notice that 69% of students were able to answer to the exception's part in their exam and 75% were able to answer to the file's part. At the end of the course we can conclude that this percentage is important, however we must work to improve it in the next year.

Table 6. Overall Satisfaction

Questions	Totally Disagree	Disagree	No Opinion	Agree	Fully Agree
The final mark reflects your work done	28,85%	22,12%	16,03%	22,44%	7,70%
I feel that I can do better next time	7,38%	2,57%	10,58%	32,06%	45,20%
Overall, I feel satisfied with the peer review as an experience	21,16%	19,24%	24,04%	24,36%	10,26%

We can see in Table 6, about 51% don't agree with their grades. We can see also that about 35% agree or fully agree that learning with peer assessment was a good experience and 40% was not satisfied. However, less than 10% said that they believe that they cannot do better next time.

Since this survey was conducted after the end of the course and more than 21% didn't validate this unit, we can understand why we have 40% who was not satisfied even if only about 10% confirms that they cannot do better next time.

5 Conclusion

In this paper, we presented our implementation of a peer assessment approach in our programming course using the Moodle workshop activity. The purpose was to ascertain whether this approach represents a viable alternative to traditional method.

The results of the study showed the impact of this approach and its influences on their grades with good assimilation of learning outcomes of the module.

While the results are encouraging, we found that many improvements should be made such as the course materials on Moodle, setting up a communication strategy to better explain the process, providing a several training sessions for new tutors.

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Peer and team assessment: strategies and applications in Engineering courses

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Abstract

Teamwork is one of the competencies that more often are referred has required to professional practice in Engineering. Working in teams in the learning process has been referred to be an effective way to promote the development of technical competencies while promoting the development of teamwork competencies. The students identify teamwork as motivating for their self-learning. In a teamwork environment student can deal with self-knowledge, critical analysis, knowledge of the others, individual and group performances, feedback, resilience, synergy, decision making, commitment, participation, self-esteem, leadership, and entrepreneurship. All these characteristics come from the understanding that a team is formed by individuals with different experiences, origins and individual profiles. But what are the criteria for peer or teamwork assessment? Which methods give fair rewards for different contributions to the team and its peers? There are several peer assessments studies where many experiences are described, but there are not many studies that compare the strategies of peer assessments between them. For example, when the criteria have different weights or when the scores given by the peers are anonymous or when the scores are decided by the group, and so on. The objective of this work is to describe several strategies of peer and team assessment, considering the categorization and organization carried out in order to assumptions and/or purposes of each strategy. Thus, a contribution will be made for increasing peer and teamwork assessment in Engineering courses.

Keywords: Engineering Education, Peer assessment, Teamwork, Transversal Competences, Project-Based Learning

1 Introduction

In nowadays, engineers face challenges that require a solid foundation in engineering, but also skills such as teamwork, project management, interdisciplinary problem-solving and oral and written communication (Fernandes et al., 2009; Vicente, Romano, Sá, & Lima, 2014). This interest is based on the need to improve the education of engineers to create the need to change Engineering Education (EE). New approaches should bring joy to students and teachers, and trust is the main ingredient for enjoying teaching and learning, and also for creating an atmosphere of empathy and openness that is necessary for collaboration. In order to create innovative approaches, the stakeholders need a trusting environment that will always accompany a changing environment. This environment should offer a modern, reliable, innovative atmosphere with fair assessment techniques and strategies. Besides, that classroom should contribute for the development of transversal competences like teamwork, communication, self-knowledge, critical analysis, knowledge of the others, and so on.

Project Based Learning (PBL) has been an innovative strategy in curriculum design in many engineering courses around the world. PBL is based on some fundamental principles (Graaff & Kolmos, 2003): Principle #1 - problem with a high relationship with the professional context of engineering that relevant and very significant to students; Principle #2 - interdisciplinarity that permits the students to link theory and practice and establish between different areas of knowledge; Principle #3 - teamwork with students and teachers engaged with the team learning. PBL is frequently accompanied by one or more assessment strategies of the team participants, since individual technical tests may not measure the entire learning developed by the team.

A modern engineer should know to work within interdisciplinary e multicultural teams and know to recognize the teammates' potentials for the development of the projects. The technical competences are very important, but it is very important that the engineer become a self-learner and be able to do self-monitoring to adapt to fast changing needs.

Assessment is an important element of the curriculum processes, which allow to assess the competences an engineer should develop. The traditional approach is mainly focused in knowledge assessment and technical competences, which does not correspond to the expectations of a modern engineer as referred previously. Thus, the combination of PBL and innovative strategies of assessment, e.g. peer assessment, is a way of improving engineering courses.

There are many peer assessment strategies and dimensions, which will be summarized in the next section. Nevertheless, there still a need to answer to the question: how to develop peer or teammates assessment in engineering courses? Thus, this paper will be focused in answering to this question, from the point of view of the methods identified in the literature. Particularly, this work aims to clarify and peer assessment strategies and develop the calculation details of two different methods. This paper starts by presenting a summary of classifications of peer assessment, goals, reliability and validity of existing methods, will continue by discussing grading issues and make some recommendations for applying peer assessment methods. Finally, will present some details of calculation to help teachers of engineering to apply peer assessment in their courses.

2 Peer Assessment Principles

Assessment can be seen as the determination of the amount, level, value or worth of something (Topping, 2003). But the term Peer Assessment (PA) has many meanings and terms as peer marking, peer correction, peer rating, peer feedback, peer review, and peer appraisal are some examples. It is difficult to establish relationships between assessments dimensions and students' learning due to the different purposes, functions, required levels of learning, and technical and transversals competences in engineering courses. A short guideline of peer assessment in engineering courses could be applied in different purposes and situations, that is the main subject of this work.

As described by Topping (2003), Self-Assessment (SA) is the arrangement for learners and/or workers to consider and specify the level, value or quality of their own products of performances; Boud, Cohen & Sampson (1999) and Boud & Falchikov (1989) refer to the involvement of learners in making judgements about their own learning, particularly about their achievements and the outcomes of their learning.

Team Assessment (TA) refers to individual assessments inside teams, to ensure that students have a fair recognition of their contribution to team outcomes (Brown, 1995). In the teammates assessment, the students are assessing concerning with transversal competences, because teamwork can deal with self-knowledge, critical analysis, knowledge of the others, individual and group performances, feedback, resilience, synergy, concluding requirements and deadlines, self-esteem, leadership, and entrepreneurship (Fernandes et al., 2009; Vicente et al., 2014).

Peer Assessment can be seen as an arrangement in which individuals consider the amount, level, value, worth, quality, or success of the products or outcomes of learning of peers of similar status (Gielen, Dochy, & Onghena, 2011; Gielen, Dochy, Onghena, Struyven, & Smeets, 2011; Gielen, Peeters, Dochy, Onghena, & Struyven, 2010; Harris & Brown, 2013; Pope, 2005; Topping, 2003, 2005, 2009). Peer assessment takes the form of feedback, face-to-face or otherwise, often reciprocally among the assessors and assesses (Topping, 2009). Assessment of teammates' contributions or achievements can become complex in this context of high interaction, and diverse variables, dimensions and variations between characteristics of the team. The overriding goal of peer assessment is to provide feedback to learners (Topping, 2009). Feedback can reduce errors and have positive effects on learning when it is received thoughtfully and positively. The primary goal of feedback is to enhance the performance of the individual and/or group by identifying the discrepancies between a member's expected and actual performance, thereby giving the member the opportunity to take a corrective action (Baker, 2008).

2.1 Peer Assessment Goals

The Peer Assessment permits involve the students in activities with different goals, but it is difficult to establish phases and learning outcomes when do not know how to apply the peer assessment. Besides, the peer assessment is described in many strategies, methods or strategies depending on the goals. The work by (Gielen, Dochy, & Onghena, 2011) developed an update bibliographic review from the work by (Topping, 1998), treating it as an inventory of peer assessment diversity. In this inventory was identified five clusters, twenty variables, and a range of variations that differ from the work by (Topping, 1998). In summary, each cluster grouped some general decisions about Peer Assessment applying. **Cluster I**: **decisions concerning the use of peer assessment**, that are related to peer assessment purpose, peer assessment objects or artifacts produced, the frequency of application and the experience of the student in peer assessment, objectives or goals of peer assessment and summative or formative peer assessment's function. **Cluster II**: **link between peer assessment and other elements in the learning environment**, that are related to degree of alignment between teammates and time available of the peer assessment, relationship with other assessments and scope of involvement the peer assessment. **Cluster III**: **interaction between peers**, that are related to output object type of peer assessment goal, flow directions of peer assessment, privacy, time and place where the peer assessment occurs, role of assess between peers. **Cluster IV**: **composition of assessment groups**, that are related to how to match the students and the organization of assessors/assesses. **Cluster V**: **management of the assessment procedure**, that are related to how do peers assess, the compulsory characteristic of participation of peers, the needs of reward by participation of peers, the need by training or guidance in peer assessment, and the last variable is the quality control that relates to reactive or proactive control of learning of peers.

Specifically, the goals of decisions concerning the use of Peer Assessment are described in Cluster I and there is a need to make a relationship with one quality concept of learning presented by the peers. In (Gielen, Dochy, Onghena, et al., 2011), there are five goals, and a set of quality concepts related to them can be viewed in Figure . This figure illustrates the relation between the five goals, sub-goals of PA, and the six quality concepts proposed by Gielen, Dochy, Onghena, et al. (2011).

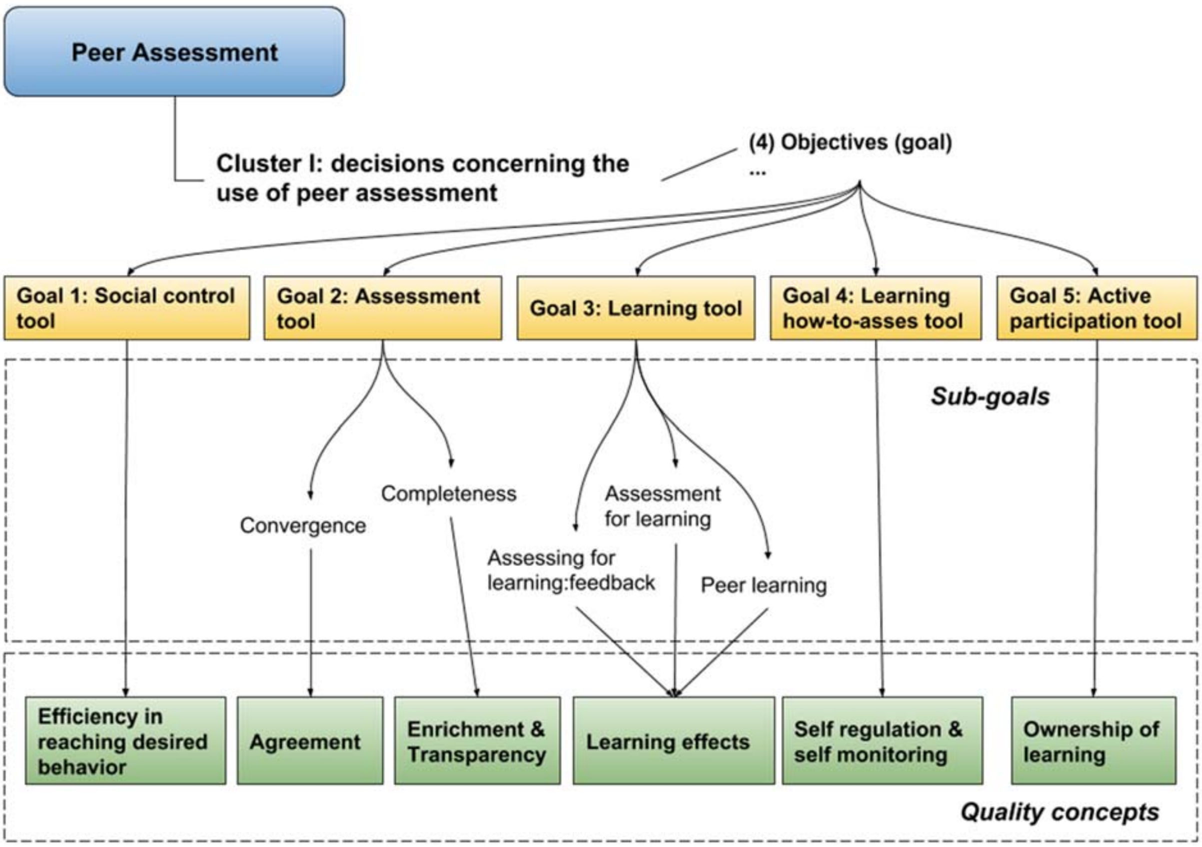

Figure 1. Illustration of the relation between goals of PA and quality concepts.

A short description of each of the five Peer Assessment goals and the quality control dimensions presented by Gielen, Dochy, Onghena, et al. (2011) are summarized in the following sentences. (1) **Social control tool**: this first goal is to make the peers assess each other using a problem's sheet with criteria to spend time on one or more tasks, and to use feedback as a social dimension with peers. Quality concept of peer assessment as social control tool: to keep the desired behavior like a controlled class. (2) **Assessment tool**: this second goal, there are two quality concepts as convergence and completeness. The convergence quality concept is related to the agreement between students and teachers with judgments of teammates with grades and the assessments received between them. Should exist comparisons with the teacher assessment realized, teammates assessment, other episodes of assessment during the course, and the self-assessment between teammates. The completeness quality concept is related to all different opinions that enrichment for the final assessment because they contribute to its validity, and they are transparent to all participants in the assessment process and are the underlying differences in assessment schemes becoming clear. (3) **Learning tool**: the third goal states that peer assessment could be a tool for learning through learning effects (quality concept) of the way it is implemented. Thus, the authors make a distinction on three ways (named subgoals) it can be implemented as a learning tool: a student undergoing the assessment process; or a student assessing another student; or an interaction between peers. This three subgoals may contribute for the learning process. (4) **Learning how-to-assess tool**: in this goal, the students should learn to become assessors in peer assessment. This is an important part of becoming a lifelong learner. Quality concept of peer assessment as learning how-to-assess tool is self-regulation and self-monitoring of students regarding to their own learning. (5) **Active participation tool**: in this last goal, the student become an active participant in assessment process and in this way takes ownership of the learning process. Peer assessment contributes in this way to the empowerment of the student.

2.2 Reliability, Validity, and Utility of Peer Assessment

Research findings on the reliability and validity of PA mostly emanate from studies in higher education (Topping, 2009). The reliability and validity of peer assessment tend to be at least as high, and often higher, than teacher assessments (Topping, 1998, 2003). Reliability tends to be higher in relation to: the degree of advancement in the course, the nature of the product or performance assessed, the extent to which criteria have been discussed and negotiated, the nature of assessment instrumentation, the extent to which an aggregate judgment rather than detailed components are compared, the amount of scaffolding, practice, feedback and monitoring, and the contingencies associated with the assessment outcome. Irrespective of relatively high reliability, student acceptance is variable (Topping, 2003).

The reliability and validity of PA might be compromised because social processes might influence and contaminate the process. The Peer Assessments might be partly determined by friendship bonds, animosity or other power processes, group popularity levels of individuals, the perception of criticism as socially uncomfortable or even socially rejecting and inviting reciprocation, or collusion leading to lack of differentiation. The social influences might be particularly strong with *high stakes* assessment, for which peer assessments might drift toward leniency. The reliability and validity of self-assessment tend to be a lower and more variable, while the reliability and validity of peer assessment tend to be as high or higher (Topping, 2003).

3 Peer Assessment Strategies

This section is dedicated to presenting peer assessment strategies main issues, including assessment methods, grading details and some recommendations found in the peer assessment literature.

3.1 Assessment Methods

Considering a summative function in the PA, the adoption of assessment methods needs to be moderated by two important factors: first, the assessment method must be as accurate as the traditional methods existents in higher education, and second, the method must not be prejudicial to the students themselves. The teachers have used a variety of methods to assess peer performance in small groups. According to Baker (2008), some assessment methods as rate scales, single rate, allocation of points, peer comparisons, and project diaries can be used. Peer Assessment methods are described by Baker (2008) and summarized below.

The Rating Scales method is used to assess a variety of behaviors and can provide more detailed information about the rates than other methods. In a particular type of rating scale known as Behaviorally Anchored Rating Scales (BARS), each point on the rating scale is associated with a specific observable behavior that is considered critical to the success of the team, thereby reducing ambiguity.

The Allocation of points is other common peer assessment method used in small group settings involves an allocation of points based on overall contribution to group performance. For example, the number of points to be allocated is determined by multiplying the number of team member by 10, with the stipulation that the average rating for the group total was 100%.

The Peer comparisons method compares teammates with each other, that is, each teammate identifies the team member who was most outstanding on one or more performance dimensions. The points are assigned based on the number of times a student is listed by his or her peers for each dimension.

The Project diaries method assess teammates contributions made at various stages in the group project. In various checkpoints during the semester, peers were asked to list the names of the team members who had performed those specific tasks. At the end of the semester, the instructors could count how often each student was mentioned and comparing that to the maximum number of times that a team member could be mentioned. This approach serves to clarify performance expectations, ensure accountability, and reduce the effect of memory deterioration on peer assessment.

3.2 Grading Issues

The grading issues in the summative assessment of students involve many assessment factors. Therefore, the assessment methods become rates or grades that meaning the amount level learning of students. According to the description made by Baker (2008), the rating systems seem easier than ranking systems to convert into grades because they are based on absolute as opposed to relative standards. For example, the Autorating System described in Brown (1995), uses the weighting factor for each student to multiply the team rating obtained from the teacher to obtain the final rating for an individual. This weighting factor is a ratio of the average of the assessments of the individual to the average of all assessments of all individuals. Another alternative to determine the grade of ratings is based on the idea that the students divide the individual score by the total points achieved. A key concern when using peer assessment for grading purposes is the extent to which group members accept the ratings of their peers, questioning peer bias. When peer feedback affects the grade, student concerns about the grading accuracy are legitimate.

3.3 Recommendations

In the literature there are some recommendations to rating process discussed previously that are related to students' behavior in their attitudes with peer assessment. The PA offers triangulation, and thus seems likely to improve the overall reliability and validity of the assessment. A peer assessor with less skill at assessment but more time in which to do it could produce an equally reliable and valid assessment. Peer feedback should be available in greater volume and with greater immediacy than teacher feedback, which compensates for a quality disadvantage (Topping, 2009).

To avoid the leniency error when peers give all their teammates the same score, Baker (2008) recommends that students should not be allowed to give everyone the same score. To maintain marks balance and reduce the effect of an unfairly high/low rating, the top/bottom rating may also be thrown out. Alternatively, the median could be used instead of the average because there is a sometimes a tendency for peer marks to bunch around the median (Topping, 2009).

Should think about penalizing teammates that fail to contribute to peer assessment because it can compromise team performance. According described by (Baker, 2008), to remind students of the importance of their rating decisions, teachers could place an honor pledge at the bottom of the assessment instrument that states, "*To the best of my recollection and ability, the above ratings accurately reflect the performance of my peers*". This pledge hopefully encourages students to take the assessment seriously and that it is important to inform students early about how they will be assessed.

4 Implementation of two Peer Assessment methods

The implementation of a Peer Assessment method requires some levels of decision, as illustrated by Figure 2. This section proposes a model of three level of decisions: (a) Selection of an assessment method; (b) Selection of a threshold or not; (c) Utilization of absolute or relative grading? Additionally, this model is applied through the details of the implementation of two peer assessment methods.

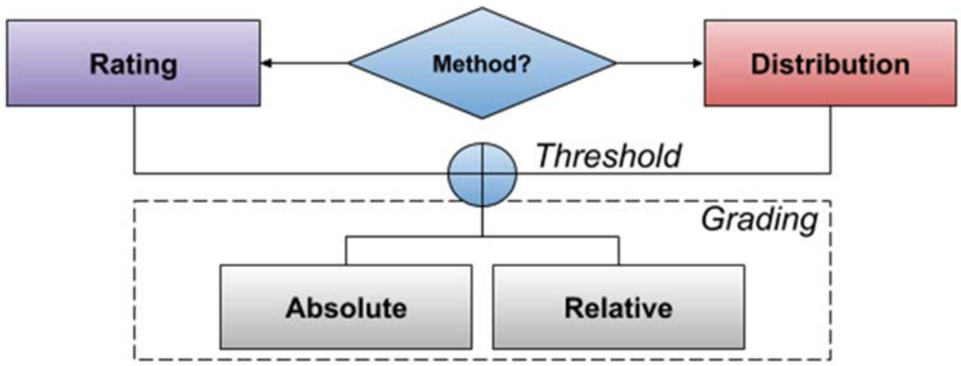

Figure 2. Three levels of decision to apply Peer Assessment Methods.

The Rating method uses a grading process is equivalent to the Rating Scale (Baker, 2008), in which students will assign a level of performance for each criteria to all peers. The Distribution method is similar to the allocation of points described in (Baker, 2008), in which students will have to decide a distribution of points among its peers. The threshold is a limit on percentage of a rating assigned/calculated in the peer assessment method. Ultimately, it is used to keep the rating received by a student between a lower and upper bound on the desired scale. Limits can be used to manage one or more students with much smaller (much larger) performance on the team. After selecting the method, it is still possible to select an absolute or relative grading process in relation to the teachers' grading. An absolute grading considers that the peer assessment will be considered as a percentage of the student's final grade. A relative grading considers the peer assessment to be used as a corrective factor to adjust the student's final grade. The next subsections will explain each level and their possible values.

4.1 Rating Method

The scale values for the Rating Method can be based on Likert scale or on other scale of values, e.g. as 1 to 10. The teacher can suggest a scale that students should agree upon. This implementation examples will consider assessment dimension as criterion defined between the students and the teacher. Some examples of criteria in PBL environments can be observed in (Mesquita, Chagas, Lima, & Chagas, 2018). For each assessment dimension, each student assigns a scale value to teammates. If there is the intention of using the self-assessment, then students should assign a value to themselves. A matrix example of one assessment dimension can be seen in Table .

Table 1. A matrix example with N peers for assessment of Dimension #1.

Dimension #1	Peer #1	Peer #2	...	Peer #N
Peer #1	$Grade_{1,1}$	$Grade_{1,2}$	...	$Grade_{1,N}$
Peer #2	$Grade_{2,1}$	$Grade_{2,2}$	...	$Grade_{2,N}$
...	...	...	...	...
Peer #N	$Grade_{N,1}$	$Grade_{N,2}$	...	$Grade_{N,N}$
	$Sum_{1,1}$	$Sum_{2,1}$	...	$Sum_{N,1}$

For each row *i* of Table , each student (peer *i*) assigns a scale value to teammates, including himself/herself. The sum ($Sum_{1,N}$) of all scale values in column *j* is equivalent to the total value assigned to student *j*, by all peers.

Table 2 presents a matrix with peer grades for M dimensions. The column *TOTAL RATE*$_i$ in each row of Table 2 is the total grade assigned to that peer by all peers and him/herself.

Table 2. A matrix example with N peers by M assessment dimensions.

	DIMENSION #1	DIMENSION #2	...	DIMENSION #M	$TOTAL\_RATE_i$
Peer #1	$Sum_{1,1}$	$Sum_{1,2}$	...	$Sum_{1,M}$	$\sum_{j=1}^{M} Sum_{1,j}$
Peer #2	$Sum_{2,1}$	$Sum_{2,2}$	...	$Sum_{2,M}$	$\sum_{j=1}^{M} Sum_{2,j}$
...	...	...	...	...	
Peer #N	$Sum_{N,1}$	$Sum_{N,2}$	...	$Sum_{N,M}$	$\sum_{j=1}^{M} Sum_{N,j}$
					$AVERAGE\_RATE$

In the last row and last column is calculated the average grade for all students denoted by *AVERAGE_RATE*, calculated using the formula of Equation 1.

$$AVERAGE\_RATE = \frac{\sum_{i=1}^{N}\sum_{j=1}^{M} Sum_{i,j}}{N * M} \quad \text{Equation 1}$$

The weight factor PEER_FACTOR (Equation 2) is equivalent to the ratio of each peer's TOTAL_RATE divided by AVERAGE_RATE. This PEER_FACTOR indicates each peer's assessment as seen by teammates. Instead of the average of peer's ratings, some works (Baker, 2008; Topping, 2003, 2009) refer to the use of the median of ratings. The weight factor PEER_FACTOR can be used by teachers to establish a relationship with a final grade of the team project. This relationship can be absolute or relative to the teacher's course. If a threshold is set, the weight factor can be used by the teacher to observe and motivate teammates with more difficulties in the course. The threshold can be defined in 10 to 20 percent of the PEER_FACTOR to up or down.

$$PEER\_FACTOR_i = \frac{TOTAL\_RATE_i}{AVERAGE\_RATE} \quad \text{Equation 2}$$

4.2 Distribution Method

The Distribution Method uses a proportional amount of points based on the number of teammates. In Baker (2008) is defined as the number of teammates multiplied by 10 but can use other value like 100, for example. Each peer should distribute all points between teammates, but the sum of all peers should not exceed the total amount of points. The idea is somehow similar to that of the Rating Method, but instead of assigning an absolute scale value to each teammate, it assigns relative values by comparison of performance. The remainder of the Distribution method calculations can be similar to those already performed using the Rating method previously described.

5 Conclusions

The objective of this study was to describe a set of peer assessment strategies and the calculation process for some methods identified in the literature. Thus, this paper make contribution in terms of what strategies has been implemented in Higher Education contexts and, particularly, how to calculate the grades of teammates. One important conclusion is that these grades should reflect the value of the contributions of each student as viewed by teammates. The grade values may use criteria or assessment dimensions agreed by students and the teacher. Given the importance of team skills in almost any organizational setting, it is good for teachers to provide group learning experiences, which can benefit from peer learning and assessment.

In (Fernandes et al., 2009; Mesquita et al., 2018) and (Kilic, 2016) are described some applying situations using peer assessments strategies with engineering course students and PBL methodology.

Some studies of peer assessment have been described and integrated aiming to help and support teachers to organize the assessment model in order to make the learning of their students more motivating. To improve the learning process and assessment for learning, decisions about peer assessment should be made intentionally, with a clear understanding of the goals of the course and the objectives of group assignments.

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Team-Based Learning in an Engineering course: an experience in Brazil

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Abstract

Team-Based Learning (TBL) is an active learning strategy, used for the first time in medical education, and its use in Engineering Education is still not well established as in health science education. This work is about an experience of use of TBL in two consecutive years (2017 and 2018) in undergraduate Engineering course in a public university in Brazil. The objectives are to describe an experience using TBL, its impact over students' performance and perception of students and teacher about this approach. Initially, students were divided into groups from 5 to 7 members. The subject of the courses was divided into 4 modules, each one of 4 weeks. Each module started with the Readiness Assurance Process - RAP (pre-class individual assignment, e.g. readings), followed by in-class Individual Readiness Assurance Test – *iRAT*, and Team Readiness Assurance Test – *tRAT*. Both tests were applied using Information Technology tools, in this case either Socrative, or Kahoot or Plickers. During classes, students performed activities designed to develop students' critical thinking skills, applying concepts learned from RAP. Moreover, the students had to perform processes of self and peer-assessment. Average scores from the RAP were statistically higher in tRAT (group tests) than in iRAT (individual tests) (t-test; $p \leq 0.05$), in both years, indicating that teamwork and peer-instruction were important to achieve a greater understanding of the subject. The perception of the students about TBL was collected by an end of class questionnaire. For 81% of the students, TBL methodology was better than teacher centred classes. Another point to be highlighted was the use of Information Technology tools for feedback, approved by 100% of the students who answered the inquiry. As suggestions for future improvements emerged the need to improve the didactic material for pre-class studies.

Keywords: Tem-Based Learning; Peer Instruction; Peer Evaluation; Teamwork; Feedback.

1 Introduction

In the last decades Engineering Education has become an increasingly field of interest (Lima, De Graaff, Mesquita, & Aquere, 2018). Project-based and problem-based learning are widely used and well-known pedagogies in this field (Henri, Johnson, & Nepal, 2017). However, reports on Team-Based Learning (TBL) implementation in engineering and science education are scarce (Najdanovic-Visak, 2017).

Team-based learning (TBL) is an active learning approach based on small group instructional strategy that provides students with opportunities to apply conceptual knowledge through a sequence of activities that includes individual work, teamwork and immediate feedback (Parmelee, Michaelsen, Cook, & Hudes, 2012). TBL was originally developed for a business administration school to promote the benefits of small-group teaching in a large group setting, as an alternative for classes taught by the lecture method (Michaelsen, Watson, Cragin, & Dee Fink, 1982).

The primary learning objective in TBL is to go beyond simply covering content and focus on ensuring that students have the opportunity to solve problems using course concepts. Thus, TBL is designed to provide students with both conceptual and procedural knowledge. Team-based learning (TBL) has many aspects (Michaelsen & Sweet, 2008):

- ✓ group work is central to exposing students to and improving their ability to apply course content;
- ✓ the vast majority of class time is used for group work;
- ✓ courses taught with TBL typically involve multiple group assignments that are designed to improve learning and promote the development of self-managed learning teams.

TBL is a pedagogical approach that can be implemented through the following four elements (Michaelsen & Sweet, 2008):

(i) Groups: must be properly formed and managed.

(ii) Accountability: Students must be accountable for the quality of their individual and group work.

(iii) Feedback: Students must receive frequent and immediate feedback from the teacher.

(iv) Assignment design: group assignments must promote both learning and team development.

TBL's strategic sequence, when repeated multiple times during a course or academic term, encourages conscientious individual preparation while developing teams into cohesive learning groups. Faculty motivate students to thoroughly study the advance assignment by writing questions that assess mastery of critical concepts in that assignment. TBL provides frequent opportunities for peers to enhance learning, as teammates talk and listen to one another to arrive at consensual reflected decisions. Faculty invite teams to explain and support their choices publicly, and facilitate as teams debate justification for the best decision. Ideally, application questions require students to engage in critical thinking, rather than to merely retrieve relevant knowledge. Well-crafted application questions motivate teams to "make a concrete decision based on analysis of a complex issue." Faculty often observe considerable energy and engagement of students during intra and inter team discussions (Koles, Stolfi, Borges, Nelson, & Parmelee, 2010).

The aim of this work is to discuss the experience, evaluation and lessons learned from the implementation of the TBL within two Environmental Engineering courses in the years of 2017 and 2018.

2 Description of the TBL implementations

This study is an experience of implementing TBL as a methodology for teaching in two Environmental Engineering courses in an undergraduate program at a public university in Brazil. This experience was done in a first year (Ecology course, year 2018, 39 students) and third year (Limnology course, years 2017 and 2018, 40 and 27 students, respectively) courses. TBL strategy was implemented based upon Michaelsen & Sweet, 2008, with some adaptations, and will be described in this section.

2.1 Context and process of application

Both courses had an amount of 32 hours each, divided into 16 weeks. Each course was divided into four modules, each module of 4 weeks. Figure 1 presents a workflow of each module. Team formation was done randomly, with the aid of the institutional learning environment, with teams from 5 to 7 members, depending on class size. A total of 106 students have been enrolled on these courses.

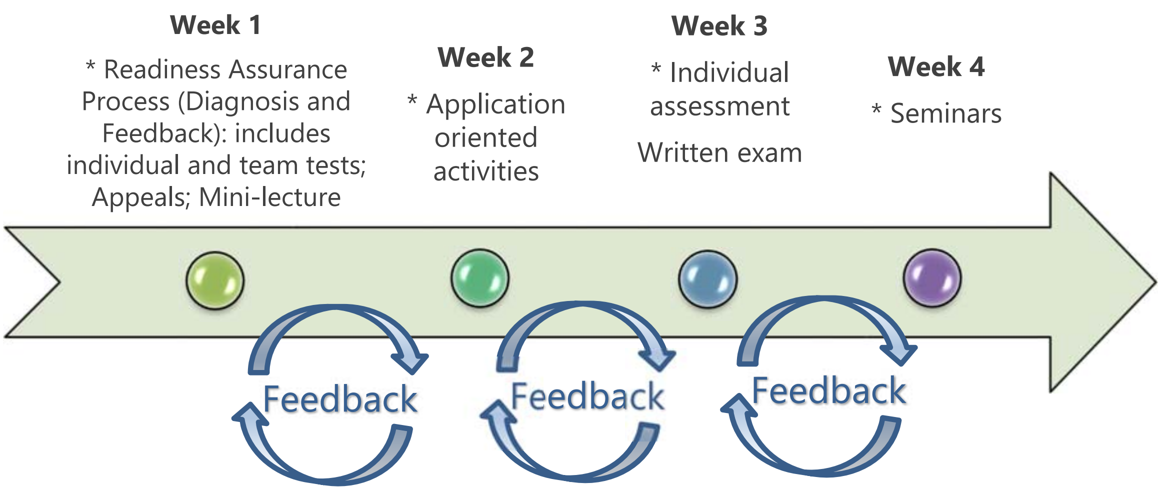

Figure 1. Workflow of each module.

The procedure of each week is described below.

- ✓ *Week 1*: Readiness Assurance Process, with five steps, that are *Pre-class preparation*; *Individual Readiness Assurance Test* (*iRAT*); *Team Readiness Assurance Test* (*tRAT*), both done using Socrative® or Plickers®. On each module the tests had ten multiple choice questions, with four possible answers each. The students had 15$\pm$2 minutes for *iRAT* and 20$\pm$2 minutes for *tRAT*. The *iRAT* and *tRAT* ensure that students comprehend basic concepts, allowing teacher to move towards more detailed and multifaceted discussions, application activities, and/or lectures (Andersen, Strumpel, Fensom, & Andrews, 2011). *Appeals*: After tests students had the opportunity to make a written appeal, in group, if they do not agree with any question. *Mini-lecture (with discussions)*: after *iRAT* and *tRAT*, based on reports of Socrative® or Plickers®, started this part of the class. Contents covered on topics where there was more doubts, based on reports, were further discussed. Videos, slides, board were also used in order to clarify and give a deeper view on the main topics in this part of the class. Formative assessment was also used, mainly using Kahoot®, which provided competition between individuals or groups.
- ✓ *Week 2: Application oriented activities*, in class. Based on the 4S problem-solving of TBL principles (Michaelsen & Sweet, 2008). These activities were based mainly on case studies, from several sources, cited on each activity. In some occasions an adaptation was done, using the approach "Pass the problem" (Ballard, 2001), with open ended questions. Questions from previous "Brazilian National Exam of Students Performance" (ENADE) were also used successfully. Formative assessment was also used, mainly using Kahoot®, which provided competition between individuals or groups.
- ✓ *Week 3:* Individual test about the subject of the module (written; sometimes, part of it online with instantaneous feedback, using Socrative®)
- ✓ *Week 4*: Seminars with subjects about the actual or previous modules (in teams).

2.2 Assessment process

Any group-based instructional format requires students to be accountable for their learning (Cestone, Levine, & Lane, 2008). In this TBL experiences, each module had a total score of 100% (see Table 1) and the final grade was an average of the four modules. Considering all assessment activities, 60% of the scores were based on individual activities and 40% on group activities.

Table 1. Description of assessments in each module, including individual and group assessment.

Assignment	Weight	Individual Activities	Group Activities
iRAT	10%	X	
tRAT	10%		X
Application activities	5%		X
Self-assessment	5%		X
Peer-assessment	5%		X
Seminars	15%		X
Exam	50%	X	
Total	100%	60%	40%

Self-assessment and peer-assessment, in this case, were related only to activities done in Readiness Assurance Process and Application activities, based on the five criteria described below, using Google Forms®.

1. You/your peer has positively contributed with group discussions.
2. You/your peer has helped the group to be focused on the questions given by teacher.
3. You/your peer has actively contributed with knowledge and opinions.
4. You/your peer worked in harmony with the group.
5. You/your peer previously studied the pre-class material (material given by teacher).

For each question, a 1 to 5 points scale was used, adapted from (LIKERT, ROSLOW, & MURPHY, 1993). Students were instructed about the scales, where the following scores should be used: 1-completely disagree; 2-disagree; 3-neutral; 4-agree; 5-totally agree. The scores for each student were averaged, either for self-assessment or peer-assessment, in a scale of 1 to 5. For grading it was normalized using a weight of 5% for each module.

Individual tests were done at the end of each Module, with open-ended questions and/or multiple choice questions.

Seminars were also done at each module, in group. The subject could be either the same for all groups or one topic for each group, with a brief discussion after the presentation. These seminars were complimentary to the topics covered on each or more than one module, for example, about peer reviewed papers. In seminars, there were also a new criteria for assessment (Michaelsen, Knight, & Fink, 2004): each student was peer-assessed and the average grade provided by group made up a factor. Therefore, the grade of each student on the topic *Seminar* was defined by the grade from teacher multiplied by the factor defined by the group for each student. All the team members had to assess the contributions that each member of the group made to the seminars, taking into account the level of preparation, contribution, flexibility and respect for others. Each student distributed 100 points among other team members. All the members of the team got the "peer evaluation factor", which is the sum of the points they were granted from each teammate, divided by 100. This approach tried to overcome one common complaint by students in group work, that is "an unfair grade" (Fink, 2002), because not all members contributed the same way to the success (or not) of the group.

So, the grade for the Seminars were calculated as Equation 1:

$$Seminar\ grade\ (individual) = Team\ grade\ x\ (peer\ evaluation\ factor) \qquad \text{(Equation 1)}$$

2.3 Students' perceptions

A questionnaire comprising six multiple choice questions and one open-ended question were done by students, at the end of the term, using Google Forms®. The questions and its possible answers are presented in Table 2. As it was not mandatory, only 42 students from an amount of 106 completed this form. In each question students had to choose one possible answer.

2.4 Students' scores

In *iRAT* and *tRAT* students did the same test twice, first individually and afterwards on teams. So, *t-test* for paired samples was used to test if averages differed statistically, at a confidence level of 95%, using Microsoft Excel® "Data Analysis" tool. In this case, for all the courses the scores of the four modules were compared. If a student eventually missed the class his data was excluded from analysis, for both *iRAT* and *tRAT*.

Students also graded themselves (self-assessment) and their teammates (peer-assessment). *t test* was also used to check if average scores differed, at a confidence level of 95%, using Microsoft Excel® "Data Analysis" tool. Grading was done using Google Forms®. Sometimes some students failed to do the self-assessment (so, his grade on this item was considered zero) and the data were excluded from analysis, together with the respective peer-assessment.

Table 2. Questionnaire to students' perception about TBL.

Questions	Possible answers
1. **Group formation, by instructor, was?**	( ) Very good, I was closer to colleagues who I had little contact.
	( ) Bad, I already have my preferred group and doing this way it did not work as it usually did.
	( ) I liked, in the job market I would hardly have the chance to choose my co-workers
	( ) For me it was indifferent, I get along well with everyone.
	( ) I do not know or I do not want to answer
2. **Activities done in teams, as solving questions in class, seminars, were they important to improve the learning goals of the course?**	( ) Yes
	( ) Reasonably
	( ) Not
	( ) I do not know or I do not want to answer
3. **Dividing the contents of the course into 4 modules, with previous study in each module requested, for me it was...**	( ) Very good, because it allowed to me to use the time in class to clarify my doubts, as I always studied the material before classes.
	( ) The same as lectures, because I could not understand completely the material content.
	( ) Bad, because it already had many other activities of other disciplines and therefore I had no time to study the material previously.
	( ) I prefer lectures, with teacher centred classes.
	( ) I do not know or I do not want to answer
4. **The material available for previous studies, at the beginning of each module, was generally ...**	( ) Insufficient
	( ) In accordance with the content
	( ) Extensive
	( ) Confuse
	( ) I do not know or I do not want to answer
5. **About learning check methods using online Information Technology tools and instantaneous feedback.**	( ) I did not like, as I prefer exams using paper, in a traditional way
	( ) I liked, it is better because you have instantaneous feedback and it is better than using paper.
	( ) For me it does not matter
	( ) I do not know or I do not want to answer
6. **About the use of TBL strategy during the course, you consider that it was...**	( ) Better than lectures
	( ) As same as lectures
	( ) Worse than lectures
	( ) I do not know or I do not want to answer
7. **Open ended question**	If wanted, leave a compliment, criticism or suggestion about the discipline. Feel free to write, be honest so that the discipline can be improved the next time it is offered. If you want, identify yourself.

3 Results and discussion

Discussion will be based on three aspects: students' perspectives; teacher's perspectives; student's scores.

3.1 Students' perspectives

Fifty percent of the respondent students said that liked group formation by the teacher. An argument is that in labour market probably they will not have the opportunity to choose whom they were going to work with. For 38% of students it was indifferent, as they got along well with everyone.

About the group activities, 56% agreed it improved learning, while 31% considered it was not so good and 13% considered that group activities did not improve learning.

About the courses and their division into 4 modules, 56% of students answered that it was not a good idea. But the reason they said that is because they had other courses and because of that they did not have enough time to do the due activities. For 25% of students, TBL was considered very well, because it allowed these students to use class time to ask questions and clarify some topics about the content. 6% did not like TBL, other 6% consider TBL as same as lectures and 6% do not know or did not want to answer.

With respect to the previous material, they complained about it, as 88% said that the material was too extensive or too complicated. Students also complained about the time to dedicate to previous study, because they had also five or even more courses simultaneously, so they said they did not have sufficient time to dedicate to study the material. This is a point that clearly should be improved. Giving the students an extensive material (it was mainly book chapters) has not given students a good opportunity to learn, because they do not have time to read it carefully. Remington, Hershock, Klein, Niemer, & Bleske, 2015 also observed that this was a problem when trying to implement TBL in a pharmacy course, observing that the texts were not ideal for time-limited self-instruction and caused excessive workload to students.

A challenge here could be to create new types of materials that are complete, in terms of content, but that are easier to understand and to deal with the main ideas of the subject, for the previous study. So, later in class will be possible to work deeper into content with book chapters and other materials with more information

The only aspect students were unanimous is about the use of Information Technology (IT) tools (Socrative®, Plickers® and Kahoot®) for formative or summative assessment. They really liked the use of them. Aspects like ease of use, instantaneous score feedback, competition with pairs (in this case, mainly Kahoot®) were aspects that increased their engagement and approval of these tools.

A large majority of the students (81%) considered TBL better than lectures, 13% considered TBL worse and 6% did not know.

Another complaint that emerged on the open-ended questions was also about grading all classes. Some students felt this was not good because sometimes they were not able to be present in class and felt impaired.

3.2 Teacher's perspectives

It was clear that during the classes students were more engaged in discussing the questions, although they do not always realized that. A better level of participation and peer instruction could be perceived. Students improved their learning, by discussing with their peers. For Webb, 1995, group work promotes learning encouraging discussions and debate, which leads to the justification of ideas, resolution of disagreements and understanding of new perspectives.

The use of Socrative®, Plickers® and Kahoot® also improved the quality of the teaching and learning process. In the teacher's perspective, with the instantaneous feedback and a sheet of answers provided by these IT tools, it was possible to focus the mini-lecture on the most important topics that students had trouble, based on the tests results. This approach was very efficient, but it has some limitations on the wireless internet provided by the institution, that sometimes was unstable. Despite this, it has proved a very good way to give feedback, as it was not necessary to use paper forms and correct them manually. Socrative® was a very important tool to improve feedback about formative and summative assessment. As also described by Dervan, 2014, Socrative® permitted that the main questions about content could be discussed and cleared in class, also improving students' interaction.

The preparation of previous material and in-class activities (Readiness Assurance Process and application activities) was very time consuming, as also reported by (Andersen et al., 2011; Remington et al., 2015). Nevertheless, it clearly increased the level of discussions and students' engagement during classes. Also Koles et al., 2010 observed that both faculty and students noted that TBL's emphasis on individual preparation and peer-to-peer teaching seemed to enhance learning.

The previous material is one point that clearly emerged from students perspectives that should be improved. The material was cited to be confused or too extensive, so it could have obscured students' performance. For future applications of TBL, this should be a point to be improved, namely giving students a more resumed material. The use of videos and other more interactive tools is a perspective to be reached in the future. To reach that Vatterot, 2010 describes five fundamentals that homework should have: purpose, efficiency, ownership, competence and aesthetic appeal.

Other possible approach is integrate TBL with Problem and/or Project-Based Learning (PBL). As the courses have theoretical and a practical components, the use of TBL for theory and PBL for practice could improve even more students' learning and outcomes.

3.3 Students' scores

The average scores and standard deviation for exams were 70%±18% for Limnology 2017; 75%±15% in Limnology 2018 and 72%±18% in Ecology 2018. These averages are consistent with the histogram of Figure 2, where the interval 71-90% was the most common score of the students on the courses.

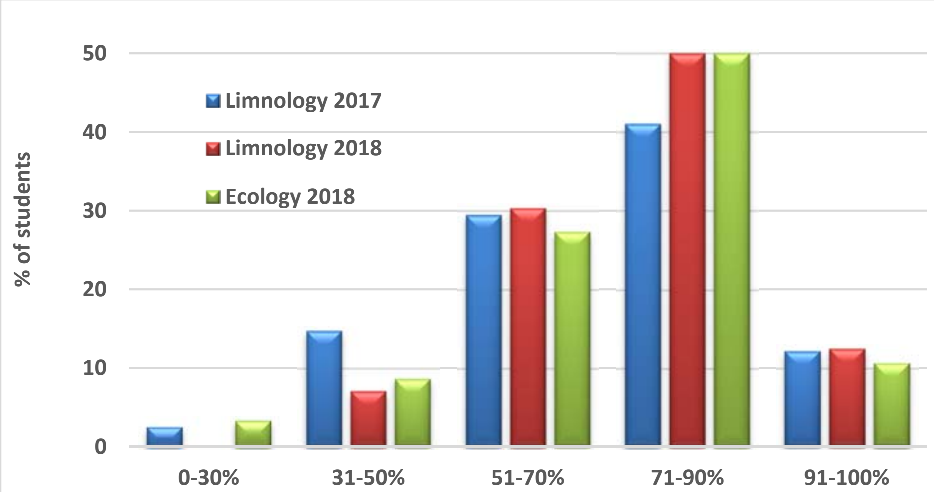

Figure 2. Exams scores in courses. Abscissas refers to scores intervals.

Scores were compared individually and in teams, in *iRAT* and *tRAT*, respectively, in Table 3. For the two courses it was observed that the average grade in *tRAT* was statistically higher than in *iRAT*, in both years, 2017 and 2018. Results indicates that average team scores outperformed individual scores from 15% to 24%, suggesting team interactions, as also observed by Najdanovic-Visak, 2017. When comparing scores between the two years in Limnology course, scores in *iRAT* did not differ ($p \leq 0.05$), but *tRAT* were statistically higher in 2017 than in 2018 ($p \leq 0.05$). Considering self-assessment and peer-assessment (except those in seminars), average scores did not differ statistically for all courses, either in 2017 or 2018 ($p \leq 0.05$).

Table 3. Statistical analysis of *iRAT* and *tRAT*.

	Limnology course		**Ecology Course**
	2017	*2018*	*2018*
***iRAT* average**	$67.7\%^{a,\alpha}$	$61.3\%^{a,\alpha}$	$68.2\%^{a}$
***tRAT* average**	$92.3\%^{b,\beta}$	$81.3\%^{b,\Omega}$	$83.4\%^{b}$
p-value	<0.001	<0.001	<0.001

[a,b]: averages differ statistically, $p \leq 0.05$, same year. Greek letters: averages comparing 2017 and 2018; same letters: no difference ($p \leq 0.05$).

4 Conclusions and recommendations

TBL proved to be a good strategy to improve students' engagement in the learning process. The use of Information Technology tools seemed to be very effective in helping teacher to give instantaneous feedback that could lead teacher's interventions to the most important topics, according to results of the tests. Students seemed to be more engaged, as the quality of class activities increased. About students' perception, 81% considered TBL better than lectures and that it improved learning. 56% of the students also considered that group activities improved learning. The use of Information Technology tools for feedback was approved by 100% of the students who answered the inquiry. Peer instruction seemed to be an important outcome of TBL, increasing scores and learning, as suggested by statistical analysis that demonstrated higher scores up to 24% higher in group activities than in individual activities. The main recommendations that emerged from the results are the improvement of material for previous study, turning them more suitable with the time students have to do it, as they have several other simultaneous courses. Furthermore, future integration of TBL with Problem and/or Project-Based Learning (PBL), in theory and practice into these courses could improve even more students' learning and outcomes.

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Curriculum Analysis Process: analysing fourteen Industrial Engineering programs

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Abstract

The fourth industrial revolution is demanding for new competences, thus requiring curricula redesign. A comprehensive analysis of current curricula contributes for the design of the new foreseen curricula. According to Hoffman (1999, p. 283): "the design of learning programs may be based on the inputs needed or the outputs demanded". Thus, curriculum analysis is helpful to identify aspects that are working and those that need a change (Wolf, Hill, & Evers, 2006). This purpose is crucial in the context of Industry 4.0, in order to prepare future engineers to face the challenges of their practice. Considering that in Europe, in general, formal curriculum level presents the structural aspects (e.g. hours and number of courses) and the learning outcomes of each course, it is possible to identify the areas of knowledge and the competences students are expected to develop. This paper aims to make a curriculum analysis, based on areas of knowledge and learning outcomes. This was based on a process exploring information from the formal level of curriculum that can be replicated in other contexts. Additionally, the process was applied to fourteen European Industrial Engineering master programs. The results show that there is a high level of diversity regarding main areas of knowledge and technical competences of each program. Moreover, it showed an enormous lack of attention in terms of transversal competences in all programs.

Keywords: Active Learning; Project-Based Learning; Engineering Education; Curriculum Design; Curriculum Analysis

1 Introduction

According to Hoffman (1999, p. 283): "the design of learning programs may be based on the inputs needed or the outputs demanded". Thus, curriculum analysis is helpful to identify aspects that are working and those that need a change (Wolf, Hill & Evers, 2006). This purpose is crucial in the context of Industry 4.0, in order to prepare future engineers to face the challenges of their practice. In fact, the professional practice requires the combination of different competences and, for that reason, they must be included in the curriculum. However, the curriculum and the pedagogical practice are not always aligned with this purpose (Jackson, 2012; Markes, 2006; Nair, Patil, & Mertova, 2009; Stiwne & Jungert, 2010; Tymon, 2013). In short, for an understanding about the curriculum it is essential to understand it as a project that includes (i) the teaching and learning experiences, (ii) the process of its development - design, development and evaluation - and (iii) the following key elements - objectives, content, resources, assessment, and teaching and learning strategies (Barnett & Coate, 2005; Biggs, 1996; Zabalza, 2009). With this in mind, two important issues should be addressed, considering the scope of this work: planning and curriculum levels.

Planning the curriculum as a project involves thinking about the activities that will be developed, the strategies to present the contents to students, the learning outcomes that should be defined, amongst others questions. Issues such as methods: contents; the organization of learning environment to interact with students; student support (e.g. tutorials); learning support material (e.g. guides); teachers' coordination and cooperation; and the evaluation must be also considered. These elements cannot be defined separated from each other (Barnett & Coate, 2005; Cowan, 2006; Kirkpatrick & Kirkpatrick, 2005; Mesquita, 2015; Wolf, 2007; Zabalza, 2009). All of them should be aligned (Biggs, 1996), in order to create meaningful teaching and learning experiences.

Analysing the curriculum implies identifying and defining it at different levels (Goodlad, 1979). The Ideal Curriculum refers to the rational of basic philosophy underlying a curriculum, it represents ideas on believes and intentions. All possibilities are allowed, because it is all about the ideas. The Formal Curriculum is a transformation of the ideal curriculum in formal documents. Can be developed at different contexts: Ministry of Education (macro), University (meso), and Teacher (micro). The Operational Curriculum refers to what actually happens in the classroom. This is related to the teaching and learning practices and the interaction between teachers, students and, in some occasions, other stakeholders (e.g. companies' representatives).

The term Industrial Engineering (IE) is most of the times referred with a meaning that can be seen as being mostly equivalent or overlapped with some other terms, e.g. Industrial Engineering and Management, Engineering Management, Engineering Systems, Production Engineering, and Manufacturing Engineering. This is can be caused by the diversity of the field itself and by the close relation it has with all other engineering fields. Industrial Engineering can be defined as an engineering field related to the project, improvement and management of systems composed by people, materials, equipment, financial resources, information and energy, that deliver products and services (IISE, 2017; Lima, Mesquita, Rocha, & Rabelo, 2017). Thus, as can be inferred by this definition, IE can be seen as the field related to designing, organizing and managing processes related to production of products and services, being this products and services designed and produced / executed under the concepts of other engineering fields.

The diversity within the IE field reflects on the curriculum organization, which implies an interdisciplinary approach, bringing together the different areas of knowledge that IE integrates. The context of Industry 4.0 is challenging the industries for change, connecting technologies together, and for that reason, preparing industrial engineers for these challenges is mandatory. It is an opportunity to re-think curricula, pedagogical practices and the competences that students need to develop to be prepared for this challenging environment. This is the main objective of a European project consortium involving three European universities, from Poland, Portugal and Romania, and six Thai universities (http://ise-portal.ait.ac.th/). In this context, this work aims to provide a comprehensive analysis of existing IE Master curricula, contributing for the design of the new foreseen curricula. The output of this work may contribute for creating a methodology for curriculum analysis and to an understanding about the IE curricula in European countries. This understanding may create a ground base for the identification of existing gaps between competences' needs for Industry 4.0 and the academic development of Industrial Engineering master students.

2 Methodological approach

In the scope of this work, the diversity of institutions and programs to be analysed implies a definition of multiple sources and methods, as recommended by Wolf et al. (2006). With this in mind, and focusing on formal level of the curriculum (Goodlad, 1979), several types of information may be analysed in order to identify specific curricula elements, mainly concerning to the structure of the different programs, type of educational experiences, areas of specialization and objectives / learning outcomes. These elements are essential to analyse the IE competences in the context of Industry 4.0. This paper will focus on collecting different information regarding formal curriculum (documents related to the master program). An Excel template was developed and filled by different partners to collect information about curriculum structure, areas of specialization and learning outcomes. Figure presents a schematic representation of the method followed during the execution and analysis phases.

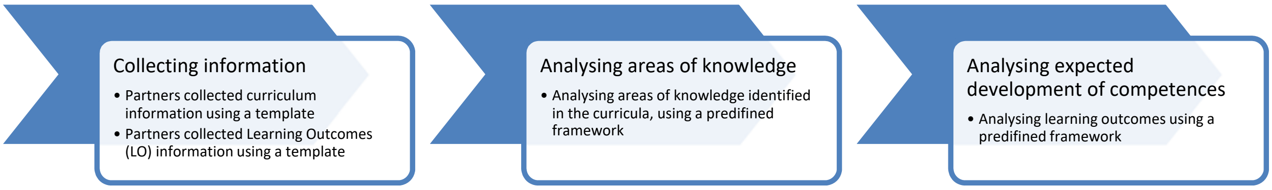

Figure 1. Execution and analysis phases of Task 1.2 methodology

Reviewing IE curricula is based on data collected from partners. First, information is collected from the courses, class types, hours of contact and credits. In a second form, information is gathered from learning outcomes in order to identify the expected competences to be developed by the graduates. The programs were selected for analysis based on two main criteria, being related to the HEI enrolled in the previously referred European project, and being from other HEI selected by convenience of accessing the required data.

2.1 Framework for analysis

Considering that courses mainly involve 1 or 2 main fields of knowledge, their title, objectives and short descriptions allow to identify the main areas of knowledge (AK) of each course, and consequently of each program. Additionally, as learning outcomes (LO) can be seen as "statements of what a learner is expected to know, understand and / or be able to demonstrate after a completion of a process of learning" (CEDEFOP, 2009), that makes possible to identify the expected competences that students should be able to develop with those courses. Aggregating this information will allow to create a map of competences (LO) that are being considered in the context of the different programs.

Regarding the IE areas of knowledge (AK) analysis, a framework of analysis was developed. This framework used as a baseline some previous works (Lima, Mesquita, Amorim, Jonker, & Flores, 2012; Lima et al., 2017), which defied Areas of Knowledge based on a thorough analysis of literature and professional associations. The final list of areas of knowledge were updated considering additional areas (marked with *), which were necessary for the classification of several courses. The final list follows: AK1 Automation; AK2 Computer and Information Systems (*); AK3 Economics Engineering; AK4 Ergonomics and Human Factors; AK5 Industrial Engineering and Management; AK6 Industrial Optimization; AK7 Innovation and Entrepreneurship (*); AK8 Maintenance; AK9 Marketing; AK10 Product Design; AK11 Production Management; AK12 Project Management; AK13 Quality; AK14 Research Methods (*); AK15 Sociology and Law (*); AK16 Supply Chain Management; AK17 Sustainability (*); AK18 Systems Design (*); AK19 Other (*). Two broad categories deserve a special explanation: (i) "Industrial Engineering" implies an interdisciplinary approach, in which several elements of IE, from distinct areas, are included in the same context; usually this category should be used for classification of interdisciplinary projects, dissertations, internships and other similar curricular approaches, and, (ii) "Other" refers to other areas that can be identified in the courses but are not commonly included in IE programs. An example could be a course of "English for Industry".

Regarding to the competences identified from learning outcomes, a framework of competences for Industrial Engineering was considered based on Mesquita, Lima, Flores, Marinho-Araujo, and Rabelo (2015). The framework includes a total of 8 technical competences (TC) and a total of 11 transversal competences (TRC). The technical competences, also known as core competences (Yorke, 2004) or subject specific competences, are related to a specific area of knowledge (expertise). The transversal competences, also known as transferable (Yorke, 2004), general (Mertens, 1996), generic or soft skills (Ramesh, 2010), are relevant in several areas of knowledge and professional activity. The list follows: TC1 - Production systems analysis and diagnosis; TC2 - Production systems design / Production planning and control processes design; TC3 - Planning production and project processes; TC4 - Monitoring and controlling processes and production system performance; TC5 - Developing projects, implementing systems, applying methods and procedures; TC6 - Evaluating production systems and processes; TC7 - Describing, comparing and selecting technologies, methods and paradigms; TC8 - Articulating knowledge objects from various areas; TRC1 - Communication competences; TRC2 - Ability to deal with the unexpected / working in environments of uncertainty; TRC3 - Teamwork competences; TRC4 - Ability to solve problems; TRC5 - Leadership competences; TRC6 - Innovation / Creativity; TRC7 - Planning and organization competences; TRC8 - Professional ethic; TRC9 - Ability to making decisions; TRC10 - Foreign languages knowledge; TRC11 - Entrepreneurship;

2.2 Data collection summary

Table summarizes the data gathered from 14 programs of Industrial Engineering, or related, that were selected from European countries. Five of these programs (from 2 countries) do not define LO for each course and for that reason they were not considered in the analysis of competences / learning outcomes. Two programs from Poland were analysed: CUT - Częstochowa University of Technology and AGH - University of Science and Technology. The results from the Portuguese context includes 5 programs, in which 3 are from University of Minho (UMinho_IEM; UMinho_IE; UMinho_ES), 1 from University of Porto (UPorto_IEM) and other from University of Aveiro (UAveiro_IEM). Three of the programs are from UPB - University Politehnica of Bucharest and another from UGhAIasi – "Gheorghe Asachi" Technical University of Iasi. Finally, other programs from EU countries were also considered in the analysis, particularly from IPG - Institut Polytechnique de Grenoble – INP; UG - University of Greenwich; and UPM - Technical University of Madrid.

Table 1. Summary of the European IE programs' curricula analysed

Country - University	Programs	Programs with areas of knowledge	Programs with courses' LO
Portugal – UMinho	3	3	3
Portugal – UPorto	1	1	1
Portugal – UAveiro	1	1	1
Poland – CUT	1	1	1
Poland – AGH	1	1	1
France – IPG	1	1	1
Romania – UPB	3	3	-
Romania – UGhAlasi	1	1	-
Madrid – UPM	1	1	-
UK – UG	1	1	1
	14	**14**	**9**

2.3 Higher Education in Europe - a contextualised brief perspective

For a better understanding about the curriculum analysis, a short overview of European Higher Education contexts must be addressed, specifically regarding to master curriculum principles, structure and organization. The European Higher Education system usually follows the principles of the Bologna Process (Bologna_Declaration_CRE, 1999), focusing on:

- Three cycle system, composed of bachelor (3 years or 4 years), master (2 years or one and half year) and doctorate (3/4 years);
- A standard *European Credit Transfer and Accumulation System* (ECTS), which contribute to enhance the recognition of qualifications and periods of study;
- Strengthened quality assurance, in order to provide students with the knowledge, skills and core transferable competences they need to succeed after graduation.

Different European countries have different approaches to these principles, and a brief analysis of three countries with different approaches will be presented: Poland, Portugal and Romania. Poland has a higher education structure for engineering programs of 3.5 years bachelor (Engineer at Poland) followed by a 1.5 year master of 90 ECTS. Romania has a 4-year bachelor followed by 2 years of master (4+2 model), 240 + 120 ECTS. Finally, Portugal has a structure of 3 years of bachelor (180 CTS) followed by 2 years of master (120 ECTS), i.e. a model of 3+2. It is important to refer the organization of the master programs regarding to ECTS, course units, typology and hours. The general principles are:

- The total estimated workload of a full-time student is 42 hours/week;
- It is expected that the students will have no more than 20 hours of classes in contact with teachers, being the remaining time dedicated to autonomous study work;
- One academic year has 40 weeks and 1 semester has 20 weeks, including 2 to 4 weeks for assessment;
- 1 ECTS credit is worth 28 hours of student workload;
- Each course unit has the total student estimated workload clearly identified and the breakdown is also provided according to the different categorisations. As an example, at University of Minho the following is applied: **T:** Theoretical Lectures; **TP:** Theoretical-practical Lectures; **PL:** Laboratory Classes; **TC:** Supervised Field Work; **S:** Seminars; **OT:** Tutorials; **E:** Placements; **TO:** Guidance Works; **O:** Other Works; **TI:** Independent Work and Assessment.

In the 3+2 model, the master programs have 120 ECTS, usually, during 2 years, i.e. 4 semesters. In some countries, master programs of 1.5 year and 90 ECTS are also accepted, as in the case of Poland. Each semester can have a different number of courses with different number of ECTS, summing up 30 ECTS per semester. As an example, in the specific case of the Master years of the Industrial Engineering and Management Integrated Master (IEM-IM) of University of Minho, each semester is made up of 6 courses with 5 ECTS. The dissertation course is developed approximately during one and a half semester, at the end of second year, and corresponds to 40 ECTS.

3 Analysis of areas of knowledge

This section presents the results related to the analysis of the areas of knowledge (AK). The course title / name / description was crucial to help the research team to identify the AK. The weight of the AK was defined based on: each course individually corresponds to 1 point and the classification focuses on the main AK that the course involves. In some cases, a maximum of 2 AK might be considered. For example, "Supply Chain Optimization" is one course of one of the UMinho programs and was classified with a weight of 0.5 as Industrial Optimization (AK6) and a weight of 0.5 as Supply Chain Management (AK16). Industrial Engineering and Management (AK5) covers several elements of IE representing a significant weight in all programs. Therefore, interdisciplinary projects, dissertations, internships and similar approaches were included here. Under this classification, a sum of the values was computed for each AK of each program, as well as the percentage of each area in each program. The results are provided in Table 2. The first and second columns represent the AK and its code, the next 14 columns refer to the European programs analysed, and, the last 2 columns present the mean and the standard deviation.

Table 2. Areas of knowledge from selected European master programs

Area of Knowledge	AK CODE	AGH_ MPE	CUT_ MPE	UA_ IEM	UM_ IEM	UM_ IE	UM_ ES	UP_ IEM	UGhA Iasi	UPB_ DIPI	UPB_ IE	UPB_ IPFP	IPG	UG	UPM	Mean	STDV
Automation	AK1	0.00	0.00	0.05	0.04	0.00	0.00	0.00	0.07	0.11	0.13	0.10	0.00	0.00	0.13	0.04	0.05
Comp. and Inf. Systems	AK2	0.06	0.09	0.17	0.08	0.07	0.09	0.06	0.03	0.00	0.00	0.03	0.07	0.00	0.04	0.06	0.04
Economics Engineering	AK3	0.06	0.04	0.00	0.00	0.07	0.06	0.06	0.03	0.03	0.00	0.03	0.10	0.20	0.04	0.05	0.05
Ergonomics and Human Factors	AK4	0.01	0.04	0.00	0.05	0.07	0.00	0.00	0.02	0.06	0.00	0.00	0.00	0.00	0.09	0.02	0.03
IEM	AK5	0.04	0.13	0.05	0.15	0.13	0.19	0.13	0.13	0.12	0.25	0.15	0.03	0.21	0.02	0.12	0.07
Industrial Optimization	AK6	0.04	0.09	0.07	0.08	0.11	0.14	0.19	0.05	0.00	0.06	0.00	0.12	0.00	0.00	0.07	0.06
Innovation and Entrepren.	AK7	0.04	0.08	0.16	0.00	0.00	0.02	0.04	0.06	0.06	0.09	0.03	0.03	0.04	0.03	0.05	0.04
Maintenance	AK8	0.00	0.00	0.00	0.05	0.00	0.00	0.06	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02
Marketing	AK9	0.02	0.00	0.05	0.00	0.00	0.04	0.06	0.00	0.00	0.06	0.03	0.01	0.02	0.00	0.02	0.02
Product Design	AK10	0.08	0.04	0.05	0.04	0.05	0.00	0.03	0.03	0.30	0.06	0.18	0.11	0.00	0.12	0.08	0.08
Production Management	AK11	0.24	0.17	0.00	0.25	0.20	0.11	0.06	0.06	0.08	0.06	0.10	0.10	0.11	0.00	0.11	0.08
Project Management	AK12	0.04	0.04	0.00	0.05	0.00	0.00	0.00	0.03	0.00	0.00	0.03	0.00	0.07	0.08	0.02	0.03
Quality	AK13	0.00	0.04	0.05	0.10	0.07	0.00	0.04	0.03	0.00	0.00	0.05	0.03	0.07	0.00	0.03	0.03
Research Methods	AK14	0.04	0.04	0.00	0.05	0.07	0.06	0.05	0.06	0.12	0.19	0.15	0.03	0.07	0.00	0.07	0.05
Sociology and Law	AK15	0.16	0.05	0.00	0.05	0.00	0.00	0.06	0.13	0.00	0.03	0.00	0.01	0.03	0.00	0.04	0.05
Supply Chain Management	AK16	0.00	0.00	0.05	0.03	0.07	0.25	0.06	0.00	0.00	0.00	0.00	0.07	0.11	0.03	0.05	0.07
Sustainability	AK17	0.00	0.04	0.15	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.03	0.03	0.05
Systems Design	AK18	0.08	0.09	0.15	0.00	0.04	0.03	0.06	0.15	0.06	0.06	0.03	0.15	0.07	0.34	0.09	0.08
Other	AK19	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.06	0.00	0.10	0.03	0.00	0.04	0.03	0.04

For the Polish case, a specific AK emerge from the results in both programs - Production Management (AK11), with a weight of 17% at CUT and 24% at AGH. Furthermore, at the AGH program, it is also possible to see that Sociology and Law (AK15) related courses have an important role in the curricula (16%), as well as the AK19 "Others", which, in this particular case, are related to "Foreign language (A1 English)" and "Foreign language (B1 English)". The same relevance of Production Management (AK11), previously noticed in the Polish context, can also be found in two Portuguese programs at University of Minho, namely UMinho_IEM (25%) and UMinho_IE (20%). The other UMinho program (UMinho_ES) shows a strong emphasis on Supply Chain Management (AK16) (25%) and Industrial Optimization (AK6) (14%). A similar weight for this AK6 is found in

UPorto_IEM (19%). In the case of the UAveiro_IEM master program, four AK emerge as equally relevant: Computer and Information Systems (AK2) (17%), Innovation and Entrepreneurship (AK7) (16%), Sustainability (AK17) (15%) and Systems Design (AK18) (15%). These results might suggest that a different perspective was adopted in shaping the curricula of this program.

For Romania, one can see that Research Methods (AK14) plays an important role for all programs at UPB (UPB_IE, UPB_DIPI and UPB_IPFP) with a weight of, at least, 12%. This result can be explained by the fact that the courses included in this AK14 are, mainly, related to the final dissertation. In spite of this result, some differences can also be found among these three programs regarding AK. For example, 13% of the UPB_IE curricula focuses on Automation whereas Product Design (AK10) has an important weight in the other two programs (UPB_DIPI 30% and UPB_IPFP 18%). Moreover, both these programs offer courses in Foreign Languages (English and French) that were included in AK19 (Other). Regarding the other Romanian university master program analysed (UGhAIasi), AK18 (Systems Design), AK15 (Sociology and Law) and AK19 (Other) emerge as the most relevant in the curricula, with percentages of 15%, 13%, and 9%, respectively.

A strong focus on AK18 (Systems Design) is also found for IPG (15%) and, particularly, for UPM (34%) master programs. AK10 (Product Design) has a similar weight in both these two programs (11% and 12% for IPG and UPM, respectively). From the analysis of IPG program, one can see that AK6 (Industrial Optimization) (12%) and AK17 (Sustainability) (11%) are also significant AK. As for the case of the UG program, and differently from all the previous programs analysed, AK3 (Economics Engineering) emerges as the most relevant, with a weight of 20%. AK11 (Production Management) and AK16 (Supply Chain Management) are also important having a weight of 11% each.

The last two columns of Table 2 show the mean and standard deviation of the relative weight of each AK for the 14 master's programs analysed. As would be expected from the outset, AK5 (IEM) is the one that represents, on average, the largest relative weight (12%). The second AK that stands out is AK11 (Production Management), with a weight of 11%. Next, the AK of Systems Design (9%), Product Design (8%), Industrial Optimization and Research Methods (7%) and Computing and Information Systems (6%) arise. At the same time, these results also confirm the diversity that encompasses the Industrial Engineering field of study when looking at the values for the standard deviation. This is particularly evident for AK: Automation, Ergonomics and Human Factors, Maintenance, Project Management, Sociology and Law, Supply Chain Management, Sustainability and Other. Therefore, the curricula might vary significantly among different Industrial Engineering master programs, although some AK are a core part of most of the programs analysed.

4 Analysis of learning outcomes

The results related to the development of competences in Industrial Engineering (IE) programs are associated to the learning outcomes (LO) each course aims developing in the students. As explained in the methodology of the study (section 2.1), the learning outcomes of each course have been qualitatively classified based on the predefined framework of technical (TC) and transversal competences (TRC).

As each course usually refer 3 to 6 LO, the classifications of competences are weighted in relation to the number of LO in each course. Thus, for each course, the sum of weights of competences will be up to 1.0. The project participants collected the learning outcomes of IE courses and related programs, mainly in their own universities. Other universities were added to the study in order to create a larger database for analysis. The universities and programs involved were already mentioned in the study about areas of knowledge (section 2.2). Nevertheless, one important issue, that would influence the main recommendations for curriculum design, should be mentioned: several universities, both from Europe and Thailand, do not need to define learning outcomes for their courses. Usually, they define general program objectives, and for the courses, they add some descriptions, topics and objectives, but not a comprehensive set of learning outcomes.

Following the same structure that was used for the areas of knowledge analysis (section 3), the LO analysis was organized in two different sections. The first focuses on Thailand context and the second part focuses on the European context. For the Thai part, only 1 program presented a comprehensive list of learning outcomes useful for the analysis: the AIT program. Regarding the European part, it was possible to collect and analyse information about courses' learning outcomes of 9 programs.

Considering the European project participants, Poland and Portugal define LO for all courses but Romania does not. This is similar to the three additional programs used for the areas of knowledge analysis, from France, UK and Spain; the first two programs define LO for all courses and the third one does not. In summary, this study includes the analysis of 9 IE, or related, master programs learning outcomes.

The integrated perspective of all selected European programs is presented in Table 3 and Figure 2. This perspective shows already identified patterns in the analysis by country. The first pattern is related to a much greater emphasis in technical competences when compared with transversal competences. The second pattern is related to the emphasis in the definition of expected technical competences of graduates: TC7, TC5, TC2 and TC1, respectively, from knowledge acquisition and its application to design and analysis of systems, products and processes. Finally, it cannot be referred as a pattern, but the most common reference to transversal competences is made to the communication competence.

Table 3. Learning outcomes results – overall perspective of selected European programs

CODE	DESCRIPTION	AVERAGE	STDV
TC1	Production systems analysis and diagnosis	0.05	0.03
TC2	Production systems design / Production planning and control processes design	0.14	0.06
TC3	Planning production and project processes	0.02	0.02
TC4	Monitoring and controlling processes and production system performance	0.01	0.01
TC5	Developing projects, implementing systems, applying methods and procedures	0.24	0.07
TC6	Evaluating production systems and processes	0.02	0.01
TC7	Describing, comparing and selecting technologies, methods and paradigms	0.40	0.11
TC8	Articulating knowledge objects from various areas	0.02	0.02
TRC1	Communication competences	0.04	0.03
TRC2	Ability to deal with the unexpected / Working in environments of uncertainty	0.00	0.00
TRC3	Teamwork competences	0.01	0.01
TRC4	Ability to solve problems	0.01	0.01
TRC5	Leadership competences	0.01	0.02
TRC6	Innovation / Creativity	0.00	0.00
TRC7	Planning and organization competences	0.00	0.00
TRC8	Professional ethic	0.01	0.02
TRC9	Ability to making decisions	0.00	0.00
TRC10	Foreign languages knowledge	0.02	0.04
TRC11	Entrepreneurship	0.00	0.00

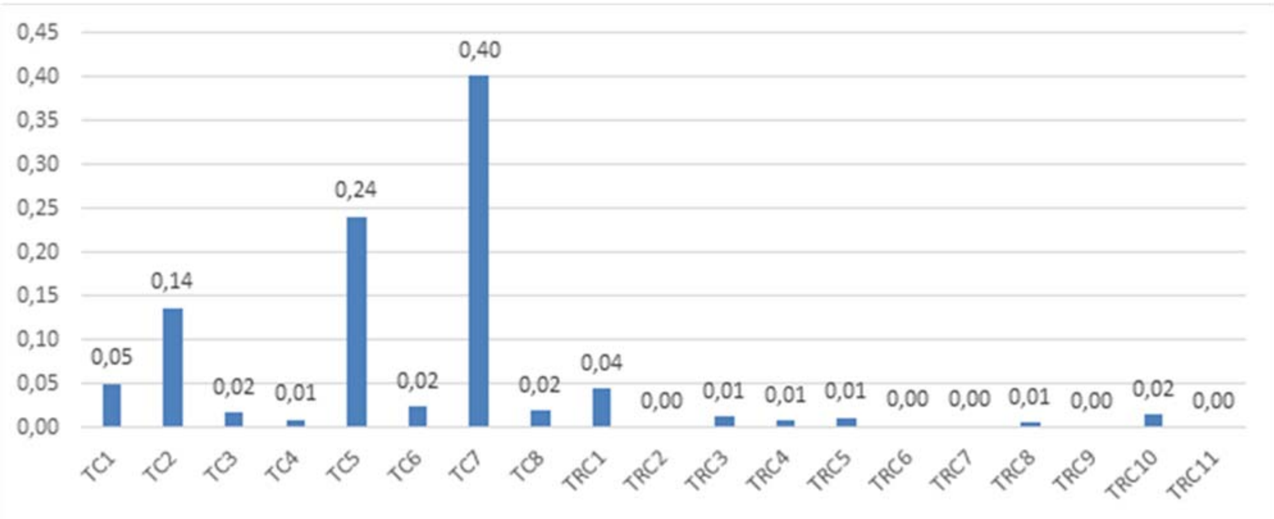

Figure 2. Learning outcomes graph – overall perspective of selected European programs

5 Discussion

The report developed in this part of the project had the intention to present an overall perspective of IE curricula without focusing in any specific trend, area of knowledge or competence. For that reason, the data collection intended to cover a large set of different programs and the analysis was made with a broad framework for the Industrial Engineering area.

The contextual background of master curricula allowed to identify some main master structures for Europe and Thailand. In Thailand, master programs have a duration of 2 years after 4 year-bachelor programs. The program can have between 6 and 8 courses (9 for AIT), ranging from 18 to 24 hours of course work (26 for AIT). The thesis work will vary from 12 to 22 credits, with a duration of 2 or 3 semesters. In Portugal and Romania, the master courses have 120 ECTS (European credit transfer system) in 2 years, after a 3 year-bachelor in Portugal and a 4-year bachelor in Romania. In Poland, the master courses have 90 ECTS in 1.5 years, after a 3.5 year-bachelor. In all cases, the thesis work will be developed during 1 or 2 semesters.

A comprehensive analysis of selected Industrial Engineering and related master degrees curricula was made. This analysis was based on the formal curriculum, using information collected from documents, and allowed to create a perspective on the main areas of knowledge developed in each program and the main types of competences that graduates are expected to develop during their degrees.

Considering the multiple structure models, it seems wise to create a solution that will fit on Thailand formal requirements, trying to approach, as much as possible, to the European models and methods of credit measurement. Thus, it seems that a two-year master proposal would be a best-fit model. This model could have 4 semesters with 4 to 5 courses per semester in the first year.

Recommendation 1: The structure of the master program should have 2 years with 4 semesters, made up of a flexible solution of 4 to 5 courses per semester during the first year.

The analysis of areas of knowledge of the selected programs has an explicit result: the high level of diversity of areas identified in the Industrial Engineering master programs. This is coherent to the overall definition of the area and its multiple professional types of activities. Additionally, it was clear that most of the Thai master programs have a strong emphasis in optimization, and European programs have higher focus on production management and production systems design. Nevertheless, all selected programs from Thailand and European countries have a common emphasis in activities oriented to thesis work.

It seems wise to create a flexible solution made up of a set of courses, with both elective and compulsory courses, that could lead to different profiles. This flexibility would allow for regional and / or personal customization of the profiles. Additionally, the operational level of the curriculum can be implemented in such ways and methodologies that allow different in-depth developments in the areas of knowledge. As an example, Problem and Project-Based Learning (PBL) courses can make the curriculum more flexible, because PBL allows for different learning paths.

Recommendation 2: Create flexible solutions for developing different areas of knowledge in order to have customized solutions related to the personal, regional or future unforeseen requirements.

Regarding the analysis of competences, the first important result is that not every programs define learning outcomes (LO) for each of their courses. Considering that competences are an important factor for the definition of a graduate's profile and also that this is a strong emphasis for the European Higher Education system, it is recommended that this project defines LO for each course. The number of LO should allow a clear identification of the "DNA" of a course and, additionally, should help the student to understand what is expected from him / her and, somehow, how he / she will be assessed. There is not a magical number, but usually a number between 4 and 8 LO can be found in the course descriptions of the European countries.

Recommendation 3: Definition of 4 to 8 learning outcomes for each course.

Technical competences are the core competences of a professional activity, and they represent what makes a person identifiable as being able to execute activities from specific professions. Thus, it is normal that courses implementation give a strong emphasis to the definition of these type of competences. Nevertheless, in the last decades, a stronger emphasis is being put on the need to develop professionals able to perform with higher efficiency and efficacy right from the beginning of their professional activity. Due to this, the European Higher Education system has been stressing the importance of defining the expected transversal competences that graduates should develop in their degrees. Thus, the following recommendation is that this project give due importance to the development of transversal competences, which are required by the professional activities. The development of competences need the implementation of specific educational strategies to be effective, and this should be considered in the curriculum development.

Recommendation 4: Explicit definition of learning outcomes for transversal competences. Additionally, explicit consideration of teaching and learning methods for the development of transversal competences.

This report was based on the formal level of curriculum, which is the most visible part of the programs. Nevertheless, one should be aware that the development of competences is mainly related to operational level of curriculum, including the way it is implemented by the teacher in the classroom, and the way it is experienced by the students. This awareness reveals a fifth recommendation: it is essential to align the formal and the operational level of the curricula in order to approach, as much as possible, the desired ideal curriculum.

Recommendation 5: Explicit and clear alignment of the elements of the curriculum, and explicit linkage between the operational, the formal and the ideal levels of the curriculum is a key factor for effective development of competences.

This report provides helpful inputs for the construction of the perspective about the current state of learning and teaching methods and for developing some recommendations based on partner's existing best practices and state of the art best practices. This can then be compared with the industry and students identified needs for Industry 4.0, as a starting point to identify gaps, which should be addressed in the identification of competitive factors and final recommendations for curriculum development.

6 Acknowledgements

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Engaging Engineering Students – a Success History

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Abstract

Active Learning (AL) applied to engineering is a very new experience in Latin America. Despite all discussions and professors engagement throughout the last 10 years, the raw truth is that there is still a long and difficult path for us to reach an adequate way to use AL in complex environment, such as an engineering school. The mix of old ways, resistance and disbelieve of many of our professors do not make it easier. This paper reports a successful experience made at São Judas University (USJ) by a Professor of Mechanical Engineering that transformed a discipline considered boring and useless in the most disputed one, due to the use of Computer Aided Engineering (CAE) Simulation Technology to allow the students to "be a real engineer", "solve real problems" and "investigate real world options". This experience, started in 2015, was a real game change and, in the last 2 years, is allowing students to even attack and solve some real problems that afflict the community around the university, as a hospital nearby. Finally, this paper also aims to show the process developed, the needed resources and the evolution of the number of interested students and the natural change of approach, evolving from one physics-traditional mechanical problem solution to even Multiphysics-bio-fluid-mechanical problem solution.

Keywords: Active Learning; Engineering Education; Student Engagement

1 Introduction

Many academic institutions have been trying hard to modernize the engineering teaching. It is clear to these institutions that one needs a different engineering professional in the future years. Nevertheless, the key aspect of this movement is to keep the engineering students interested in this future and connected with all these needs. Actually, not only he needs to be connected but also the new engineer student needs to understand and embrace this future. This new engineer needs to be engaged and challenged.

Computer Aided Engineering (CAE) technology, from now on just referred as CAE, is showing itself as a strategic partner to this end. And this is due to three main issues: it makes easy to give a taste of real engineering for the students; it allows and incentives cooperative work in areas like young engineering competitions; it makes it feasible the use of the Virtual Laboratory Concept in educational activities. CAE itself is a big attractive for new engineers, since the industry is using it vastly in its R&D efforts. Moreover, physical labs are much more expensive, and sometimes prohibitive, to be offered as part of several engineering disciplines.

In this paper, one aims to show a success case that is taking place in Mechanical Engineering Department of São Judas University (USJ), São Paulo, Brazil. This University, which belongs to ANIMA group, is developing an interesting and successful experience to improve and modernize engineering teaching throughout the last 5 years.

2 Defined Methodology

One cannot start a plan of changing engineering education based on one's willing. It is very important to have a defined plan.

The strategy used on this successful case was as presented in Figure . Basically, it has become clear that only with the combination of these four factors one will succeed in implementing this engaging program.

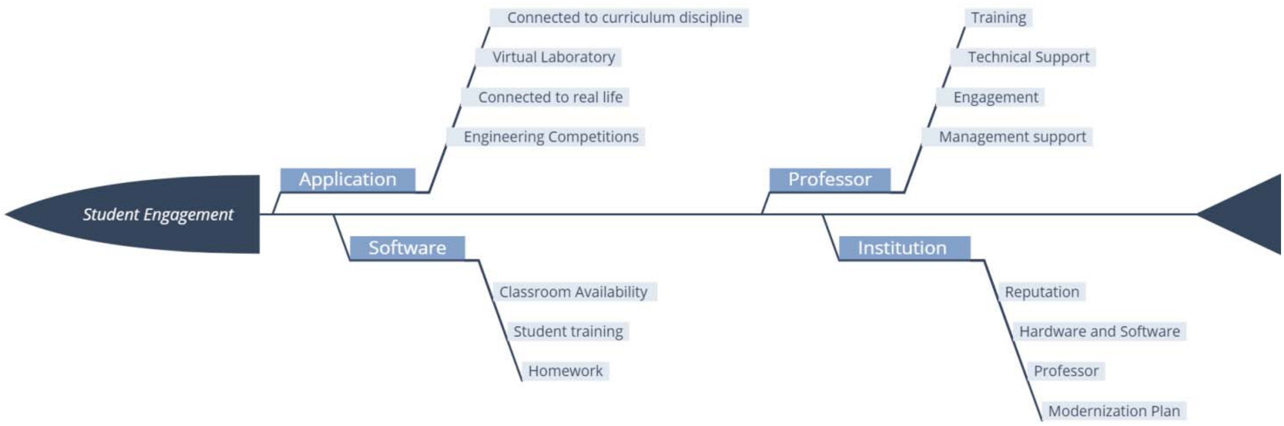

Figure 1. Pre-requisites to change Engineering Education and Engage Students

First of all, the institution must understand the necessity of changing engineering education, so that it can make all necessary efforts to provide adequate installations and to find the right professor, someone capable of technically leading the program. The University may find it internally or externally, but it will need this technical leader. Then the teaching staff must also be convinced that these changes are essential or the staff will undermine the program. This alignment may be achieved by the technical support of the software provider, including trainings and help to produce the first cases of each professor's Virtual Laboratory.

The other two factors are external: one must need a software provider that has to be a real partner, helping the teachers to achieve capability and to develop usability of the CAE software and, mainly, supporting the technical leader to develop the experience in its initial steps. This factor will guarantee that students and professors know the software and its capabilities as a Virtual Laboratory builder. However, the bonding aspect of the plan will be at the last one of these pre-requisites: find a way to connect engineering education and the world. One is facing a very interesting new generation, to whom the connection with the real world is essential.

The results of the implementation of such strategy were analyzed using, mainly, two tools: questionnaires and number of students registered in the disciplines where the methodology was applied, in special, the Final Project discipline.

2.1 The importance of Virtual Laboratory in the new engineer student engagement

A Virtual Laboratory based on CAE technology, is an essential and key aspect of the engaging effort. The Virtual Laboratory can be used to extend and concretize traditional book exercises, making the exercise topic "real" for the student and allowing the exploration of many possibilities of a simple problem. For instance, let's consider the traditional study of heat transfer in fins. Once the professor solves a traditional book problem, one can make the case virtual inside the simulation interface and explore the comparison between analytical and numerical solutions, or change the fin profile, or change the number of fins or change the material of the fins. One can even explore the very new concept of Digital Twin using this simple exercise. It should be stressed that these activities will be better addressed if the software partner makes it possible for the student to complete its study at home, using some kind of a Free Student License.

The main outcome of these activities, and the professors must be able to stress and explore these, is the development of a kind of "Engineering Feeling", a better understanding and knowledge of physics and, hence, the development of a better engineer understanding of the world, allowing them to develop a unique capacity of abstract and fast analysis, having been able to experiment a much larger series of engineering situations than any traditional physical laboratory would be able to do in a standalone way. It was very interesting to see these undergraduate students come up with ideas to solve engineering problems in their final projects or in their discipline works that would be expected only in a more experienced engineer.

In other words, the students start to feel and behave like real engineers, solving high level challenges. Nothing is more engaging than this feeling.

The main obstacle for using Virtual Laboratory is the necessity of having skilled professors able to use the CAE tool efficiently. Again, Figure is adequate to describe the importance of institutional and supplier supports in order to train a willing professor.

2.2 The importance real world cases for student engagement

Besides Virtual Laboratory application, engineering competitions, such as those found at Society of Automotive Engineers Brasil (SAE Brasil), typically AERODESIGN SAE Brasil, BAJA SAE Brasil, Formula SAE Brasil and others, consist in other excellent opportunity for the engineering students to deal with challenges like team work, leadership, real world problem and high technological tools, like CAE software. Therefore, engineering competitions are a strategical tool to engage students.

To understand a little bit the interest of engineering students in this kind of activity, in less than 5 years ESSS (Engineering Simulation and Scientific Software) sponsored competition team leaped from 10 teams to more than 80. Some of these teams are as complex as 40 people working in the equipment design, optimization, logistics, embedded software, documentation and field tests.

Any university that wants to have an adequate solution for future engineering education should pay attention to these kind of activities. In USJ, recognizing this true, the university is working hard to make it possible for their students to have access to competitions with adequate resources.

Finally, another great weapon to achieve student engagement may be found at the end of the graduation: the final project. This is historically the first opportunity that engineering students have to deal with a complete engineer project. All industries that have any P&D activity will have to use CAE software to save money and time-to-market in a new product development. Based on this, many universities already accept final projects done on simulation basis.

The one thing that connects all these engaging activities is that these students are always looking for the possibility of developing a real engineering work, solving real problems and, mainly, feel like an engineer. It is evolving to be more than just engineering education to become a complete experience.

3 USJ success case

São Judas University, from ANIMA Group, is being developing many student engaging activities since 2014. In that year the university detected that it was imperative to change the way engineer is taught if the university was to keep its tradition to deliver mechanical engineers loved by the industry. As Figure suggests, the first step was to align the new education plan with the director's targets. Once this alignment was made, investments in computers and software were necessary.

The ANSYS CAE Software Solution was chosen and a partnership was built with the software provider (ESSS/ANSYS) in order to guarantee that the activities of the lead professor could be supported.

Based on this software and hardware infrastructure, USJ professors started to use commercial software at the final project discipline. Aligned with the "new engineer profile", these professors started to suggest that their students should try to find real cases around the university to be studied. As there is a small public hospital nearby the university, the engineer students looked for cases there.

In Figure 2, Figure 3 and Figure 4 one may find the main information and results generated in the wheel chair case. It was a not so small problem at the hospital and this simple final project work enlighted the real problem.

Figure 2. Wheel chair real and virtual geometry.

Figure 3. Wheel chair lock geometry, real and virtual.

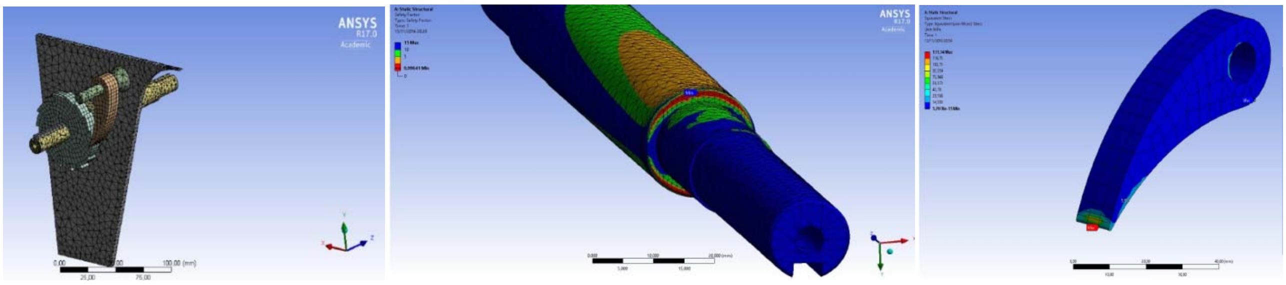

Figure 4. Results of the lock simulation. Axis is to fail, unlocking the wheel chair.

Another example is the case shown in Figure 5, an interesting study about an orthosis that was about to be bought by the hospital and the students helped the hospital to evaluate the equipment. It is important to stress that, once more, this simple study was very valuable to the "client" and created an interesting feeling among the student teams.

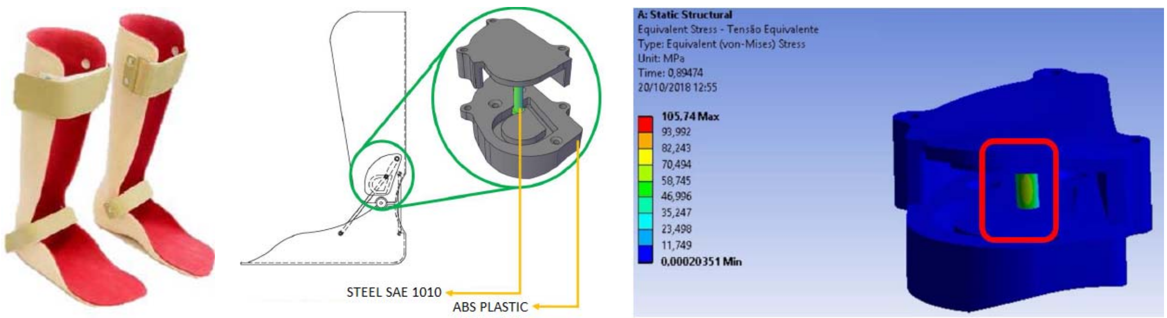

Figure 5. Orthosis simulation. Critical load for plantar flexion (foot down).

It is also very important to remember that these students belong to a generation that is very connected to social causes, sustainability and innovation. Professors must be connected to these trends and try to align the "real cases" with these values. If a professor succeeds in doing this, the student's commitment will be even stronger. In the case of USJ, the students were an important part of the observed growth of interest in this new engineering education, since they start to advertise and advocate favoring the changes.

The final projects impact in the nearby community has guaranteed the advanced students interest, and it is seen in Figure 6. One can observe a very big growth rate and that it is accelerating year after year. There was a growth of 45% between 2017 and 2018.

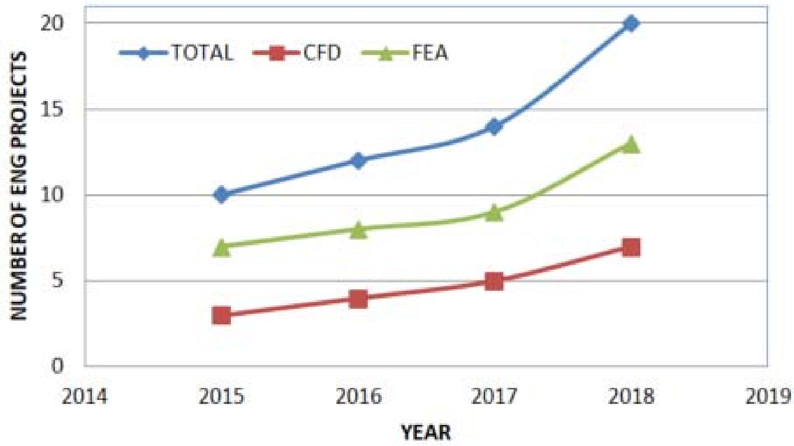

Figure 6. Impact of CAE use on Under Graduate Final Projects

Another interesting consequence of this work was that the attention of the beginners was also captured. They started asking for the implementation of the Virtual Laboratory in their disciplines. As can be seen in Siqueira, C.D.L.R., Fontes, C. E. (2018), the following classes are taught using ANSYS CAE technology:

- Turbo machinery (using Santos, S.L. (2007) as the main reference for theory classrooms)
- Vibrations and Applied Mechanical Topics (with the support of Filho, A.A., (2011) and Filho, A.A., (2012)
- Special topics in Mechanical Engineering (using Balachandran, B. (2011), Rao, S. S. (2008), Diesel, F.N. et. al. (2013) and Assan, A.E. (2003).

Professors started to offer a batch of carefully selected exercises, adequate to be used in the Virtual Laboratory program, capable to be solved and explored in the computer lab of the university or even at home, using the free ANSYS student license. Among the engineering themes included in these selected exercises, one should highlight these:

- Static linear analysis, Modal analysis and Thermal Steady State analysis
- Fluid-Structure interaction
- External flow (2D) over a NACA profile
- Fatigue analysis
- CHT – Conjugated Heat Transfer
- Vibration analysis
- CHLADNI Pattern (flat plate vibration);
- Spring-Mass System (with and without damping, 2 degrees of freedom…)
- Harmonic analysis of car engines parts

Every year more and more students are getting to the last year of study already capable in the use of the CAE Software, increasing the number of final projects using simulation. Of course this increases the program visibility and more students get interested, generating a virtuous cycle. For this year (2019), the disciplines involving CAE technology have more than 100 students subscribed, in an explosive growth.

4 USJ: next steps

Having tasted this success, USJ is planning its next steps:

- Hardware and software infrastructure to be enlarged
- Training of more professors
- Include Virtual Laboratory experience in all mechanical engineering disciplines
- Expand the CAE experience to other engineering disciplines
- Expand the CAE experience to become Multiphysics, including careers like medicine or odontology

During the last semester of 2018, one pilot Multiphysics discipline class was formed. Engineers and Medical Doctors and Physicists were attending and it was developed a series of small studies combining these knowledges. One may find some interesting images in Figure 7, which results were compared with those obtained from Fernandes, I. S.,(2016).demonstrating mechanical efforts being applied to a bone.

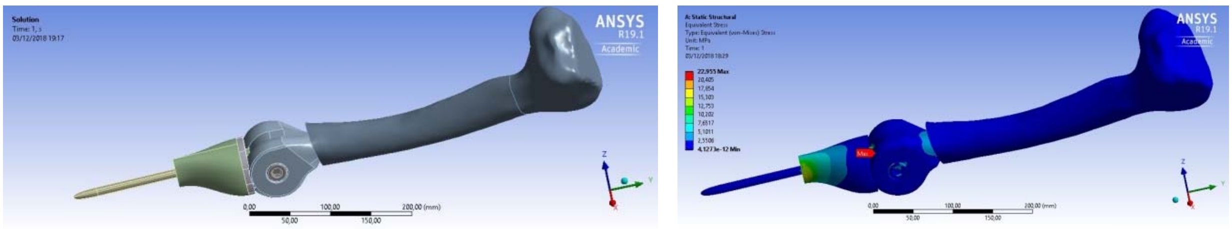

Figure 7. Geometry used and simulation results of one studied bio-engineering case (bone-connection)

The results were very encouraging and a specialization course in bio-engineering is being planned to be launched in 2019.

Finally, three new USJ campi will start using this methodology in 2019, using the ESSS and the original USJ campus support.

5 USJ: one special remark

During the last year, professors made an effort to identify the main engaging factor, what was the key for the growing interest the students are showing during their undergraduate studies.

It quickly became clear that there was not just one factor that has made things happen. One should remark some:

- University engagement, which generated an adequate environment (hardware, software, professors) to include more "real" engineering and real life challenges in the student's life
- Professors engagement, which led them to an interesting use of simulation technology, to the development of materials and opportunities that exposed their students to a more clear and concrete engineer, allowing them to better understand abstract mathematic concepts like tensions, stresses, pressure drop, electric or magnetic fields
- Software usability and training, making it easy for the professors and students to start its use fast and to deliver interesting works in less than a semester

But all professors agreed that the possibility of using real world challenges was decisive. The health care cases, in particular, raised enormous interest in the student community, not only for the technical challenge that this type of study comprises, but also for the social and community benefits that stem from these initiatives. All students cited this aspect as decisive in USJ's end-of-course questionnaires. If one wants to engage students, one should expose them to their creative and engineer-to-be side.

6 Conclusion

It was shown in this paper what are the key factors to use CAE technology as an anchor of engineering students. It was demonstrated how the patient and carefully implantation of a CAE base Engagement Program in USJ is producing very encouraging results based on the fact that the university is delivering more than just education, but a complete engineer formation experience. As a consequence, classes full of very willing engineer students are forming, more and more each year.

It was also shown that most of the success of this endeavor is due to the strategic professor's choice to look for real world themes in the neighborhood of the university, making the problem, and the solution, something very close and valued by the students.

USJ is now moving to the next steps of expansion of this methodology application aiming not only to grow the use of CAE technology in undergraduate engineering school, but also in multidisciplinary classes and even in the engineering specialization effort, extremely connected with R&D nowadays needs.

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A PBL Curriculum design for an Engineering Electronics program, from traditional to student-centered education

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Abstract

This document presents a PBL design for transforming a traditional curriculum of an Engineering Electronics program to a student-centered curriculum. The proposed PBL model considers as the main strategy the 'Rotation,' the name was given by researchers for referring to the action of transforming the traditional syllabus into the new syllabus structure. For the PBL proposal, researchers considered two years for education in Math and Sciences, and some courses related to the career (mandatory courses non-project work); two years for disciplinary courses, which are organized by projects, and one year for dealing specialized topics, professional work or graduate studies. Moreover, students take some courses relates to the philosophy of the University, context, and citizen education. The main change incorporated in the PBL syllabus is the organization and connection of the academic spaces and the new roles of actors. This 'rotation' goes beyond a change of order; this implies substantial changes in how the distribution of the workload for students and teachers is. Likewise, the new syllabus demands a different organization of topics, and the redesign of academic activities, all that at seeking to encourage self-management and meaningful learning. The new organization is based on the learning outcomes, which is different to the traditional program whose structure is based on contents.

Keywords: Active Learning; Engineering Education; Project Approaches.

1 Introduction

Currently, many researchers around the world examine the application and evaluation of Problem- and Project-based learning (PBL). In the engineering education, the curriculum design must consider both the curricular and organizational transformation of the institutions, some examples of these transformations are presented in studies like (De Graaff & Kolmos, 2007; Du, De Graaff, & Kolmos, 2009). In other cases, the curriculum design is oriented to a particular subject, such as computation (Indiramma, 2015), industrial electronics and electrical power (Hosseinzadeh & Hesamzadeh, 2012; Quesada et al., 2013), processing signals (Kiray, Demir, & Zhaparov, 2013; Kumar, Fernando, & Panicker, 2013; Pardo, 2014), and control (Fernández-Samacá, Ramírez, & Orozco-Gutiérrez, 2012; Fernandez-Samaca, Scarpetta, Rodriguez, & Mejia, 2017; Yuan & Shen, 2012). These examples present successful PBL models, which focus on a single course and offer good results in situations where organizational change is more difficult to achieve because this requires additional funding resources, new institutional policies or a longer period. Usually, these experiences are encouraged by teachers who want to have the advantages of a PBL education in their courses and whose courses are oriented to develop competencies in a professional area. The work presented here is a PBL design for transforming a traditional curriculum of an Engineering Electronics program to student-centered curriculum.

Project-based learning is a good alternative that meets the requirements of engineering education. As is stated in (Kolmos, De Graaff, & Du, 2009), deep learning approaches instead of superficial approaches are encouraged, which improves active learning, develops the critical skills in learners, improves self-directed learning capabilities, increases the consideration of interdisciplinary knowledge and skills, develops management, collaboration and communication skills, shapes a professional identity and responsibility, and develops and improves meaningful learning.

Currently, there are universities with institutional PBL models such as McMaster University, Republic Polytechnic Singapore and Aalborg University, in which their policies, facilities, teacher training programs, and syllabus have been designed by using a PBL philosophy. Otherwise, this paper deals with a PBL design for an Electronics

Engineering Program of a University conceived in a traditional model. Therefore, the proposed PBL model is developed as a pilot test, which seeks to encourage the use of PBL in other engineering programs.

The proposed PBL model considers as the main strategy the 'Rotation,' the name was given by researchers to refer the action to transform the traditional syllabus into the new syllabus structure, which takes into account the previous experience of the faculty staff. In Colombia, the bachelor considers five years (ten semesters) and the academic credit is 40 working hours. For the PBL proposal, researchers consider two years for education in Math and Sciences, and some courses related to the career (mandatory courses non-project work); two years for disciplinary courses, which are organized by projects, and one year for dealing specialized topics, professional work, and graduate studies. Moreover, students take some courses relates to the philosophy of University, context, and citizen education.

The main change incorporated in the PBL syllabus is the organization and connection of the academic spaces and the new roles of actors. For example, in the traditional program, there are three courses related to digital electronics, namely, Digital Electronics I, Digital Electronics II and Microprocessors. These courses are developed in 5th, 6th and 7th semester, respectively. In contrast, the PBL proposal would have a single semester dedicated to Digital Electronics; this means that students can be concentrated in all issues related to the subject. In other words, three courses in three different semesters turn to one semester. This 'rotation' goes beyond a change of order; this implies substantial changes in how the distribution of the workload for students and teachers is. Likewise, the new syllabus demands a different organization of topics, and the redesign of academic activities, all that at seeking to encourage self-management and meaningful learning. The new organization is based on the learning outcomes, which is different to the traditional program whose structure is based on contents.

This study proposes a PBL model that aims to answer a question related to the adoption of PBL in a specific program, How to design a PBL engineering program in a Traditional Education University? As a previous work with PBL, researchers answer a similar question for a PBL model for single courses, which considered the facilities and policies of the university and the culture and customs of the university context (Fernandez-Samacá, Ramirez, Franco, & Rodríguez, 2014), which took advantage of the support resources for traditional education.

This document is organized in five sections, in Section 1, authors describe the context, Section 2 presents the current traditional curriculum, Section 3 devotes to the proposed PBL design, Section 4 lists the main needs and resources for PBL application; finally, Section 5 concludes the paper.

2 Background -Traditional Model at UPTC

Usually, a traditional curriculum focuses on the contents, where each course has specific goals and the teacher stresses on to meet these; nevertheless, this approach does not give the suitable feedback to students, and neither keeps a constant assessment of the relationship among courses. Moreover, there is the possibility of not meeting the intended objectives for a disciplinary area (e.g. Digital Electronics), because students take classes from different areas in the same semester, and their performance make defining different routes from those considered in the curriculum. Thus, students can lose the sequence determined for a specific area.

The bachelor's curriculum in Colombia ranges between 160 and 175 credits and dedication on average of 48 hours per week for the student, and 40 hours for the teacher. The bachelor's curriculum in Colombia ranges between 160 and 175 credits and dedication on average of 16 credits per term and 48 hours per week for the student, and 40 hours for the teacher. With this consideration, the students besides to take courses from different disciplinary areas in the same semester, which some times do not have a close articulation, students must divide their time to understand other issues related to other courses that complete the syllabus. Therefore, They do not have enough time to comprehend appropriately the concepts and develop the skills of a disciplinary area. Then, although students could meet seemingly all the assignments the deepening learning is difficult in this structure. Moreover, another important aspect for analyzing, it is the effect of this structure on the dropout and repetition of the courses (Higuera-Martinez, 2017). But, What happens if students could concentrate all their attention in a disciplinary area?

Figure 1 shows the current electronic engineering curriculum at Universidad Pedagógica y Tecnológica de Colombia. In this instance, the traditional curriculum is structured by areas. An area is understood as the grouping of knowledge, practices or competencies differentiated according to degrees of specificity, affinity or complementarity about the profiles, objectives, and mission established by the academic programs, which are derived from a profession or discipline by the objectives and aims of higher education. At UPTC, for the preparation of the academic programs in the credit system, the intitutional areas are defined as follows:

2.1 General Area

This is understood as the integration of knowledge and practices that complement comprehensive, axiological and cultural training. Its purpose is to provide the necessary knowledge for the formation of subject and citizenship. This area should characterize the 'UPTC student.'

2.2 Interdisciplinary Area

This is defined as the knowledge, competencies and related and close practices that share several Academic Programs or according to the existing and possible affinities, among several professional profiles

2.3 Disciplinary and Deepening Area

This is understood as the knowledge, skills, and practices that determine the strict and specific profile of an Academic Program that defines a profession and responds to the fields of knowledge of the respective discipline, as well as the emphases that respond to the research lines of the respective program. In this area, there are six sub-areas, namely, Circuits and Signals, Analog Electronics, Digital Electronics, Telecommunications, Power Electronics, and Instrumentation and Control, as well as other basic subjects in the training of the electronic engineer.

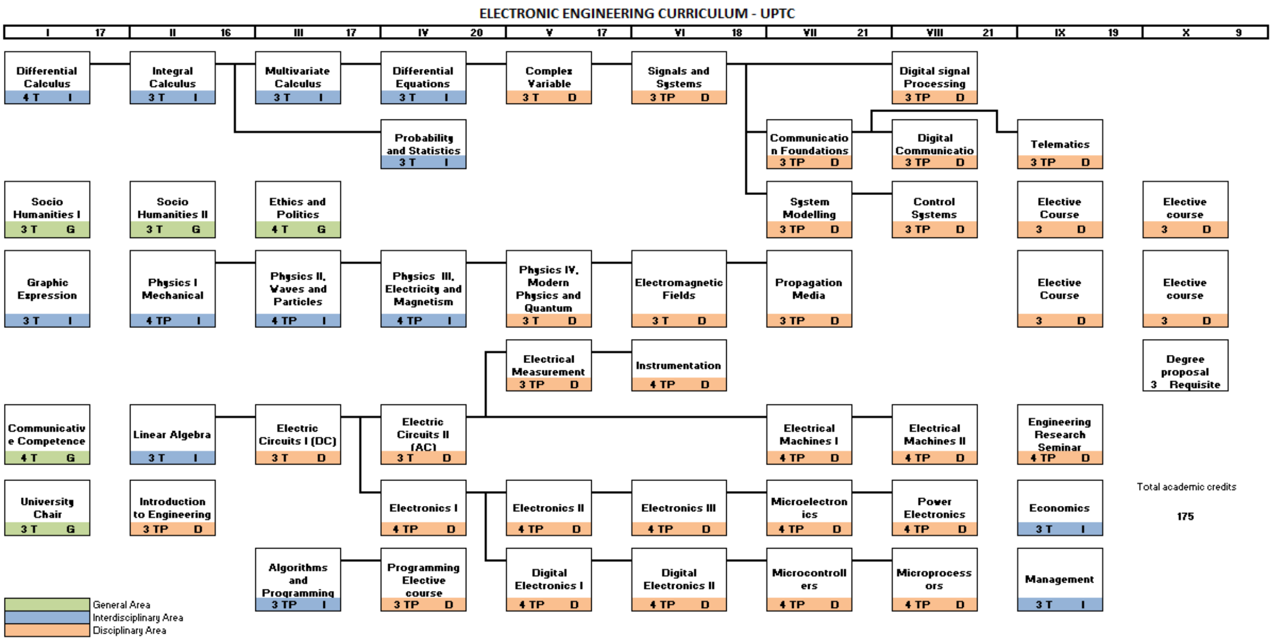


Figure 1. The current traditional curriculum of Electronic Engineering program

According to their specialty, teachers are grouped by institutional areas and disciplinary sub-areas, in which they work evaluating the content and proposing methodologies, changes and new didactic strategies. In Electronics Engineering, teachers have been using strategies and learning approaches for planning the curriculum such as: Project-based learning in courses (Fernandez-Samaca, Scarpetta, et al., 2017), inquiry-based learning (Silva-Garcia & Fernández-Samacá, 2011), learning based on research (Moreno-Rubio, Cely-Angarita, Rodríguez-Mora, & Angarita Malaver, 2014) and participating methodologies with communities (Fernandez-Samaca, Barrera, Mesa, & Perez-Holguin, 2017). These approaches have been applied to specific subjects, but not throughout the curriculum.

3 The Proposed PBL approach

In the proposed approach, the electronic engineering program is divided into two stages that group Foundation courses and Disciplinary subjects. The first one comprises courses related to Mathematics, Physics and Programming, and the second one, courses related to the core of the career like Analog Electronics, Digital Electronics, Signals and systems, Telecommunications, Instrumentation, and Control. Likewise, the approach involves courses of Human Science and considers English as a transversal competence, which is integrated into the curriculum.

The proposed transformation is focused on the graduate profile defined by Programme Educational Objectives and Learning Outcomes; then, each area defines, in turn, the competencies that the student will develop, and its contribution to the Profile –this task is known as 'Micro-design'–. Likewise, each disciplinary area establishes the necessary courses to develop the competencies, as well as the number of academic credits and the content, (See Figure 2).

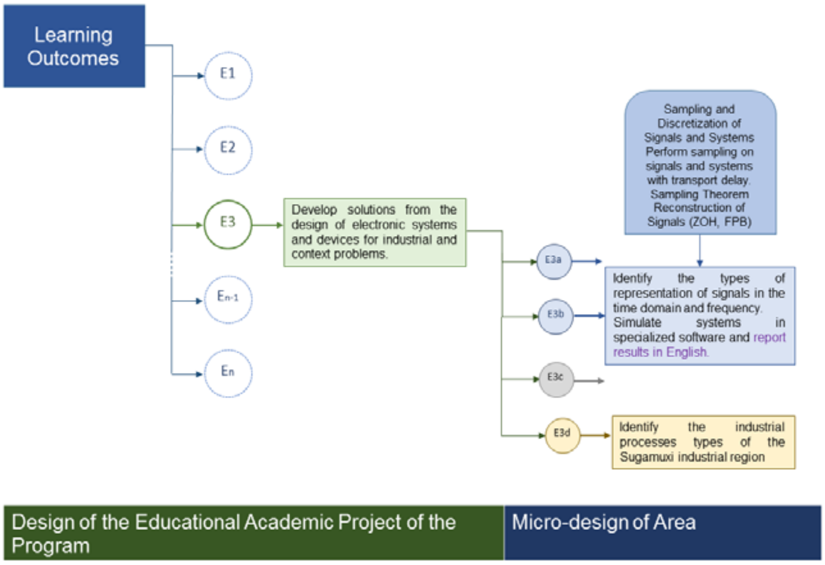


Figure 2. Example of the design of Competences and objectives for a disciplinary area.

3.1 From Traditional Education to Student-centered education, 'Rotation.'

The "Rotation" Proposal is a PBL design strategy applied to disciplinary areas. This strategy starts in the 5th semester and devotes to dedicate a semester to a specific disciplinary sub-area of the program (Specialized Semester).

In the stage of the foundation, the student study mathematics, physics and programming, to strengthen the mathematical thinking, modelling, computational thinking and understand the physical phenomena that underlie scientifically the engineering, understand engineering concepts through the identification of their relationships with basic sciences and comprehend the importance of basic research in the development of Engineering. Likewise, the curriculum considers from the first semester the disciplinary training, as an academic space that allows to students to observe how the selected engineering field works, motivate their study, strengthen the vocational decision and decrease the dropout rate.

3.1.1 Specialized semester

This means a single semester dedicated to a unique disciplinary area; therefore, students concentrate on all issues related to the subject. In other words, three courses in three different semesters 'rote' to one semester, (see Figure 3). Moreover, the project focus changes because it considers the whole area and not just a course as a PBL approach designed for single courses.

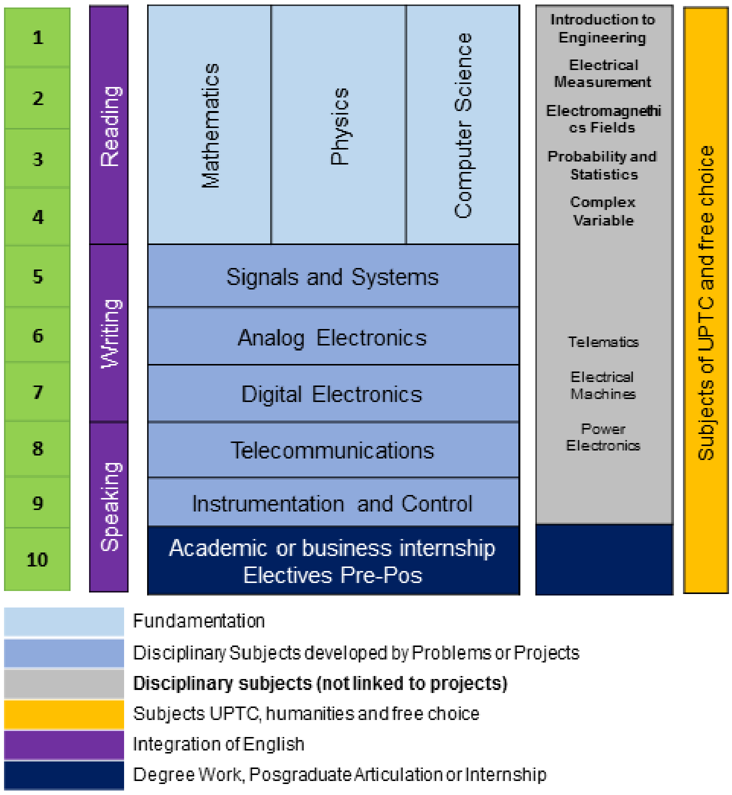


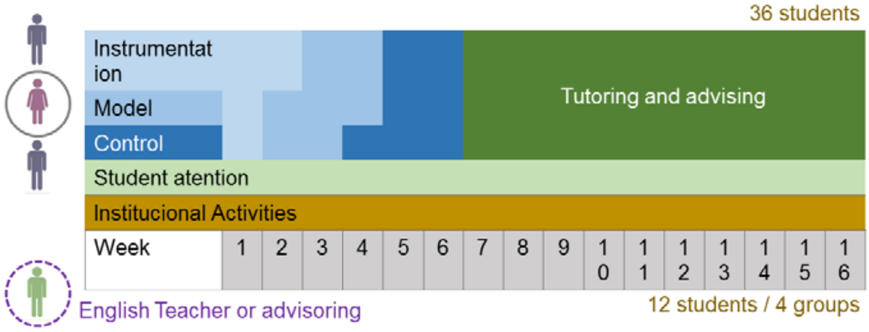
Figure 3. Proposed curriculum for the Electronic Engineering program

This ‘rotation’ goes beyond a change of order; this implies substantial changes in how the distribution of the workload for students and teachers is. Likewise, the new syllabus demands a different organization of topics, and the redesign of academic activities, all that at seeking to encourage self-management and meaningful learning. The new organization is based on the learning outcomes different from the traditional program whose structure is based on contents. The areas order was established according to the learning outcomes and the previous knowledge necessary for the achievement of the objectives of the area, for example, in this order, the use of telecommunications is potentialized in the industrial applications of instrumentation and control. Moreover, the learning of a second language, English for this case, is distributed as a transversal competence by three different levels, focusing on 'reading' during the first four semesters; on 'writing' the next three semesters, and on 'speaking' the last semesters. Thus, each specialized semester would have a Language teacher who will be an advisor to achieve the strengthening of the second language.

Furthermore, this proposal changes the way of work of both student and teacher. For example, the student takes a course of 10 credits (480 hours of student work) distributed into face-to-face and independently activities. In face to face experiences, students work with a teacher team on the theoretical conceptualization and development of skills, these experiences stresses on students are able to understand the topics related to the project (In each semester, a project will be carried out that contemplates the objectives of the area). The independently work is advised by a teacher team throughout the rest of the semester. See Figure 4a Likewise, the workload of the teachers also are concentrated in a more direct way about students' work, thus, the facilitation becomes a crucial issue in the PBL application.

3.2 Teacher workload

In this approach, each specialized semester will must be designed in order to achieve the learning outcomes defined by each disciplinary area. Attending to 'Exemplarity' principle of PBL, the semester must be managed by a teacher team instead of a single teacher (a common practice in a traditional curriculum) because, as it was mentioned in the Introduction, the PBL encourage the work with others. Figure 4b shows an example of the distribuition of teachers’ time, which includes activities related to PBL course, other non- project courses, research, and institutional activities. In the first six weeks, teachers have a greater dedication to teaching, planning, and follow-up PBL courses, but less dedication to research; in contrast, in the last weeks of the semester, they would have a greater research work and facilitation, and less dedication to tutoring.



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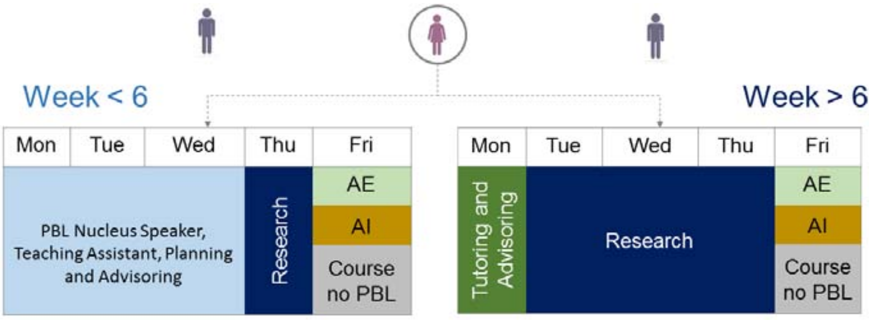


b)

Figure 4. a) Example of course distribution in a semester. b) Distribution of activities for the teachers

3.3 Student workload

Students also are grouped in teams for executing the projects. At UPTC, a semester has 16 weeks, which means that students will dedicate 48 work hours per week for developing academic activities. These activities include the PBL course and to practice a second language, as well as, take at least three credits of an institutional course (e.g., University Philosophy, arts, Social Human sciences, deports), and three credits extra of a non-project course such, as it is shown in Figure 5.

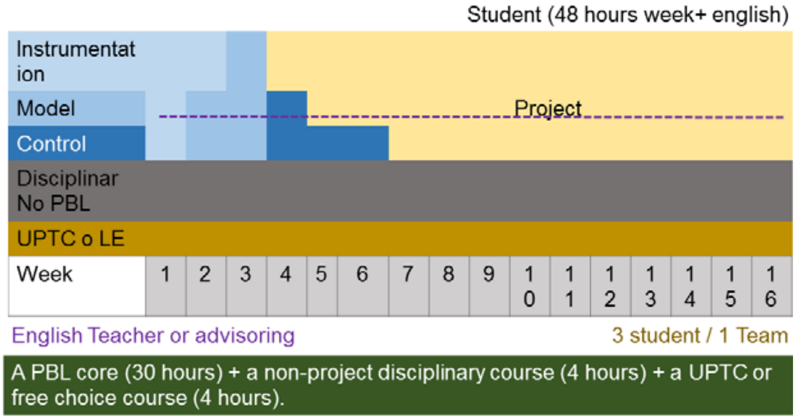
Similar to teachers workload, which changes while semester runs, students' workload considers more time for the independent work from the sixth week.

The proposed PBL design seeks, among others, improve the time management and self-management along to decision making of teachers and students, increasing the institutional capacities as learning outcomes and research results. The specialized semester creates a learning environment that promotes the research attitude of students and strengthens the scientific research because the projects developed each semester will face contextual challenge identified by the research groups.

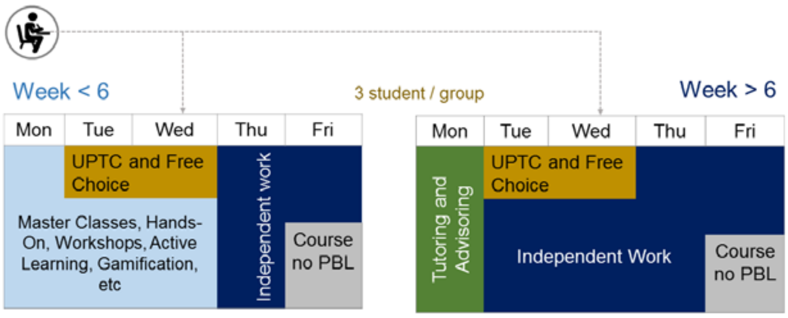
4 Implementation Requirement and challenges

For the implementation of this proposal should be considered two important aspects, the human resources and facilities.

In terms of human resources, especially the teaching and management staff, training and support is required for the design of the PBL program, and their development modules, as well as, assistance in the development of the activities related to the development of specialized semester. So far, the University has carried out teacher training on Active Learning and Engineering Curriculum Design; more than 100 teachers are participating in those. After these training, it is planned to carry out training in PBL, student-centered learning, among others. Likewise, it is important, to define strategies that allow harmonizing the traditional approach that would be kept in science courses with PBL courses of the disciplinary areas.



a)



b)

Figure 5. a) Student's time distribution per week. b) Distribution of activities by the different weeks for the Student..

Regarding facilities, University should consider new spaces that offer exclusive use for the development of PBL semesters; for example, specialized rooms, where students perform their project work. For the case described here, it is necessary four specialized rooms for each disciplinary area, namely Analog Electronics, Digital Electronics, Communications, and Control, three of which would be already available. Besides these rooms, it is necessary to have access to active learning classrooms, this requirement is already met since currently, the UPTC, Campus Sogamoso, has 18 active learning spaces thanks to an investment project support by the National Education Ministry of Colombia.

Taking into account that a progressive implementation of the new approach is required, researchers carry out pilot tests in areas as Control and Signal processing; to evaluate the effect of this PBL design on the performance of students and to observe how the university policies affect it, this to expand the PBL adoption to other engineering programs.

5 Conclusion

This paper summarizes a PBL design proposal for implementing this educational approach in the Electronics Engineering Program. The Approach uses a strategy called 'Rotation', which transforms the courses of disciplinary areas, of a Traditional curriculum, into a specialized semester of a PBL curriculum. This transformation implies changes in way the courses and subjects are deal, creating a learning scenario, in which the development of a project determines the workload for teachers and students during the semester. The PBL design takes as a basis the learning outcomes defined in the graduate profile emphasizes mainly on two PBL principles, the communication with others and exemplarity.

This work seeks to promote the use of student-centered approaches in engineering programs through an example focused on an experience that is being carried out at UPTC, Sogamoso, Colombia.

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Industrial Engineering and Management PBL implementation: an effortless experience?

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Abstract

The School of Engineering of the University of Minho offers 15 distinct engineering programs, being Industrial Engineering and Management (IEM) one of them. This program includes 45 compulsory courses over a 5-year timeframe period, from which 16 are directly involved in three Project-Based Learning (PBL) experiences, conducted in the first and fourth years. This study focuses on the PBL experience conducted in the first semester of the first year, which involves six courses. This is an interdisciplinary semester-wide project, which promotes active learning within teams of students. It is known that this approach challenges the students' perceptions and understandings on learning at higher education institutions, and promotes the development of soft and technical competences. On the side of the staff, the management of the PBL semester represents a challenge on its own, as it requires the coordination of a reasonable number of teams, lecturers, tutors, activities and deliverables, project rooms and other resources. A huge challenge relates to the monitoring of progress and inner dynamics of the teams themselves, supporting the teams, giving feedback on their work, assessing their reports, presentations, and prototypes, among others. This paper investigates the effort involved in planning and conducting an interdisciplinary PBL semester, namely by gathering perceptions and detailing the wider context and depths of the main activities. The findings are based on the results of questionnaires and on authors' PBL practical experience at the University of Minho.

Keywords: Industrial Engineering and Management Education; Active Learning; Project Approaches, PBL Effort.

1 Introduction

Effective teaching in Higher Education is neither a straightforward path nor follows a recipe. It could demand experience, taking risks, do not fear challenges and try alternatives that best facilitates students learning. According to Gibbs and Habeshaw (1992) there are some powerful ideas to take into account when choices need to be taken about teaching methods and conducting classes, namely: 1) Students construct knowledge; 2) Students need to see the whole picture; 3) Students are selectively negligent; 4) Students are driven by assessment; 5) Students often only memorise; 6) Students attention is limited; 7) Students can easily be overburdened; 8) Adults students learn differently; 9) Students learn well by doing; 10) Students learn well when they take responsibility for their learning and, finally, 11) Students have feelings.

Active learning methods are teaching methods that consider all these ideas, or at least some of them, emphasising the importance of student ownership and activation, by being student-centred approaches (European University Association, 2019). Student-centred approaches put students in the learning centre and teacher is seen as a coach or mentor, not an authority as in the traditional teaching methods (Zhang, Zimmerman, Mihelcic, & Vanasupa, 2008).

One example of such active learning methods is Project-Based Learning (PBL), based on seminal works of Dewey (1916) and Kilpatrick (1918, 1921), as referred by Knoll (1997). PBL have been extensively applied in universities such as Aalborg (Graaff & Kolmos, 2007; Kolmos & de Graaff, 2014), Twente (Powell & Weenk, 2003) and, more recently, Portugal (Alves et al., 2012; Alves, Moreira, Fernandes, Leão, & Sousa, 2017a; Alves & Leão, 2015; Fernandes, Mesquita, Flores, & Lima, 2014; Lima et al., 2017; Lima, Carvalho, Flores, & Van Hattum-Janssen, 2007), Brazil (Pereira & Barreto, 2016) and others (Guerra, Ulseth, & Kolmos, 2017). According to Harmer (2014), the key features of PBL models are: 1) learning by doing; 2) real world problems; 3) role of the tutor; 4) interdisciplinarity; 5) collaboration and group work; 6) existence of an end product.

Thus, some of these PBL key features match well some of the ideas to take into account, as referred above. Additionally, by putting students in the centre of their own learning, they construct their own knowledge, integrating STEM contents (Berry, Chalmers, & Chandra, 2012) and developing competences (technical and transversal) that prepare them to their professional future (Alves, Leão, Moreira, & Teixeira, 2018a; De Los Ríos-Carmenado, López, & García, 2015).

To achieve this, students pull what they need from teachers and other sources and, by doing this, they consolidate their knowledge and learn for life, not only for the exam day. Additionally, PBL is pointed out as an important active learning methodology that motivates students and avoid their drop out, mainly, in first year (Heywood, 2005). Nevertheless, this learning approach brings challenges for teachers who continually need to seek improvement while at the same time, adapting to a new position – the one of a facilitator. These challenges imply several aspects such as: to know the right balance between giving students what they ask or letting them search, to find time and resources for PBL, to build a close relationship with students and colleagues from other departments and schools, to adjust contents to projects, to rethink assessment methods and training among others (Alves et al., 2016a; Frank, Lavy, & Elata, 2003; Parulekar, 2004).

Thus, this role of facilitator should not be confused with an eased learning for students or a facilitated task for teachers, unwinding who thinks in this way. This demands a high workload and an effort of all involved students and teachers as well as managing some difficulties (Alves et al., 2016b; Alves, Moreira, Sousa, & Lima, 2009). To support this, this paper presents all detailed activities and documents prepared and delivered to achieve the Integrated Project of IEM of first year, based on a PBL wide-semester interdisciplinary project. Main deliverables of this project are satisfied and competent students are prepared to face the following years and their future, i.e. with the learning outcomes established. During the project, a lot of other deliverables are essential to smoothly run the project such as project guide, worksheets, tasks preparation and feedback, written test, students' grades, among others.

This paper is divided in five sections. After this first introduction, the research methodology is presented. The study context is described in section three, while section four presents the results analysis and discussion. Finally, section five depicts some concluding remarks.

2 Research methodology

To fulfil the defined objective, i.e. analyse the effort involved in planning and conducting an interdisciplinary PBL semester, some coordination team members resorted to their own experience and prepared a questionnaire for lecturers. The questionnaire, available online by the end of the semester, includes a series of questions exploring matters concerning PBL evaluation and how this process/work was carried out.

Following the main purpose identification, the online questionnaire is divided into six different parts. The first five encompassed a total of eighteen questions/sentences evaluated based on a 5-point agreement Likert-type scale (where '1' corresponds to "strongly disagree" and '5' to "totally agree"). The closed questions and the corresponding parts are depicted on the Table 1. The last part included five open questions allowing the lecturer to indicate the aspects that deserve greater reflection, the most positive aspects of this experience, the less positive aspects of this experience, and suggestions for improvement. Due to the nature of the open questions in the sixth part, a content analysis was done in order to identify these aspects according to the lecturers.

From the seven lecturers involved in the 2018-19 Integrated Project on Industrial Engineering and Management 1 (IPIEM1) PBL activities, five completed the online questionnaire. This sample's size may be apparently low, however it corresponds to almost the entire population of lecturers involved (5/7), so the findings can determine trends and characteristics in the data, in order to understand and establish assumptions for future studies (Saunders, Lewis, & Thornhill, 2008).

Table 1. PBL Questionnaire for lectures

Part	Code	Question/Sentence
I. Theme chosen relevance	Q1	I consider the PBL project theme appropriate to the competencies to be developed in the CU where I collaborate.
	Q2	The fact that the project is opened (with several solutions) is not a problem for the project development and equitable evaluation of the different teams.
	Q3	The theme of the project is up-to-date and stimulating
II. Developed Learning and Skills	Q4	The project stimulates interest in the contents of the CU where I collaborate.
	Q5	The project allows alternative approaches to the development of CU competencies.
	Q6	I am convinced that there is greater retention of long-term knowledge in PBL.
	Q7	Communication skills (oral and written) were clearly exercised and developed.
III. Team Learning	Q8	Teamwork learning enables a dynamic that enhances the development of transversal competences.
	Q9	The project imposed team members specialization, and therefore not all team members applied the CU competencies in the project.
	Q10	The number of members per team is too high.
IV. Evaluation in PBL	Q11	Overall, I am satisfied with the PBL assessment methodology.
	Q12	I consider adequate the existing mechanisms for individual differentiation, relative to that of the team.
	Q13	The peer assessment (members of each team) is adequate to partly execute such a differentiation.
	Q14	The individual written test is suitable to partially effect this differentiation.
V. PBL as Teaching-Learning Methodology	Q15	The PBL contributes to reduce the annual retention rate to the CU where I collaborate.
	Q16	The PBL has a positive impact on the relationship that I have established with students.
	Q17	IPIEM1 PBL promotes active learning and the development of Learning by Doing activities.
	Q18	IPIEM1 PBL requires excessive effort when compared to other traditionally lectured CU

Taking into account the question posed in the title (Industrial Engineering and Management PBL implementation: an effortless experience?), its response will meet the objective of this study. This response will be based on the questionnaire results and in the lecturers' experience.

3 Study context

This section describes the settings under which the interdisciplinary PBL experience is conducted at the School of Engineering of the University of Minho (UMinho). The following description is based on the 2018-2019 IEM1 PBL edition conducted at the UMinho.

3.1 Industrial Engineering and Management – first year, first semester

The first semester of the first year of the IEM encompasses six courses. Half of the courses pertain to the School of Sciences and, the other half, pertain to the School of Engineering. Four departments are involved in total, as represented in Figure 1. Each course represents five European Credit Transfer System (ECTS), amounting to a 30 ECTS semester.

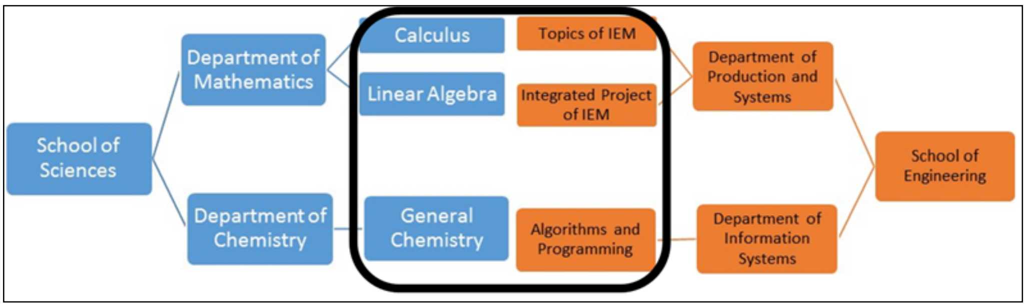


Figure 1. Courses of the 1st year, 1st semester of IEM11 Integrated Master degree (Alves & Leão, 2015)

3.2 Integrated Project on Industrial Engineering and Management 1

The Integrated Project on Industrial Engineering and Management 1 (IPIEM1) is supported by the remaining five courses or curricular units (CU), which are named project supporting courses (PSC), as represented in Figure 2. Courses might hold distinct content weights within the project. For instance, Introduction to Industrial Engineering and Management (IIEM) course and its contents is mostly aligned with the expected development of the project, meaning that multiple contents of the course can be, and indeed, are applied during the project progress. General Chemistry (GC), Algorithms and Programming (AP), Linear Algebra (LA) and Calculus (CC) have more content than the students of the team applied to the project.

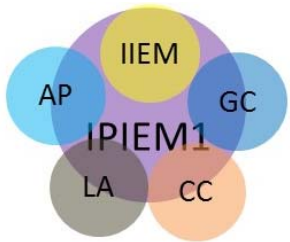


Figure 2. IPIEM1 schematic representation, Project Supporting Courses (Alves et al., 2017)

The IPIEM1 is a semester wide interdisciplinary PBL project. The 2018-2019 edition was conducted by six teams of students, each of which holding nine students, amounting to 54 students in total. The project runs every academic year from september to january in the Campus of Azurém of the UMinho. Each team is supported by two tutors, Tutor A and Tutor B. Tutor A is a lecturer at the school of Engineering, usually, coming from Department of Production and Systems (DPS). Tutor B is a 3rd grade IEM student, who volunteered to assist one of the teams in developing the project. The introduction of tutor B is recent and will continue as the results achieved have been positive (Alves, Moreira, Leao, & Teixeira, 2017b). Each team is allocated to a project room space, where most of the activities related to teamwork in the project occur. This is also the preferable space for students to conduct team meetings, hold meetings with Tutor A and Tutor B, and additionally hold some sessions with PSC lecturers.

A number of deliverables is required from each team. A list of them, with specifics and deadlines, is given to each team. The present edition included: (1) presentation of the preliminary project; (2) presentation of the project development; (3) extended tutorial with all the PSCs lecturers; (4) delivery of the report (preliminary version) and assessment of another teams' report; (5) delivery of the final report and prototypes; (6) final presentation and discussion and an individual written test about the project. The feedback regarding all team deliverables is given by the lecturers. However, feedback on deliverables (1) and (3) is formative, being summative in the remaining ones.

A coordination team is responsible for the deployment of the PBL semester. This team involves all the lecturers of the PSCs, plus the tutors A (lecturers) and a representative of the directive comission of the IEM degree, amounting a total of 15 people. The coordination team has regular meetings in order to plan the PBL semester, execute the planned activities and monitor the teams' progress, as well as assessing the full PBL experience and approving the required change improvements. Moreover, the coordination team provides a Project Guide, aiming the provision of written PBL fundamentals and semester wide specifics, for aiding and guiding the teams throughout the semester.

The assesment model is rather complex, involving a great number of evaluators over a considerable number of itens (reports, presentations, prototypes, etc.) plus peer assessment within the teams and an individual written test about the project at the end of the semester. The team grade is adjusted to individual grades (within each team) by these two individual mechanisms, i.e. (1) the peer assessment and (2) the test. The weights of each assessment component might slightly vary with each edition. Specifics on the assessment model of the IPIEM1 can be found in Alves et al. (2016b).

The design and execution of each PBL semester includes five main stages: (1) preparation; (2) setup; (3) Start; (4) execution; and (5) conclusion. Stages (1) and (2) involve the coordination team only, and occur before the beginning of semester. These two stages are concerned with the definition of available resources (PSCs/lecturers, project rooms, tutors, etc.) to set up the PBL semester and the specifics under which it will be deployed (project theme, assessment model, learning outcomes ought to be achieved, etc.). Stages (3), (4) and (5) involve both the student' teams and the coordination team, and takes place during the semester. These three stages are concerned with launching and explaining the PBL methodology, while imposing a teamwork pace from the start, and smoothly run and monitor the teams's progress on the project and the learning itself. Additionally, it is also concerned with acquiring perceptions on how the project went, from individual perceptions as well as promoting improvements on subsequent editions. This normally occurs in a final PBL workshop involving all stakeholders, i.e. students, lecturers and tutors.

4 Planning and implementing IPIEM1_PBL resulted effort

This section details the planning and implementation of IPIEM1_PBL activities. Attending to these activities, a workload analysis is discussed.

4.1 Work Breakdown Structure (WBS)

The Work Breakdown Structure (WBS) with main phases for the IPIEM1_PBL and their estimated duration is represented in Figure 3, without the tasks performed in each phase.

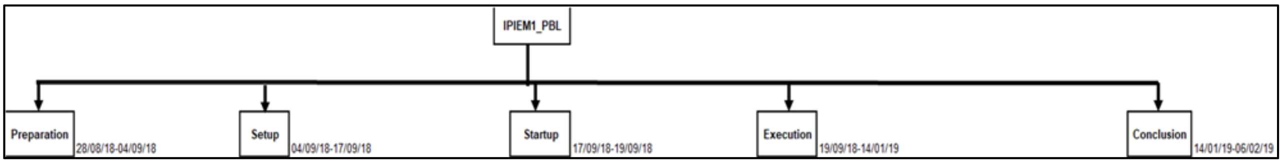


Figure 3. Work Breakdown Structure for the IPIEM1_PBL main phases

Table 2 details all the activities developed by course coordinator and project phases. The activities for AP, GQ, CC, LA courses are aggregated as they are very similar in terms of activities type and number.

Table 2. List of activities performed by IIEM, AP, GC, LA and CC courses

	Preparation	Setup	Start-up	Execution	Conclusion
IIEM		1. Schedule of classes TIEM 2. Identify IPIEM1 and non IPIEM1 students 3. Define non-PBL project theme 4. Define non-PBL presentations and report date 5. Define non-PBL assessment model 6. Teams building (with and without IPIEM1) 7. Meetings attendance 8. Prepare PBL related-tasks 9. Launch task1 and define deadline 10. Ask for volunteers for student-tutors (3rd year) 11. Meeting minutes	1. Classes 2. Teams building and multimedia training 3. Attendance PBL presentation to students (kick off session) 4. Launch task 1	1. Attendance to 1st PBL teams presentation 2. Receive and give feedback of task 1 3. Launch task 2 4. Receive and give feedback of task 2 5. Launch task 3 6. Receive and give feedback of task 3 7. Provide feedback to preliminary report 8. Attendance to 2nd PBL teams presentation 9. Grade 2nd presentation 10. Attendance extended tutorial 11. Prepare prototypes session 12. Support teams 13. Grade Reports and prototypes 14. Publish grades 15. Attendance coordination meetings 16. Meeting minutes	1. Attendance to final PBL teams presentation 2. Attendance to final non-PBL teams presentation 3. Assess final presentation, prototypes and final report 4. Attendance to the final coordination meeting 5. Attendance to workshop 6. Collect lessons learned 7. Write summaries on Blackboard
AP & GC & LA & CC		1. Coordination meetings attendance 2. Select project theme 3. Define milestones 4. Define assessment model 5. Define PBL presentation date 6. Schedule of classes CC 7. Prepare PBL related-tasks	1. Classes 2. Attendance PBL presentation to students 3. Launch the 3 tasks	1. Attendance to 1st PBL presentation by teams 2. Receive and give feedback of tasks 3. Attendance extended tutorial 4. Give feedback first preliminary report 5. Attendance to 2nd PBL presentation by teams 6. Give grades 2nd presentation 7. Support teams 8. Assess 2nd presentation, reports and prototypes 9. Publish grades 10. Coordination meetings attendance 11. Meeting minutes	1. Attendance to final PBL presentation by teams 2. Grade final presentation, prototypes and final report 3. Attendance to the final coordination meeting 4. Attendance to workshop 5. Collect lessons learned 6. Write summaries in Blackboard 7. Meeting minutes

Table 3 details all the activities developed by course coordinator and project phases.

Table 3. List of activities performed by IPIEM1 Coordinator

	Preparation	Setup	Start-up	Execution	Conclusion
IPIEM1 Coordinator	1. Define semester coordinator 2. Identify teachers involved in the semester 3. Search interested teachers-tutors 4. Identify suitable project themes 5. Schedule first coordination meeting 6. Check availability and make reservation of project rooms 7. Book a meeting room 8. Prepare agenda and inform all members of first meeting	1. Prepare & conduct/attend 1st coordination meeting 2. Prepare the project guide 3. Promote discussion and selection of project theme 4. Define milestones 5. Agree on the assessment model 6. Define semester plan 7. Define first week calendar 8. Define date for PBL kick off session 9. Prepare the pilot project assignment 10. Collect information about students (freshman and others) 11. Book room for PBL kick off session (by coordinator) 12. Contact a sponsor/company 13. Agree on e-platform for document sharing (coordination team) 14. Share documents with coordination team 15. Prepare and conduct/attend 2nd coordination meeting	1. Prepare and conduct/attend PBL kick off session 2. Prepare and validate worksheets for peer assessment 3. Book PBL presentation room (1st presentation of teams) 4. Prepare company visits 5. Prepare training sessions 6. Prepare sessions with tutors 7. Define, publish and update PBL teams 8. Share PBL docs with teams/students on e-platform 9. Distribute teams over the scheduled classes typologies 10. Teams reminder of 1st PBL presentation	1. Prepare and conduct/attend 1st PBL presentation by teams 2. Book presentations room (2nd presentation, extended tutorial, final presentation) 3. Prepare and conduct/attend 2nd PBL presentation by teams 4. Prepare project individual written test 5. Collect, compile and publish grades (2nd presentation, preliminary report) 6. Prepare extended tutorial 7. Reminders to teams: 2nd PBL presentation; extended tutorial; final PBL presentation 8. Reminders to teams: preliminary report; final report; prototypes 9. Reminder to teams: written test 10. Prepare worksheet on PSC contents to include in the preliminary report 11. Prepare template for Reports 12. Publish templates and references guides 13. Prepare and conduct/attend extended tutorial 14. Reminders to coordination team members: several 15. Assist the compilation of the peer assessment mechanism 16. Compile PSCs' grades on each project team assessment of others preliminary report 17. Prepare and conduct/attend 3rd, 4th and 5th coordination meeting 18. Check conformance to deliverables requirements (deadline, deliverable format) 19. Blog monitoring	1. Check PSCs' PBL sessions summaries 2. Book presentations room (workshop) 3. Prepare, give and correct the individual written test 4. Prepare and conduct/attend final presentation and teams discussion 5. Compile all grades 6. Final coordination meeting 7. Validation of the grades 8. Prepare surveys (students about PBL and tutors, teachers, tutor experience) 9. Collect surveys results 10. Prepare and conduct/attend workshop 11. Collect lessons learned 12. Design, make and send Tutor certificates 13. Publish final individual grades 14. Check return back of prototype kits 15. Prepare and conduct/attend 6th coordination meeting 16. Verify project rooms and keys returned

4.2 Workload analysis and discussion

From Table 2 and Table 3, it was possible to summarize the number of activities by project phase and course, as illustrated in Figure 4. As expected, execution phase is the most demanding phase in terms of activities performed, and IPIEM1 coordinator has the high number of activities, as also expected. IIEM has more activities than others, because it is nuclear to the IPIEM1 project. The main difference in relation to the other courses is because IIEM is an introductory course to the IEM program, having a lot of students transferred from others engineering degrees. Normally, these students do not have conditions to develop the project as regular students. To theses students, IIEM teachers give a different project called non-PBL. Details could be found in Alves, Moreira, & Leão (2018).

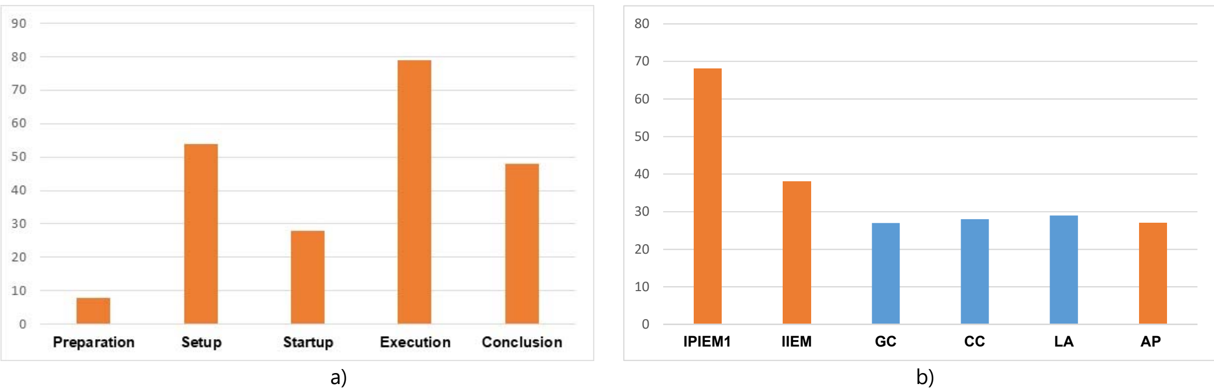


Figure 4. Planning and implementing IPIEM1_PBL in number of activities: a) by project phase; b) by course

It is also clear from Table 2 and Table 3 that many activities are frequently repeated such as attendance to presentations, book presentation rooms, feedback to reports, components assessment and communication emails. Bearing in mind the activities aggregation and classification established in Alves et al. (2009), in this paper the same classification scheme was used with some adaptations, namely, introducing new activities such as activity 10, 18 and 20. Table 4 presents 20 types of activities and their frequency, average duration, average number of lectures/tutors involved (tutors' presence is not compulsory in all events). These values were an estimate based on the project coordinators experience. The result is calculated in workload (man-hours). The final workload was of 623 man-hours. Given that 12 lectures and tutors (not including student-tutors) were involved and 17 weeks were considered, a total of, approximately, 3 hours per man-week is consumed in IPIEM1_PBL.

Table 4. Types of activities, frequency and workload

	Item frequency (semester based)	Duration (avg hours)	Lecturers/tutors (avg)	Workload (man-hour)
1. Coordination team meetings	5	2.00	7	70
2. Tutorial sessions	16	1.00	6	96
3. Extended tutorials	1	2.00	6	12
4. Training on Teamwork and Multimedia Presentations	2	1.50	2	6
5. Initial Presentation (kick-off) PBL by coordinator	1	2.00	8	16
6. Student teams presentations (attendance)	2	2.00	8	32
7. Final student teams presentation (attendance)	1	6.00	8	48
8. Coordinator activities	68	1.00	1	68
9. Project Guide editing	1	2.00	7	14
10. Tutor instruction session	1	2.00	7	14
11. Peer evaluation editing, validating and supporting (assist compilation)	4	0.50	1	2
12. Milestones and deliverables conditions checking	6	0.50	1	3
13. Deliverable 1 Review (presentation 1)	1	0.25	7	2
14. Deliverable 2 Review, team feedback and grading (presentation 2)	1	1.50	7	11
15. Deliverable 3 Review, team feedback and grading (Report 1 - preliminary)	1	9.00	6	54
16. Deliverable 4 Review, team feedback and grading (Report 2 - final)	1	9.00	6	54
17. Deliverable 5 Review and grading (final presentation and discussion)	1	9.00	8	72
18. Deliverable 6 Review and grading (prototypes)	1	6.00	2	12
19. Project written test and Grading (individual)	1	16.00	2	32
20. Students, lecturers and tutors questionnaires	1	2.00	3	6
			Total	**623**
			Avg. workload per person-week:	**3.06**

In spite of the effort in finding some strategies to reduce the workload (that was 2.72 hours per person) in 2009 (Alves et al., 2009), it seems, after a decade, this effort has not been reduced and, unfortunately, has increased. Some activities have been reduced, such as coordination meetings and tutor session's duration, due to the creation of the tutor-student role, allowing decreasing some tutor supervision. Furthermore, the number of milestones has been also reduced to six.

Many reasons could be behind this, but the authors' perception is that PBL is managed in a traditional "heavy" institution structure. Though the project as a course was introduced in 2012 (Alves et al., 2014) few changes happened. Many coordinator activities continue and are related with booking rooms, training, evaluate PBL process, among others, that could be dismissed if the institution supported more the PBL process. Furthermore, the work related with course management like write summaries and graded the course as it were added. In this case, the institution has not realized the set of new needs that came with the PBL: new spaces, new resources, pedagogical support and even some recognition to support the obstacles inherent to a process of change of the teaching-learning model.

Related with the spaces, the authors' department provided such space, two project rooms (one for two teams, and other for four teams), but every year this has to be discussed as the number of students is increasing and 4th year students also need a project room. There is some envy from other colleagues who try to find solutions to such timeshare spaces. They did not realize that the room is important as space for the team, as a "war" room to develop the project. Even, the project room for four teams is a short space for so many teams. When all the students are in the room, the noise is unbearable. This is also felt by other authors that try to implement PBL (Ghislandi, Silva, Correia, & Figueiredo, 2017): *"The lack of more specific spaces, such as a laboratory with tools and other types of materials needed for the construction of prototypes, hindered the production process and* improved academic achievement". Beyond the resources referred in this citation, the visits to companies are also important in this context but there is no university budget to pay students transport. Teachers and students have to pay this if they want to visit those companies.

As so, without the support of the institution, transforming traditional in PBL teaching becomes a more difficult mission. For teachers who move from traditional teaching to project learning, change is manifold, including interdisciplinarity that requires much more intensive collaboration with peers, changing the role of teacher to tutor, assessment of technical skills as well as cross-cutting, the management of team work by the students and changes at the curricular level in terms of learning outcomes specific to the project. Pedagogical support dedicated to issues regarding teacher change can greatly facilitate the transition of teachers to project learning. This support must not be incidental, but structural and should consist of several modalities. First of all, there is tutors' training, for whom this role change is a novelty with which they are not always at ease. The students' organization training is equally relevant as they need to learn to work differently and shift from a knowledge-centered individual approach to a team approach, focused on developing technical and cross-cutting competencies.

As the process can be very demanding for inexperienced people, if the involvement of the institution is not felt, it can be difficult to maintain the motivation and commitment of the direct stakeholders. Unfortunately, coordination team is not permanent and some teachers, mainly, from Sciences school, change frequently and new teachers have to be trained on IPIEM1_PBL. This support is being given by IIEM teachers that train and promote tutors role, searching volunteers among teachers and students (Alves, Moreira, Leao, & Teixeira, 2017b). Even, sometimes, due to the teaching workload, there are different teachers for theoretical classes and a teacher for project support for the same course (e.g. General Chemistry had in this particular year, three teachers). At the same time, teachers should have multiple roles: lecturers, tutors, trainers, researchers. Some teachers need to adjust the course contents to project theme every year (Alves et al., 2016), which demands a high effort. They research their practices to continuously improve and, more important, to provide a meaningful learning to IEM students (Alves, Moreira, Fernandes, et al., 2017).

PBL in UMinho is implemented in a very different way by others universities. As an example, in Aalborg, the institutional pedagogical view is considered one of the guiding principles of the PBL models used in the university. First, the university has created a framework for problem and design approaches, including guidelines for the creation of degrees, courses, and pedagogical approaches to be used by teachers. In the educational view, the university commits to principles of orientation to problem and project learning, the integration of theory and practice, participatory management, teamwork and feedback. Also, they recommend an operation in which teams have unlimited access to their spaces, for which, at the same time they have the responsibility to keep them in order.

4.3 Questionnaire results

Although the workload analysis and results, it is important to notice that teachers (four (80%) in five lecturers) ranked their individual experience as a PIEGI1 PBL teacher, with 9 (in a scale of 10, where 10 means ´more favourable´). Only one lecturer ranking with 6. They also valued the project as adequate for students to develop competences in the course they collaborate (Figure 5, Q1). All lecturers considered the theme for the IPIEM1 PBL an up-to-date and stimulating project (Figure 5, question Q3).

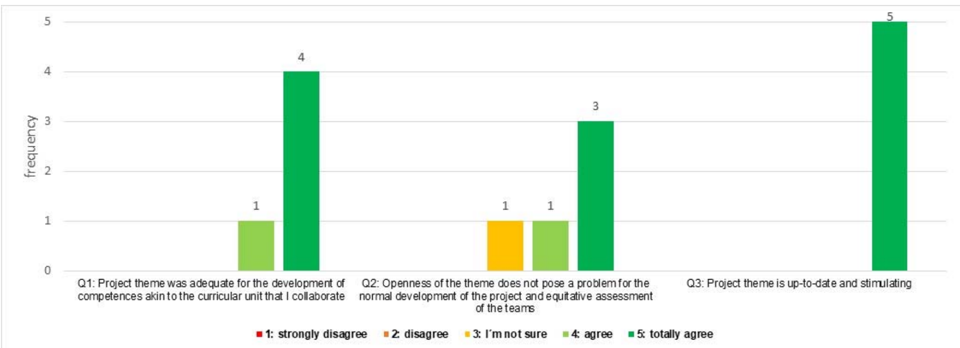
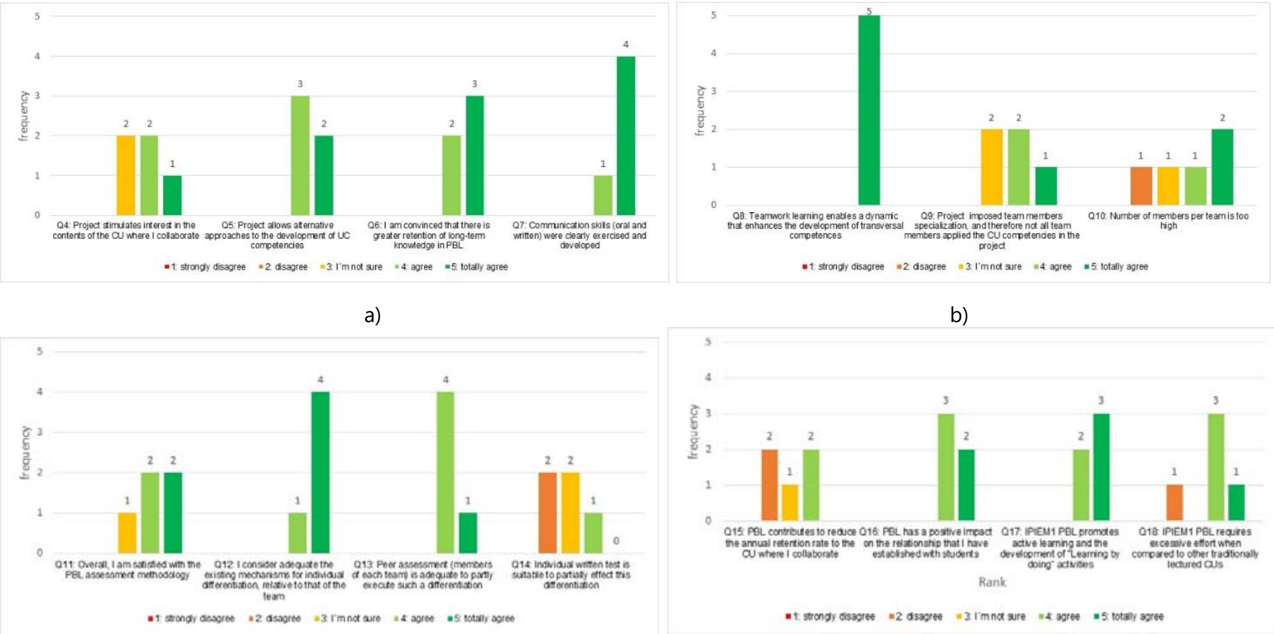


Figure 5. Theme chosen relevance

Relatively to the others responses obtained from the online questionnaire, Figure 6 summarize the results. In average the results show a positive trend ranged between 3.8 and 5. Only one question was ranked with an average lower than 3 (Q14, with an average of 2.8). Q14, is regarding the PBL evaluation, namely ´The individual test is suitable to partially effect this differentiation'. This negative response emphasizes the inherent difficulty to establish objectively an individual assessment of a work developed by a team. Regarding the IPIEM1 PBL effort when compared to other CUs (Q18), one lecturer ranked with "2" meaning that he/she disagreement as regards the excessive effort of the IPIEM1 PBL compared to other CUs. However, the average obtained to this question was 3.8. Interesting to notice that, this lecturer referred as negative point the lack of institutional support and as improvement suggestion to improve the assessment model and to have more pedagogical support.



a) b)

c) d)

Figure 6. a) II. Developed Learning and Skills; b) III. Team Learning; c) IV. Evaluation in PBL; d) V. PBL as Teaching-Learning Methodology

The results are not very different from the ones obtained in a similar study performed in 2015_16 and published in Moreira et al. (2017). In that particular edition a different mechanism to differentiate students' grade was used, beyond the peer assessment that continues being an acceptable mechanism for this differentiation. Some identified problems remain to be solved such as a better mechanism to differentiate individual performance that do not increase lecturers' workload. From the last closed question is clear that most respondent lecturers agree on the excessive effort of IPIEM1 when compared to the traditionally lectured teaching. Part of such effort also comes from the need to continuously evaluate the PBL process that is also performed by the lecturers and tutors involved in the PBL planning and implementing.

5 Conclusion

This paper presents the effort in number of activities and man-hours consumed by IPIEM1_PBL. It has been noticed that in a decade, in spite of some strategies in helping to reduce teachers' workload, workload has increased compared to traditional form of teaching/learning education methods. PBL is an active learning methodology that demands a high effort from teachers and students. Nevertheless, it is a learning methodology that engages students in their own learning and lecturers to be continuously improving. To adequately implement PBL, it is important to have the institutional support that should provide resources, spaces, pedagogical guidance. Without this, the effort will be huge and, sometimes, the stress and fatigue demotivate all the involved stakeholders. Reducing the effort without reducing the quality of PBL process is a challenge and demands more resources and support. Nevertheless, continuous improvement is always the keyword for future work.

Acknowledgments

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Using Six Sigma method in the monitoring of Project Management education within Architecture and urban planning faculty in Constantine 3 university

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Abstract

Following major reforms in higher education in Algeria, which have been going on for more than a decade, university education faces many challenges requiring the implementation of new concepts of project management and performance improvement. Processes in instructional engineering to achieve total quality. In this light , the pedagogical team responsible for the monitoring and development of teaching within the project management department, works to harmonize the aims with the content of the courses to ensure a better quality of education while meeting the requirements professional and socio-economic world. In this regard, the present paper aims to show the results of a study conducted on the education (contents / actors / organization), in order to determine the factors of success of the application of the DMAIC methodology to improve the performances teaching staff in the two cycles license and master within the department of project management in Architecture and Urban Planning Faculty , University of Constantine 3 Algeria.

Keywords: Six sigma, DMAIC, higher education, project management department, teaching team, Constantine.

1 Introduction

Educational institutions are accelerating nowadays scientific production development and improving their techniques, especially in light of big competition in the age of globalization and knowledge economics, therefore; the search for new methods must be able to solve problems and improve education the processes. Project management department, in Constantine 3 university Algeria, in accordance with state policy that aims to create a good academic environment; seeks to adapt both the labour market and the quality of the educational process to ensure the excellence of its students. The overall objectives can be achieved in this study using the approach of Six Sigma, by measuring the performance and the efficiently application of different indicators and tools.

2 Objective of study

The present study aims to assess the efficiency of the Six Sigma method in higher education institution by studying the case of project management department in Constantine 3 university in Algeria; in this framework we identified six sigma concepts and its standards in addition to DMAIC's application factors on teaching team of the department.

2.1 Previous studies:

From an Arabic authors vision we find some relevant papers like Ahmed Ben Aichaoui (aichaoui, 2014): Six sigma Method, the technique to achieve the most of Total Quality Management (TQM),the paper discusses this issue by presenting six sigma methodology and the most important statistical tools along with their applications to achieve the needed precision in the same framework (Sulim Abu Zeid:, 2009) in his article: Study the statistical standards Six Sigma Methodology to improve the quality of the university education .The study aimed to establish a conceptual philosophical framework for Six Sigma method and to identify the resulting statistical methods while applying it to higher education institutions by assessing the university scientific production and identifying a weakness in Colleges of King University for the academic year 1435/1436 AH , finally : Mohamed Abdullah Maksoud Hassan in his paper , (maksoud, 2017) when defining Six Sigma concept, criteria and methods, and determining Dmaic's application factors to faculty members, author used the analytical descriptive technique to achieve the study's objectives by data collecting and analyzing.

From an Algerian perspective :Bophas Al Sharif in his paper: (elcherif, 2015)aims to highlight Six Sigma's strategy and the possibility of applying its principles successfully in higher education institutions to achieve the objectives of improving the education's quality .in another hand Dr. Boglita Elham (siham, 2017)(2017): Implement six Sigma standards in improving the quality of higher education. in This study the author hilights the possibility of applying six sigma standards to improve the quality of higher education, faculty of economics, commercial sciences and management sciences ,university of skikda as a study case, using descriptive method, by selecting a random sample of faculty members (35 member) and a questionnaire as a tool to collect the data.

Reviewing some other international studies we can mention Vijaya Sunder M's article (Sunder, 2016): Lean Six Sigma in Higher Education Institutions , The paper focuses on the application of Lean Six Sigma (LSS) in Higher Education Institutions (HEIs) and Paul G. LeMahieu Lee E. Nordstrum Elizabeth Cudney (eMahieu, Nordstrum, & Cudney, 2017), Six Sigma in education: Quality Assurance in Education, This paper elaborates different approaches to quality improvement in education and outlines the Six Sigma methodology. Also Pavel Adina-Petrua,Sârbu Roxana (Pavel Adina-Petrua, 2014) :Integrating Six Sigma with Quality Management Systems for The Development and Continuous Improvement of Higher Education Institutions. The paper focuses on the way six sigma is applied to higher education and on integrating six sigma with one of the quality management systems, namely the model iso 9000, for the development and continuous improvement of universities. A synergetic approach created by analyzing and simultaneously using the benefits of six sigma and ISO9000.

2.1.1 Previous study analysis:

The application of Six Sigma approach in institutions of higher education aims to achieve excellence in performance; it has to be based on a database that guides the decision-making process and the availability of comprehensive measurements of performance. Some studies have adopted this approach by applying the DMAIC methodology to improve performance and quality of current processes and considered this method good and important for future research in different service areas.

We can also point that most studies refer to models for the application of Six Sigma in higher education, but did not include details of the application or results. Therefore, the absence of a clear model for this method can be applied for the purpose of continuous improvement in the processes and educational services in addition to the weakness of financial resources and human competencies; we can finally point that Six Sigma applications still in its early stages in Algeria.

2.2 Total Quality in Higher Education in Algeria:

Higher education is considered as one of the important sectors in Algeria that includes different kinds of institutes , With the technological and cognitive development, modern quality concept has become more interested in customer satisfaction first, quality has become: "Accuracy and proficiency by adhering to standards in Performance" And quality in education is: "a construction process aims to improve the final product "The overall quality of education is: "A comprehensive and continuous development approach that covers all areas.

2.2.1 Six sigma approach:

Six Sigma was first conceptualized in the mid-1980s as a business process improvement model by Bill Smith, a reliability engineer at Motorola, Inc. (Brady and Allen, 2006) The concept was subsequently implemented at Motorola by CEO Robert Galvin as a ubiquitous internal strategy to revitalize the company (Brady and Allen, 2006). Six Sigma received even greater notoriety in the 1990s when it was implemented at the General Electric Company by then CEO Jack Welch as a company-wide approach to quality improvement (Brady and Allen, 2006). Since that time, Six Sigma has achieved greater appeal to many business enterprises, more so than Total Quality Management (TQM), because of Six Sigma's focus on measurable results and its disciplined data-based approach to problem solving and process improvement (Barney, 2002).

2.2.2 Toolkit used in six sigma:

At the middle management level, Six Sigma is used by project managers as a methodology to achieve quality improvement by reducing defects in products, services and processes (Mitra,A., 2004). In the case of products, they propose the DMAIC approach (define-measure-analyze-improve-control) and for products and process another approach is popular in the literature, namely DMADV (design- measurement-analysis-design-verification)(Pfeifer, T. et al., 2004).

2.2.3 Limits of Six Sigma application in higher education:

A number of expected barriers may be identified when using this method, firstly, the lack of data, especially at the beginning the project's operations. Secondly, the statistical definition of Six Sigma is 3.4 defects or failure in one million opportunities. It can be calculated in the industry besides the service sector, where anything that does not meet the needs or expectations of the client is considered a failure or a mistake in higher education through focusing on the quality of the educational process and its performance with real theoretical performance planned. Thirdly, the selection and preference of projects are still based on personal decisions in educational institutions. Fourthly, The change in Six Sigma at the level of services may not be tangible. Fifthly, the measurement and monitoring phase in services is more difficult than in the industry. Sixth, Lack of conviction or support of senior management in institutions of higher education of the importance of Six Sigma concept Use it in various operations. Seventh, The existence of six tools and alternative tools for Six Sigma. Eighth, Lack of financial, human, physical, and information resources for the use and application of Six Sigma. Ninthly, Fear of failure to use Six Sigma and its application. Finally, Internal resistance from individuals and groups within the university institution to the idea of Six Sigma and its application.

3 Research methodology:

The research methodology used in the study is mainly quantitative in the first part, the second one we used a questionnaire in order to achieve the objectives of the study by collecting and analyzing the data. The study community includes all members of the faculty of the Project Management Department.

3.1 Study tool

Using a survey structured according to various stages based on the analysis of previous studies ,the expertise of the researchers, as well as the opinions of the specialists in the fields of production and TQM focusing on success factors of the Dmaic methodology. DMAIC (Define Measure Analysis Improve Control) is a problem-solving method used in lean Six Sigma projects.

This method is based on a structured approach in 5 steps:

a) Define: definition of the problem, the studied scope and the associated objectives (in terms of performance, user waiting ...).
b) 2. Measure: choice of variables to be analyzed and instruments of collection, implementation of data collection.
c) 3. Analyze: assessment of the gaps between the current situation and the objectives set. Identification of the causes and the levers that can be actuated to remedy them.
d) 4. Improve: inventory, ranking and choice of solutions. Implementation of the selected actions.
e) 5. Control: definition of a control plan for the solution put in place, choice of relevant indicators. The goal is to provide the means to correct the plan if the desired results are not at the rendezvous.

This method uses on many tools like: "five why", the diagram of cause and effect, the method of 5 S, Kaizen.

The questionnaire included two parts.

The first part relates to independent variables of study such as characteristics of vocabulary and the sample of the study (the section of the study). The second part included the success factors of applying the DMAIC methodology according to the phases divided into five main stages.

4 Results and Analysis:

4.1 Study variables:

In this paper we studied two type of variables : dependent variables which are in this case the five Success factors of the DMAIC phases (Define Measure Analysis Improve Control) depending on the values of independent variables like gender , grade and experience years ... , The dependent variables represents the outputs of the method whose variations are being studied: in every phase a number of stages presented as expressions to be evaluated by the study sample : by choosing from "strongly disagree" to "strongly agree" according to what they think about it , and then analyze these results to make interpretations .

4.1.1 Independent variables

A. Grades include 5 levels:

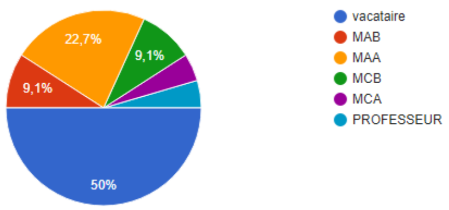

Figure 1 Teachers distribution by type

We can say from the survey result concerning the teaching team grades distribution that almost half of them are temporary teachers the other half is composed of professors, MAB , MAA, MCB and MCA's.

B. Experience years:

Figure 2 experience years

According to the experience years of the teachers, the majority have less than 5 years of teaching experience the rest have more experience with variation from 5 to 30 years.

C. Gender

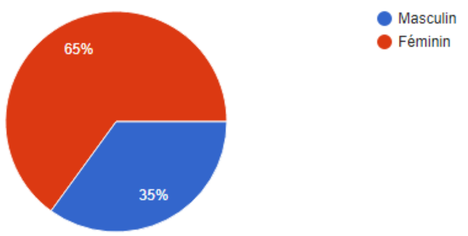

Figure 3 Gender %

According to the survey we found that 65% of the teaching team in the department are females, the rest (35%) are males

4.1.2 Dependent variables

a) Success factors of the DMAIC" Define" phase:

	Strongly disagree %	disagree %	Neutral %	agree %	Strongly agree %
Encouraging faculty members to improve teaching quality.	5	10	5	15	65
Encourage the teacher to excel in scientific research	0	5	25	15	55
Sharing Six Sigma Culture Between Teachers	0	10.5	15.8	21.1	52.6
Specify the criteria of satisfaction of the administrative team of the department	5.3	10.5	0	36.8	47.4
Study the requirements of the labour market to link programs to market needs	5.3	5.3	5.3	31.6	52.6
Form Six Sigma Teams in the department	5	10	10	25	50
There is a good system for the promotion of department members	5.3	5.3	15.8	21.1	52.6
Participation of faculty members in scientific conferences	10	10	0	20	60
Support college administration on an ongoing basis to improve teacher performance and graduate quality and accept the idea of change	0	10.5	10.5	21.1	57.9
Develop a planning for the Six Sigma project	10	0	15	20	55
Training the faculty to accomplish tasks correctly from the first time	0	15.8	15.8	10.5	57.9
Follow up the lecturers and lecturers and make sure that their scientific journey in the right way	0	5	25	15	55

Table 1 success factors of the DMAIC definite phase.

In the Define Phase, process performance objectives were identified, and the project objectives were agreed with the stakeholders .The table 1 shows that the success factors proposed by the researchers in the identification phase are significantly important from the teaching staff's vision. The first expression, that provides the advancement of improvement, has obtained a 65% of the high performance and the 11th expression that obtained 56.9% likewise the 4th expression, reflects the importance of supporting senior management to implement six Sigma.

b) Success factors of the DMAIC method " Measure" phase

	Strongly disagree %	disagree %	Neutral %	agree %	Strongly agree %
Identify key indicators for kpis performance evaluation	5.3	10.5	21.1	31.6	31.6
Preparation of measuring tools and participation of teams in the completion	5.6	11.1	0	50	33.3
Use of experts in measurement and evaluation of measurement tools	5.3	21.1	15.8	15.8	42.1
Develop the standards needed to implement and evaluate the performance improvement plan	0	0	11.1	44.4	44.4

Training of faculty members on the statistical tools used in the Six Sigma method	5.6	11.1	5.6	33.3	44.4
Use advanced methods in the data collection process to identify problems in the optimization process	16.7	0	11.1	27.8	44.4
Develop mechanisms to determine the extent to which the desired objectives are achieved	5.6	11.1	16.7	22.2	44.4

Table 2 success factors of the DMAIC measure phase.

After the definition phase, the project team moved to the measurement phase and starts collecting data. The data sources were on the process main steps, to develop the standards we needed to implement and evaluate the performance improvement plan. Table 2 shows that the success factors proposed by the researchers in the assessment phrase: the most significant from the point of view of the teaching staff were the factors with 44.4%, and 31.6% respectively

c) **Success factors of the DMAIC method "analyze" phase**

	Strongly disagree %	disagree %	Neutral %	agree %	Strongly agree %
Use swot analysis to evaluate the current state of operations and activities of the department	16.7	5.6	11.1	27.8	38.9
Study the problems and analyze their causes	5.3	5.3	21.1	15.8	52.6
Specify a reference scale for the process	5.6	11.1	16.7	38.9	27.8
Determine the differences between the current situation and the desired situation	10.5	10.5	10.5	21.1	47.4
Define minimum and maximum specifications for complete performance improvement	5.6	5.6	27.8	27.8	33.3
Divide faculty members into teams according to Six Sigma application requirements	5.6	16.7	27.8	5.6	44.4
Identify the differences causes between different processes	0	5.6	33.3	38.9	22.2
determine a leader between the different teams of the department	5.6	5.6	22.2	22.2	44.4

Table 3 success factors of the DMAIC analyze phase

It is clear from Table 3 that the success factors proposed by the researchers are of high importance according to the teaching structure. This reflects the homogeneity of the responses of the study sample and the importance of applying DMAIC. The second factor obtained 52.6 %. This indicates the importance of studying the problems and analyzes their causes to find out why they occur.

d) Success factors of the DMAIC method "improve" phase

	Strongly disagree %	disagree %	Neutral %	agree %	Strongly agree %
Identify alternatives to solve current problems using brainstorming	0	5.3	10.5	36.8	47.4
Finding non-traditional solutions to intensive problems	5.9	0	17.6	29.4	47.1
Use peer evaluation	0	5.6	50	22.2	22.2
Work to eliminate mistakes when they occur	0	15.8	10.5	31.6	42.1
Develop a planning for improvement	0	21.1	5.3	21.1	52.6
Provide an organizational climate to improve the performance of teachers	0	21.1	5.3	5.3	68.4
Analyze the results obtained and compare them to what is planned	0	21.1	0	26.3	52.6

Table 4: success factors of the DMAIC improve phase.

In the Table 4 we can notice that the 6th factor: Provide an organizational climate to improve the performance of teachers, has obtained the highest percentage, which is 68.4, which indicates the need for a coherent environment for the teaching staff to increase their performance.

e) Success factors of the DMAIC method "control" phase

	Strongly disagree %	disagree %	Neutral %	agree %	Strongly agree %
Document new improvements.	5.6	11.1	0	22.4	61.1
Develop plans to evaluate improved processes	5.6	5.6	11.1	38.9	38.9
Evaluating the performance of work teams	5.3	10.5	10.5	10.5	63.2
Make sure to follow the mechanisms of six Sigma	0	10.5	21.1	26.3	42.1
Develop controls to ensure sustainable performance improvement	5.6	11.1	5.6	33.3	44.4
The process of feedback between teams	5.6	5.6	16.7	11.1	61.1
Improve Results in light of the criteria identified in previous steps	5.6	5.6	16.7	22.2	50
Evaluation of different products under specific objectives	0	11.1	11.1	33.3	44.4

Table 5 success factors of the DMAIC control phase.

Table 5 shows that most success factors in control phase proposed by the researchers received strong reactions from teachers. This reflects the homogeneity of the responses to the study sample and the importance of applying DMAIC, most of the statements obtained approximate percentages getting between38.9 % to 63.2 % as a “strongly agree” which indicates the importance of control phase in this study.

5 Conclusion and recommendations

The Application of the Six Sigma method particularly in the administrative and academic processes and in university faculties generally through the implementation of projects and teams of Six Sigma to improve the performance of the members and to encourage them for scientific research, especially since the majority of the Commission members are assistants. Six Sigma follows to what extent faculty participate in professional development activities to improve their academic performance, after the present study we recommend strongly:

-Including six Sigma tools in the academic courses content.

-Making the the missions and goals of the university clear in order to achieve the Six Sigma level and reduce the margin of errors in the plans and programs of studies in future research,

- Application of the same study on other faculties to assess its credibility and performance .

-promoting the role of organizational culture in the application of the Six Sigma method in educational institutions.

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Contributions of the Dresden School of Engineering Pedagogy: A Needs-Oriented Approach in Engineering Pedagogy

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Abstract

Prof. Hans Lohmann founded in 1951 the Engineering Pedagogy Institute (Institut für Ingenieurpädagogik) at the Technische Universität Dresden (Technical University of Dresden, TU Dresden), in his quest to systematize and to professionalize at an institutional level the teaching and research in engineering. Engineering Pedagogy is an interdisciplinary scientific subject that collect the „needs“ and „demands“ of: engineering and technical sciences, pedagogy and didactic and the education system in itself (Lohmann, 1954; Melezinek, 1999). Lohmann's work was continued at the Institute for Vocational Education at TU Dresden, in charge of Prof. Dr. habil. Hanno Hortsch (currently President of IGIP), who leaded many research projects in Engineering Education and didactic in Germany and another countries. Dr. Steffen Kersten (TU Dresden) proposes a scheme that describes the factors that influence and condition (demands) the Engineering Education: (i) the economic and production sectors of a country, (requirements determined by the prevailing structures of production and service), (ii) engineering sciences (regarding the matters of engineering sciences; the terms technique and technology play a key role), (iii) society and culture of the country, (the development of technique and technology is also driven by social needs), and (iv) the individuals who study engineering (as person) (see Kersten, Simmert & Gormaz, 2015). The results of two surveys, leaded by Prof. Hanno Hortsch (TU Dresden) in cooperation with academics from engineering faculties of four Chilean universities, show the (1)„needs“ of academic training related to the different pedagogical and technological aspects that influence the training of engineers in the engineering faculties of Chilean universities, seeking to improve the quality of the academic training and teaching-learning process; and (2) „needs“ (as well as „demands“) for different knowledge, skills and technological tools for the teaching in engineering careers in relation to current and future industrial requirements.

Keywords: Engineering Pedagogy; Dresden School of Engineering Pedagogy; Needs-Oriented Engineering Pedagogy; Needs-Oriented Engineering Education; Engineering Education.

1 A short history of the Dresden School of Engineering Pedagogy

Through the foundation of the Institute for Engineering Pedagogy at the Technische Universtität Dresden (TU Dresden) in 1951, Lohmann laid the starting point for the tradition of the Dresden School of Engineering Education and Pedagogy. With his paradigm of technology and its teaching, Lohmann influenced the Engineering Pedagogy and research at the TU Dresden in the following decades and is still valid for the design of teaching and learning processes in academic Engineering Education.

The starting point of Lohmann's scientific reflections was the connection between the structure of a science and its teaching: every scientific teaching requires first the analysis of the corresponding science. Engineering science, which seeks and gains knowledge in and from the state of the art (see Lohmann, 1954), requires therefore an analysis of technology. The concept of technology itself was defined by its function of "transforming the natural world" (602). The methodology of the engineering science fields and the methodic of its teaching are decisive for the connection of specialized science and educational science. While methodology refers exclusively to ways of finding knowledge in the field of science, methodic encompasses the paths of knowledge in which the teacher leads his students from the unknown to the known (see Lohmann, 1954). From the investigation of theory and practice of technology Lohmann derives conclusions for the design of the teaching of technology and technics. This was done both for the "internal", methodical design (goals, structure of contents, methods, and procedures for instance), as well as for the "external", organizational design of this teaching (for example, the choice of students based on their suitability for the job description or the trainings coordination based on requirements of the economy) (see Hortsch & Reese, 2012).

In 1963 Prof. Franz Lichtenecker took over the management of the Institute for Engineering Pedagogy with new scientific reflections. In cooperation with Hering published in 1963 "Lösungsvarianten zum Lehrstoff-Zeit-Problem und ihre Ordnung" (Solution Variants on the Contents-Time-Problem and Its Order), a text that presented new perspectives about didactic questions on Engineering Education. The solution variants to the contents-time-problem offers possibilities to resolve permanent dilemma of increasing amount of knowledge and limited training time. Through very concrete scientific and technical examples will try to find solutions for this problem. This solutions are derived on a high level of abstraction and thus universal applicability. The solution variants had two main focuses (see Hortsch & Reese, 2012):

- the "contents restriction" (for example by modeling or didactic simplifications) and
- the "qualification for/to a" contents manage (for example developing skills or using algorithms)

Through Lichteneker's administration other colleagues at the TU Dresden were able to continue researching and complementing key didactic elements of Engineering Education. In particular, the basic of didactic categories (e.g. goal, content, method), supporting organization forms (e.g. lecture and exercise, Wenzel,1983), laboratory internship (Malek, 1980), as well as subject-specific Study processes (Geiger, Klose, Lichtenecker, Wenzel, 1975) (see Hortsch & Reese, 2012).

Since 1986 Prof. Lehmann directed the Dresden School of Engineering Pedagogy with focus at the research on the entire process of training and further education of engineers, and thus on the design of curricula for entire engineers degree programs at discipline and specializations level (see Hortsch & Reese, 2012).

The political change in East Germany had different effects and changes at TU Dresden. Prof. Eberhard Wenzel leaded since 1992 the School of Engineering Pedagogy at the Institute for Vocational Education. His scientific endeavors are aimed at researching the term "university-didactic thinking". Wenzel defines "university didactics" as a special kind of didactic. In this way, he makes term explications in such a way that the basic concepts of the didactics of vocational education and training are transferred to the teaching and learning situations in the higher education sector. One of his merits is for example the transfer of the "goal" categories to the field of academic teaching. In this connection were specified the functions of classical organizational forms of academic teaching such as lecture, seminar, proseminar and exercise (see Hortsch & Reese, 2012). Another important goal for Prof. Wenzel was maintaining or even expanding the traditions of engineering pedagogical teaching in national and international context. A further step in engineering pedagogical research was presented at the 1st Engineering Pedagogy Colloquium organized at the TU Dresden (February 2000) by Prof. Binger (Faculty of Mechanical Engineering) and Prof. Hortsch (Faculty of Education). With participations of guests of all universities of the Free State of Saxony, the International Society of Engineering Education (IGIP), VDI, Siemens AG and guests from other universities was an important step to fix and present scientific results on Engineering Education.

During the time of the occupation of the professorship for Engineering Pedagogy by Prof. Wenzel were offered two-semester courses with the name "University didactics". They aimed a "didactic minimum qualification" on the academic staff and were positive evaluated by the academics at the TU Dresden (see Hortsch et al., 2012). Since the retirement of Prof. Wenzel the tradition and innovation of the Dresden School of Engineering Pedagogy continued working at the Chair of Didactics of Vocational Learning leaded by the Prof. Hortsch. The majority of the courses with matters in Engineering Pedagogy and didactics are realized at the present by Dr. Kersten, Chair of Didactics of Vocational Education at the TU Dresden.

2 Needs-oriented Engineering Pedagogy

2.1 The approach of the Dresden School on needs-oriented Engineering Pedagogy

At the development of the Dresden School of Engineering Pedagogy can be recognized different contributions. On the one hand could be clarified that Engineering Pedagogy, in a traditional view of higher education didactics, is a target group oriented design of teaching and learning processes in academic Engineering

Education. Moreover, Engineering Education at TU Dresden is also aimed at future engineers, for instance at the design of social-communicative processes in the leadership of engineers. From this point of view, in the last 20 years, have been developed different courses that prepare future engineers for their tasks in the areas of employee management, team development, conflict management, problem-solving processes as well as the design of informative, explanatory and argumentative communication processes. In this way, it is possible to recognize research processes for the Engineering Education and Pedagogy that are geared to different demands and, at the same time, needs to be covered for different factors.

Kersten (2015) proposes a differentiation between four different factors that influence and condition (demands) the Engineering Education: (i) the economic and production sectors of a country, (ii) engineering sciences, (iii) society and culture of the country and (iv) the individuals who study engineering (see Kersten, Simmert & Gormaz, 2015):

- **Economy.** The labour market is a window that shows the demands of production and services. The labour market of a region has a strong relationship with the structure of the economy. Concerning this, the relation between industry, agriculture and service has the same importance than the development of different sectors in industry, trade and service. These factors determine decisive the demand for qualified engineers and the characteristic of their qualifications, for the present and the future. The specific demands on the employees concerning their required qualifications, abilities, skills, knowledge and experiences are determined by the character of professional work in the structures of production and service.
- **Society.** Engineering Education and Higher Education is part of a social and political system. In so far, Engineering Education has to meet the demands and needs of the society. These demands are determined by political systems, cultural developments, the history and the development of the society, ideologies, religions and concluding from it, by values, norms, views and attitudes. The term "demand-orientation" contains accordingly also the social demands. The individual development of social adjusted values, norms, views and attitudes is the socialization part of the Engineering Education.
- **Science.** Production processes and professional labor are influenced by the development of technique and technology and thus by the development of related sciences. Technological advances and the new knowledge generated are constantly observed, as well as the optimization of systems and production processes based on scientific knowledge that sometimes must be reformulated. All this generates permanent demands and needs to update knowledge the verification and new uses of them.
- **Student.** The design of teaching and learning processes in Engineering Education has to correspond with the individual characteristics of the personality of learners: pre-conditions of the learners, age-specific psychological characteristics, individual values, norms, attitudes and needs of learners.

To these factors must be added a key-factor to the learning process in engineering: the **teacher**. Since Lohmann (1951) to the actually has been looked with special emphasis the domain of the academic staff on the specific knowledge of each area of the engineering sciences but also of the knowledge, methods and tools for its teaching. Figure 1 shows a systematization of the five factors that generate the demands and needs in the Engineering Education.

The university didactic perspective in Engineering Pedagogy works for the qualification on academic teaching of the staff in the engineering sciences. In addition to demand-oriented further education courses on Engineering Pedagogy and didactic fields of activity (for example laboratory didactics, control and evaluation of study results and intercultural communication), has been developed a range of courses for university teachers that builds on the requirements of designing teaching and learning processes in the field of Engineering Pedagogy prepared specially for the academic Engineering Education.

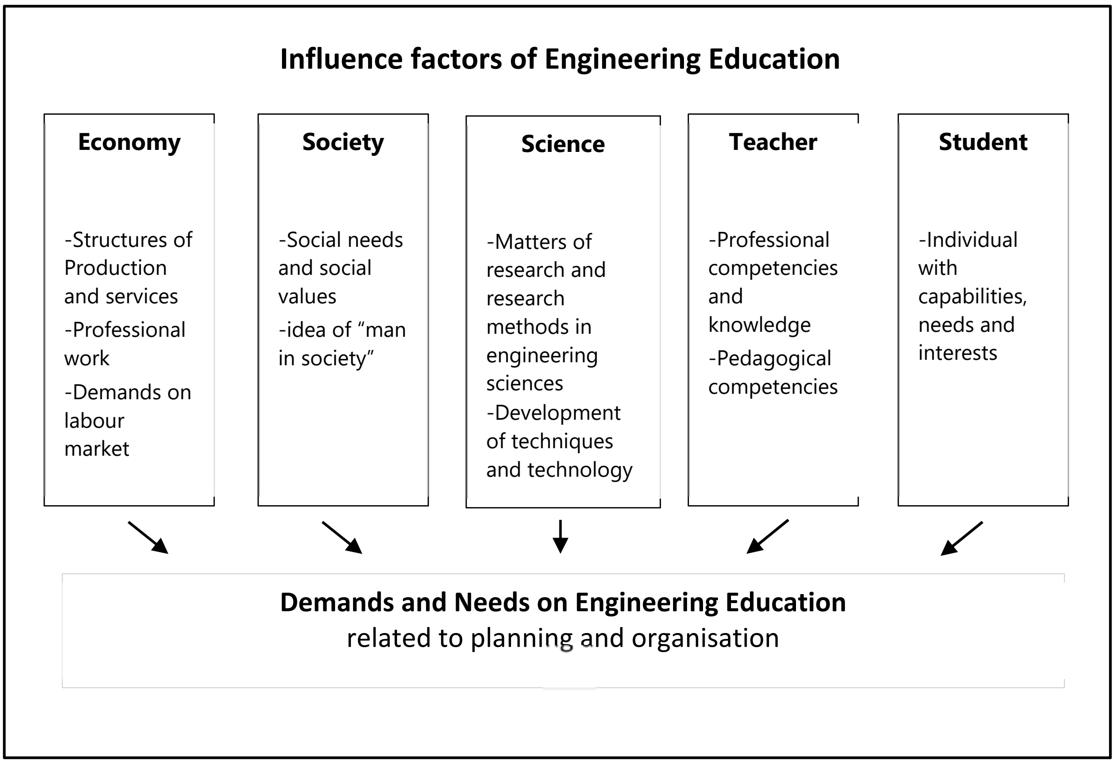


Figure 1. Influence factors of Engineering Education

For the project E-Didactic a Team headed by Prof. Hortsch and Dr. Kersten (Chair of Didactics of Vocational Learning, TU Dresden), developed a needs-oriented training program for academic staffof engineering faculties with a scope of 20 Credits Points and consists of 4 module areas with a total of 12 study modules.

Goals and contents of the study program were determined together with the engineering science staff of the University of Applied Sciences Zittau / Görlitz in a needs analysis and led to the following module structure (see Table 1). The study program is accredited by the International Monitoring Committee of the International Society for Engineering Pedagogy (IGIP) as a study course for the certification INTERNATIONAL ENGINEERING EDUCATOR "ING.PAED.IGIP", and certified by the board of the Engineering Pedagogy Science Society (IPW) as a degree program for the ENGINEER EDUCATOR (IPW).

Table 1. Modules overview of the Training Program "ING.PAED.IGIP"

Training Program INTERNATIONAL ENGINEERING EDUCATOR "ING.PAED.IGIP"	
I. Engineering didactics fundamentals	
Units	Contents * (*simplified version for this publication)
I.1. Design of teaching- learning processes in engineering sciences	I.1.1. Psychological foundations of teaching and learning I.1.2. Theoretical and practical bases of engineering didactics I.1.3. Didactic Principles I.1.4. Organisation of the teaching – learning processes I.1.5. Structuring of the teaching – learning processes
I.2. Didactic media for teaching in engineering	I.2.1. Concepts and classification of didactics media I.2.2. Functions of didactic media and technological tools I.2.3. Field of action of didactic media I.2.4. Elaboration of didactic media
Units	Contents * (*simplified version for this publication)
I.3. Communication	I.3.1. Design of communication processes I.3.2. Monologic and dialogic Communication procedures

	I.3.3. Conflict identification and resolution
I.4. Control and Evaluation of the learning outcomes in Engineering Education	I.4.1. Registration and evaluation of the learning outcomes I.4.2. Operationalisation of Learning outcomes I.4.3. Procedures for the registration of learning outcomes I.4.4. Evaluation of the learning outcomes
II. Forms of structuring the teaching-learning processes in university contexts	
II.5. Lectures (theoretical courses)	II.5.1. General structure of a University course planning II.5.2. Preparation of a university course II.5.3. Execution of a university course II.5.4. Feedback in a university course
II.6. Laboratory practical training/ self-study	II.6.1. Laboratory training II.6.2. Experiment functions in the teaching – learning processes II.6.3. Exercises and self – study planning
II.7. Engineering internships, written reports, research colloquium	II.7.1 Engineering Internship preparation and research preparation II.7.2 Support systems for internships and for autonomous research II.7.3. Internship analysis and research activities analysis
III. Determining objectives and contents of engineering studies	
III.8. Determination of the study programme objectives	III.8.1. Analysis of the activities in engineering III.8.2. Analysis of the activities related to an university engineering study programme III.8.3. Analysis of social aspects in engineering III.8.4. Analysis of personal aspects in engineering
III.9. Determination of the engineering study programme contents	III.9.1. Fundamentals for the determination of contents III.9.2. Contents determination of an university study programs with regard to the academic activities III.9.3. Contents determination of an university study programs with regard to the societal activities III.9.4. Contents determination of an university study programs with regard to the personal activities
IV. Practical module	
IV.10. Case discussion	IV.10.1. Exemplary documentation IV.10.2. Exemplary reflection IV.10.3. Exemplary evaluation
IV.11. Classes observation	IV.11.1. Documentation IV.11.2. Reflection IV.11.3. Evaluation
IV.12 Final Colloquium	IV.12.1. Planning IV.12.2. Implementation IV.12.3. Evaluation

2.2 Transferences on needs-oriented Engineering Pedagogy

Continuing with the objectives proposed by Prof. Wenzel (internationalization of the Engineering Pedagogy), the Chair of Didactics of Vocational Learning of the TU Dresden headed by Prof. Hortsch established since 90´s work proposals in Engineering Pedagogy and Education with various universities and organizations in Asia (in Vietnam and China for example) and other countries.

Since 2014 works the TU Dresden in cooperation with Chilean universities in two projects with the objective of strengthening Engineering Education.

The aim of the first project "Engineering Didactics at Chilean Universities" (PEDING-Project) is the development and testing of training modules for teaching qualifications of teaching staff in academic Engineering Education based in the IGIP Curriculum offered for the TU Dresden. Through an analytical adaptation of the results of one study about the training requirements of lecturers at engineering faculties from Saxony (Germany) (see Köhler, Umlauft, Kersten & Simmert, 2013), Gormaz (2014) systematized in clusters categories and indicators/aspects, which later were used in the recollection instrument on teaching needs of the engineering faculty of three Chilean universities: Universidad Autónoma de Chile (UA), Universidad de Magallanes (UMAG) and Universidad de Talca (UTAL) (see Gormaz & Kersten, 2014). In general the instrument and indicators seek to obtain information about: (i) characteristics of lecturers (years of experience, subject matter, etc.), (ii) experience and needs related to engineering didactic fundamentals, (iii) requirements for the structuration of Teaching -

Learning forms in a university context, and the setting of objectives and contents of an engineering degree, and, (iv) identification of strengths and weaknesses, together with the conditions to enrol in a training course. The results of this research about the needs in Engineering Education were used in the development of the training modules and created the bases of a training course offered in 2018, modelled from the learning module structure according to IGIP (International Society for Engineering Education) and the TU Dresden, Faculty of Education.

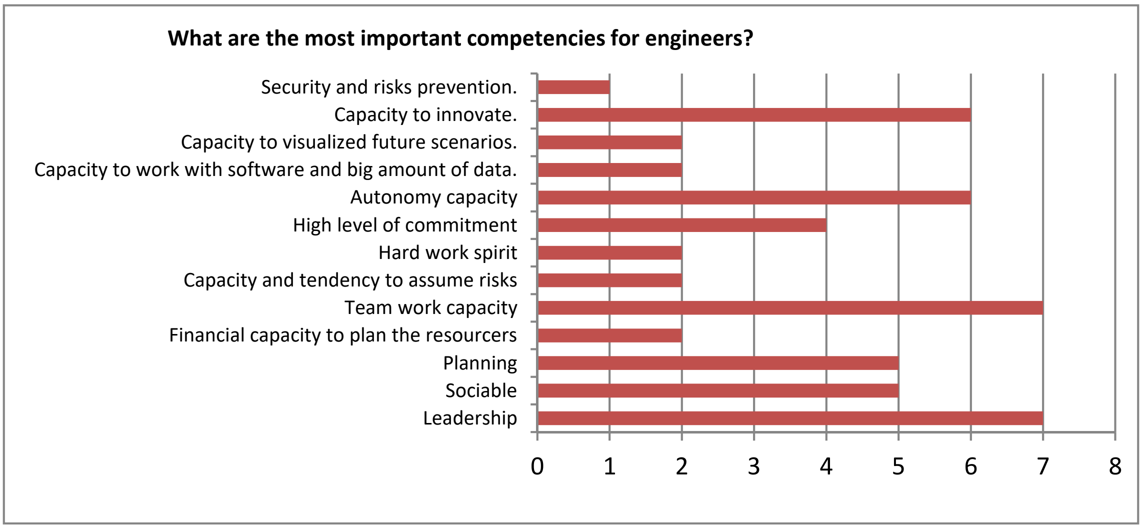
The aim of the second Project "Strengthening engineering training at Chilean universities through practice partnerships" (STING-Project) is the development and testing of training modules for students (either for electrical or mechanical engineers) and teaching qualifications of teaching staff in academic Engineering Education based in demands and employment- requirements of German and Chilean companies. For this reason was developed a questionnaire by the TU Dresden and the Universidad de Santiago (USACH) as part of a stage of information gathering to obtain the strategic positioning and future development of the participant enterprises. The goal of the application of this questionnaire is to know the opinion of strategic staff of the companies regarding the actually needs and the projected future scenario for engineers, and the type of "technology transferences" between university-company. The results of this survey were used in the development of two training modules for students at the USACH.

Some results obtained with the surveys applied to the academics of three Faculties of Engineering and the strategic Staff (experts) of seven companies are presented below (see Hortsch, Gormaz-Lobos, Galarce-Miranda & Kersten, 2019):

- **Perception and needs in Engineering Pedagogy and Education at the universities**
  Regarding the need for different skills and pedagogical tools for university teaching in engineering careers, was asked "How necessary do you consider the following aspects of Engineering Pedagogy in relation to your teaching experience?" For this section, 28 aspects were considered based on criteria and results of the E-Didactic-project (see Gormaz & Kersten, 2014), being the most relevant those related to the evaluation methods, among which stand out with more than 90% of the preferences aspects such as: "Evaluation and assessment of achieved learning" and "Knowledge about design for effective measurement of achieved learning". Then with more than 85% of the preferences are "Structuring of teaching-learning processes in the scientific training of engineers", "Use of didactic resources and information and communication technologies" (ICTs). The results by university do not suffer major modifications. Some discussed aspects present a great difference between the institutions. In 3 aspects, the UA has preferences above 85%, while UMAG and UTAL are under 66%: "Recognition and resolution of conflicts within the classroom", "Planning of activities for individual study" and "Analysis of the personal scope of engineering in Chile". Another aspect where there is a marked difference is "Knowledge about strategies to support professional practices and independent research activities" where the UA and UMAG have preferences over 81% while UTAL does not reach 55%. These differences may be due to the different programs given at each University, as well as to the institutional and social context and to the training given to the participants.
- **Perception and needs in Engineering Pedagogy and Education at the companies**
  Regarding the need for different knowledge, skills and technological tools for the teaching in engineering careers, the strategic Staff (experts) of seven companies answered to the question "What are the most important competences for engineers?" The results are presented in Figure 2 and show many different competences like "leadership", "team working" and "autonomy" are the most valuable skills for companies, whit 87.5%, 87.5% and 75% of the preferences, respectively. Another question was oriented to the importance of innovation and research. The companies were asked "How relevant is for you that engineers students have experience in innovation and research project through their university time?". The 37.5% gave 5 out of 5 points (most relevant) to these characteristics, while a 37.5% gave out of 4 points and 25% gave 3 out of 3 points. Therefore, the tendency to appreciate the experience of students in innovation and research projects is noticeable. In relation to needs about technical software for electrical and mechanical engineers, the most popular option was Microsoft Office, which includes Excel, Power-Point, Word, and Outlook, with five preferences (93%). Then, AutoCAD was the second option (86%), and finally "Project" comes in the third place.

In the same line of thought, the following question is "Choose the most important technical subjects in electrical and mechanical engineering".

Figure 2. Competencies for engineers, STING survey 2017



3 Conclusions

The contributions and impacts of the scientific developments generated at the Dresden School of Engineering Pedagogy over the years are considerable. The conceptions, methodologies and tools developed by Lohmann, Lichtenecker, Lehmann, Wenzel, Hortsch and Kersten among others have been fundamental to understand and generate better teaching and learning processes inside the engineering faculty of the TU Dresden and other faculties of the world. In this article, we have focused specifically on the need oriented perspective of the Engineering Pedagogy that as mentioned above appeals to collect needs of five "actors" (economy, society, science, university teachers and students) to plan, develop and evaluate a better engineering learning processes.

From the results obtained from the "needs" surveys, it is possible to conclude, that the academic communities of the studied engineering faculties, tend to converge on the pedagogical capacities that are required to train the future engineers. Chilean academics from different engineering faculties are willing to train and incorporate systematic knowledge and skills, based on the tools of Engineering Pedagogy, to enhance the skills they already possess and thus improve the strategies and methods of teaching directed to its students. From the results of the survey of the PEDING project were identified many different needs in the field of engineering didactics: (i) "Evaluation and assessment of the students' learning achievements", (ii) "Organisation of teaching and learning processes for the scientific formation of engineers", (iii) "Theoretical and practical knowledge about the didactics for the teaching and learning process in engineering", (iv) "Knowledge about how to design effective measurements of the learning accomplishments", and (v) "Use of didactic resources and of information and communication technologies (ICTs)".

As shown on the results of the STING survey, the companies identified many needs for the education process of engineers in relation to current and future industrial requirements. In general, the main needs in Engineering Education for the companies were: (i) to increase team working during student's careers, (ii) to renew high-tech equipment to improve laboratories and thesis projects, (iii) to increase the link company-university through the development of joint projects, (iv) to incorporate new technologies into classical Engineering Education, and (v) to promote applied research. Additionally were identified for example that: (vi) engineers must have the analytic capability, and they must be able to learn on their own, (vii) the communication company-client is fundamental and must be considered in Engineering Education, (viii) team working and leadership are fundamental either for junior or senior engineers, and (ix) because of the characteristics of Chile, engineers must know how mining industry works and the security regulations.

A need-oriented Engineering Pedagogy seeks to establish a teaching and learning process that is better focused on the context where it develops. This process can start meeting needs of the labor market, the society, or another "factors": but everything should be oriented to facilitate the development of skills and acquisition of knowledge by the future engineers, based on appropriate scientific knowledge with the appropriate pedagogical methods in the context of the 21st century.

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Course Design and Development: Focus on Student Learning Experience

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Abstract

Learning is not an outcome and, as a process, is more than just taking classes. It is a transformation journey a student walks through, and experiences picked up along the journey contribute gradually to student competence development. Competence, what companies are looking for from graduates, cannot be handed directly and will not be built unless the learning process is properly designed, developed and executed. This research work aims to present a process for course design and development, focused on embedding learning experience into a course. Bloom's Taxonomy is utilized for identifying learning outcomes. Kolb's Experiential Learning Cycle is introduced for planning learning activities for ease of learning. Last, but not least, a recently developed LOVE model is applied for the selection of teaching and learning methods for offering a diversified learning experience. An existing project-based learning engineering postgraduate course on Product Design and Development is assessed to illustrate the proposed process for course design and development.

Keywords: Bloom’s Taxonomy, Kolb’s Experiential Learning Cycle, LOVE model, Course Design and Development, Learning Experience.

1 Introduction

Learning is not an outcome. It is a process that creates neither knowledge nor skills nor competence. In fact, it is a process that creates an experience unique to individual students. It is a transformation journey an individual student walks through, and experiences picked up along the journey contribute gradually to the development of the student’s knowledge, and skills. According to the report from the world economic forum (WEF, 2016), employees of 2020 are expected to be equipped with these top 10 skills: complex problem solving, critical thinking, creativity, people management, coordinating with others, emotional intelligence, judgment and decision making, service orientation, negotiation, and cognitive flexibility. Graduates are expected to be equipped with these skills and developed to have the competence to apply their knowledge and the skills to solve unforeseen complex problems. Unfortunately, competence cannot be handed directly and will not be built unless the learning process is properly designed, developed and executed because competence is developed from a strong experience.

Over the last six decades, engineering education has been designed principally based on engineering science model (Dym et al. 2005). The first two years are dedicated to a solid basis in science and mathematics to be a foundation for the next two to three years where students apply those principles to technological problems. Knowledge-focused teacher-centered learning has been a common practice and balanced with technical skills development. With this learning approach, knowledge is pushed to the students. Instructors typically design a course in a forward manner, meaning they decide what the students should learn; focus on the content development and on how to teach the content; develop assessments around their learning activities; and then attempt to draw connections to the learning goals of the course (Bowen, 2017). Since only the beginning is clear but the destination is not, learning outcomes may not be achieved. Students learn and gain their experiences mainly from lectures, assignments, laboratory sessions, project works, and a final-year project but what they have learned most of the time is inadequate to produce strong experience to build their competences. Furthermore, it is also not unusual to see the students manage to pass examinations without a comprehensive understanding of the subjects which reflects the failure to achieve the learning outcomes of the courses.

Backward course design has been introduced and well accepted as an alternative to help improve student learning. With this design approach, knowledge is pulled to fulfil the requirements for achieving the learning outcomes. The instructors start thinking from a student's side with what they want students to be able to do after the completion of the course, followed by how to assess whether the students have achieved the learning outcomes, and move back towards the content development and on how to teach the content (McTighe & Wiggins, 2012). With a clear final destination, it keeps the instructors focus on achieving the final outcomes, and Bloom's taxonomy as illustrated in Figure 1 is a helpful and widely used resource for developing learning outcomes (Krathwohl, 2002).

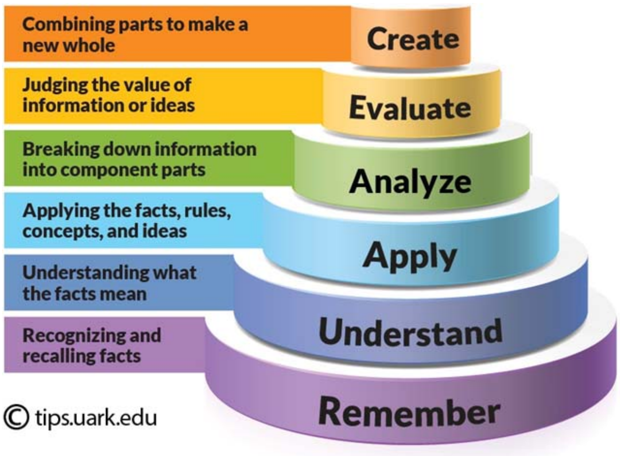


Figure 1. Bloom's Taxonomy (Shabatura, 2018).

Besides reversing process from pushing to pulling knowledge, shifting emphasis from instructors to students will also enhance the student learning experience. Student-centered learning has received much attention in engineering education in the 21st century (Mohd-Yusof, 2017; Lima, Andersson & Saalman, 2017; Koomsap, 2018). Putting students in an active role will further improve their learning beyond remembering and understanding the context of a subject towards being able to apply the knowledge and skills gained in other unseen problems. Lecture, a predominant direct teaching method in many higher education programs (Sajjad, 2010; Močinić, 2012) in particular, has been critiqued of being insufficient to support the intellectual and emotional involvement of the students in the cognitive process because activities for the students are listening, watching and reiterating, and is perceived to be inadequate for deeper understanding, problem-solving and creative work (Sajjad, 2010). Replacement with more efficient teaching and learning methods has been voiced out. Problem-based learning—PrBL (Mohd-Yusof et al., 2005; 2011; Salleh et al., 2007), project-based learning—PjBL (Hadim and Esche, 2002; Arana-Arexolaleiba and Zubizarreta, 2017; Lima et al., 2017), online learning (Iqbal, 2014) and flipped classroom (Toto and Nguyen, 2009; Zappe et al. 2009; De La Croix and Egerstedt, 2014; Gullayanon 2014; Kiat and Kwong 2014) are a few examples of innovative teaching and learning methods that have been seen more in delivery of engineering education to support active learning.

Recently, a LOVE model has been introduced to describe learning experience (Hussadintorn Na Ayutthaya & Koomsap, 2017). Student involvement in any educational process can be seen either as active or passive and it would usually depend on the type of approach used by teachers, methods and tools used, and also on students attitude. The nature of the learning process represents the type of connection offered to students during coursework. Absorption occurs when a teacher brings the ready-to-use content to the students. As opposite, students can physically get involved in the process, by participating in it. Learner role implies active engagement of students but with rather specific, teacher originating, content. Observer role is a passive type of experience that is also made on teacher-based content. Visitor role is also passive but the circumstances are not ordinary ones and students can get immersed with the experience that is not, or not completely, prepared by the teacher. Experimenter role is both active and immerse type of experience that gives students partially or fully opportunity to use its own understanding and competences to participate and create the experience. In order to attain to researcher role, students must gain a variety of experiences which are transformative, influential, practical, effective and memorable to shape their research capability (Hussadintorn Na Ayutthaya & Koomsap, 2018). The outcome of this transformation is changing students from knowledge consumers to knowledge producers (Lovitts, 2005; Gardener, 2008). No matter if researcher like attitude and competences or just well-educated graduate are the desired outcomes of educational process LOVE model suggest to include all type of experiences in studying programs and in specific courses. If this is the case, balancing the experiences, which nowadays means including more active and more immersive approaches in education, should give the best results (Prince, 2004; Freeman et al., 2014).

Since some of teaching and learning methods, by their characteristics, share some similarities resulted in providing the same type of learning experience. The teaching and learning methods, reported in the pieces of literature, have been classified into four different categories of experiences (Hussadintorn Na Ayutthaya et al., 2019), as illustrated in Figure 2, to assist instructors for the selection of teaching and learning methods.

V-Visiting (passive immersion)	E-Experimenting (active immersion)
1. Field classes, trips and excursions 2. Conference 3. Virtual reality	1. Project-based learning (PjBL) 2. Laboratory classes 3. Virtual laboratory
O-Observing (passive absorption)	**L-Learning (active absorption)**
1. Lecture 2. Guided conversation 3. Integrated or interdisciplinary teaching 4. Showing video material 5. Seminars conducted in classes 6. Live lecture from a remote place	1. Discussion 2. Demonstration with exercising 3. Class debate 4. Small groups debate 5. Simulation 6. Problem-based learning (PrBL) 7. Programmed teaching 8. Workshop 9. Brainstorming 10. Case study 11. Online interactive learning 12. Game-based learning 13. Guided practical exercises 13. Role play 14. Assignments 15. Individual presentation

Figure 2. Teaching and Learning Methods on LOVE grid (Hussadintorn Na Ayutthaya et al., 2019).

Graduates who have exposure to a variety of learning activities are expected to perform much better than those who have gone through the conventional lecture, homework assignment and conducting laboratory experiment. However, not only learning outcomes and teaching and learning methods should be considered, but how the class is conducted is also important for the student learning experience. According to Kolb's experiential learning theory (Kolb, 1984), learning has a cycle having four stages: concrete experience, reflective observation, abstract conceptualization, and active experimentation, and they connect in this sequence to form a cyclic order. An instructor can design the learning process, to enter students into the learning experience cycle of a subject at any stage, and effective learning occurs when the students cycle through the four stages. Therefore, it is very important for all instructors to be aware of a journey that students walk through and try to ease their learning and to create a strong experience.

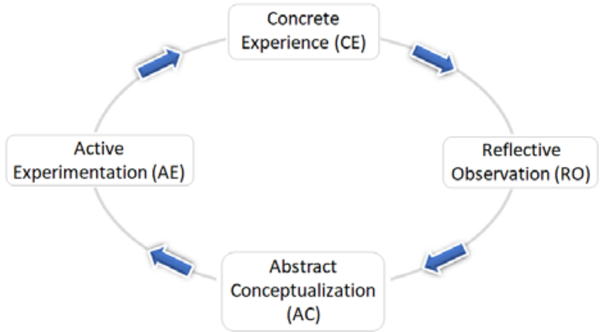


Figure 3. Kolb's Learning Cycle (Kolb, 1984).

This paper aims to make a contribution to the course design and development, focusing on embedding learning experience into a course. This contribution will be based on a process for course design and development following a backward design approach. Bloom's Taxonomy is utilized for identifying learning outcomes. Kolb's Experiential Learning Cycle is introduced for planning learning activities for ease of learning. Last, but not least, a LOVE model is applied for the selection of teaching and learning methods for offering a diversified learning experience. These three modes will be introduced in the next section before the introduction of the proposed approach for course design and development.

2 Learning Experience-Focused Course Design and Development

This section presents a proposed Learning Experience-Focused Course Design and Development (LEF-CDD) process.

2.1 LEF-CDD Concept

LEF-CDD is a student-centered approach focusing on designing a student journey of a course, which eases a student learning and creates a strong experience. How students will learn is as important as what they will learn. Bloom's taxonomy can guide on how to write and set the course learning outcomes properly. According to the Kolb's four-stage learning cycle, effective learning will occur when a student completes the cycle, but rather than expecting the individuals to complete their learning cycle by themselves, a proper design of the course will ensure the majority, if not all, of the students to achieve the learning outcomes. For each of the topics, the instructor can design to enter the students to this cyclic order of concrete experience (CE), reflective observation (RO), abstract conceptualization (AC) and active experimentation (AE) at any stage. When leading with sequential topics, if the cycle of one topic is completed before the introduction of the next one, the students will have a better understanding of the topic, and be ready to learn the new ones. Besides, diversifying teaching and learning methods as described in the LOVE model will further enrich their learning. Therefore, by having a clear set of the learning outcomes and assuming that the topics of the course are arranged logically to achieve them, the skeleton of the student journey is formed. The selection of activities to complete the cycles for all topics provides details to the journey, and the selection of teaching and learning methods decorates a memorable journey. This "ideal" student journey is illustrated in Figure 4.

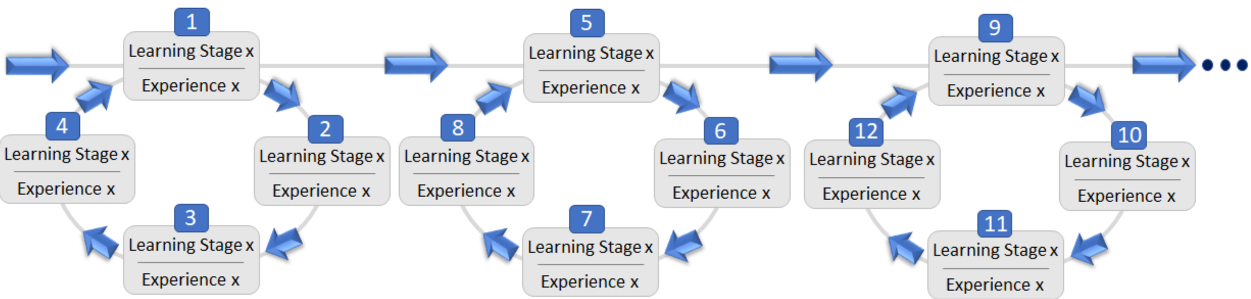
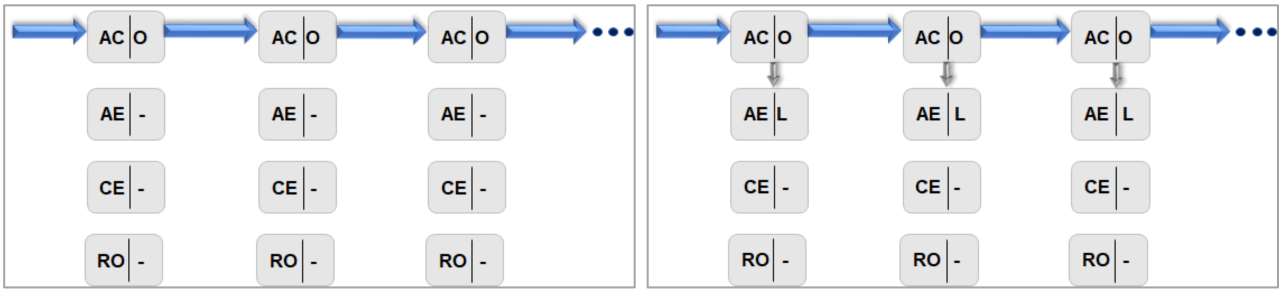


Figure 4. LEF-CDD concept.

The concept can also illustrate a flaw in the old teaching style that an instructor delivers lectures week after week, students enter their learning experience at abstract conceptualization stage and gain observing-experience. If there are no other learning activities and the students do not try to complete the loops by themselves, they will be stagnant at this stage and limited to only one type of experience. As a result, they will only manage to pass the examination, not to achieve the learning outcomes. Homework assignment and laboratory sessions will move them to the active experiment stage and give them learning-experience, but still, they are asked to close the loop by themselves. Unless they put effort to complete a cycle for each topic, their learning remains ineffective. Figure 5 illustrates the scenario.



(a) Intensive Lecture Type Class (b) Intensive Lecture and Assignment Type Class

Figure 5. Student Journeys in Conventional Lecture Type Classes.

2.2 LEF-CDD Process

Similar to other backward designs, LEF-CDD process starts with writing course objective(s), aligned with the expected professional competences, and applying Bloom's taxonomy to write course learning outcomes. The objective presents the purpose of the course and what an instructor will cover in the course while the outcomes present what the instructor expects students to be able to do after the completion of the course. According to the outcomes, course assessment and topics for attaining the learning outcomes are identified. Next, ease of learning and learning experience are considered together for each of the topics. By progressing topic-by-topic, the entry stage to the topic is decided. An entry activity is identified along with the selection of teaching and learning methods. It is important that after the completion of the entry stage the focus is on completing a cycle. The activities and supporting teaching and learning methods are identified for the successive stages. Ideally, most of the times, the cycle should be closed before starting of the next topic. In practice, it might be difficult, but the instructor should try to close the loop as soon as possible. Furthermore, the selection of teaching and learning methods should be diversified.

3 Illustration of the Application of the LEF-CDD

This section illustrates the application of LEF-CDD. Based on the current offering, a postgraduate course on Product Design and Development (PDD) is presented according to LEF-CDD process.

3.1 Product Design and Development

This is a 3-credit course containing 30 hours of lecture and 45 hours of laboratory. Students will learn and practice how to design products systematically in a team environment. It is a participant-centered learning course that the students actively involve. Lecture materials include, but not limited to, slides, case study, games, interesting animations, and videos. Most of the lecture sessions contain discussion and students are encouraged to participate actively in the discussion. For topics such as strategy, obtaining voices of customers, identifying customer needs, and concept generation, there will also be activities in class before students practice them in their projects. To increase understanding of the subject, the students are required to do literature reviews, group project, and presentations. The literature reviews are individual assignments. The group project is for the students to develop and practice several skills including, but not limited to, decision making, problem-solving, communication, critical thinking, negotiation, conflict resolution, and teamwork. Presentations are a part of the project and assignments for personal development and knowledge sharing.

Lectures and group project are run in parallel. For laboratory sessions, all groups will share their progress on the projects to the class and receive feedback from their instructor and classmates.

In sequence, the application of the LEF-CDD process will be illustrated by presenting the course objectives, the expected learning outcomes and the planned learning experiences, classified according to the Kolb's and LOVE models.

Course Objective:
Effective product design and development process is necessary for a company to be competitive in the market. The objective of this course is to provide students knowledge on a systematic approach for product design and development process. In this course, the students will learn and practice how to systematically design products in a team environment.

Learning Outcomes:
On the completion of this course, students should be able to: 1) analyse products offered in a market for their effectiveness; 2) develop a mission statement according to the identified business opportunity; and 3) systematically apply knowledge learned for the design and development of a product.

Assessment Scheme:
The weight distribution for calculating the final grade is as follows: final examination 30%, group project 40%, individual assignments 10%, and class participation 20%.

An "A" would be awarded if a student can demonstrate a clear understanding of the knowledge learned in class as well as from literature reviews, can apply the knowledge appropriately in the project, and involve actively in class discussion.

Course Outline:
The topics covered in this course are presented in Table 1, and according to learning activities in the course, the sequence of learning stages is identified. Learning experiences are also analyzed from the teaching and learning methods used.

3.2 Discussions

As illustrated in Table 1, a sequence of learning stages and learning experience have been introduced into the topics. It can be seen that abstract conceptualization (AC) is the common entry stage for most of the topics. Besides, concrete experience (CE) is the entry for course explanation and video illustration of previous years projects at the beginning, and active experiment (AE) is the entry for the Kano model and concept generation.

It can be seen that cycles can be completed quickly when the instructor introduces cases or activities during the lectures instead of waiting for the students to close them during the project time. For example, for the topic of blue ocean strategy, the instructor gives a case study for the student to practice in a group. All groups present their strategies to class to share and get feedback and finish with group discussion. The learning cycle of this topic conducted recently is illustrated in Figure 6. For other topics with no activities during the lecture, the students will complete the cycles after they experience them in the project and sharing them to the class to get feedback during the laboratory sessions. Since some of the project activities take time, the students cannot complete them before the starting of the next topics. If the instructor can bring in activities to the lecture, the cycle will be completed much sooner. There exists also topics at the end of the course that the students will have to complete the learning cycles by themselves.

In term of learning experience, the students will gain L, O and E types of experience from lecture, case study, presentation, group project, class discussion but if the instructor can take them to see this product design and development process be done in practice, LOVE learning experience will be complete.

Table 1. Learning Experience Embedded Course Outline.

Main Topic	Subtopic	Sequence of Learning Stages (Learning Experience)			
		AC	AE	CE	RO
I. Importance of Product Development	1. Introduction			1 (O)	2 (L)
	2. Product Development Strategies	3 (LO)	4 (LE)	5 (LO)	6 (L)
	3. Development Processes and Organizations	7 (LO)			
II. Product Concept Development	1. Mission Statement	8 (LO)	9 (E)	14 (LO)	15 (L)
	2. Customer Need Assessment				
	2.1 Obtaining Voice of Customers	10 (LO)	11 (LE)	12 (LO)	13 (L)
	2.2 Identifying customer needs	16 (LO)	17 (LE)	18(LO)	19 (L)
	2.3 Kano Model	23 (LO)	20 (LE)	21 (LO)	22(L)
	3. Product Specifications	24 (LO)	30 (E)	31 (LO)	32 (L)
	4. Quality Function Deployment (QFD)	25 (O)	34 (E)	35 (LO)	36 (L)
	5. Concept Generation	29 (O)	26 (LE)	27 (E)	28 (L)
	6. Concept Selection	33 (O)	40(E)	46 (LO)	47 (L)
III. System Level Design for Product Development	1. Process Driven Design	37 (LO)	41 (E)	46 (LO)	47 (L)
	2. Product Architecture	38 (LO)	42 (E)	46 (LO)	47 (L)
	3. Industrial Design	39 (O)			
	4. Design for manufacturing	43 (O)			
	5. Prototyping	44 (O)			
	6. Economics of Product Development Projects	45 (O)			
	Entry Stage				
	Fulfil during the group project				
	Self-learning				

Presented in Figure 7 is the summary of student surveys conducted after the deliveries of the blue ocean topic to Master students at two different universities. The delivery at Asian Institute of Technology (AIT) was a part of a regular course and at Thammasat University (TU) was a three-hour seminar. The feedbacks were very similar. Overall, the students were satisfied with the deliveries. Additional information about the survey are as follows:

AIT Master's Students (2nd year student):

- Demographic data (valid responses = 8): male = 50%, female = 50%
- Some comments and suggestions from this group of students are 1) a valuable course to follow in an excellent working environment; 2) PDD session is interesting because the class arrangement is different from common classroom studying sessions; 3) module is interesting and we are getting time to express our ideas and improve thinking in different ways; and 4) love attending this course.

TU Master's Students:

- Demographic data (valid responses = 47, total responses= 52): male = 34%, female = 66%; 1st year student = 57%, 2nd year student= 43%
- Some comments and suggestions from this group of students are 1) I gained pretty much of knowledge from this class; 2) the quality of instruction and instructor was good; 3) the instructor was widening my perspective from the examples of many brands; and 4) I would love to attend his other seminars.

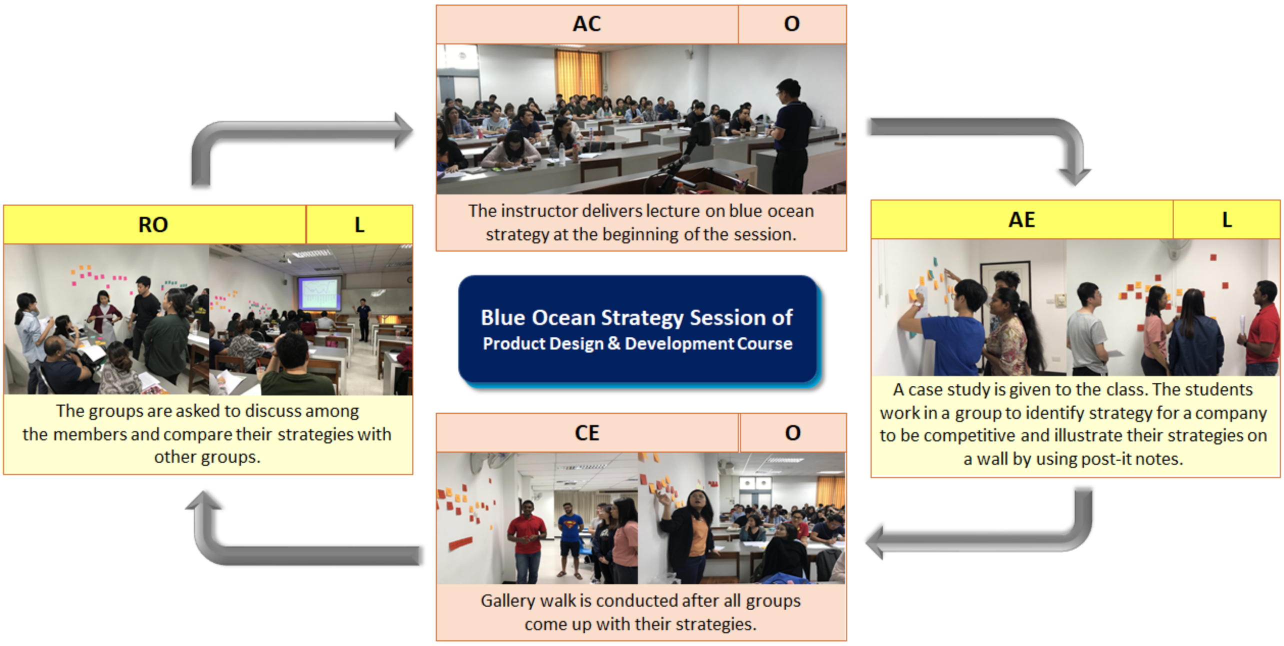


Figure 6. Learning Experience Cycle of a session on Blue Ocean Strategy.

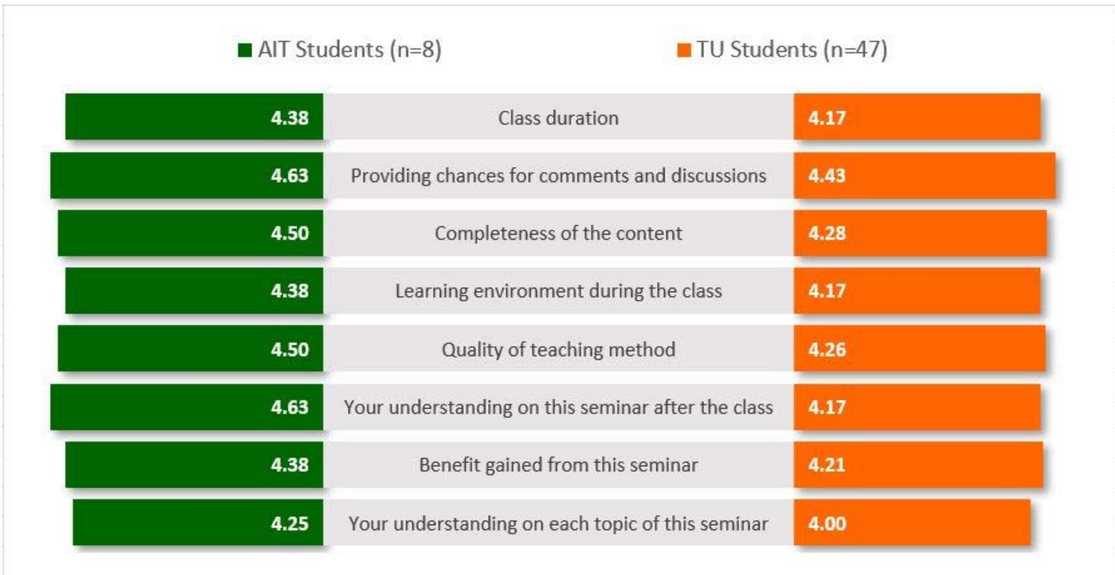


Figure 7. Student Satisfaction on Blue Ocean Strategy Session of Product Design and Development Course.

4 Conclusions

Engineering instructors are not required to obtain educational training on curriculum design, development and delivery before entering the profession of being a teacher. Thus, usually, teachers mainly replicate their experience as students, focused on teacher-centered activities. Nowadays, student-centered learning activities are known to be the most effective for learning success. A process of course design and development that embed learning experience has been developed. The development was based on the following main principles: the course should be aligned with the professional needs; the expected development of the students should be clearly stated by learning outcomes; the learning experiences should respect the Kolb's learning cycle with the application of experiences intentionally chosen by the instructor, in this case, based on the LOVE model. This model was applied to a Master Product Design course and applied into settings. The perceptions of the students were mainly positive. Despite the fact that this design process should be analyzed with a large number of courses, instructors, and students, this first experience gave good indications of its usefulness. The team has the intention to apply this model in more course design experiences, which will give an opportunity to analyze further its usefulness and its robustness.

5 Acknowledgements

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Proposal of a collaborative interaction in an engineering discipline with an active approach based on problems and projects

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Abstract

Active teaching approaches have been widely used in engineering and some aspects of collaborative learning, target studies and applications. In this context, among the expected gains from entering collaboration is that besides improving individual outcomes, student teams can contribute and interact with others to drive learning. This study aims to present an experience of insertion of a collaborative learning in a discipline whose methodology involves Problem Based Learning and Project Based Learning. The methodology is proposed in an engineering discipline where the projects are developed by teams in order to solve real problems related to Production Planning and Control. The proposed collaboration extrapolates the universe of each team and the results of the experiment contemplate, among other aspects, the students' understanding of the projects developed by other teams and the proposal of different solutions to the problems worked. In this way, the teams contribute technically with others and the perspective of the evaluated teams is shared with the whole class in search of enriching the teaching-learning process.

Keywords: Collaborative Learning; Problem-based Learning; Project-based Learning; Engineering education

1 Introduction

Traditional engineering educational strategies, such as lectures, lab experiments, and work from home, have been criticized as inadequately preparing engineering students to engage in collaborative partnerships that are essential to the practicing engineer (Kalonji, 2005). These methods have also been criticized because they promote passive learning and a compartmentalized curriculum that may not prepare students for the innovative and flexible role of today's engineers (Duderstadt, 2008; Guzdial, Ludovice, Realff, Morley, Carroll, & Ladak, 2001; Heywood, 2008; Prince, 2004). In an educational context, collaboration is often described as an approach involving joint intellectual efforts among students or between students and the instructor (Smith & MacGregor, 1992).

Despite the recognition by the private sector that collaboration is a vital skill for the practicing engineer and the recognition by researchers that collaborative learning contributes to academic performance, much of the engineering literature describes the curriculum oriented towards the retention of facts and analytical skills (Guzdial, Ludovice, Realff, Morley, Carroll, & Ladak, 2001; Felder, & Brent, 2005; French, Immekus, & Oakes, 2005; Zhang, Anderson, Ohland e Thorndyke, 2004; Reis, Barbalho, & Zanette, 2017).

The central element of collaborative learning is collaborative versus individual work, and therefore the analysis focuses on how collaboration influences learning outcomes. The results of some existing studies on this issue are consistent. In an analysis of 90 years of research, Johnson, Johnson, & Smith (1998a) found that collaboration improved learning outcomes in relation to individual work across all sectors. Similar results in Johnson, Johnson, & Smith (1998b) research, which analyzed 168 studies between 1924 and 1997. Springer Stanne & Donovan (1999) also found similar results looking at 37 studies of students in science, math, engineering and technology.

The Project or Problem Based Learning (PjBL / PBL), both with PBL acronyms, is a teaching approach aimed at engaging students in the investigation of real problems. In this model, students seek solutions to non-trivial problems by discussing ideas, making predictions, developing plans and/or experiments, collecting and analyzing data, communicating their conclusions to other students, raising new questions, and creating artifacts

(Blumenfeld, Soloway, Marx, Krajcik, Guzdial, & Palincsar 1991). This method gives students the power, together with their professors, to build a global (Brandão, Lessandrini, & Lima, 1998).

This study aims to present an experience of insertion of a collaborative learning in an engineering discipline whose methodology involves PBL and PjBL, which projects are developed by teams to solve real problems related to Production Planning and Control.

Section 2 presents the discipline object of study, then in section 3 the methodology adopted, section 4 the results and discussion, section 5 the conclusions, and the references are in section 6.

2 The PSP4 discipline in the PBL context

The student of Production Engineering at the University of Brasília (UnB) has his curricular subjects based on the Production Engineering areas according to the Brazilian Association of Production Engineering (ABEPRO). These subjects, called Production Systems Project (PSP), were designed to carry out projects in the period of one semester, using the PBL/PjBL approaches and collaborative learning as a way to solve real problems. Several studies presented the application impacts of the active learning within the Production Engineering of the UnB (Reis, Barbalho, de Araújo, Brito, Ishihara, & Teixeira, 2018; Monteiro, Reis, Silva, & Souza, 2017; Barbalho, Reis, Bitencourt, Leão, & Silva, 2017; Barbalho, Reis, da Silva, & Malta, 2018), involving some indicators from historical analyzes, even the development of competences from the perspective of the students. As Monteiro, Reis, Silva, & Souza (2017) cites, with the application of this methodology, students are able to assimilate the theoretical content, looking for knowledge that aims at solving a given problem.

The anchor field are the disciplines carried out in the same academic period that act together through some technical content, usually taught by the same professor. The anchoring courses of Information Systems in Production Engineering (SIEP), Production Planning and Control (PCP), Production Quality Management (GQP), Product Engineering (EP) and Strategic Management (GE) act as co-requisites for the realization of the main PSPs disciplines. Due to the diversification of the proposed disciplines for each course, there are several variations in the way each on them is taught, and consequently, changing the way in which the PBL is implemented. As shown in Figure 1, among the basic disciplines of the course, the PSPs are usually taught by the same professor and act together with another course in the Production Engineering.

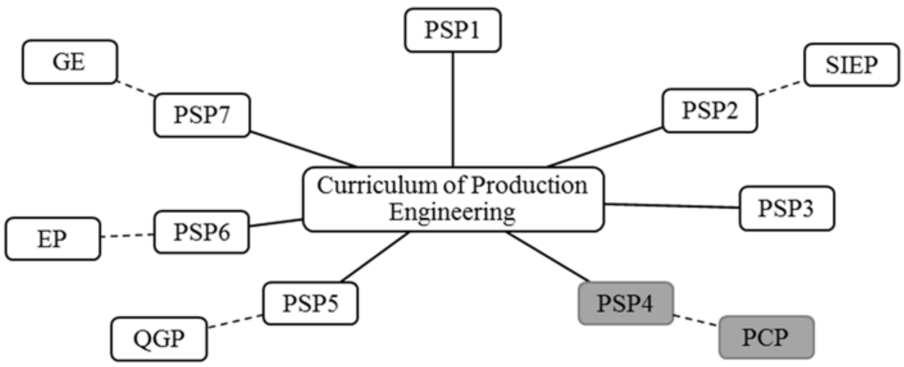

Figure 1. PBL-based Production Engineering curriculum with the identification of PSP4.

From the previous studies in the PSP4, which the anchor discipline is PCP, this work contributes to an investigation in order to understand the gains, in terms of learning and development of transversal competences, since the collaboration measures in the course have been implemented. Collaborative learning is a variety of active learning (Keyser, 2000) in which the instructional use of small groups is performed, so that students work together to maximize the learning of themselves and each other (Johnson, Johnson, & Smith, 1991). Collaborative learning should be planned, taking into consideration the size of the teams, the role of each student within, and how the results will be evaluated and used in the classroom.

According to Keyser (2000), collaborative learning is applicable to teaching advanced research skills with several steps to be followed. Thus, the implementation of a collaborative practices in PSP4 changed the basic structure of the course in the perspective that the collaboration ceased to be only between professor and teams and became interconnected, meaning that all the teams started to contribute directly and actively in all projects of other teams. The role of technically contribute to the projects of the teams is no longer exclusive to the professor, being also adopted by the teams, which contribute to each other, as shown in Figure 2.

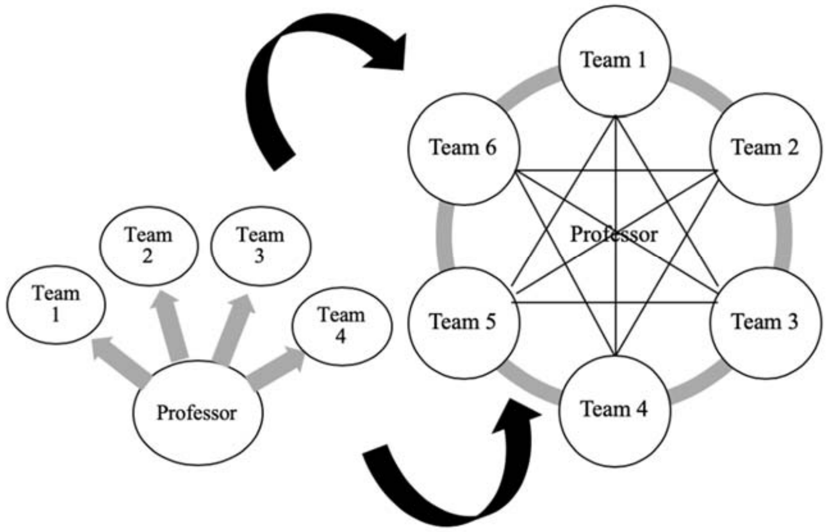

Figure 2. Evolutionary structure of PSP4: implementation of collaborative learning.

From the collaboration within a new disciplinary structure, the students began to have more contact with other projects in progress by other teams. Thus, the classroom environment became more open so that the groups aligned the methods and techniques applied in the projects themselves to address any doubts that they might have during the semester, which made possible a greater engagement among more dispersed students and those with greater involvement with the discipline.

Prior to the implementation of a collaborative interaction, the classroom environment consisted of teacher evaluation with regard to collaborations on team projects. Now, the idea of collaborative evaluation involves the participation of all students because they need to interact with others in order to give a technical opinion on the projects presented, besides contributing to the groups themselves. In this way, it is noticed that there is a greater sharing of knowledge between them, in which students with different learning elements collaborate with others, and thus, students can share different perceptions and consolidate theory by helping other teams. The collaborative evaluation shows that by exploring critical thinking about the other teams, students make constructive criticisms that add value to the projects, which allows an efficient success in the projects.

3 Method

To investigate the perception of students about the active learning environment and how the interaction between collaborative learning and PBL/PjBL impacted them, an exploratory research was conducted through a case study (Yin, 2015). The object of the study is the PSP4 discipline, offered in the course of Production Engineering at UnB. PSP4 is executed in support of tools and techniques in the area of production management and control, such as inventory control and demand forecasting (Reis, Barbalho, de Araújo, Brito, Ishihara, & Teixeira, 2018), as well as project management techniques using PMBoK (PMI, 2017).

A questionnaire was used to collect data about processes, activities and techniques involved in the projects presented, especially on the insertion of collaboration in the disciplinary environment. A total of 13 closed questions were evaluated, which the Likert 5-part scale is assigned to each of them, reflecting the importance of: 1 to very little; 2 to little; 3 to indifferent; 4 to very; and 5 to extremely. The questions were categorized into five different blocks of disciplines, as presented in Table 1. In addition, the questionnaire was also an open question so that each student could collaborate technically with the other groups during the presentation of the proposed technical solutions in the Intermediary Project. It is important to emphasize that the Intermediate

Project is the second frame of the discipline, preceded by the Preliminary Project and succeeded by the Final Project (Reis, Barbalho, de Araújo, Brito, Ishihara, & Teixeira, 2018).

Table 1. List of closed questions and issues addressed in the collection instrument.

Questions	**Q1, Q2 e Q3**	**Q4 e Q5**	**Q6, Q7 e Q8**	**Q9, Q10, Q11 e Q13**	**Q12**
Subject addressed	Understanding about the project presented.	Relationship of the project with the anchor field.	Contribution of the presentation about the project in progress.	Techniques applied in the project presented.	Team availability for collaboration.

A total of 122 questionnaires were collected related to nine teams, each of them with a project involving a specific problem to be addressed. As an exclusion criterion, the questionnaires with incomplete filling were discarded for the quantitative analysis, which totaled 110 valid answers. The data were inserted into spreadsheets for descriptive content analysis (Bardln, 1977).

4 Results and discussion

In the engineering discipline were formed teams (teams E1 to E9) with different projects, in which each project involved a different organization for the research. From the development of the projects, data were collected on the participation of the students with other teams. Each team sought from a specific client the problem to be addressed during the course, in which they should apply techniques of the anchor course PCP. Thus, Table 2 presents the relationship of the data obtained on each team, as well as their design problems.

Table 2. List of projects and number of responses obtained.

Team	Problem addressed	Questionnaires answered
E1	Forecast demand of the production about an acai company and calculation of indicators to measure the effectiveness of the inventory.	19
E2	Analysis of the productive capacity and forecast of demand of an industrial company of leather clothes.	18
E3	Demand forecasting and inventory management of the health organization with a focus on hematology.	15
E4	Analysis of the production flows and forecast of demand of a company of plant seeds.	14
E5	Forecast demand and analysis of the ABC curve in a family-owned company selling ice cream type products.	13
E6	Analysis of demand and inventory in an ice cream and candy company.	12
E7	Application of demand forecasting and inventory management methods in a traditional Japanese restaurant.	12
E8	Modeling the flow of critical activities and sizing the workforce of a service organization.	4
E9	Analysis of improvement of the processes of the university organization through lean office.	3
	Total	110

The data manipulation was made in spreadsheets by tables and graphs generation to identify the frequency of the evaluations made by the students and statistical indicators. The average evaluation was calculated by performing the weighted average of each questionnaire with a correct score of 1 to 5 for each question. The average assessments per question ranged from 3.4 to 1.8. The amplitude of the evaluations was 1.6, the standard deviation 0.42 and the mean of 2.9. Thus, the frequency chart of the evaluations (Figure 3) shows the behavior of the notes in the course of the questions asked, indicating which of them obtained the greatest results.

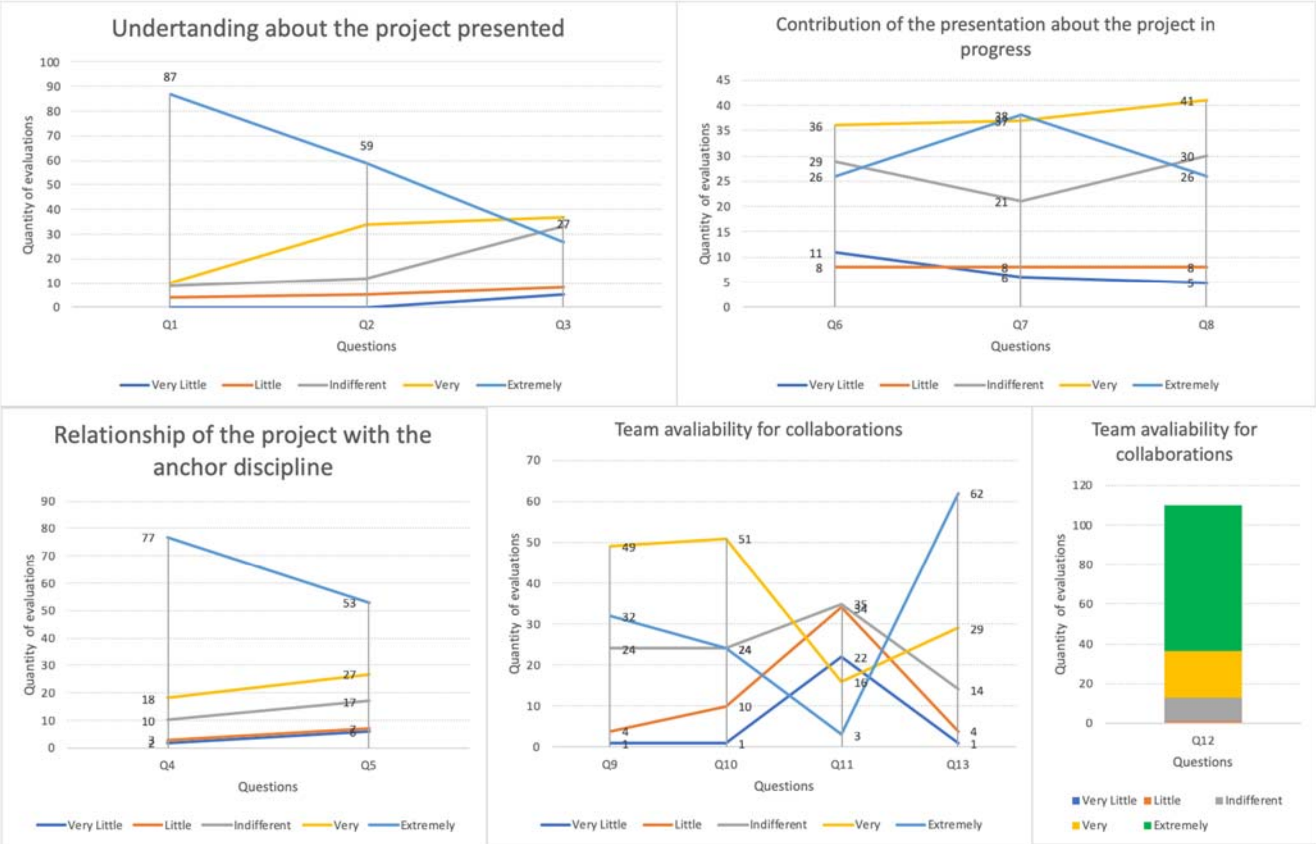

Figure 3. Quantity of evaluations per subject addressed on the PSP4 discipline.

It can be noticed in Figure 3 that the team availability for collaborations was the most relevant point for the class (average = 3,3), which demonstrated that the collaborative learning was a successful implementation in the discipline. The dimensions on the project understanding (average = 3,1) and the relation with the anchor discipline (average = 2,7) were also positive questions for the students, in which the teams demonstrated to relate correctly the problem of project with the PPC discipline. Most projects involved demand forecasting, where teams use historical data on the output of a given product to define the best forecasting techniques for each context. The contribution of the presentation about the project in progress demonstrated the lowest average (2,68) compared to the others.

From the results generated, it was possible to sort the questions through their average evaluations. It was verified that the questions Q1 - Was it clear what the project is about?, Q12 - Was the assessed group available for collaboration from other students?, Q4 - Was there a relationship between the project and PCP (anchor discipline)?, Q2 - Is it clear how the project is being developed? and Q13 - Did the assessed group demonstrate mastery over the technique? obtained the highest scores for the class, indicating that these were the most relevant points positively in their perception. This shows that there were positive issues regarding the understanding of the projects presented, the relationship between the projects and the anchor discipline, and especially the availability of the teams for collaboration. Although Q11 showed a low average, this was the question of the degree to which the student would solve the problem differently. In this way, it was verified that the teams would solve the problems in the same way as the presentation group, in which the improvement points were suggested to be performed in the technical analysis.

These results demonstrate that about 79% of the students clearly understood what the project was about, while 67% of the assessed group was considered available for collaboration with other students. It was identified by the students the direct relation of the project with the anchor discipline PCP, being this the technical part of the execution of the projects for the resolution of problems involving questions about inventory control and analysis of demands forecast. In addition, it was also pointed out that it was clear to students how the project was being developed, thus determining that collaboration in the class, among those involved, favored their perception not only of what they were developing in their own projects, but also of how the other teams were developing.

The lowest evaluations were, in ascending order, relative to Q6 - whether the presentation added value to the project, relative to the complexity of the project (Q3) and whether the presentation of the technical solution facilitated its learning (Q8). Thus, it is noticed that the contribution of the presentation on the project in execution was the point considered less important. It was verified that the teams in general demonstrated confidence in the solutions found, and that the collaborative processes carried out reflected in their opinion on the result delivered at the end. The presentation of the project proved not to be relevant to students' learning, both in technical matters and in professional experiences. The projects were evaluated as low complexity for students, a factor that may be related mainly to the high understanding of the group about the scope and development of the projects presented.

4.1 Collaborative Assessments

The open question sought the student's registration of the other teams regarding the technical contributions to the presented project, opportunities for improvement and changes that the student would perform in that project. In this way, the main information reported by all students regarding the other projects carried out in the discipline was consolidated. The 122 questionnaires collected were considered for the analysis of this question.

Key discourses on the E8 team involved opinions on different aspects of the project, so all team members pointed out their technical contributions to the project in a variety of ways. Some people focused on criticizing the processes of data collection and analysis, indicating improvements both for the process mapping process and for statistical analyzes. Other students reflected on the methodological procedures performed in the discipline, indicating that the scope changes and the final delivery of the project were not clear. However, there was praise regarding the bibliographic references chosen, as well as the questions raised on the methodology adopted in the base book.

About the E9 team, it was emphasized that the group focused mainly on the indication of new ways to apply some technical tools from the statistical control of processes to simplify the solutions to be implemented within the client organization. In addition, it was suggested to analyze the macroprocesses of the outsourced company in order to identify the causes of the organization bottlenecks processes that involved outsourced personnel. Due to the E5 team's focus on working in a retail organization of frozen products, it was mainly highlighted the search for new indicators that influence the sale of these products in places similar to the object of study. In addition, it was strongly emphasized the need to apply other techniques for a better improvement in the planning and production control diagnoses carried out, especially in the matter of working with trend and seasonal analysis of the main products raised by the ABC Curve.

The E3 team relied on implementing improvements to the issue of planning analysis and materials control of the study organization, a Hematology Center. The techniques and analyzes for inventory management were criticized by the majority of students in the other groups, and there was disagreement about the presentation of the project. In addition, it was reported that other techniques could be implemented to improve the final product, such as: kanban, lead-time indicators, supplier logistics strategies and even linear regressions for the treatment of seasonality. On the other hand, the calculations for the demand prediction error, as well as its analyzes, were positively highlighted.

The group E6 related to the ice cream industry received several criticisms regarding the presentation, mainly due to the lack of information on the slides, which left the other students with many doubts. In addition, several analyzes were questioned, implying the lack of theoretical basis, and consequently, the application of the wrong techniques to deal with the company of ice cream. The E2 team was questioned by the analyzes made outside the scope of PCP, focusing mainly on analyzes for budgetary and financial management. While some questioned the team's simplistic methodology, others report that it was applicable in their projects and that it involved several important indicators, which added value for some students. However, the presentation of the team did not contextualize the project, in which the other students reported that they did not remember the scope of this project presented in the preliminary project.

The E4 team received several accolades regarding the project developed. Positive opinions on demand forecasting methods were began, mainly due to intermittent demand. However, other analyzes were carried out with the application of methods that were not restricted only to the content of the anchor discipline, which confused some students during the presentation. Some suggestions for inventory management were indicated, such as the division of the products (seeds) according to the seasons and the consideration of the validity of the seeds for the safety inventory calculation.

The team with the most constructive criticism, E7 team, received comments on both the presentation of the project and the analyzes carried out. Many information was presented in each chart and table, which not only confused the other students but also made it impossible to understand the methodology and results found by the team. In addition, demand forecasting techniques and management indicators were questioned.

With respect to the E1 team, it was pointed out that the group offered superficial solutions to the organization problem, a comment that is often repeated among the other students. Other analyzes of demand forecasting, inventory control and seasonality tests were mentioned for the improvement of the results presented by the team. In short, the group did not delve into the theme and type of product they were dealing with, which impacted on the methodology used in the project.

5 Conclusion

This study aimed to present an experience of insertion of a collaborative learning in a discipline whose methodology involves PBL and PjBL. The methodology proposed in a discipline where the projects are developed by teams to solve real problems related to Production Planning and Control.

The PSP4 discipline at UnB has been an object of study over the last years, since the application of new techniques and approaches has made possible a greater knowledge on how to apply active methodologies for Engineering. The collaborative interaction, provided by the high communication and cooperation between the students in search of the solution of a real problem, presented results that indicated the success of the projects executed in the discipline. Among the gains of working with collaboration in this context is that, in addition to improving individual results, the student teams were able to contribute and interact with other students/professors to boost learning.

Students' perceptions regarding project teams demonstrated that students were available for collaborations with other students during the course, which reflected in the technical knowledge acquired by the class in the final result. It was possible to verify that the understanding of the presented projects, the relation of the projects with an anchor discipline and the availability of the teams for the collaboration were the most important subjects in the students’ perception for the greater reach of knowledge and technical skills in the classroom.

PSP4 is a discipline with a strong active learning component, in which there is a great concern to absorb the new and more efficient active approaches. It is suggested as a future work, besides the insertion of collaboration in more phases of the discipline, the insertion of elements of games, in order to improve the motivation and the development of other transversal competences.

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Learning experience, from the perspective of students, in the context of an active learning discipline

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Abstract

Engineering education has been the subject of studies in the search of approaches that could provide better results in terms of learning. For that purpose, the University of Brasília (UnB) utilizes a Project and Problems-based learning (PBL) approach, which begins as soon as the first semester of the university's Industrial Engineering program. The "Production Systems Project 4 (PSP4)" course is tied to "Production Planning and Control (PPC)" and is one of many that resort to the PBL methodology. This paper describes the learning experience from the perspective of students who attended the course in 2018. The project developed by the group of students addressed the problem with a seeds company, whose products' demand was characterized as intermittent. The course, also, is designed so that students' assessment is conducted after three phases: Preliminary, Intermediate and Final. The analysis carried out to identify the competencies developed by students throughout the project followed that dynamic and add to previous studies on the learning methodology. Furthermore, challenges related to techniques present in PPC and the development of the PSP4 course were narrated from the perspective of the students.

Keywords: Students experience; Project-based Learning; Active Learning; Engineering Education

1 Introduction

Engineering programs are mostly based on subjects that develop certain analytical competencies, through a passive approach, where the teaching-learning process is teacher-centered. However, it is becoming increasingly clear that Engineering students need to develop competencies that are not normally linked to traditional teaching methods (Barbalho et al., 2017). Today's highly demanding job market seeks competencies, such as communication, teamwork, innovative and critical thinking, and creativity in engineers (Aparicio, Ruiz-Teran, 2007). These competencies are key to the development of problem-solving capabilities in the context of the various areas of Engineering, where certain competencies, that go beyond technical knowledge, are required. This scenario highlights the need for inserting courses supported by active-learning into Engineering programs' curricula in order to promote transversal competencies development.

The gains provided by active-learning are notable when comparing both traditional and active methods. In addition to knowledge acquisition, students also internalize it comprehensively, and may develop, among others, self and collaborative-learning competencies, as well as creative thinking, organizational management ability and language expression ability (Ying, Xianping, 2018).

According to the study made by Freeman et al. (2013), students in traditional-learning classes were 50% more likely to fail in assessments of subjects such as science, math, technology and engineering than active learners.

The Industrial Engineering undergraduate program at University of Brasília (UnB) is permeated by active-learning, represented by courses that apply Problem-based learning and Project-based learning (both with PBL acronym) approaches. The course discussed in this case study, Production Systems Project 4 (PSP4), is taught in the seventh semester and is tied to an anchor course, Production Planning and Control (PPC).

This work aims to present an account of the learning challenges experienced by a team of students who developed a project, in the context of the PSP4 course, to solve problems related to demand forecasting in a seeds company.

The aspects covered in this text refer to the learning and technical solution challenges faced by the students, as well as to competencies developed throughout the course. The objective is to critically analyze the entire learning process in the context of the PSP4 course, considering the students' perspective, by means of the project development analysis, the problem pointed out, the challenges faced, and the required competencies.

2 Active-learning experiences

The PBL learning methodology assists in the development of key competencies for students, which will help them solve real problems in an engineering context. Therefore, student learning experiences are significant and the subject of many case studies. In the work of Reis et al (2018) 32 competencies developed in the context of PSP4 were listed and then allocated in three groups: Technical, Management and Soft skills.

Early studies on the subject date back to the twentieth century, which explains how recent the discoveries of constructivist scientists (Eberlein et al., 2008) and educators at all levels of formal education are. The usual definitions of PBL determine that the learning experience should be based on problem solving (or project execution) and student-cantered, encouraging it to be as independent as possible of a professor, who now assumes the role of a facilitator. In addition, the activities are carried out in small teams and there is continuous feedback from coordinators and colleagues.

The implementation of this active learning methodology considers the specificities of the institution, its students and professors, as revealed by the results of a review conducted by Helle, Tynjälä and Olkinuora (2006). Therefore, it's not a coincidence that case studies are the most widespread types of research. Some of those involve content analysis (Frank, Lavy & Elata, 2003), qualitative analysis accompanied by descriptive statistics (Dinis-Carvalho, Fernandes, Lima, Costa-Lobo, 2017), retention of knowledge and the use of active learning techniques, as seen in Reis et al. (2018) and Dolmans (2016), propose guidelines that can be assimilated and possibly reproduced in other contexts (Lantada et al., 2013) and conduct comparative studies between traditional and active methods for one semester (Vidic, 2008) or several years (Hall, Palmer & Bennett, 2012).

Common to those studies are the proposed discussions. There is a great deal of concern in identifying students' level of satisfaction, adaptation, and learning in the face of the proposed modifications (Fernandes, 2014), the best ways to assess learning efficiency (Yadav, Subedi, Lundeberg & Bunting, 2011) and challenges faced by those involved (Alves et al., 2016).

3 Methodology

The present study is an exploratory research through a case study (Yin, 2011), based on the student's perception of his experience in a project carried out in a PBL discipline. The main competencies developed during the course were listed considering its main milestones – Preliminary Project (PP), Intermediary Project (IP), Final Project (FP), besides the remarkable challenges faced, contrasting the theory found in the literature and the real-life practice throughout the project and its influences on competencies development.

The data collection for the accomplishment of the present work was given by the application of a questionnaire containing four open questions to be answered by the students who developed the project. The questions answered were: (I) How was the PSP4 course developed? (II) What were the learning challenges faced? (III) At what moment of the course were the challenges perceived? IV) What skills/competences have been improved or developed in the face of challenges? The answers were systematically discussed in this paper in order to present the students' perspective on the learning experience.

4 Production Systems Project 4

At University of Brasília (UnB), the Industrial Engineering undergraduate program is composed of twelve semesters and designed based on regular courses, traditionally taught, and the execution of seven projects using active-learning based on problems and projects.

At the beginning of the program, two compulsory courses are taught in order to prepare the students for the execution of the projects required by the PBL disciplines, based on basic concepts of project management. They are: Value Formation in Production Systems and Project Methodology of Production Systems. Afterwards, the PSP disciplines, denominated by PSP1, PSP2, PSP3, PSP4, PSP5 and PSP7 (Figure 1) are introduced. PSPs are compulsory, except PSP3. These range from the 4th to the 10th semester and work on four main axes: (1) project methodology, (2) technical content of the anchor discipline, (3) external partners linked to real problems, and (4) other disciplines with interests in the project (Barbalho et al., 2017). As mentioned, each PSP is tied to an anchor discipline, which is responsible for adding technical knowledge to the students and whose theme must be explored in the corresponding PSP. This format seeks to increase curricular integration and knowledge acquisition, to develop transversal competencies, to help students enter the professional market and, among other things, to enable contact with clients and real problems.

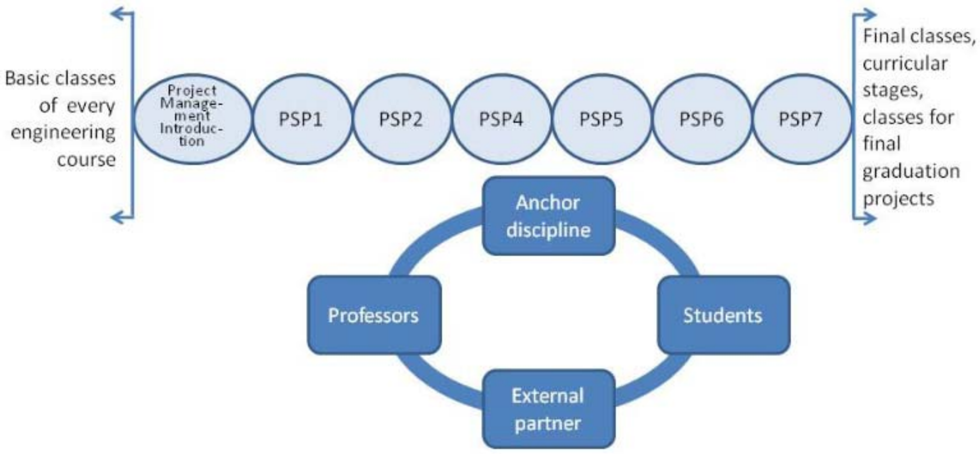

Figure 1. General structure of the University of Brasília's Industrial Engineering program (Barbalho et al., 2017).

PSP4 was chosen for analysis and consists of the elaboration of a project from the content taught in Production Planning and Control (PPC) - co-requisite and anchor (Barbalho, Reis, Bitencourt, Leão & Silva, 2017). The discipline is organized into strategic milestones to facilitate project management and student assessment. These are, the Preliminary, the Intermediate and the Final projects (Figure 2). In each of these milestones, feedback is given by the professor in order to improve general project aspects.

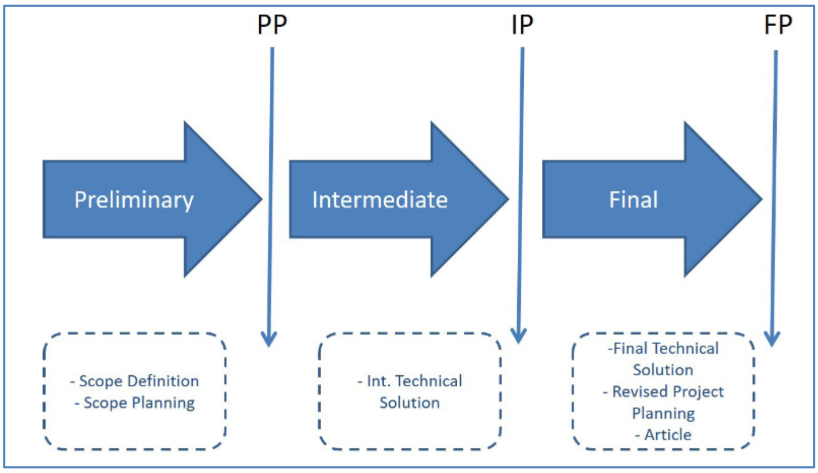

Figure 2. Basic structure of PSP4 (Barbalho et al., 2017).

The PP starts with the organization of the work teams and the selection of the project manager. Then the teams need to find a client (external agent), public or private, that has a problem to be solved and is related to the anchor' scope.

The technical solution is dealt with in the IP, where technical competencies are more explored. At this stage of the project, the teams define the problem that will be addressed in their projects and begin to seek information that contributes to the technical solution. Classes throughout the semester are weekly in a format where teams meet with the professor and discuss the progress of the project.

The FP is reserved to refine the technical solution and to write a paper that contemplates the solution of the proposed problem. It is worth mentioning that for each milestone, the teams must present, for the whole class, the results obtained until the corresponding phase and, in addition, are evaluated by the professor.

5 The project, the challenges and the developed competencies

The present work, as mentioned, reports the experience of a group of students while performing activities required in PSP4. It addresses the challenges faced by the team and the competencies developed throughout the project, considering the evaluation milestones: The Preliminary Project (PP), the Intermediate Project (IP) and the Final Project (FP).

5.1 Preliminary Project

The PP is, as said, the first evaluative stage. The content developed until the oral presentation involves the Project Management Plan (PMP) in addition to defining the target company and the problem to be worked on.

The team had to identify a goods or services business with which it could work to develop a technical solution to a specific problem in the context of PCP. Therefore, there was a need to contact some companies and present to their owners or managers the course's purpose, until the one that better suited PSP4's requirements was found.

The first challenge faced by the students was to find a company which had problems that could be solved by applying PPC tools. So, obviously, the group should have a previously acknowledgment of PPC subjects. It was needed to seek a global understanding about the potential scopes that could be developed, considering a PPC context.

Once the group selected the company, the anchor course class and, also, the PSP4 professor orientations were used to refine the project scope. The target company is a Brazilian Cerrado biome seeds selling business. This is the only private company on this field, since all the other ones are Non-Governmental Organization (NGO's).

At the beginning of the project, the team had to develop or improve some personal competencies, like disinhibition, communicability, sociability and persuasion. After all, the task wasn't only to find a potential company, but also to convince the owner or manager that the project could contribute to its business, make it to adapt itself to the course's rules and share private information.

It's worth noting that this work helped to improve some intangible students' competencies, such as teamwork, collaboration, people and time management, proactivity, and ethic and leadership. The last one was even more reinforced on who assumed the manager project role.

After the company selection and the project scope definition have been finished, the Project Management Plan (PMP) elaboration began. It was made based on the PMBoK Guide (Project Management Body of Knowledge), but in a simplified version of it, as required by PSP4. That document covered the following aspects: object, scope, non-scope, premises, restrictions, Project Analytical Structure and its dictionary, Project Schedule and Stakeholders, Communication and Risks Management Plans. Those were used to manage the project until the discipline lasted and as tools to ensure project control.

The PMBoK Guide is widely used in project management (Pant & Baroudi, 2008). At this point, the PSP4's contribution to the students' technical competencies, since those had the opportunity to improve their project management knowledge, by elaborating the PMP.

Obviously, it wasn't an easy task. Since students were attending the seventh semester and the project management concepts weren't completely unequivocal for them. Even so, a search for the knowledge needed to carry out the PMP provided a great sense of responsibility and autonomous search for learning. The weekly support by the professor in the classroom consolidated the knowledge acquired and the ability to produce skills for the preparation of PMPs for projects with greater comprehensiveness since they have already been considered the main elements of project management.

5.2 Intermediary Project

The PMP was the input of the IP, in which the defined scope and target problem were fully determined and discussed. The first goal to be accomplished was the elaboration of the company's production process flowchart. The team met with the owner in order to understand the steps involved in the production process. Students needed to understand the process, and then put all the gathered information into a flowchart. It is worth mentioning that none of the students knew how to make such charts. The project demands forced them to develop this competency independently.

The sales data was collected through meetings and electronic mail. An initial data analysis indicated that there was a large amount of seeds species sold by the company. The team considered that it would be better to construct an ABC Curve and work with only the A-Class products (which represent the 20% of species which contributes to 80% of the revenues). That was the first moment in which it was possible to see, clearly, that PSP4 make the team put into practice concepts and tools from the anchor course. Also, strategic thinking was required to solve an unexpected problem.

The seeds species amount was significantly reduced, so the team was able to start the demand forecasting analysis, a problem that was the first defined in the PMP scope. Thus, the seeds sales data were examined to identify what was the forecasting model each one of the species adhered to. At that stage, the team came across an unexpected fact: the data pattern indicated that none of the traditional forecasting models would produce feasible results. Hence, the team sought for information on alternative studies sources, since the PPC books weren't enough to help them. The students resorted to Scielo, Scopus and Web of Science databases to search scientific articles that could assist them in understanding which model would fit best that particular demand. The search results revealed that the forecasting model that best represented the sales was the intermittent demand forecasting one. This demand type occurs at random intervals, and there's often no demand at all over many periods. (Silver, 1981).

A lot of scientific articles were read and studied by the team. A bunch of them approached statics and simulation methods which the students didn't know how to deal with. This scenario compelled the students to make some unpredictable decisions, like study a topic outside the PPC context and use some simulation tools.

The group was able to forecast the demand by using the Croston and SBA (Syntetos-Boylan-Approximation) methods and it was ready to start working on stock management (the second scope element). Again, the fact that demand behaves as intermittent, was troublesome. Due to the nature of the demand, traditional inventory management methods were also ineffective. The team sought for methods in academic databases that could assist them. There were found many complex inventory management models, which would require a longer timetable to be fully implemented. Due to this situation, the professor suggested an alternative. So, the team verified how much kilograms of each seed were sold monthly until then. Spreadsheets for each species were made and it was possible to verify how much should be collected monthly to avoid stock shortage and maintain sales.

These monthly collection values that were calculated by the procedure described above were compared to forecasts produced by the SBA method (SBA was selected because its forecasts were more accurate in comparison to Croston's.). The results revealed that forecasts were slightly higher than the collected values calculated by the team. Thereby, the hypothesis was discarded.

The challenge faced by the group corroborated to essential competencies development. As reported, one of the biggest difficulties were related to the technical solution, since the team didn't have previous knowledge about intermittent demand forecasting and stock management. This situation promoted independent information gathering, since the anchor course doesn't elaborate on this demand type.

In fact, although it is quite robust, the anchor discipline does not comprehensively address all demand forecasting models, and the labor market may require challenges from diverse contexts, where demand behavior needs to be analyzed with new models and different analyzes and complementary to those already learned.

5.3 Final Project

At the final stage of the Project, the group wrote a document, in the format of a scientific paper, in which were exposed, among others, the existing previous work on the theme, the research methodology, the problem, the proposed solution and its findings. At this stage, students develop mainly academic competencies, such as bibliographic research, scientific writing and article formatting.

Students had to re-explore various aspects outlined in previous stages, such as scope, target problem, technical solution and methodology used in the project. In addition, the professor's orientations and constructive criticism, added by the classmates' feedback, after the presentations were useful to the project's enhancement.

As in the other stages, the final project contributed significantly to the learning experience of the students, since they need, when approaching graduation, well-established academic competencies in order to elaborate their conclusion thesis, in addition to being indispensable to those who intend to become prolific researchers.

The different phases of the course brought complementary challenges and development of diverse competences. In the final project there is a great expectation for the professor evaluation and the considerations about the work developed. The final project needs to incorporate professor feedback and adjustments needed to complete the assignment. As complementary learning, it is important to control all changes and evolutions, in a structured way, to complete the project.

6 Conclusion

The PBL approach, as well as the traditional one help students develop several competencies. However, active methodologies improve skills that significantly extrapolates mere technical knowledge. Proposing a solution to a real-life problem, while working in teams, gave students the opportunity to work on its social skills and to apply theorical insights, once limited to worked-out examples and exercises into an environment filled with practical activities and independency.

In addition, the need to solve the selected problem prompted students to seek answers in a variety of ways. Hence, it is verified that the PBL approach encourages proactivity in a way rarely seen in the traditional ones, since in these, the assessments only address contents that are taught by the professor, whereas the PBL discipline evaluates the ability to solve problems, regardless of whether the students have prior knowledge to do so or not.

An evaluation of the competencies described in this article suggest that throughout the execution of the Preliminary Project, the competencies primarily developed were related to project management and dealing with external clients. By the Intermediate Project, however, when lots of unforeseen aspects emerged, it was possible to verify that competencies related to proactivity and strategic thinking were quite necessary and, therefore, improved. In addition, it was at this stage that the knowledge derived from the anchor discipline was more crucial, since these should necessarily be used in the elaboration of the technical solution. Still, there was an academic contribution at that stage, which, a priori, was not foreseen, since the students had to search in scientific articles for a response that they did not find in a bunch of well-known PPC textbooks. Finally, the Final Project improved academic skills, since the delivery required at the end of this milestone was, precisely, a document in the format of a scientific article.

Future researches, based on the experience of other students who have taken the PSP4 course, can be useful in identifying which type of competency is most developed within the course. They can be conducted in a variety of ways, from longitudinal studies, with the collaboration of former students, comparing results outlined in PSP4 over the years or between all the recurring PBL courses taken throughout the program, to content analysis of the articles produced at the end of the semester or even to studying the existence of correlations between the development of competencies, the challenges faced and the progress of work along project milestones.

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Systematic literature review of Gamification and Game-based Learning in the context of Problem and Project Based Learning approaches

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Abstract

With the objective of improve learning in engineering courses, teaching-learning methodologies have evolved and incorporated active approaches, which are gaining ground in universities around the world. The development of problem-solving skills and transversal skills now rely on new technologies and, in this context, Gamification and Game-based Learning have been the subject of educational research. In order to identify these advances involving the use of games in engineering education in the last 10 years, this study presents a systematic literature review with the main high impact contributions, specifically involving the Problem-based Learning and Project-based Learning approaches. An exploratory quantitative research was performed using the Consolidated Analytical Meta Approach Theory, using methods such as co-citation and bibliographic coupling. For the research, it was used the Scopus and Web of Science databases, unified through the ScopusWOS algorithm, of database consolidation. The results of co-citation may prove to be a cluster of older works formed by Kolb (1980) and Barrows (1994) who defend a more experimental and practical learning, such as problem solving, supports the most relevant to the application of games or part of them in the teaching of the current generations of students such as those of Prensky (2001), Hmelo-Silver (2004) and Kapp (2011). The main research fronts were found through bibliographic coupling, one led by Fotaris, Theodoros, Leinfellner and Yasmine (2016) and another by Hwang and Chang (2016) and Warin, Talbi, Kolski and Hoogstoel (2016). In addition, the main forms of application of types or elements of games in teaching-learning, used in conjunction with active approaches and how they favor the development of skills in engineering students are presented.

Keywords: Gamification; Game-based Learning; Problem-based Learning; Project-based Learning.

1 Introduction

One of the greatest challenges of the learning process is to keep students motivated, since the engagement of them is a common problem at different levels of education, including in higher education, with the use of innovative strategies that involve students in learning, as the Problem and Project Based Learning approaches (Ponton, Edmister, Ukeiley & Seiner, 2001). According to Barbalho, Reis, da Silva and Malta (2018), the students transitions from a passive role in which he or she receives knowledge, to a more active stance. However, it is noted that even using these methods, students may not have enough motivation throughout the discipline (Reng & Kofoed, 2012; Schoenau-Fog, Reng & Kofoed, 2015; Hew, Huang, Chu & Chiu, 2016). Creating an environment that produces motivation for students is a complex process. Difficulties include the effectiveness of incorporating motivational strategies for most students and the alignment of them, the faculty, and the entrepreneurs with regard to desired goals. Rather than addressing these challenges, most programs are based on simple motivational strategies and metrics that have limited success (Fuentes, Crown & Freeman, 2008).

When students face complex learning, they are prone to feel overwhelmed, with no short-term solution to keep them engaged and motivated (Lee & Hammer, 2011). One promising way to address these counterproductive feelings is to design them using techniques similar to those found in gaming environments or even making full use of games (Fotaris, Theodoros, Leinfellner & Yasmine, 2016; Wiggins, 2016). Gamification and Game-Based Learning (GBL) become important as traditional methods lose their power as new generation students are growing interacting with games (Deshpande & Huang, 2011; Kapp, 2012; Sancho, Torrente & Fernández-Manjón, 2012; Caponetto, Earp & Ott, 2014). A significant common interest among many students are computer games (Fuentes, Crown & Freeman, 2008), knowing that different types of games have different effects on students (Alhammad & Moreno, 2018).

The purpose of this study is the systematic literature mapping of the various research and action fronts using games in Science, Technology, Engineering and Mathematics (STEM) areas of knowledge. There is evidence that while the use of games has effective application in the educational field, and particularly in higher education, it becomes more effective when applied correctly.

2 Method

This is an exploratory and quantitative approach, using the Consolidated Analytical Meta Approach Theory (CAMAT) by Mariano and Rocha (2017). This technique is based on three steps to identify the studies of greater impact and analyses according to the laws of bibliometrics. The preparation of the research is the first step, in which is treated in the determination of four essential points for the beginning of a complete bibliographic analysis. These points are (1) the research keywords; (2) temporal delimitation; (3) databases; and (4) areas of knowledge to be used.

In the second stage, the attributes were identified in relation to the data collected in step 1, such as the most relevant journals in the area, the most published journals on the theme, the evolution of the theme year by year and the most cited documents. The authors, countries and universities that have published the most, the most cited authors, the conferences that contributed the most, the agencies that most fund research, the areas that publish the most, and the frequency of keywords were also identified.

Finally, more in-depth analyzes were carried out in order to allow a better understanding of the subject, in which the main approaches and lines of research were investigated. To reach this third stage, the bibliometric indexes, such as co-citation and coupling, were analyzed. As Mariano, Cruz and Gaitán (2011) cite, the search for lines and approaches is important so that the state-of-the-art review is complete.

3 The use of Gamification, Game-Based Learning (GBL) and Problem and Project Based Learning approaches in Education

The application of games in education permeates the literature with two main perspectives, one of them is Game-Based Learning (GBL), in which complete games are used to improve the teaching-learning process (Wiggins, 2016), as well as Gamification, which advocates the use of game elements to motivate learning (Kapp, 2012). According to Caponetto, Earp and Ott (2014), the concepts of GBL and Gamification are similar but sufficiently distinct. The first one denotes the adoption of games for educational purposes and the second, the application of gaming mechanisms to global educational interventions. The elements and types of games can be used in different combinations, depending on what is aimed at their application, being very dependent on the skills that are expected to boost students (Hamari, Koivisto & Sarsa, 2014; Subhash & Cudney, 2018). Gaming and GBL practices adopted to support the active learning processes promulgated in education is a fast-growing phenomenon (Kapp, 2012; Caponetto, Earp & Ott, 2014).

The study of Ortiz Rojas, Chiluiza and Valcke (2016) analyzed Gamification in higher education in the fields of STEM, showing that several elements of games are used in this context. These elements are usually emblems, points, challenges, leaderboards and missions. However, the study shows that most applications use combinations of several other elements, and it is rare to find in the literature a Gamification with unique game elements. The Gamification learning has been shown to improve educational attributes, resulting in benefits for teachers and students, which include improved student engagement, motivation, confidence, attitude, learning perception, and performance. These benefits are a strong argument for the application of Gamification and GBL in higher education (Subhash & Cudney, 2018).

The major human areas in which Gamification may be useful are the cognitive, emotional, and social areas. In cognitive, it provides the opportunity for players to explore the games and challenges through active experimentation and discovery, appealing primarily to curiosity. Emotional play is about helping players to persist, using even negative emotional experiences, in which students can turn them into positive experiences.

Finally, the social area allows students to interact with each other during the game, providing social credibility and recognition for academic achievement (Lee, & Hammer, 2011). Warren, Dondlinger, McLeod and Bigenho (2012) analyzed the elements of Problem-Based Learning (PBL) and games and stated that both should include a strategically constructed conflict or problem, the context for engagement, goals or activities, rules, criteria or conditions governing them, the quantifiable outcome to assess success, and a cognitive conflict emerging from interaction with a projected problem.

In PBL approach students learn through a problem to be solved and make them explore the solution on their own. Project-Based Learning is an approach that organizes learning around projects that culminates in products, services or presentations of practical solutions (Jones, Rasmussen, & Moffitt, 1997; Wood, 2003; Hsu, Chang & Hung, 2018). With games, engineering students are motivated to maximize their score by trying strategies or alternatives through greater reading of content, so that the students do not have to wait for the teacher to solve the difficulties, in order to increase their proactivity and their ability to make decisions (Deshpande & Huang, 2011).

Educational games that explore student interest and knowledge can motivate them to make connections between engineering applications and their knowledge in other contexts. This non-threatening interactive environment is ideal for reviewing, testing, exploring ideas and correcting misconceptions (Fuentes, Crown & Freeman, 2008). For Sancho, Torrente and Fernández-Manjón (2012), games offer students the chance to face challenges similar to the real world, promoting the acquisition of problem-solving skills, unlike the classical teaching methods where theory predominates over practice.

4 Research presentation and data interrelationship

Quotations and articles in this area have grown substantially, demonstrating the researcher’s interest in using games in active methodologies. According to Mariano and Rocha (2017), the growth of citations and quantity of published papers reveals the scientific importance of the subject to measure the decline or progression of a certain area of knowledge, based on publications and quotations on a particular topic. The bibliometric survey was carried out by means of scientific databases, namely Scopus and the Web of Science (WoS).

For data collection, it was used as search strings the terms of "Project Based Learning and Game Based Learning" or "Problem Based Learning and Gamification" or "Project Based Learning and Gamification" or “PBL and GBL" or "PBL and Gamification" or "PBL and GBL" or "PBL and Gamification" or "Project Based Learning and Games" or "Problem Based Learning and Games" or "PBL and Games" or "PBL and Games". Thus, it was possible to obtain the largest number of papers related to the subject through several terms and keywords found in the literature, using complete expressions and their acronyms. Regarding the time limit for the research, it was chosen the papers from the last 10 years, referring to the period from 2008 to 2018. Finally, a collection filter was applied restricting the areas of knowledge related to STEM. Thus, the search in the WoS database returned 216 studies, and 327 in Scopus, with a total of 543 relevant papers on the topic.

Both the 11th International Conference on Technology Education and Development Inted and the 9th European Conference on Games Based Learning (ECGBL) were the main conferences that obtained registrations on Gamification and GBL in the context of PBL. Spain and the United States of America are the two countries with the greatest interest in the subject. The journals with the greatest impact factor, in relation to the areas of knowledge involved in the research, are the Nature Materials Reviews and the Reviews of Modern Physics. It was attempted to analyze the papers with high number of citations, literature review articles, case studies and the oldest and most recent records.

5 Application of game types or elements are in conjunction with active approaches to boost student competencies

Fuentes, Crown and Freeman (2008) paper is the oldest record on the subject of Scopus and presents challenges based on PBL and computer games, involving students in the process of games creation. This approach helps students to build connections between related concepts and an integrated knowledge base.

Besides, helps them to appropriate their education, to strengthen their skills to work in teams and to communicate technical information, to increase their ability to extract information and useful data from public sources, to create an original problem and, finally, to see the work from the point of view of other students.

The case study of Moseley, Whitton, Culver and Piatt (2009) is the oldest on the subject in WoS database. It is based on four case studies on the use of learning activities inspired by Alternative Reality Games (ARGs) to examine what can be learned about student motivation, and how these types of games could be used to influence student engagement in learning. ARGs provide the opportunity to create PBL experiences in which students can work together, both online and in the real world, to discover secrets and solve mysteries. The solution to problems is autonomous and collective, but what differentiates ARGs is the potential for autonomous development through research and the willingness of the gaming community to work collaboratively, having much more intensity than in traditional PBL. From the case studies of Moseley, Whitton, Culver and Piatt (2009), it was observed that the creation of a motivating game is directly linked to the clarity of logic used for students to engage in the game. It is necessary to ensure that games have a variety of elements, such as competition, something to complete, enigmas, narrative, creativity and community, in order to allow easy acceptance and initial participation, giving various opportunities for students to evolve in the game.

Sancho, Fuentes-Fernández and Fernández-Manjón (2008), Sancho, Moreno-Ger, Fuentes-Fernández and Fernández-Manjón (2009) and Sancho, Torrente and Fernández-Manjón (2012) are among the most published and cited authors in Scopus and WoS. They present the results of an experience applying a pedagogical approach that combines game mechanics, including collaboration and competition, PBL, and narrative metaphor. This approach has been used in several courses in order to improve the dynamics involving computing from a Spanish university (Sancho, Torrente & Fernández-Manjón, 2012). The research used an immersive virtual world as a user interface through Multi-User Virtual Environments (MUVEs) (Sancho, Fuentes-Fernández & Fernández-Manjón, 2008). For Sancho, Moreno-Ger, Fuentes-Fernández and Fernández-Manjón (2009), learning teams are complementary and semi-autonomous, enabling the development of solutions to the problems provided by the teacher. The dynamics of the game are positive for motivation and induce students to take a more active role and help them acquire social skills and teamwork. The collaborative procedure within a group is specified according to a classic PBL scheme and members have different responsibilities according to the role assigned to them.

The literature review of Deshpande and Huang (2011) was the most cited paper on both bases. The paper shows that GBL, more specifically simulation games, is an extension of PBL because it has all its inherent characteristics as well as additional advantages. Both are experiential, collaborative and active learning approaches, besides student-centered. In simulation games, the instructor is a facilitator of the learning process and students have a responsibility to learn as in PBL, so that one approach can complement the other. For the authors, the use of problem-based simulation games is more advantageous than PBL alone because they allow engineering students to experience various consequences, depending on the assumptions made.

The case study of Takahashi and Saito (2011), the most quoted of WoS, focuses on the application of a commercial simulation game in regular undergraduate courses at a university in Japan. For the authors, simulation game is a type of PBL that simulates almost realistic contexts, where students solve problems and tasks in groups with the implementation of game and show a significant increase in understanding of content. Furthermore, students increase communication and cooperation between them in comparison with conventional education, authenticity in the development of tasks, improvement in the ability to negotiate and make decisions.

Rave (2011) is the earliest case study on the subject of Scopus. The author proposes a game called "airplane of the muda", designed to complement theoretical classes of lean manufacturing with practical elements that allow incorporating constructivist and collaborative principles of PBL in the teaching-learning process of 7 seedlings, 5S and management concepts. Five independent tests were carried out with different groups of engineering students from Antioquia University, where a collaborative environment was observed, exchanging opinions, stimulation of critical thinking, teamwork was encouraged, leadership and a greater practical association theoretical concepts previously presented.

Warren, Dondlinger, McLeod and Bigenho (2012) was the fifth most cited paper on Scopus and has a high impact factor. The authors analyzed the games to determine where they intersect with principles of PBL as a means of supporting teaching and the involvement of students with learning. The overlapping of these two approaches was used to redesign the introductory course in basic computer applications of a university in the United States. In redesign, the entire course was anchored and contextualized in an Alternate Reality Game. Doing the tasks with a sense of responsibility, autonomy in learning, authenticity in developing solutions, collaboration and interpersonal communication, as well as dealing with the complexity of group work, examining alternative visions and critical thinking are expected competencies to be driven.

The study of Villagrasa, Fonseca, Redondo and Duran (2014) combines several approaches, which are PBL, Quests Based Learning (QBL) and Gamification. They have developed a platform to allow users to implement game mechanics in a fastest way, like badges, analytics, progress bars, lives, 3D portfolio, adventure map, avatars, leaderboards, levels, rewards and narrative. The plot of the game is that the class is a producer specializing in 3D modeling for the toy industry and for mobile applications games. The students were "hired" in order to gain experience and even money. This approach has increased the motivation of students to work in 3D and has made an improvement in their exams performances. In addition, increased collaborative participation, accomplishment of assignments or optional extra work to acquire more knowledge. The authors conclude that when the teacher mixes Gamification with other methodologies, such as PBL and QBL, and with new technologies as virtual reality, they are creating the perfect environment for students to participate in class. This paper is the most cited case study in Scopus.

Schoenau-Fog, Reng and Kofoed (2015) explored how game development motivates students and what they learn when creating games. To investigate the experiences of the students during this game production, the authors set up an experiment where students were "hired" to work in a virtual game development company and had to produce a game about global warming. A group of seven CEOs of gaming companies was called to evaluate the quality of the final product. The main results indicated that students acquired several new technical and analytical skills. They have increased their skills in production management, stimulated active and autonomous learning, acquired communication skills and learned to work in a company. The paper was quoted 5 times and has the 2nd and 4th most published authors in Scopus.

Carvalho, Rodríguez, Escudeiro and Nistal (2016) presented a simulation game that supports the PBL called eCity. The game was applied in secondary schools to stimulate the interest of students in pursuing a career in engineering. The paper focus is to discuss and to propose a sustainability strategy for game maintenance and development of new versions. A research on existing game related projects was conducted to analyze best practices on the use of games in PBL and engineering education and resulted in simulators being used in the most diverse contexts and environments, from professional urban planning to sociological studies. In the context of eCity, urban simulation project is used as a game environment that supports the configuration and resolution of problems and challenges, making it possible to use them in the context of PBL. The most rewarding aspects of the game were observing students' satisfaction by employing their individual resources and knowledge in practice, addressing and solving representative real-life problems, and the ability to control the results of their actions. This paper has the most published author on the WoS list.

The research of Hsu, Chang and Hung (2018) deals with literature review and has a high impact factor. Learning strategies focus on computational thinking as competence. This competence consists on the ability to solve complex problems and concepts through a process with the thought that programmers need to involve before starting to operate computers and machines in order to use these technologies to their advantage in a correct, agile and efficient way. It is not limited to computers to solve problems, but it allows adopting a way of the programmer thinking when facing problems.

Martins, Concilio and Guimarães (2018) is the most recent study on the subject and describes a PBL teaching approach that is associated with the development of educational games in a computer science course. The research was conducted in a case study with 30 students at a private Brazilian university located in the city of São Paulo. In the proposed approach students take the role of game developers, which provides them the practice of a professional opportunity. The main competences were the proactive attitudes of students, especially to seek autonomously new knowledge, teamwork through attitudes such as cooperation, ethics and respect for colleagues' opinions, imaginative ability and logical reasoning.

Table 1. Application of game types or elements in conjunction with active approaches

Paper	Active Methodology	Application form	Elements or types of games used	Competencies developed in students	Type of study
Fuentes, Crown and Freeman (2008)	PBL	GBL	Computer games	Integrated knowledge, teamwork, communication, self-improvement and creativity	Case study
Moseley, Whitton, Culver and Piatt (2009)	PBL	GBL	Alternative Reality Games	Self-improvement and collaboration	Literature review
Sancho, Fuentes-Fernández and Fernández-Manjón (2008), Sancho, Moreno-Ger, Fuentes-Fernández and Fernández-Manjón (2009) and Sancho, Torrente and Fernández-Manjón (2012)	PBL	GBL	Multi-user Virtual Environments (MUVEs)	Self-improvement, communication and teamwork	Case study
Deshpande and Huang (2011)	PBL	GBL	Simulation games	Proactivity, decision-making and rapid assimilation of content	Literature review
Takahashi and Saito (2011)	PBL	GBL	Simulation game	Communication, cooperation, authenticity, negotiation and decision-making	Case study
Rave (2011)	PBL	GBL	Analog game	Collaboration, criticality, teamwork, leadership and ability to put knowledge into practice	Case study
Warren, Dondlinger, McLeod and Bigenho (2012)	PBL	GBL	Alternate Reality Game	Criticity, objectivity, self-management and self-improvement	Case study
Villagrasa, Fonseca, Redondo and Duran (2014)	PBL and QBL	Gamification	Badges, analytics, progress bars, lives, portfolio 3D, adventure map, avatars, leaderboards, levels, rewards and narrative	Self-improvement and collaboration	Case study
Schoenau-Fog, Reng and Kofoed (2015)	PBL	GBL	Games development	Self-management, self-improvement, communication, objectivity, teamwork and leadership	Case study
Carvalho, Rodríguez, Escudeiro and Nistal (2016)	PBL	GBL	Simulation game	Ability to put knowledge into practice and self-management	Case study
Hsu, Chang and Hung (2018)	PBL	GBL	Board games and game development	Computational thinking	Literature review
Martins, Concilio and Guimarães (2018)	PBL	GBL	Games development	Proactivity, teamwork, creativity and logical reasoning	Case study

6 Co-citation e coupling maps

The Co-citation analysis verifies those papers that are regularly cited together, and may suggest a similarity between these studies, since Coupling has a very similar metric of search, based on the premise that papers that mention equal works, have points in common (Mariano & Rocha, 2017). Figures 1 and 2 illustrate the map of co-citation and coupling, respectively.

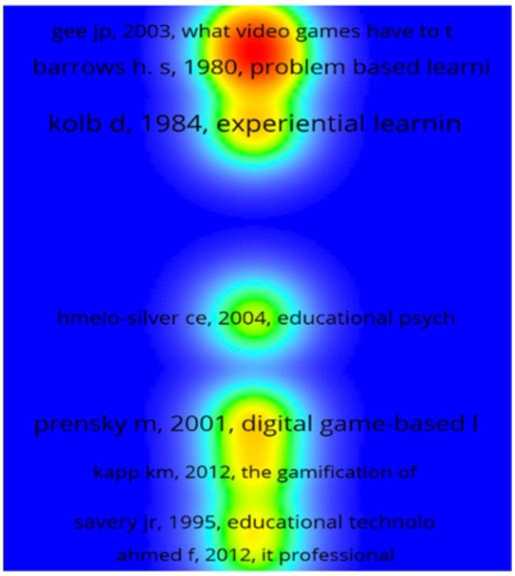

Figure 1. Co-citation map

The results from the co-citation map reveal that the cluster of older works by Kolb (1980) and Barrows (1994), who advocate a more experimental and practical learning as problem solutions, support the most relevant studies of application of games in the teaching of current generations of students, such as those of Prensky (2001), Hmelo-Silver (2004) and Kapp (2012). This shows that both GBL and Gamification are similar to PBL, so problems are placed within the framework of play, when they are applied in education.

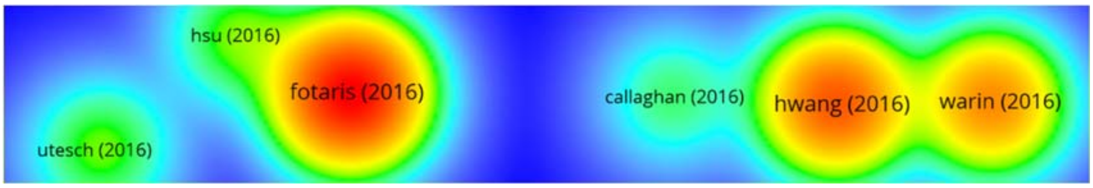

Figure 2. Coupling map

In the coupling map, two clusters representing two main research fronts, one on the left led by the work of Fotaris, Theodoros, Leinfellner and Yasmine (2016) and another on right by Hwang and Chang (2016) and Warin, Talbi, Kolski and Hoogstoel (2016). Fotaris, Theodoros, Leinfellner and Yasmine (2016) carried out a case study with the application of an interactive learning model in a programming course designed to increase students' motivation and engagement. Hwang and Chang (2016) and Warin, Talbi, Kolski and Hoogstoel (2016) has a greater focus on increasing student interaction. The first one, through a learning approach based on a competition strategy for local cultural activities during a field trip, and the second describing the implementation and evaluation of the Multi-Role Project (MRP) method in the context of a STEM course, considering the PBL activity as RPG game where students seek to develop, mainly, skills to work in teams.

7 Conclusion

It was shown that games are adequate to support the development of teaching skills in the areas of Science, Technology, Engineering and Mathematics (STEM), so that GBL and Gamification tend to be an improved PBL approach. In this research, simulation and virtual world games appear to be the most used one in conjunction with PBL. GBL approach is predominantly used in the areas of knowledge chosen for this study. The deepening of the use of Gamification in these areas is one of the gaps of this research, due to the fact that CAMAC did not have in its main results a relevant number of works on this form of application.

There are indications that although the definitions of Gamification and GBL are simple, their effective application in the educational field, and particularly in higher education, is not immediate, since the different variables and decisions must be carefully considered and treated. The economic impact appears as a relevant impediment in the application of games, since the costs of digital games, such as simulation or virtual world, still appear to be high.

Heat maps suggest that research fronts from a more practical and experimental approach to learn have served as the basis for game application studies in higher education. This statement is supported by the articles analyzed in section 5 in showing that games can leverage multiple skills in students when applied in conjunction with PBL, such as self-improvement, communication, decision-making, and creativity, but it is necessary to define in advance what skills students want to boost in order to achieve better results in the learning process.

The concepts of GBL and Gamification have proven to have many possibilities to support better university-level learning in engineering areas. However, there is also a great potential in the use of games to encourage those who are still choosing their college course or even to those who have already graduated, such as professors or graduate students. It is noteworthy that the case studies raised show that the cost of applying games with PBL is greater than using them separately, but the results appear to be better when applied together.

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Models, Processes and Evaluation of Problem-Based Learning: A survey of the literature

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Abstract

PBL approach represents a large field in education research. This approach has been proven over the past two decades, and theories and practices have been defined to treat several issues such as the evaluation/assessment of students and their skills, learning design and the teacher's roles and interventions.

This paper provides in the first part an overview of the literature on models, taxonomies and processes in PBL and their application in different areas and contexts. In the second part, we present an overview of methods treating how can we evaluate a PBL and discuss the strengths and limitations of these methods. It discusses then the effectiveness and relevance of each proposed method particularly for engineering education. Results concerning the impact of these methods on student's engagement, motivation, problem solving ability and autonomy are then presented and discussed.

After that, we expose and discuss other approach related to PBL as Team Based Learning or Project Based Learning and their commonalities and differences with PBL. We discuss so the positioning of PBL with these active learning approaches and technics.

Finally, future challenges of PBL for educational practice and research will be exposed.

Keywords: Problem-based learning; Evaluation; Assessment; Problem-solving; Engagement; Motivation; Active learning

1 Introduction

In everyday life and professionnal workplaces, people expend their gretest intellectual effort solving problems (Jonassen & Hung, 2015). Problem solving is an essential thinking skill for workers (US Department of Labor, 1991). For an engineering outcome, the abilities to identify, formulate and solve engineering problems as essential learning outcomes (ABET, 2007). It is obvious that the problem solving should also be integrated to education. By consequence, Problem-Based Learning (PBL) has appeared and has been considered as an instructional model that assumes the centrality of problems to learning.

PBL is characterized by the fact that learners are actively engaged in working at tasks and activities which are authentic to the environment in which they would be used. So, learners are constructors of their own knowledge and have ownership of the problem and facilitation is focused on metacognitive processes and is not knowledge driven (Savery & Duffy, 2001). Students are faced to an authentic context, problems with multiple solutions, inquiry experiences, real-world application of science knowledge, and collaboration (Navy, Edmondson, Maeng, Gonczi, & Mannarino, 2019).

In this vision, PBL was defined as *"a way of constructing and teaching courses using problems as the stimulus and focus for student activity. It is not simply the addition of problem-solving activities to otherwise discipline-centred curricula, but a way of conceiving of the curriculum which is centred around key problems in professional practice"* (Boud & Feletti, 1997). PBL is a pedagogical approach that enables students to learn while engaging actively with meaningful problems. Students are given the opportunities to problem-solve in a collaborative setting, create mental models for learning, and form self-directed learning habits through practice and reflection (Yew & Goh, 2016).

The main objectives of this type of this learning is to Think critically, find, evaluate and use appropriate learning resources, work cooperatively, demonstrate communication skills and use content knowledge and intellectual skills to become continual learners (Duch, Groh, & Allen, 2001).

Concretely, according to Boud & Feletti (1997), learning is launched by posing a problem, query or puzzle that the learner wants to solve. The learning is then conducted by the problem and the content and skills to be learned are organized around this problem.

2 Taxonomies, models, and processes in PBL and their application's contexts

In learning science, all students should learn to think effectively, to argue and communicate scientifically, to develop skills of analysis and synthesis, to solve problems (Bennett, 2008). PBL is an instructional approach that has been used successfully for over 30 years and continues to gain acceptance in multiple disciplines. It is an instructional learner-centered approach that empowers learners to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem (Savery, 2015).

Originally, PBL was developed for use in medical schools in response to criticisms that lectures were not preparing medical students for authentic challenges in the field [Barrows 1986]. PBL has been most commonly successful in medical schools and continue to prove his success in recent works (Alrahlah, 2016; Korpi, Peltokallio & Piirainen, 2018) where students learn to solve diagnosis-solution problems. PBL has been expanded in different learning areas like Science & engineering studies (Cawley, 1989), Nursing (Glen, 2017) (Barnard, Nash, & O'Brien, 2005; Higgins, 1994), physics (Argaw 2017), law (Boud & Feletti, 1991; Kurtz, Wylie, & Gold, 1990; Pletinckx & Segers, 2001), etc.
With the flow of migration to other academic disciplines, research needs to consider the nature of the problems being solved and how efficacious PBL methodologies are for those kinds of problems (Jonassen & Hung, 2015). So, multiple taxonomies and models have appeared that we discuss in the next session.

2.1 Taxonomies and models in PBL

Jonassen (2000) proposes a typology of problem types and order them according to the degree of structuredness of the problem as shown in the Figure 1.

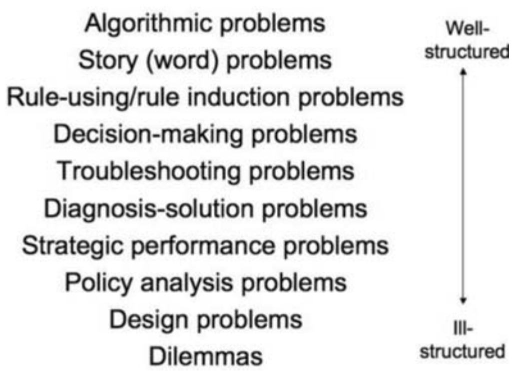

Figure 1. Typology of problem types (Jonassen, 2000)

In more recent works, Jonassen & Hung (2015) identify types of problems to be solved depending on the discipline of the learning, like design problems (for students in architecture, chemical engineering and engineering studies), diagnosis-solution problems (for nursing social work and teacher education), decision-making and policy analysis problems (for Business administration and leadership education), rule-using problems (in law schools) and case analysis problems (in graduate business programs). The authors are conscious that research needs to consider the nature of the problems being solved and how efficacious PBL methodologies are for those kinds of problems, so they examine what kinds of problems are likely to be most successful in PBL methods. In consequence, they articulate a model for evaluating problem difficulty motivated by the fact that the literature on PBL doesn't paid attention to the nature of the problem. They assess the problem difficulty in term of complexity including breadth of knowledge, attainment level, intricacy of procedure, relational complexity and problem structuredness including intransparency, heterogeneity of interpretations, interdisciplinarity, dynamicity or competing alternatives.

In other part, Becerra-Labra, Gras-Martí & Torregrosa (2012) have developed a model (T&L model) for specifically teaching and learning physics with a problem-based structure. The proposed model of physics develops both cognitive skills (scientific knowledge), and procedural and transverse skills (skills for life), like the development of logical, analytical and creative thinking. The authors found that the students insist on theory construction when they are involved in PBL. They develop an initial theory, test it by self-directed learning activities then elaborate, change and deep their understanding of the topic. Same works founds also that authentic problems or real-life problems encourage students to become interested in the treated topic and help them to gain a deeper understanding of the principles or processes underlying the problem.

2.2 PBL Processes

PBL can be viewed as an iterative process starting by a problem analysis phase, a period of self-directed learning and then a reporting phase (Yew & Goh, 2016). Causal models suggest that this type of process is important to predict students' learning. However, having only the collaborative component or the self-directed learning, component is insufficient (Yew, Chng & Schmidt, 2011).

Multiple processes and cycles have been also defined in literature. For example, Barrows (1993) proposes a problem-based learning process based on a constructivist learning environment. This process is organized into 5 main steps as follow:

- Starting a new class,
- starting a new problem,
- problem follow-up,
- performance presentation,
- after conclusion of problem.

Another process has defined by Boud and Feletti (1997) where steps are enumerated as:

- Presenting the problem and defining the broad nature of the problem by the students
- Defining and ranking the learning issues by groups and then the assignation of this learning issues and needed resources.
- Explore previous learning issues, summarize new knowledge and connect concept to old ones
- Continue defining new learning issues

In other part, Becerra-Labra, Gras-Martí & Torregrosa (2012) propose different stages (that they call the resolution indicators) related to the previously defined T&L model:

- Analyse qualitatively and understand the problematic situation.
- Hypothesis formulation
- Strategy elaboration
- Problem solving
- Analysis of results
- Consider the prospects opened up

In these works, authors insist that the stages of a problem-solving strategy will depend on the type of problem to be solved and the students' mental models with which they study science and that it is essential to promote and encourage students to develop their own strategy for resolution.

PBL is considered as an approach to higher education that needs to be conducted following these following steps (Rotgans, & Schmidt, 2011):

- Small groups of students discuss a problem guided by a tutor,
- Based on the discussion about the problem, students generate learning goals for subsequent self-directed learning. The choice of the learning goals is in the charge of the students.
- After a period of self-directed learning, students share what they have learned about the topic and test whether their new understanding of the problem is now more accurate and elaborate than before.

- Once students are satisfied with their learning outcomes, they engage with a new problem and the cycle starts all over again.

In these PBL models and processes, we need to know what is the role of both tutors and students.

2.3 Student and tutors' roles

Barrows (1988) insist on the importance of the tutor as the metacognitive coach for the learners. A tutor, is principally a facilitator acting as a guide to scaffold students' learning, particularly in the problem analysis and reporting components of the PBL tutorial, as well as facilitate students' inquiry paths as they make sense of their ideas through discussion and sharing (Yew & Goh, 2016).

Another study (Hmelo-Silver & Barrows, 2008) analysed in detail how students construct their knowledge in a PBL tutorial throughout the problem analysis and reporting phase. The discourses of students and facilitators were examined and described to show how both groups played important roles in the collaborative and collective knowledge building. This study provided important insights into how an expert facilitator effectively used open-ended metacognitive questions to facilitate students' discussion and how students' collective knowledge developed throughout verbal interactions within the PBL tutorial. However, the relationship, if any, between the quality of students' verbal contributions with their subsequent learning achievements were not examined here.

Savery, J. R. (2015) identify the role of the tutor as a facilitator of learning, the responsibilities of the learners to be self-directed and self-regulated in their learning and the essential elements in the design of ill-structured instructional problems as the driving force for inquiry. The challenge for many instructors when they are adopting a PBL approach is to make the transition from teacher as knowledge provider to tutor as manager and facilitator of learning. However, learners who are new to PBL require significant instructional scaffolding to support the development of problem-solving skills, self-directed learning skills, and teamwork/collaboration skills to a level of self-sufficiency where the scaffolds can be removed.

3 Evaluation of a PBL

3.1 Characteristics of a PBL and evaluation criteria

To achieve the educational goals of PBL and to success this approach, researchers have summarized a number of general principles for designing good PBL problems. These principles can be used to evaluate a problem on PBL:

- open ended, ill structured, however,
- with a moderate degree of structuredness;
- complex, however, the degree of complexity should
- be challenging and motivating, engaging students' interests;
- provide opportunities for students to examine the problem from multiple perspectives or disciplines;
- adapted to students' prior knowledge;
- adapted to students' cognitive development and readiness;
- authentic
- contextualized as to students' future or potential workplaces.

A number of commonly accepted characteristics that are common to problem-based learning courses was also identified (Beasley & Ford, 2004):

- Use of a real-life, complex, ill-structured, cross-disciplinary problem, with any number of correct solutions.
- The problem is presented to the students without direct instruction of how to solve it; however, resources and scaffolding are made available for the students to solve the problems themselves.
- Students work in small groups, with the help of a facilitator.
- The problem is used as the focus from which the learning is structured.

3.2 Effectiveness and Impacts of PBL on Student's engagement, motivation, problem solving ability and autonomy

Different studies evaluate the effectiveness and the impact of the application of PBL in different contexts. They worked on the impact of applying this approach on various characteristics of the students. We will focus in this paper specifically on the characteristics of student' engagement, motivation, problem solving ability and autonomy.

The study of Argaw, Haile, Ayalew, & Kuma (2017) was to determine the effect of problem-based learning strategy on students' problem-solving skills and its role in building their motivation through a quasi-experimental research method. Results show that the PBL experience can improve students' achievement in physics and prove that PBL is more effective method of instruction for the selected physics topics as compared to the conventional method of teaching and succeed to improve the academic achievement of students. The study shows however that there is no improvement on motivation of students to learn physics.

It was proved that the PBL improve the quality of learning by developing students' reflective, critical and collaborative skills (Yew & Goh, 2016). Although, about knowledge acquisition, results vary from one study to another, but generally they all agree that the PBL is favourable in terms of longer-term knowledge retention (Capon & Kuhn, 2004 ; Strobel & Van Barneveld, 2009). However, compared to students in a lecture-based learning environment for example, students who have experienced PBL achieve similar or less learning gains when it treats short-term knowledge acquisition (Pourshanazari, Roohbakhsh, Khazaei & Tajadini, 2013). In addition, Norman and Schmidt (1992) conducted a review of the evidence from PBL research. The ascertainment is that PBL students consistently retain knowledge for longer periods of time than students in a traditional curriculum, apply basic science knowledge and transfer problem-solving skills in real world professional or personal situations more effectively; and become more self-regulated, lifelong learners.

Becerra-Labra, Gras-Martí, & Torregrosa (2012) applying the T&L model of teaching/learning based on a "problem-based structure" of the contents of the course, in combination with a training in paper and pencil problem solving that emphasizes discussion and quantitative analysis, rather than formulate plug-in. The results show that there is "a significant improvement in conceptual learning, a significant increase in the ability to solve pencil and paper problems and in the attitudes and interests of students " and that students following the new method can develop scientific reasoning habits in problem solving skills, and show gains in conceptual learning, attitudes and interests, and that the effects of this approach on learning are noticeable several months after the course is over. This join the idea that PBL is effective for longer-term knowledge retention.

A more recent empirical study (Loyens, Jones, Mikkers, & Van Gog, 2015) adds a favourable finding regarding the effectiveness of the PBL. The authors show that, compared to lecture-based or self-study groups (randomly assigned), PBL group had a higher likelihood of conceptual change immediately after the lesson and in a delayed post-test after one week.

For analysing the impact of PBL on student's autonomy and engagement, a study was conducted with the objective to examine to what extent autonomy in PBL results in cognitive engagement with the treated topic and how cognitive engagement develops as a function of the learning process during a one-day PBL event. The results showed that the new measure of situational cognitive engagement is valid and reliable. Furthermore, the results revealed that students' cognitive engagement significantly increased as a function of the learning event. In the other hand, a study suggests that student engagement with the problem is sufficient to enhance students' learning gains over the traditional approach and the collaborative component did not make a significant difference to student learning (Yew, Chng, & Schmidt, 2011).

The study performed by Rotgans & Schmidt (2011) shows that the autonomy criteria evolves depending on the learning stage: "students perceive different levels of autonomy and consequently engage differently". For example, when students are brought to work in a team in a first phase under the guidance of tutor, the autonomy is relatively low. The autonomy is relatively higher when students initiate independent self-study and thus are more cognitively engaged. After that, a decrease of autonomy and cognitive engagement is perceived when students converge and share their findings.

4 Positioning PBL with other active learning approaches

Other active learning approaches exist and can be jointly related or contrasted to the PBL (e.g. Case-Based Learning CBL, Project-Based Learning – PjBL, and Inquiry-Based Learning - IBL). All these approaches tend to move students along the path to becoming more self-directed in their learning.

Like problem-based, case-based and project-based approaches act in an active learning fostering analysis and synthesis. A case that is well constructed will help students to understand the important elements of the problem/situation and thus prepare them to resolve similar situations. This type of approaches has the advantages to develop critical thinking skills and to identify logic flaws or false assumptions (Savery, 2015). However, Contrary to PBL where the learning is synthesized and organized from the beginning in the context of the problem, and so all learning emerges from the examination of the problem, the CBL is presented after the topic is covered in order to help test understanding and support synthesis (Savery & Duffy, 2001).

The PjBL learning converges with the PBL in the fact that the learning activities are organized around achieving a shared goal (project). However, when working on a project, "learners are likely to encounter several problems that generate teachable moments", so the roles of teachers change being instructors and coaches (rather than tutors). They are thus brought to provide expert guidance, feedback and suggestions (Sun & Li, 2017).

PBL is also very similar to IBL that is a student-centered, active learning approach focused on questioning, critical thinking, and problem solving (Savery, 2015). According to this author, the difference is also about the role of tutor while in IBL that is both a facilitator of learning and a provider of information. However, in PBL, the tutor supports the process and expects learners to make their thinking clear without provide information related to the problem.

5 Conclusion and future challenges

In conclusion, after this review of the literature, it has shown that the PBL is spreading in several disciplines and has proved his effectiveness in a large learning context. The reviewed studies show globally an effectiveness of the learning, particularly for problem solving ability and autonomy, knowledge acquisition (especially long-term knowledge retention). Studies shows, by cons, a "relatively" good impact on engagement and motivation depending on the process phase and on used contexts.

Following his success, many challenges are raised. Developing PBL resources, scenarios and tools assisting the tutors to better achieve the PBL goals is one of the challenges. Some researchers are working on this, like Navy, Edmondson, Maeng, Gonczi, & Mannarino (2019) developing PBL a planning template and a question map tools, and this axis needs to be developed. The use of benefits of technology is also recommended.

On the other hand, more controlled researches are needed to study the effects of PBL on student learning outcomes and performance in both academic and workplace situations and to further uncover the mechanisms behind how PBL works (Yew & Goh 2016). We suggest that researchers employing this approach to apply existing research and theoretical frameworks and models to assist them in their instructional contexts.

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Development and Assessment of Engineering Project Management Competences in the context of Project-Based Learning (PBL)

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Abstract

The International Association of Project Management (IPMA) has defined the Individual Competency Baseline (ICB) as a three-dimensional competency structure that the project management professional must develop: competences focused on practice, people, and perspectives. The ICB presents as an example the following approaches to developing competences: self-development, peer development, teaching and training, mentoring, and through simulation and games. Some of these examples are related to active learning, which enables greater autonomy of the student, stimulation of creativity, encouragement of communication and teamwork with frequent feedback from the teacher. In the Masters of Engineering Project Management of the University of Minho, Portugal, there are two courses focused on the development and assessment of competences focused on people, designed to provide moments of active learning. This paper aims to analyse how these courses have contributed to the development and assessment of people-focused competences through Project-Based Learning (PBL) and portfolios. This study is based on a documentary analysis of 70 portfolios of one academic year of the two courses, and a focus group of 10 students, in order to understand their perception about the impact of different teaching-learning moments. The results showed that the development of competences has been more enriching for the students, when compared to learning more centred in the teacher than in the student. The specificity to develop and create the activities (development of an individual portfolio) was proven in the study, as well as projects with real contexts are fundamental for the development of personal competences, being the most outstanding teamwork, communication, conflict management and interpersonal relationship. Finally, the results show that the development and assessment of competences with teaching strategies using active learning instigates the student to discuss and make practical the presented content.

Keywords: Engineering Education, Competences Development, Competences Assessment, Project-Based Learning (PBL).

1 Introduction

In the context of Project Management, the International Project Management Association (IPMA) presents, in the Individual Competences Baseline (ICB), a competency structure classified in three dimensions that the project management professionals should develop (IPMA, 2015): competences focused on practice, people and perspectives. Thus, for the practice of Engineering Project Management, using the ICB as a basis for identifying the necessary competences, it will also be necessary to deepen the understanding of the concept of competence and find ways to support the development and assessment of these competences. Mesquita, Lima, Flores, Marinho-Araujo, and Rabelo (2015) define "competence" as the process of mobilizing personal resources, such as knowledge, skills, previous experiences, values and beliefs in specific contexts to solve problems. Competence always refers to people (Le Boterf & Garrido, 2005) and relies on how to mobilize resources in a situation or a problem. For this reason, it cannot be reduced to a status or knowledge to be acquired (Le Boterf & Garrido, 2005), but must be represented in a context where competences are materialized. For Lima, Carvalho, Flores, and van Hattum-Janssen (2007) the development of competences must be stimulated and experienced in real contexts in the academic environment. Students acquire a more central role, since the active involvement of the student in the formative assessment is increasingly encouraged.

In addressing the challenges of training new engineers, Project Based Learning (PBL) is an alternative that shows fertility not only to meet the specific technical training of these professionals, but also to promote the learning of people competences, necessary in the work market (Mesquita, Lima, & Flores, 2013). The University of Aalborg in Denmark, with more than 40 years of experience in project-based learning, identified a number of shortcomings in traditional education (Hansen & Luxhöj, 1995), including the inability to work with others and discuss, the inability to solve creative problems and solve complex problems that require integration of social, economic, legal and technical factors. The goals of project-based learning are to reduce student attrition rate, increase self-confidence, communication competences and creativity, emphasize integrated problem solving, and improve faculty leadership competences to direct project teams to solve interdisciplinary problems (Lima, Carvalho, Assunção Flores, & Van Hattum-Janssen, 2007). However, they are able to identify interdisciplinarity, high student motivation and the acquisition of social competences as key characteristics of project-led education (Lima et al., 2007). Classroom discussion is one of the most common strategies that promote active learning. If the objectives of a course are to promote long-term retention of information, motivate students to learn more, allow students to apply information or develop students' cognitive competences, then discussion is preferable (McKeachie, 1987). In learning processes that may be called "traditional", the assessment is mainly an end-of-course process in which the acquired fundamental competence would be the competence to pass the final exam. A more contextualized, autonomous, interdisciplinary and student-centered learning, which is continually assessed, could contribute to a more effective learning process (Freeman et al., 2014; Prince, 2004). During the last decade, it has been recognized that students must engage in their learning process with a student-centered approach that the work of interdisciplinary projects can provide (Mesquita et al., 2013). There are several reasons behind the shift from "traditional learning" to project-oriented higher education (Helle, Tynjälä, & Olkinuora, 2006). For professional reasons: learning must be more work-based and work-oriented. Students not only reinforce and create new knowledge, but also develop competences that are recognized by employers as important tools for professional practice transversal competences (Mesquita et al., 2013). The promotion of critical thinking may be a second reason to embark on a shift to project-based learning (De Graaf & Kolmos, 2003) approaches in comparison to traditional engineering curricula. PBL models seem to inspire a greater degree of involvement in study activities and, consequently, a higher level of understanding.

This study is focused on the students' perception on the impact of innovative teaching learning in the development and assessment of competences focused on people. In this way, the objective is to show the teaching-learning perceptions promoted by the courses through active methodologies.

2 Project-Based Learning (PBL)

Project based learning (PBL) was introduced in the preparation of students for the engineering professions since the 1970s (Christie & de Graaff, 2017). Project-based learning (PBL) is widely regarded as a successful and innovative method for engineering education (De Graaf & Kolmos, 2003).

In essence, the two pedagogical variations of the PBL model have existed for thousands of years. Confucius and Socrates (500 BC and 400 BC, respectively) believed in stimulating learning rather than transmitting information. Socrates is famous for his dialogues that started with a problem and forced students to think, question and seek solutions. Confucius gave his students a jigsaw puzzle room, and if his students could not return with the other three quarters, he would not continue his lesson. One of the earliest and best known varieties of PBL is the form that was introduced at the Faculty of Health Sciences at McMaster, a Canadian university in 1969. It was soon adopted elsewhere, including the medical colleges of the University of Limburg in Maastricht, Holand University of Newcastle, Australia, and the University of New Mexico in the United States. About the same time, Project Based Learning was developed in Roskilde and Aalborg in Denmark (De Graaf & Kolmos, 2003).

Today, the PBL is a worldwide phenomenon in higher education (Christie & de Graaff, 2017). A good example is the case of the University of Aalborg, which practices problem-based learning since 1974 (de Graaff & Kolmos, 2007). In Aalborg, the physical layout of learning spaces (project rooms) across the campus is suitable for that specific brand of PBL (Christie & de Graaff, 2017). However, assessment methods should be compatible with the learning process objectives. With PBL this means testing the progress to establish knowledge and competence test rather than isolated factual knowledge. On the other hand, assess portfolios and project reports are necessarily subject to more qualitative issues, and designing reliable methods with ranking and assessment can be difficult.

An effective approach is to identify aspects of the product or presentation to be evaluated (eg, to classify project or laboratory reports, aspects such as technical strength, organization, depth of discussion, writing quality), select a weighting factor for each aspect, and construct a rubric - a form in which the evaluator assigns numerical rankings for each specified aspect, and then uses the specified weighting factors to compute an overall rank (Felder & Brent, 2003). For example, some possible assessment tools: student surveys, individual and focus group interviews; self-analyzes, learning records, periodicals; peer reviews, self-assessments; written tests or test items clearly linked to the learning objective; written project reports; oral presentations (live or on video); research proposals, problems formulated by students; written criticisms of documents or oral presentations; assessment techniques in the classroom and so on (Felder & Brent, 2003).

3 Methodology

The main objective of this work is to analyse how two courses of the Master of Engineering Project Management (MGPE) of the University of Minho, which are focused on the areas of communication management and human resources management, have contributed to the development and assessment of competences focused on people, through Project-Based Learning (PBL) and portfolios.

The International Association for Project Management (IPMA) defined the Individual Competency Baseline (ICB) as a competency structure and established the definition of the term competence as the application of knowledge, competences and abilities. Each individual has to have a specific set of competences to successfully work in projects. The individual must have perspective competences that respond to the context of the projects, social competences that respond to the personal topics and project competences that respond to the specific practices of the project management (Table). MGPE's disciplines are focused on the development and assessment of people competences, so they are based on their own competencies.

Table 1. Framework of Competences ICB4.0 (IPMA, 2015)

PRACTICE COMPETENCES (13)	PEOPLE COMPETENCES (10)	PERSPECTIVE COMPETENCES (5)
Project design	Self-reflection and self-management	Strategy
Requirements and objectives	Personal integrity and reliability	Governance, structures and processes
Scope	Personal communication	Compliance, standards and regulation
Time	Relationships and engagement	Power and interest
Organisation and information	Leadership	Culture and values
Quality	Teamwork	
Finance	Conflict and crisis	
Resources	Resourcefulness	
Procurement	Negotiation	
Plan and control	Results orientation	
Risk and opportunity		
Stakeholders		
Change and transformation		

3.1 Context of study

The structure of the MGPE degree was fundamentally based on the Project Management Body of Knowledge (PMBOK) of the Project Management Institute (PMBoK, 2013). There are two courses of this master's degree centered on the areas of communication management and human resources management, with emphasis on team management. The main purpose of these courses have been to develop and evaluate people-focused competences (IPMA, 2015) relevant to Project Management practice, through Active Learning and Project-Based Learning (PBL). The courses are based on four teaching and learning moments to promote, encourage, assess and develop such people competence.

- Free project: the students choose, with teachers' moderation, the type of project they are going to develop, the respective context and form of development. In this case, the teacher does not impose the context of the project and focuses on the supervision of the project.
- Pre-defined project: the teacher propose a real context where the project will be developed. For example: follow-up of the team work of a team project in another course/program.
- Teamwork assignments: case studies, presentation of seminars, etc.

- Individual portfolio: students must choose one of the ten people focused competences promoted by the IPMA framework to develop throughout the semester.

3.2 Collection and analysis of data

This paper aims to analyze how these courses have contributed to the development and assessment of people-focused competences through Project-Based Learning (PBL) and portfolios. This study is based on a documentary analysis of 70 portfolios of one academic year of the two courses, and a focus group of 10 students, in order to understand their perception about the impact of different teaching-learning moments.

Considering the purpose of the study, the research design followed a predominantly qualitative approach, focused on data collection techniques and procedures such as documentary analysis and focus group, which allowed to understand student's perception on the impact of different student centred teaching-learning activities. A qualitative approach is predominantly based in data collection techniques such as questionnaires, interviews, focus groups, secondary data, or data analysis procedure (such as categorizing data) that generates or uses non-numeric data (Saunders, Lewis, & Thornhill, 2009). In this study, therefore, it refers to one focus group and documents, including photos and video clips.

This study is based on a Document Analysis of 70 individual portfolios of the 2017/18 academic year of two subjects, and two focus group of 10 students. In the first phase of the study, a detailed documentary analysis of the 70 portfolios was carried out in order to extract and capture information and excerpts pertinent to the objective of the study. This data was structured in a matrix and consolidated. The information was synthesized in questions such as: What is the competence developed in the portfolio by the student? What is the contribution of the courses to the development of competences? Teaching-learning moments? Critical reflection of the courses? How did mobilize the competences developed? Finally, comments and observations. The main purpose of the analysis was to know the students' perceptions and to obtain the first evidences of the moments of teaching learning developed throughout the year.

After analyzing the portfolios, which allowed to extract evidences of the importance of the used teaching and learning strategies, two we focused on the focus group were developed. The focus group is a technique that proposes to investigate an in-depth subject through a collective approach, facilitates moments of interaction and debates in a specific group (Sehnem, Alves, Wilhelm, & Ressel, 2015) values group interaction for generation of data, given that people are encouraged to talk about experiences and points of view on a given topic. The main objectives of the use of the focus group in the context of the study were to understand the students' perceptions about the moments of teaching learning promoted in the courses, emphasizing that they do not derive from a process of "traditional teaching". Students were encouraged to explore their views on the subjects, to present suggestions for improvement, to present difficulties according to their experiences and to give examples of a particular learning situation. The sessions were held in a circular table so that all participants could feel involved in the discussion. The intention with the focus group was to find deeper meanings for the dimensions of analysis, considering the perspectives of these participants.

The process of selecting students for the focus groups was based in two main criteria: volunteers and groups with students from the same academic year. An extended invitation was sent to all of these students via e-mail and it was possible to enroll 11 students, forming two focus groups of 6 and 5 students respectively. Due to time constraints, a student in the 1st focus group could not attend. It should also be noted that all sessions were recorded in audio with the permission of the students. Subsequently, they were transcribed for data analysis. The students were informed of the confidentiality of the information collected, mentioning that the data was exclusively for research purposes.

4 Results

In this study, we present data related to the students' perspectives regarding the development and assessment of people-focused competences, through Project-Based Learning (PBL) and portfolios. The portfolio developed in both courses have slightly different objectives. For the course of the first semester, the purpose is to present a personal reflection articulated with the contents envisioned in the *team and communication management* course, allowing an articulation with contexts of developing projects experienced inside and outside of class.

For the second course, the purpose of the portfolio is to present evidences of development of one of the 10 (ten) people focused competences defined by the IPMA. In both courses, the portfolio format is free and quite diverse. As an example, other forms of development of the portfolios, in the form of newspaper, website, event diary, promotional pamphlet format, board game, letters and etc.

The creativity of the student is developed throughout the semester, it is up to the teacher to show examples, to encourage him to leave their "comfort zone", so that the students will be able to promote and present evidences of competences.

4.1 Impact of teaching-learning strategies

In the data analysis, excerpts were extracted that highlight the teaching-learning structure of the courses, such as the evidences on the impact of teaching-learning strategies and the differentiation of the courses in relation to more traditional strategies. Students show evidence of impact in relation to the use of active learning, which allows for more dynamic, interactive, playful classes, greater student autonomy in the development of projects in real contexts, strong interaction with methodologies used in real contexts of the professional activity of Management of projects, promotes and encourages creativity at all teaching-learning moments and, according to the students, such impacts are not evidenced in so-called "traditional" courses. According to De Graaf and Kolmos (2003) it is a very common experience that students are more motivated and work much more with the PBL model than with traditional teaching methods.

The results also point out that active learning makes classes lighter and livelier, allowing more concentration, interest and student participation in the classroom. (Edström & Kolmos, 2014) that with the PBL, higher levels of motivation, collaboration, communication and collaborative knowledge construction are promoted. The individual portfolios present some evidences related to the impact of strategies (Table 2)Table 2. Evidences related to the teaching-learning strategies.

Table 2. Evidences related to the teaching-learning strategies

Teaching-learning strategies	"Many of the techniques presented can change how we relate to business and personal life, rapport, backtracking and feedback are essential to the leaders we want to become, I will certainly bring those competences to life. "
	"The classes were always very interactive which helped us to be focused and dedicated in the contents taught, always having a team dynamics in order to apply the theoretical content addressed."
	"The methodologies used allowed me to get out of my comfort zone. The methods covered are very pleasant and I feel that I can apply much of what I learned in my profession as a project manager."
	"The work I've done has always made me reflect on my life, both personal and professional, and how I can evolve as a human being. One of the most basic lessons I may have learned here is that communication is the key to everything."
	"The way the course is guided, highlights the importance of content in a very ludic way."
	"We conducted an assessment of a case study in the automotive industry. We fill the Project Model Canvas together. Personally, I really enjoyed this activity, because it was quite informative and didactic. In the future, it will be a tool that I will use. "
	"The way of presenting content made the course lighter and livelier in relation to the more, increasing the desire to learn."
	"The methodologies used made the classes were interactive and captivated by the way they delivered the content, perhaps the most innovative and interesting subjects I've had."
	"I found the approach used in the course unit to be very interesting, focusing mainly on teamwork, but also checking individual competences that are complementary in a group work."
	"During the course we had the opportunity to experience a project environment in practice. Every class has had the opportunity to develop their technical and cognitive competences. "
	"The insertion of real contexts is an excellent strategy to do the projects in practice, we live conflicts, interpersonal relations, leadership, communication and other competences developed throughout the real project."
	"The specificity to develop the activities of the context of each student, as an example: building a portfolio, is not only to reach and add all the concepts we learn in the course in the same way that is in the book or slides, but to build your portfolio with their perception, one of the positive factors of this type of methodologies."

	"The methodologies used by the courses are more enriching for the student than the traditional form of assessment. One of the few subjects we will know is that we will apply 100% of content to personal and / or professional life. "
	"Active methodologies encourage students to discuss and make practical what is presented."
	"Project management tools are passed in a very practical way, portraying real contexts."
	"The teachers looked very good as classes, they were recent practical lessons that actually simulated the principles of project management."

4.2 Competences development

Numerous sections in the analyzed portfolios evidenced the development of people focused competences. These evidences reinforce the positive results of active learning strategies presented in several references. According to (Mesquita et al., 2013) that learning must should be more work-based and professionally oriented, students not only reinforce and create new knowledge, but also develop transversal competences that are recognized by employers. The courses, according to students' views, allowed the development of such competences with some examples of real learning situations illustrated in the portfolios. Moreover, they stressed that courses with so-called "traditional" method classes make it difficult to develop and evaluate competences.

Students have identified a wide range of learning outcomes and processes. They said they learned how to engage in teamwork and how to collaborate with colleagues. Peer interaction emerges as a source of motivation. Conflict management is also considered one of the greatest lessons learned. The main competences that show evidences of development were teamwork, communication, conflict management and interpersonal relationships. Table 3 shows some excerpts from the portfolios summarizing the evidence of the contribution of the courses to development and assessment of competences.

Table 3. Evidences related to the development of competences

Development of competences	"I intend to use all the knowledge acquired in my daily life and professional career whenever possible."
	"It was of utmost importance for my personal and professional development, developing my competences in communication and teamwork."
	"I was able to more easily make an introspection of all the changes and implications that the change in communication has had in my life. It has changed my posture relative to others, allowed me to learn to listen and speak before there is a "snowball" ".
	"Today I recognize that through the development of people and the relationships among team members, success will come."
	"As far as the execution of the team work outside of the classroom environment, allowed the development and the fomentation of my creativity.
	"I was able to make an introspection of all the changes and implications that the change in communication has had in my life. It has changed my posture relative to others, allowed me to learn to listen and speak before there was a communication failure and allowed me to perceive that we all have different perceptions of situations within a group, and that it is therefore necessary that these tools and techniques be embraced and used by all, to increase overall performance.
	"I acquired several tools for my life as a future team manager, and it was a great form of self-knowledge."
	"Having the company of a team, where many are inexperienced, with different nationalities, running behind, seeing who will help, building the project where we ourselves are managers is fundamental to the development of competences."

4.3 Competences assessment

Assessment of and for learning are promoted throughout the semester. As an example, at the end of each presentation, teachers assess the learning process, give written feedback and ask for written feedback from other students. One purpose of this type of assessment is that all students are simultaneously evaluated and evaluator. In this assessment process the teacher performs his / her feedback and deliver considerations to the team or student. According to (Christie & de Graaff, 2017) PBL has the ability to revitalize and stimulate higher education and provide an authentic assessment of learning in real life.

The evidences of assessment of competences are closely linked to the development of competences. Thus, it is worth emphasizing that the evidences regarding assessment competences were basically related to the importance of feedback throughout the learning process and auto evaluation. Table 4 show evidences of self-evaluation and of feedback as being truly effective for the learning process

Table 4. Evidences related with the assessment of competences

Competences Assessment	"I was not expecting such a development in such a short time."
	"It is a competence that I still have to deepen, but that during these months was stimulated."
	"With the assessment of competency in feedback form, I can have a clearer view of the way forward to develop my competence."
	"As a final result of the portfolio, we have had both feedback from teachers and from course colleagues. Even from ourselves, we made ourselves review and see the applications of what we have learned, by way of facts."
	"I was able to make a general overview about all my activities during the semester, as well as the knowledge acquired throughout the year."

5 Conclusions

As a result of the study, there were evidences about the impact on teaching and learning promoted by the disciplines, which in fact, portrayed as a differentiation in relation to the so-called "traditional" learning. The specificity to develop the activities in the context of each student (development of an individual portfolio), the insertion in real project contexts]

and a strong interaction with methodologies used in real contexts of the Professional activity of Project Management, stimulating the creativity, were the main impacts on teaching and learning promoted by the disciplines. However, students have identified a wide range of outcomes and learning processes. They said they learned how to get involved in teamwork and how to collaborate with colleagues. Peer interaction emerges as a source of motivation. Conflict management is also considered one of the greatest lessons learned.

The importance of the structure of the courses is highlighted, with notary engagement and participation in the classroom and a higher attendance rate and enthusiasm in the development of the promoted activities. As a recommendation, students emphasize the willingness / desire that other courses seek to employ active methodologies and, thus, promote greater excellence in teaching-learning.

Finally, through examples it was possible to demonstrate the mobilization of the competences developed in the courses, the teamwork, communication and management of conflicts, were trained and improved in the professional environment.

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Competencies based curricula (Electro-Mechanical Department Case Study)

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Abstract

Continuous Improvement of the Electro-Mechanical training provided by ESPRIT School of Engineering has been always one of our first worries. In this context, a project on competency-based-study plan was lead aiming at reforming the study program unifying main competencies provided by CTI and CDIO programs. The main objective of our work is to set up a management process allowing aligning learning outcomes and required market competencies. The first step consisted in involving professionals in this process by filling a questionnaire aiming at defining expected nowadays competencies from an Electro-Mechanical engineer. Considering key-verbs from Bloom's Taxonomy, the questionnaire takes into account the knowledge, know-how, personal and interpersonal skills aspect related to different fields of engineering skills. The panel of professionals was diversified in order to insure credible results. Adding to define the degree of in-depth-study, Bloom's Taxonomy was later used in rewording competencies to learning outcomes. The second step reposed on analyzing the collected data in order to reword the societal and entrepreneurial needs expressed as knowledge, know-how and attitudes to competencies extracted from crossing the two matrices relating the CTI and CDIO initiatives. A reference competency document was then written. The next crucial step consisted in involving all teachers of the department in analyzing extracted competencies and translating them to learning subjects and teaching activities insuring that learning outcomes will match with expected competencies. How the competency-based learning impacts higher education? How the competency can be translated to corresponding study subjects? How evaluating and insuring that targeted competency is acquired? The last step consisted in drawing up the new study plan according to all collected data. Some of proposed modifications were drastic and some others were not so significant. A new study plan was consequently developed. The important dimensions of our project are analyzed such as taking into account professional world expectations or the construction of an exchange space between teachers. Finally, some issues to avoid in such a project are discussed.

Keywords: Engineering Education, Competency based program, learning outcome, CTI, CDIO, Electromechanical Engineering

1 Introduction

Competency-based learning is a recent approach developed in higher education in several institutes around the world in recent years (Gu, X. Y., 2009, Song, D. 2018, Jianfeng, B. 2013). The aim is to build a reference framework based on the skills of the target business skills, taking into account in an integrated manner all the facets of this business (knowledge, know-how and know-who). A quantitative and qualitative analysis of the survey, established among industrialists and researchers, gave rise to three major results: the skills framework, the skills matrix and the new study plan. Starting from competencies of the target business skills of an "Electromechanical Engineer", the study plan has been redefined in perpetual exchange and involvement of all the teachers of the electromechanical department. In this paper, we describe the documents produced as well as each of the new dimensions created for the update of the study plan considered for the start of the academic year 2019-2020.

2 Competencies reference

The training profile of ESPRIT electromechanical engineer is mainly focused on the creation / development / implementation / operation of solutions for the mechanical, electrical and information sciences sectors, particularly to deal with coupling issues. In order to acquire these skills, the engineering student must study the fundamental subjects and the engineering sciences with in-depth studies proposed for different optional specific courses starting from the 4th year. From this year, the student accure more specialized methodological and technological skills and have several professional activities. For these activities, the necessary skills that flow from the survey analysis process are shown in Table 1.

Table 1. Competencies List

N°	Competencies
1	Mastering a solid body of knowledge in the basic sciences
2	Mastery of a solid body of knowledge in engineering sciences and techniques
3	Deployment of a wide range of knowledge to imagine, design, build and operate adapted, robust and innovative systems
4	Planning, management, contribution, in team, to the realization of a multidisciplinary project
5	Taking into account environmental and societal constraints
6	Effective team work and structured and contextualized communication.

These skills are interdependent and describe a basic academic professional profile, geared towards the efficiency of the EM engineer and can be applied to other engineering courses. Competency 1 deals mainly with the requirements of a transversal initial training cycle focusing on the basic sciences. Central skills 2 and 3 characterize electromechanical training and form the core of the engineering profession. Skill 3 adds the CDIO aspect (Concieve, Design, Implement and Operate). Basically, the engineer analyzes complex situations (competency 2), designs, implements, evaluates and performs a financial analysis of typical and innovative robust solutions (competency 3). Therefore, he must master the basic sciences (competency 1), master a solid body of knowledge in engineering sciences and techniques (competency 2), plan and manage activities, projects and people (competency 4). He must consider economic, societal and environmental issues while acting as a responsible professional (competency 5) and a communicator and confirmed writer (competency 6). These competencies will be transformed during the reform process into a process for developing of a new study plan.

3 Reform process

The questionnaire was validated by a multidisciplinary committee of teachers and consultants according to the reform process in figure 1. Teachers of electromechanical department were involved in the process and took charge of the visit of professional representatives in order to have the inquiry form completed. In fact, answers were collected from about twenty companies with different fields of activity: Manufacture electronic equipment, construction public works, Robotics, Mechanical parts manufacturing, para-pharmaceutical, Electricity generation, Paper processing, Aeronautics, Mechatronics, ICT, Plastic injection, Packaging, Manufacture of medical devices, etc. The interviewees were engineers, project managers, managers or company directors. In addition, the survey included academic teachers and researchers.

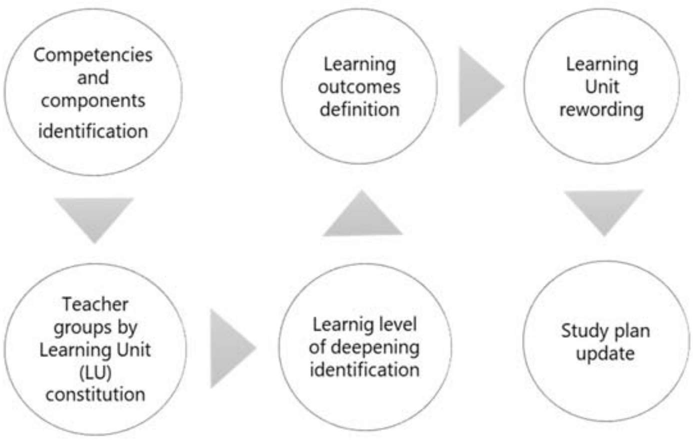

Figure 1. Reform process

4 Learning Unit reform

To illustrate the approach of the changes in the study plan, we will show two examples of skills acquired throughout the course of the course via the CDIO (concieve, Design, Implement and Operate) approach (Berggren, K.F, et al 2003, Bankel, J., et al 2003).

Tables 2. and 6. below show a correspondence approach between competencies, level of depth of learning, learning situation and evaluation for an electrical and a mechanical unit respectively.

Table 2. Electrical Systems Unit

Competencies	Level of deepening	Learning situation	Evaluation
1) Ability to understand and model physical phenomena related to electrical energy production, transportation, distribution, conversion, storage, and management **2)Ability to master digital tools to simulate the processes of electrical energy production, transportation, distribution, conversion and management**	Know (Electromagnetism Laws)	Courses	Exam
	Understand (the link between electrical and magnetic energy)	Courses	Exam
	Collaborate in groups to analyze (analyze a network using simulation tools)	Practical Work	
	Evaluate (the network quality)	Seminar	Quizz
3) Ability to master the concepts of electrical networks and their optimal management.	Know (the standards of electrical networks)	Courses	Exam
	Understand (Analyze an electrical diagram)	Problem-Based Learning	Presentation
	Evaluate (compilance of an elec. installation with the standards)	Practical Work	
	Create (design an elec. installation based on specifications)	Project	Presentation
4) Ability to master the advanced concepts of power electronics and develop their control. **5) Ability to realize electronic control interfaces.**	Know (semiconductors)	Courses	Exam
	Understand (converterstopology)	Courses	Exam
	Apply (choose the appropriate converter for a given application)	Problem-Based Learning	Presentation
	Analyze (convertersoperation)	Practical Work	
	Create (converter control board)	Practical Work	
6) Ability to size electric machines and ensure its control **7) Ability to use simulation and design tools to optimize the performance of electrical machines.**	Know (elect. machine construction)	Courses	Exam
	Understand (conversion of elect. Energy to mechenical energy)	Courses	Quizz
	Apply (choose appropriate machine for a given electromechanical application)	Problem-Based Learning	Presentation
	Analyze (Size a machine with practical tests)	Practical Work	Presentation + Report
	Create (a power chain « network+ converter+machine+control interface » based on specifications)	Project	Presentation +Report

The associated objectives/activities learning matrix for the Electrical Systems Unit learning is given in Table 3.

Table 3. Objectives / Activities Learning matrix

	Course	Prob Based Learning	Practical Work	Project
understand and model physical phenomena related to electrical energy production, transportation, distribution, conversion, storage, and management	xxx	x	xx	
master the concepts of electrical networks and their optimal management.	xx	xxx	xx	x
master the advanced concepts of power electronics and develop their control	xxx			
realize electronic control interfaces		xx	xxx	
size electric machines and ensure its control	xxx	x	x	
use simulation and design tools to optimize the performance of electrical machines		xxx	xxx	xx

In Table 4. "Electricity Installation" was added in the second year of the Study program. Besides, "Electrical Motors" which was included in Electrotechnics course is now an independent course which is given after "Power Electronic" one. This facilitates the assimilation of motors control procedures. Also, a course named "Quality of Electrical Energy" is added in the final year of the study program.

Table 4. Learning Unit Sequence For competence 1 and 2 of Electrical Systems Unit

1EM		2EM		3EM		4EM		5EM
1st Sem.	2nd Sem.	1st Sem.	2nd Sem.	1st Sem.	2nd Sem.	1st Sem.	2nd Sem.	1st Sem.
Electromagnetism	CAO	Electrotechnics	Analog Electronic	Embedded Systems	Power Electronics	Electrical Motors	FPGA	Quality of Electrical Energy
Electrical Circuit Theory		Electricity Installation						Renewables Energies

According to Table 5., the evolution of skills is quite clear when moving from one learning level to another.

Table 5. Courses/ competences matrix

	Competence N°1	Competence N°2	Competence N°3	Competence N°4	Competence N°5	Competence N°6
Electromagnetism	X					
Electrotechnics				x		X
Electricity Installation		x	X	x		X
Power Electronics		x	X	x		X
Electrical Motors		x	X	x		X
Quality of Electrical Energy	X	x	X		x	

Renewables Energies	X	x	X		x	X

Table 6. below shows the correspondence approach between competencies, level of depth of learning, learning situation and evaluation for a mechanical unit. (PBL is Problem Based learning)

Table 6. Modeling and sizing of mechanical structures Unit

Competences	**Level of deepening**	**Learning situation**	**Evaluation**
1) Capacity of understanding different properties of materials at a molecular level	- Define the atomic bonds in solids - Detect the different defects in the materials	Course PBL	Written exam
2) Capacity of developing material specifications and forming process	- Make a reasoned choice of a category of materials - Describe the principles of implementation and materials forming processes - Dimension some elements according to specifications	Course PBL	Written exam
3) Ability to solve solid mechanics problems by linear and isotropic elasticity theory	- Calculate isostatic/hyperstatic beams by the resistance of materials - Dimension simple structural elements with idealized support conditions and subject to basic loadings - Perform the necessary checks for strength and stiffness	PBL Practical Work	Written exam PW exam
4) Describe principle operations, normative aspect, technological tools, and size the mechanical elements of mechanical power transmission and vibration	- Choose suitable systems to dimension a more or less complex functional mechanism - Collaborate as a group to analyze, deduce and evaluate - Apply specific techniques of mechanical vibration theory by studying simple models	PBL Course Practical Work	Written exam PW exam
5) Apply a rigorous modeling methodology to a given concrete problem from a set of specifications	- Model simple geometry problems and optimize complex topology to generate appropriate element type - Model complex geometry problems and solution techniques	Project	PW exam

Bellow, in Table 7., the associated objectives/activities learning matrix for the mechanical unit learning is illustrated. In fact, in the learning process, our courses are consolidated by the problem-based learning method. Besides, courses are based on integrated projects and practical work. The evolution towards the projects is quite clear according to learning levels.

Table 7. Objectives / Activities Learning matrix

	Course	**Problem-based learning**	**Practical Work**	**Project**
Describe different properties of materials at a molecular level	xx	xxx		
Make a reasoned choice of a category of materials	xx	xxx	xx	
Describe the principles of implementation and materials forming processes	xxx	x	xx	
Dimension some elements according to specifications	x	xx	x	xxx
Solve solid mechanics problems by linear and isotropic elasticity theory	Xxx	xx	xx	x
Dimension simple structural elements with idealized support conditions and subject to basic loadings	Xx	xxx	xxx	x
Describe principle operations, normative aspect, technological tools, and size the mechanical elements of power transmission	Xx	x	x	xxx
Apply the specific techniques of mechanical vibration theory by studying simple models	Xx	xx	xxx	x
Apply a rigorous modeling methodology to a given concrete problem from a set of specifications			xx	xxx

Table 8. Learning Unit Sequence or competence 2 and 3 of Modeling and sizing of mechanical structures Unit

1EM		2EM		3EM		4EM		5EM
1st Sem.	2nd Sem.	1st Sem.	2nd Sem.	1st Sem.	2nd Sem.	1st Sem	2nd Sem.	1st Sem.
Mechanics of rigid bodies	Technical drawing and CAD	Chemistry of materials	Plastic materials	Mechanics of Deformable Solids	Structural Analysis	Mechanical power transmission	Mechanical vibration	Numerical simulation project
Molecular chemistry		Metallurgy	Mechanism analysis				Finite element method	

According to Table 8., at the end of this process, chemistry of materials was consolidated and associated to metallurgy and plastic material courses. For further levels, courses of continuous mechanics and resistance of materials were associated in order to master the concepts of linear structures analysis. A numerical computation session was considered in order to perfect fundamental training while mastering finite element method for solving engineering problems and mathematical physics.

Table 9. below represents the cross between courses by learning level evolution affected the mechanical studied unit (modeling and sizing of mechanical structures) and the skills extracted from the questionnaire. The evolution of skills is quite clear when moving from one learning level to another.

Table 9: Courses / competences matrix

	Competence N°1	Competence N°2	Competence N°3	Competence N°4	Competence N°5	Competence N°6
Molecular chemistry	x					
Chemistry of materials	x					
Metallurgy	x	X				
Plastic materials	x	X				
Mechanics of Deformable Solids	x	X	x			
Structural Analysis		X	x	x		
Mechanical vibration		X	x	x		
Numerical simulation project			x	x	X	x

5 Competencies matrix verification

5.1 Competencies during the training

Each module responsible was asked to express his course in terms of learning outcomes. He also indicates the necessary knowledge, skills and attitudes as well as evaluation methods. The acquisition of a competency can be staggered over the training cycle by identifying the validation milestones (partial or global) over the duration of the course. The teacher establishes the links between his course and the competencies identified and described in the competency framework. In order to create the competencies matrix. For example, in figure 2, we see that the competency (C1) which is "Mastering a solid body of knowledge in the fundamental sciences" is decreasing from 50% for the 1st year to 29% for the 3rd year and after that 0% for the 4th & 5th year.

Competency (C2) has exactly the same tendency as that of (C1). This trend proves the consistency of the results obtained, which favor fundamental training at the first stage of engineering training. Then, we made new decisions on the study design: (1) increase in Mathematics ECTS (European Credits Transfer System) from 6 to 8 (2) addition of new fundamental modules such as "geometrical optics", "metallurgy", "plastic materials" following the results of the questioner which requires more knowledge in chemistry (3) Algorithmic module addition. For proficiency (C3) it becomes weak in 3rd year to prepare the transition between basic sciences and engineering sciences.

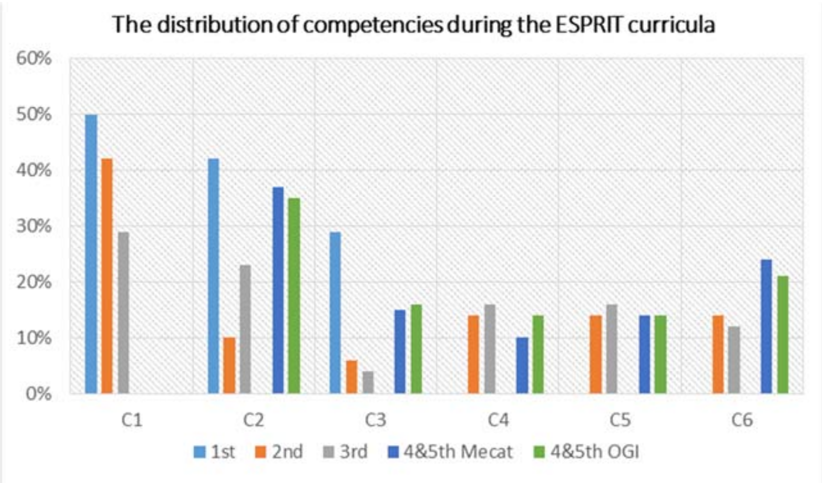

Figure 2: Distribution of competencies during ESPRIT curricula

For the two years of specialization, the OGI and mechatronic options have a homogeneous distribution of skills (C2), (C3), (C5) and (C6) with: (a) an industrial engineering tint for the OGI (Organization and industrial management) so more time for the Competency (C4) that focuses on organization, planning and project management (b) Mechatronics engineering tint, therefore a higher level of the competency (C2) Science and Engineering Technology.

5.2 Competencies and CDIO levels

We also followed the evolution of CDIO learning levels in relation to the subjects taught. We checked the evolution of the CDIO skills of some teaching units in the curriculum.

In table 10., we have highlighted some courses that highlight the CDIO approach. For instance, in a first level, students acquire skills "technical knowledge and reasoning" as well as "personal and professional skills and attributes" via fundamental modules such as "Technical drawing and CAD", "Electronical board design", "Multimedia techniques" and " Communication, culture and English citizenship 1,2,3". Then the competence "CONCEIVING, DESIGNING, IMPLEMENTING, AND OPERATING SYSTEMS IN THE ENTERPRISE AND SOCIETAL CONTEXT" is required by (1) The projects of the 3rd and 4th year (CDIO of the 4th year) (2) the courses with situation of simulated business or with solution design as developed. We have referred to the CDIO competencies to develop the objectives of the projects as modules and those affiliated with the courses. By structuring the training objectives according to Bloom's taxonomy (Brame, CJ., 2019) (Bloom, B.S., 1972), we are able to best promote the progression of learning to higher levels. In fact, Bloom's taxonomy is used with the intention of determining the learning objectives to be attained by the learner and promoting his learning. While preparing course sheets, projects and teaching units, we again referred to the pedagogical objective, looking for the operational dimension that will prove that the learner has achieved this goal.

Table 10. Projects and CDIO competencies matrix

		Integration project at 1EM and 2EM	Technical drawing and CAD	Communication, culture and English and French citizenship 1,2,3 and 4EM	Multimedia techniques 1EM and 2EM	Concieve and design project 2EM and 3EM	Electronical board design	Algorithmics and programming project	Mechanisms analysis Project	Maintenance project	Innovation and entrepreneurship project	Concieve and Design/Implement and Operate project	Finite element method project	Sustainable development and social responsibility (SDSR) Project	End of studies project
TECHNICAL KNOWLEDGE AND REASONING	KNOWLEDGE OF UNDERLYING SCIENCE	X	x				x	x		x					
	CORE ENGINEERING FUNDAMENTAL KNOWLEDGE		x			x	x		x	x					
	ADVANCED ENGINEERING FUNDAMENTAL KNOWLEDGE								x	x		x	x		x
PROFESSIONAL CAPABILITIES AND PERSONAL SKILLS AND ATTRIBUTES	ANALYTICAL REASONING AND PROBLEM SOLVING	X			x	x	x	x		x		x	x		
	SCIENTIFIC METHODS: EXPERIMENTATION, INVESTIGATION AND INITIATION TO RESEARCH					x				x		x			x
	SYSTEMIC THINKING					x		x		x		x			x
	ATTITUDES AND LEARNINGS	X	x	X	x	x	x	x	x	x		x		x	
	ETHICS, ETHICS AND OTHER RESPONSIBILITIES										X			x	x
INTERPERSONAL CAPABILITIES: TEAMWORK AND COMMUNICATI	MULTI-DISCIPLINARY TEAMWORK				x	x				x	X	x	x		x
	COMMUNICATIONS	X		X	x	x					X	x		x	x
	COMMUNICATIONS IN FOREIGN LANGUAGES			X	x						X	x			
CONCEIVING, DESIGNING, IMPLEMENTING, AND OPERATING SYSTEMS IN THE ENTERPRISE AND SOCIETAL CONTEXT	EXTERNAL AND SOCIETAL CONTEXT			X							X	x	x	x	x
	ENTERPRISE AND BUSINESS CONTEXT									x		x		x	x
	CONCEIVING AND ENGINEERING SYSTEMS		x				x	x					x		x
	DESIGNING		x				x						x		x
	IMPLEMENTING					x							x		x
	OPERATING	X				x							x		x

6 Synthesis

Three main documents were developed as a result of the questionnaire conducted. The analysis of the obtained graphs showed a coherence between the established competences and a complementarity and continuity ensured between the different modules which will be taught. This result is the fruit of the cooperation of the industrialists and the teachers in order to offer a better training to the electromechanical engineer of ESPRIT in adequacy with its specialty and the demand of the Tunisian and International industrial market. The required competencies of manufacturers are approved by the "trade repository" so we have no contradiction. Several tasks will be necessary and are envisaged in the rest of the project, in order to meet the initial objectives. These tasks were certainly discussed orally before being able to establish the documents mentioned above, remains their formalization. The first will be the reformulation of learning outcomes in the form of skills and their distribution on existing courses and activities. A second task as important as the first one will be the preparation of the module sheets of the different courses realized, and the reflection between the teachers on the coherence between the acquired competencies in their course, the methods to develop them and evaluate them. The updated study plan of the electromechanical department envisaged for the start of the academic year 2019-2020 is elaborated. During the first two years, 1st and 2nd year of training, the fundamental sciences occupy an important place. During the 3 years of the specialization cycle, it is up to the engineering sciences and techniques to take over. Soft skills are transversal skills spread over 5 years of training. We also note the presence of projects from the 1st to the 5th year which are only a fundamental pillar in the pedagogy that we adopt. Note that the study plan of the harmonization period in the third year is separated from the study plan of the other three periods of the same year given its diversity. The harmonization period inserted allowed converging to a single study plan from the second period of the 3rd year and eliminating the old names and separations "A" and "B" for all the classes. We mentioned that the classes will be mixed between students from electrical or mechanical specialty before coming into ESPRIT "B group" and ESPRIT students "group A" who are studying since the 1st year in "ESPRIT". It is important to underline the fact that the 2018-2019 school year presents a transitional year where for example some modules included will be taught for two levels at a time, deleted temporarily or also provided during the harmonization period. The overall improvements of the project are somewhat constrained due to lack of availability of rooms for specialized activities (like projects or club activities). However, these criticisms can be overcome through the construction of a new building that will include specialized rooms, workshops, closets for project materials and pre-arranged classrooms with good sound insulation and good lighting.

7 Conclusion

Three overall goals direct the steps done for establishing the study plan. They are to educate students to: (1) Master a deep working knowledge of technical fundamentals. (2) Lead in the creation and operation of new products and systems. (3) Understand the importance and strategic value of their future research work by projects and working in industry. In the future, measuring the quality of the result and taking actions in order make the process outcome come closer to the target as recommended by (Gunnarsson ,S., 2017; Bankel, J., et al., 2005) is an obligation.

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Competences based curricula (Case Study)

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Abstract

We present the process and the results of a project laid out to define the objectives of the Civil Engineering and electro-mechanic engineering programs in terms of competences according to the CTI (Commission des Titres d'Ingénieurs) and CDIO (Conceive Design Implement Operate) requirements. The process consisted in setting up and adapting a questionnaire relating to civil engineering and electro-mechanical engineering taking into account the knowledge, know-how and personal and interpersonal skills aspect related to different fields of engineering skills, it reposes on collecting the societal and entrepreneurial needs expressed as knowledge, know-how and attitudes from a panel of (27+24) active professionals, civil, electrical and mechanical engineers themselves or collaborating with them. These attitudes consist in crossing the two matrices relating the CTI and CDIO initiative. The consecutive quantitative and qualitative analysis allows us to highlight expected competences for the civil and electro-mechanical engineer. How the competency-based learning impacts higher education? What are the crosspoints of the skill matrices of the CTI and the CDIO initiative and how does they represent and affect the challenges of the competency-based approach? Three important dimensions of this type of project are analyzed: taking into account expectations of the professional world, the transformations of the academic programs and the development of a construction space and exchange between teachers. Finally, some issues to avoid in such a project are discussed. This contribution attempts to respond to these questions through the analysis of the project that has culminated to redefine the study plan of the civil and electro-Mechanical Engineering Sections of the School ESPRIT. This paper assesses the role of the company in defining the skills of future engineers according to CTI and CDIO requirements and discusses its stakes especially in terms of the implication of the different actors.

Keywords: Engineering Education, Competence based program, learning outcome, CTI, CDIO

1 Introduction

This paper describes the approach we followed to ensure the adequate matching of training to employment, which is one of the main challenges that universities around the world strive to meet. In higher education, the revision of curricula necessitates a return to the skills required by the labor market to train skilled labors.

The adequacy between training and employment is considered one of the main economic challenges in Tunisia. It is essential and it is the keystone to any desired development. Graduates should be able to learn new skills, new expertise to achieve progress in a world increasingly laborious and demanding. The involvement of all parties is very important to deal with this problem and to guide young people towards the right paths.

The natural extension of the idea of training-employment adequacy is that training needs to be built with professionals, which is a common practice (Vincens, J. 2006).

The integration of the expectations of the business world into training is one of the main features of the competency-based approach. However, developing a study plan based on the skills required by the labor market remains a delicate task, because it must both take into account the expectations of the business world and implement goals that can be considered and evaluated.

It is important to define the purposes that are attributed to the relationship between training and employment. What is the correspondence? A number of job vacancies and the number of graduates? Training and work activities? Generic training and skills? Training and employability of the workforce? What is the purpose of this correspondence? The increase in productivity? Integration into employment? Skills development of the workforce? (Simoneau, F. 2017)

Several authors have examined the training-employment relationship and criticized the paradigm of adequacy according to which education must build training that best matches jobs. They propose to substitute the paradigm of convenience that would answer students' questions (with a given diploma could I do what would suit me?) And employers (for a given job what training would be appropriate?) (Vincens, J. 2006)..

Engineering education at ESPRIT is of paramount importance, engineers in different disciplines integrate the professional world every year, with the changes engineers face such as emerging technologies, sustainability requirements and the needs for continuous growth in terms of skills and ability to solve increasingly complex problems. Traditional training proves to be insufficient, engineering training has changed radically requiring more important and different know-how. It is true that ESPRIT training is increasingly adapted in terms of active pedagogy and innovative teaching methods and impacting simply the skills approach that motivated this project and led to define the skills required from professionals in order to deploy them in a reference system for skills, especially for ESPRIT's civil and electromechanical engineer.

2 The match between training and jobs

To put training in the logic of the division of labor is to identify a target, that is to say jobs that occupy a specific place in the organization, define the skills or abilities required for a recent graduate to apply for one of these jobs and build training accordingly. Training is then deemed adequate for the job. The underlying premise is that of double comparative advantage (Vincens 2005): the intended job is considered to be the best of all to which the graduate can claim (best in terms of meeting the expectations of the graduate) and the graduate with this training is reputedly the best the employer can find (the best in terms of cost / efficiency ratio).

All of these concerns about the adequacy of Training / Job-market were not exotic to us. We felt we had to do something. In our meetings we get lost in discussions about this or that course and its relevance or not. Courses were defined because others schools taught them. There was no logical justification coming from us. For example, we had the intuition that the civil engineer needed some knowledge in architecture and urban planning, since he collaborated with architects in construction projects, but we could not estimate the extent of this knowledge, their degree of depth and the number of hours to devote to it etc. Until we started the accreditation process, the discovery of the CDIO Initiative standards and methodology of the competency based curricula approach.

2.1 Competence: concepts and definition

In a general definition, Le Boterf defines competence as the ability to know how to act and react in a particular work situation, the person must be able to implement professional practices to manage in order to perform prescribed tasks, and desirable achievement criteria are associated to these tasks in order to achieve expected results (products, services) for a recipient. (Le Boterf, G)

If we refer to the Roegiers (2000) definition of competence, it resides in the ability of the individual to mobilize an integrated set of resources in a conscious and organized way, these resources consist of knowledge, skills and strategies and this in the goal of solving a family of issues situations. (GILBERT P. PARLIER M. 1992).

Parlier joins him in defining competence as a characteristic of the individual that enables the person to focus on the individual regardless of the organizational context (Parlier, 1994: 96), he also defines it as a way of dynamically reconstructing the various elements that constitute it (knowledge, practical know-how and resonance) (Parlier, 1994: 96), and in its heterogeneous aspect, the competence brings together technical know-how and 'behaviors', 'attitudes', 'know-how', etc. (Bellier, 1999a)

The definition presented by Le Boterf (as quoted in Perrenoud 2002) considers the competence as ‘knowing how to mobilize’ (Perrenoud, P. 2002). Perrenoud (as quoted in Tarek, A. 2010) considers that the competence allows one to face a complex situation, build an appropriate response, without going into a register of preprogrammed responses. According Zarifian (as quoted in Batime 1999), competence involves taking initiative and responsibility in the professional situations one faces. It is characterized by the ability to build on prior acquisitions and turn them according to different situations (Batime, C. 1999). For Tardif (as quoted in Arena-Daigle 2006), a competence is a 'knowing-how-to-act' complex based on the effective mobilization and combination of a variety of internal and external resources within a family of situations (Arena-Daigle. L. 2006). Based on these definitions, competence can be likened to the integral mobilization of a diversity of internal resources ('knowledge', 'technical skills', and 'social/interpersonal skills') and external (material and human) to solve a given complex situation. 2.2.2. Competency-based approach: definition and objectives According to Rogiers (Rogiers X. 2004), the competency-based approach relies on three fundamental objectives: • "Emphasizing the competencies that the student must master at the end of each school year and at the end of compulsory schooling, rather than stressing what the teacher must.

2.2 Need for a scientific approach that starts from requirements of the professional world

Being aware that the best starting point for improving the current and existing situation was to ask the right questions, It was necessary to seek solutions to the problems encountered at meetings of the CSP, the first outcome has shed light on the following points: On the one hand, it was necessary to follow a scientific approach that starts from the market and, on the other hand, to find the right work methodology that allows a good sequence of steps to follow. A project has been launched to take into account profession competences, to ensure coherence in the training at the level of the objectives to be achieved, the courses and the evaluations.

3 The process of piloting the reform project and the intervention of the actors

A coordination team was set up to work closely on the reform project. Since the work has been done at the civil engineering and electromechanical departments, two teams were formed in each department. They were composed of the director of the concerned department, a coordinator, and two teachers. The two teams worked simultaneously and in coordination with each other. Weekly meetings were set to report on work progress. These teams were supplemented by other stakeholders depending on the progress of the project stages, such as school researchers.

In addition to coordinating actions, these teams had to ensure the overall coherence of the project, respond to project progress, and encourage the participation of the concerned stakeholders, etc.
The launch of the project generated some doubts about its outcome, the effectiveness of the interventions, and the relevance of the results.

Our starting point was CDIO's approach as well asthe EPFL's (Ecole polytechnique Federale of Lausanne).
The second step was to gather details about EPFL's approach. We approached Mr. Jean-Marie Fürbringer, the project leader of EPFL, to clarify many points by organizing some video-conferences that permitted us to base our work on their approach for the first part of the project (figure 1).
The following Schema illustrates our approach (Figure 1).

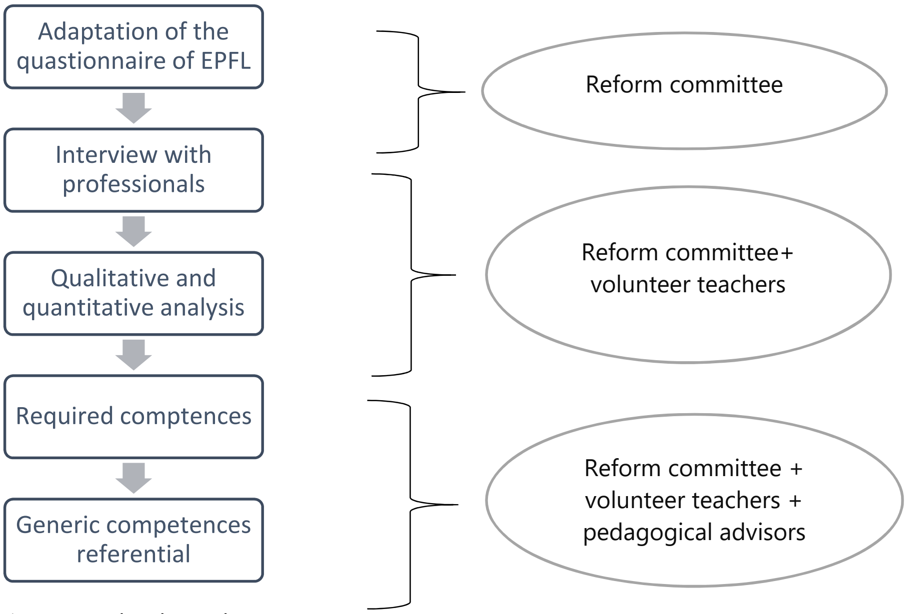


Figure 1: Approach adopted

3.1 Survey questionnaire and the panel of professionals

EPFL's approach was in line with our expectations regarding the reliance on the competences required from the professional world. We had to bring together the societal and entrepreneurial needs as expressed by a panel of 27 professionals, engineers, academics in civil engineering and 24 in electromechanical department. They consist in knowledge, know-how, and personal, interpersonal, and professional skills.

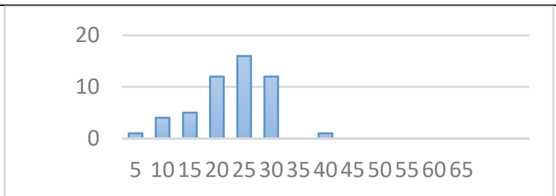
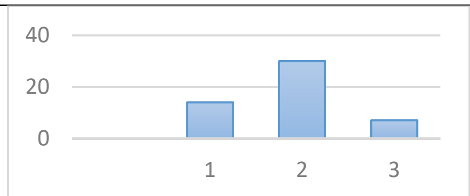
The panel had to define the order of priority and quantify the importance of knowledge, know-how and skills for the engineering profession. They were also asked to indicate the level of deepening corresponding to these components.

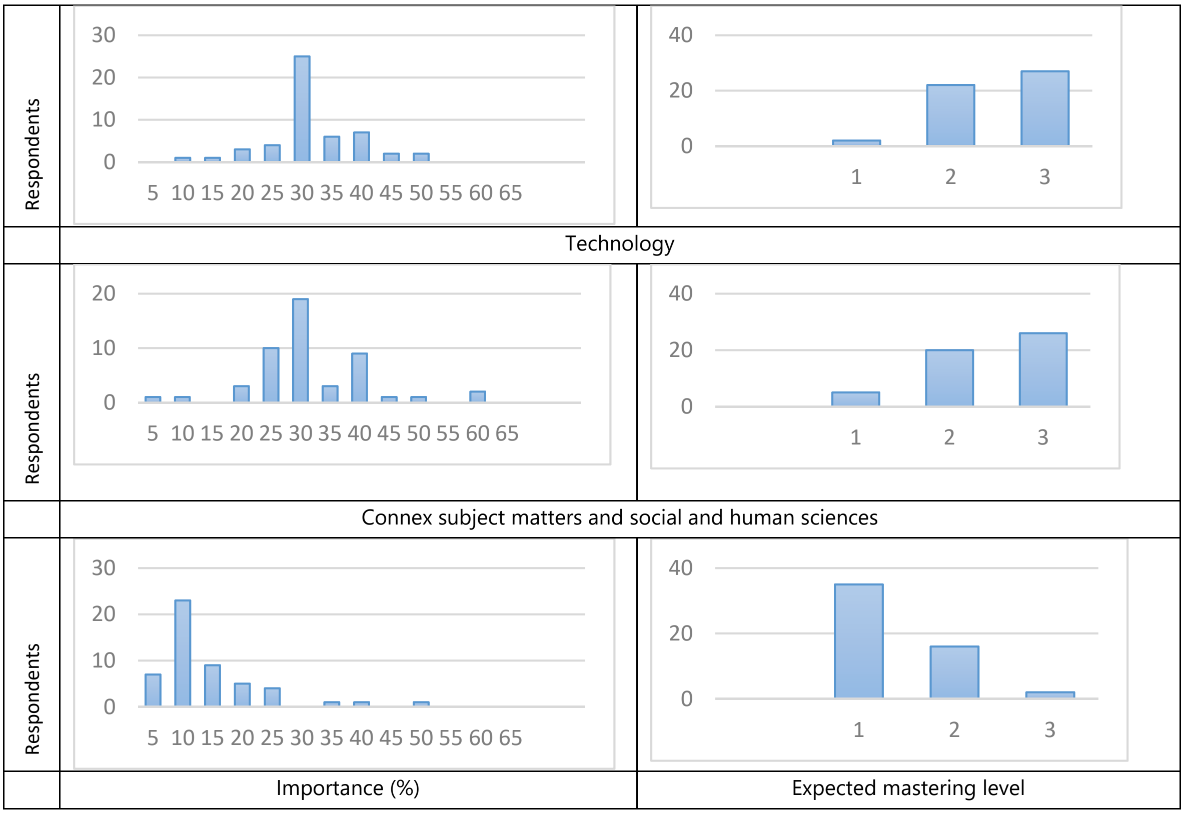
Interviews were arranged with the respondents to provide and discuss their answers in details. Along with answering questionnaire parts, respondents had to justify, argue, and clarify their answers, or comment on content. The discussion gave us enough data on which the qualitative and quantitative analyses were based.

3.2 Qualitative and quantitative analysis

The responses and opinions of professionals belonging to electromechanical and civil engineering fields were accounted for. The quantitative analysis showed similarities on the part of the respondents with regard to the portion sciences are supposed to fill in the training. We can see below (Table 1) the questionnaire results regarding fundamental sciences, engineering sciences, technology and related subject matters and social and human sciences distribution, and the level of depth required.

Table 1: Quantitative Analysis' Results

	Fundamental sciences	
Respondents		
	Engineering sciences	



The results from the panels revealed several surprises; (i) basic sciences are of paramount importance for the training of engineers, (ii) they are a key discipline, (iii) they are a pillar of training in the sense that they offer students skills that make their minds agile to learn other sciences. Students' learning of basic sciences, especially during the first years of training, develops their ability to resolve complex situations and deal with different issues.

The qualitative analysis allowed us to collect all the remarks that had been discussed as previously mentioned. We ordered respondents' remarks and classified them, what helped us to settle a generic skills referential.

3.3 Generic skills referential

The implementation of the generic skills referential is the result of work established by the committee in charge. Teachers, experts and advisors from both civil engineering and electromechanical departments have also contributed.

The qualitative analysis of professionals' answers resulted in determining a set of macro competences, which were later divided into sub-skills.

Following a substantial number of workshops, we finally were able to present our generic skills referential (Table 2) that reflected the skills an engineer is supposed to have at the end of his/her studies in order to be in adequacy with the job requirements.

Table 2: Generic Skills Referential

Mastering a solid body of knowledge in the basic sciences	o Develop critical thinking by mastering mathematical concepts and reasoning o Identify involved physicochemical phenomena o Know how to equate a practical situation o Translate an issue into the appropriate programming language o Visualize and interpret the results o Use basic science knowledge for the acquisition of new knowledge and skills
Mastering a solid body of knowledge in engineering science and technology	o Construct simplified models to evaluate orders of magnitude. o Check the plausibility and confirm the validity of the results obtained toward the nature of the problem o Analyze and model an engineering problem o Identify and use the appropriate modeling and calculation tools to solve problems related to Engineering o Simulate one or more solutions o Evaluate the solutions with regard to all the criteria contained in the specifications o Implement and test to improve and / or optimize the chosen solution
Deploying a wide range of knowledge to imagine, design, build and operate adapted, robust and innovative systems	o Organize and complete an engineering process o Imagine and create innovative, effective solutions in a sustainable development approach o Test and validate solutions o Evince a critical thinking toward a technical solution o Study the costs of production and operation o Ensure the follow-up of implementation and plan interventions on an installation o Check the conformity of the installation and implement corrective actions o Participate in research activities
Planning, management, contribution, team, to the realization of a multidisciplinary project	o Determine and explain the objectives of a project given the issues and constraints that characterize it o Follow up on the implementation and plan the maintenance interventions on an installation o Relativizing solutions by integrating non-technical issues o Collaborate in a multidisciplinary environment o Define customer needs, considering technologies, company strategy and current regulations o consider costs, deadlines and quality of achievement
Taking into account environmental and societal constraints	o Act as a responsible professional o Display an openness and take actions in an ethical approach o Self-evaluate his own work o Position the company's actions toward environmental issues o Position the company's actions toward social issues o Apply work safety and health standards
Effective team work and structured and contextualized communication	o Make decisions in multidisciplinary, multicultural and international contexts o Communicate and exchange in a structured way orally and in writing, according to the objectives and the public concerned o Communicate in graphical and schematic form; interpret a diagram, present the results of a work and structure the information o Organize and facilitate team meetings o Make a convincing oral presentation using modern communication techniques o Redact documents taking into account contextual requirements

3.4 Adequacy between generic skills and CDIO requirements

To ensure the conformity of our compliance with the standards of the CDIO, we have checked the adequacy between the competences retained and the skills of the CDIO.
The results, as shown below, allowed to notice that we are matching to CDIO syllabus (Table 3).

Table 3: Match between Generic Competences and CDIO Competences

CDIO Competences / Generic competences	TECHNICAL KNOWLEDGE AND REASONING	PERSONAL AND PROFESSIONAL SKILLS AND ATTRIBUTES	INTERPERSONAL SKILLS: TEAMWORK AND COMMUNICATION	CONCEIVING, DESIGNING, IMPLEMENTING, AND OPERATING SYSTEMS IN THE ENTERPRISE AND SOCIETAL CONTEXT
Mastering a solid body of knowledge in the basic sciences	X	x	x	
Mastering a solid body of knowledge in engineering science and technology	X	x	x	x
Deploying a wide range of knowledge to imagine, design, build and operate adapted, robust and innovative systems	X	x	x	x
Planning, management, contribution, team, to the realization of a multidisciplinary project		X	x	x

Taking into account environmental and societal constraints		X	x	x
Effective team work and structured and contextualized communication		X	x	x

3.5 Crossover of CTI and CDIO competences

Our approach is to follow the CDIO syllabus (CDIO standards 2019) and comply with the standards of the CTI (CTI competences 2019). For this, we needed to demonstrate that there was a correlation between the skill matrices.

The process is to verify the relationship that existed between the skills on CDIO syllabus on the one hand and the CTI standards on the other (Table 4).

The aim was to demonstrate the correlation between each skill proposed by the CTI and the ones established by CDIO. The darker the colour, the stronger the correlation.

Table 4: Match between Standards of CTI and CDIO Syllabus

	TECHNICAL KNOWLEDGE AND REASONING			PERSONAL AND PROFESSIONAL SKILLS AND ATTRIBUTES					INTERPERSONAL SKILLS: TEAMWORK AND COMMUNICATION			CONCEIVING, DESIGNING, IMPLEMENTING, AND OPERATING SYSTEMS IN THE ENTERPRISE AND SOCIETAL CONTEXT					
	1	2	3	1	2	3	4	5	1	2	3	1	2	3	4	5	6
Competence 1	XXX	XX	XX		XX	XX											
Competence 2	X	XXX	X	X	X	XX	X										
Competence 3		XX	XXX	X	X		X										
Competence 4	X	X	X	X	X	XX	XX	X					X	XXX	XXX	XXX	XXX
Competence 5					XXX		XX		XX								
Competence 6				XX	X	XX	XXX	X		XXX						XX	XX
Competence 7							XX					XXX	XX				
Competence 8							X	XX	XX	X							
Competence 9							X										
Competence 10							XX	X	X			XX	XX				
Competence 11					X	X	XX	X	X	XX	X			X			
Competence 12						X	XX										
Competence 13							X		X	XX	XXX						
Competence 14						X	XXX			X							

4 Experiment Feedback and Criticism

- The project, which was basically inspired by EPFL approach, took six months to be realized instead of three years as it was the case for EPFL. We have based our work on their questionnaire and adapted it to suit our objectives. That has facilitated our task, and made us save time.
- The reluctance of teachers in the electromechanical department was felt given the high number compared to the Department of Civil Engineering; it was more difficult to convince them to join the project. Yet, it was observed that as the project progressed, doubts began to dissipate and the involvement was felt in a relevant way. We can associate this to the fact that the results were of a convincing coherence.
- We faced a problem related to time constraints; teachers could not cope with the demands of the project as they had to ensure their regular working loads, and extra hours. Meetings and workshops

needed to be either postponed, rescheduled, or cancelled. A full coordination between the two departments, and flexibility regarding schedules are required.

- Team work has also posed problems related to interdisciplinarity and divergent, sometimes conflicting opinions. Differences resulting from interdisciplinarity are ought to be among the strongest points of the project. They have rather posed a huge challenge.

5 Conclusion

When we started this work, we had no information on the job market expectations from a Civil or Electro-mechanical engineer. Even the "Tunisian standards of jobs and skills" were under construction and not yet published. We had to build everything from scratch. The survey we conducted with professionals allowed us, after quantitative and qualitative analysis, to identify a set of skills desired by the job market.

In addition to these results, we have held meetings with academicians and experts to find out what will be the requirements of the coming years as the fields of engineering are in a perpetual mutation accelerated by the effect of new technologies - especially by the effect of development of artificial intelligence.

The skills we have identified have been established with a dual purpose: to meet the immediate requirements of the job market but also to provide the student with the ability to learn on his own throughout life. Personal, interpersonal and professional skills (PIPS) have been integrated into almost all teaching units. Thanks to CDIO standards, we have changed our paradigm: we no longer consider PIPS as "soft skills" but as "engineering skills" to develop everywhere on the whole curriculum.

We are quite satisfied with the results of this first phase, we are aware of the improvements to be made in the future, and we believe that this work will be a good start for the development of training plans in the civil and electromechanical engineering departments.

The descriptions of curricula development starting from the present work are described in two other papers presented at this conference.

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CTI and CDIO Competences based curricula (Civil Engineering Case Study)

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Abstract

This communication describes the elaboration process of Civil Engineering curricula that are derived from a set of competencies defined by a previous investigation. For the development of the curricula we adopted the approach of the CDIO initiative - of which ESPRIT is a member. Recall that the CDIO standards describe curricula that are centred on the student and translate the essence of engineering by focusing on the core areas of Conceiving, Designing, Implementing and Operating real-world systems and products. As Esprit is accredited by the CTI (Commission des titres d'Ingénieurs, the French ABET) our study plans must also comply with the requirements of CTI. In (Ajailia, N. & all. 2019) it has been shown that by complying with the standards of the CDIO we will also meet the requirements of the CTI since both are highly correlated. The first step of this process, described in (Ajailia, N. & all. 2019), was to develop the qualitative and quantitative analyses based on collecting the societal and entrepreneurial needs expressed as knowledge, know-how and attitudes from a panel of 27 active professionals in the civil engineering domain. The second step, object if the present article, is a translation of the expected competencies of our Civil Engineer in sets of learning outcomes combined with the definition of learning situations and assessments modalities. The project has culminated by the reorganization of the civil engineering education program starting from the academic year 2018/2019. The paper evaluates the enterprise and discusses its stakes especially in terms of the involvement of the actors. From the point of view of educational engineering, the issue of operationalization remains a major challenge. How to adapt training curricula at the request of the company? What construction processes should be put in place with the actors (institutional leaders, teachers, students)? What new training and evaluation methods to put in place? What are the pitfalls to avoid?

Keywords: skills, skills framework, training reference system, learning outcomes, training program, higher education.

1 Introduction

This paper is a continuation of the approach adopted in the Civil Engineering Department of ESPRIT School of Engineering and Technology aiming at setting up a curricula based on the competency-based approach taking into account CTI (Commission des titres d'Ingénieurs) and CDIO (Conceive, Design, Implement, Operate) standards. The reference to skills for the organization of curricula in higher education has become widespread in just few years worldwide. This recent and large-scale dissemination is undoubtedly linked to the new mode of social regulation consisting in ensuring higher education quality (Chauvigné,C & Coulet, J.C. 2010).

We should state that while considering the reform, the Tunisian Repository of Jobs and Skills was not published yet [8]. As a school that has opted for international standards and with more than 15% students entering the international job market (according to surveys carried out among our former graduates), we did not limit ourselves to the Jobs referential of Tunisia. We have kept an eye on the requirements set for the Civil Engineering Job market at the international scale.

In its Anglo-Saxon sense, the curriculum designates the design, organization and programming of teaching / learning activities along an educational path. It includes the statement of goals, contents, activities and learning processes, as well as the methods and means of assessing student achievement (Miled, 2005). Initially, we aimed at setting up new curricula based on the survey conducted with professionals. The analysis of the answers that led to the generic skills referential has showed that the current curriculum is broadly in line with market demand, and an update is essential.

It is rather necessary to update the number of ECTS (European Credit Transfer and Accumulation System) allocated to the different courses, learning situations, skills, assessment methods, etc. This paper details the approach followed in the civil engineering department, the feedback resulting from this reform, the difficulties encountered, and the points to consider or avoid.

2 Approach

To start the process, it was necessary for us to take into account the expectations of the professional world while formulating objectives that can be targeted and evaluated in civil engineering training.

Three questions we have formulated are the following:

- What are the links that exist between the skills required for civil engineer job?
- What are the learnin0g objectives defining these skills?
- How will they be ensured through the disciplinary domains in the training?

What makes this approach interesting is that the referential of skills has been established with reference to the professionals of the civil engineering domain. Besides, it is well argued and its structure is well defined compared to a regular referential made by compilation.

2.1 Match between job requirements and existing curricula

The analysis of the opinions of the panel reveals an interesting difference between the expectations set regarding innovation in the field of civil engineering, and the results obtained. Respondents were almost unanimous on considering the importance of the classical aspect of civil engineering.

Let's take the example of engineering sciences, which consists in knowledge, know-how, and PIPS. Concerning Knowledge, professionals of the civil engineering field were asked to prioritize and quantify its importance for their profession, and to indicate the corresponding level of student's mastering (Bloom, Krathwohl 1956) and (Anderson, Krathwohl 2001). The table (1) summarizes the first 5 essential skills for engineering sciences.

Table 1: Classification of Civil Engineering skills and mastering level required

Knowledge	Mastering level (1 à 3)*
1-Reinforced and prestressed concrete	3
2- Materials strength	2
3- Geotechnics and soil mechanics	2
4- Roads and Networks	3
5- Metal Construction, masterpieces and Pathology	2

* : 1 Remembering and understanding/ 2 : Applying and analysing/ 3 : evaluating and creating

According to professionals, the know-how is of paramount importance; the practical aspect is very important in the training, and the disciplines complement each other. The sciences of the engineer draw from and interweave with the various sciences, and disciplines, namely basic sciences, connex subject matters, social, and human sciences, and technology.

The professionals were also asked to choose five skills that distinguish ESPRIT future engineers from other graduate civil engineers. They stated that ESPRIT civil engineers should be more methodical, pragmatic and rigorous in solving problems as shown in figure (1).

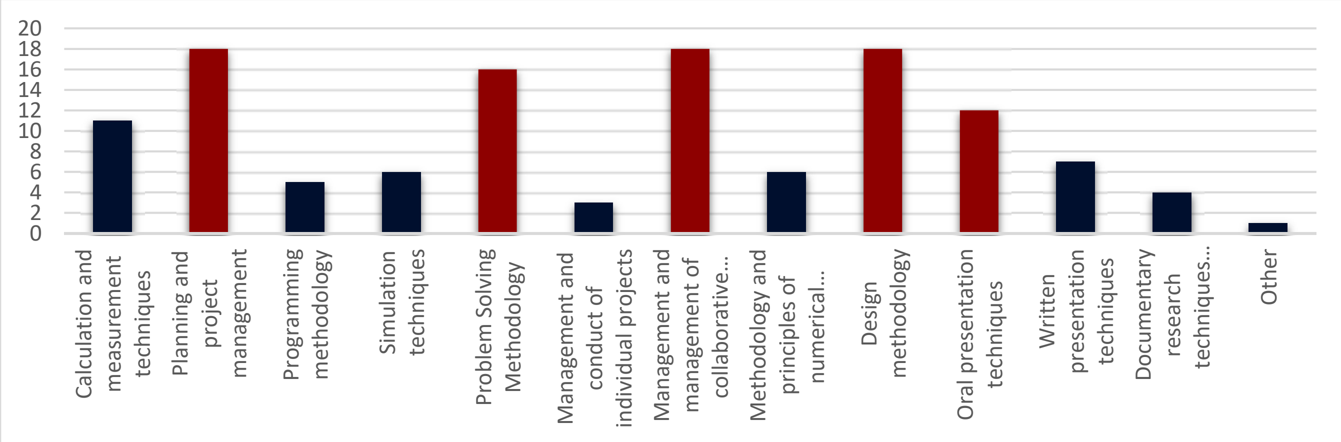

Figure 1: 5 Know-how approving the ESPRIT Civil Engineer distinction

Classical Civil Engineering matches the expectations of the profession requirements; this result was a surprise; we expected to discover a high demand for the innovating technologies, the fact is through discussions professionals recommended to integrate innovation but according to them engineers must master the fundamental first.

We organized workshops gathering teachers and experts, the aim was to decide what the best way to integrate these technologies was.

The results of the survey stipulated that the current curricula greatly corresponded to the market demand, so we decided to update these curricula by concentrating our efforts on the points to be reviewed, particularly the content of the courses, learning outcomes, learning situations and assessment methods.

We ordered all the propositions and classified them with giving a range of opinions and rationales about the expectations that awaits the young civil engineer.

2.2 Process adopted

The curriculum reform committee organized weekly working meetings over a period of 2 months in order to set learning objectives leading to the acquisition of skills. This committee, made up of a group of teachers and pedagogical advisers, worked in collaboration with all Civil Engineering Department teachers so that decisions could be taken after all parties involved agree.

We first considered the set of skills needed for an engineering training. After which, we formulated learning outcomes to match them covering all training domains. For each of these outcomes, courses or activities supporting them, as well as the prerequisites in the basic knowledge were specified.

The phase began by clarifying the links existing between competencies, and defining all the learning outcomes that allowed to acquire them. Workshops gathering the teachers of the civil engineering department led us to define the learning objectives, eliminate the redundancies, and group the different objectives in similar disciplines.

The volume of work was considerable considering the objectives that exceeded 400 at the first. It was finally possible to reduce them to a well-sorted two hundred.

The next step was to define the Teaching Units allowing the validation of these objectives.

3 Re-design of the civil engineering curriculum: CDIO and CTI approach

3.1 Adjusted curricula

In previous paper (Ajailia, N. & all. 2019), cross matrix of CTI and CDIO skills was presented. Following the same approach, and aiming at complying with international requirements, we situated our teaching units in relation to the 14th CTI's competences (CTI Competences 2019) as illustrated in table (2). Our objective was to check the conformity of our teaching units with the CTI requirements.

Tableau 2: Relation between Teaching Units and The 14th CTI requirements

Semester		T.U	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	**1.1**	TU Mathematics 1	■	■			■	■								
	1.2	TU Edition & Presentation			■		■	■		■						
	1.3	TU Physical - Chemistry	■	■			■									
	1.4	TU Architecture and Urbanism		■	■	■	■	■			■			■		■
	1.5	TU Communication, Culture and Citizenship F1					■					■	■		■	
2	**2.1**	TU Mathematics 2	■	■			■	■								
	2.2	TU Basic Computer Science	■	■	■	■		■								
	2.3	TU General mechanic	■	■	■			■								
	2.4	UE Introduction to Civil Engineering		■		■	■									■
	2.5	TU Communication, Culture and Citizenship A1					■						■		■	
3	**3.1**	TU Mathematics Numerical Calculus	■	■	■	■	■	■								
	3.2	TU Materials		■		■	■	■			■					
	3.3	UE Mechanic	■	■		■		■								
	3.4	TU Environment Project					■	■			■					
	3.5	TU Collaborative Associative Project					■	■		■		■	■			
	3.6	TU Communication, Culture and Citizenship A2					■	■				■	■		■	
4	**4.1**	TU Mathematics & Programming	■	■	■	■	■	■								
	4.2	TU Applied Physics		■	■	■		■								
	4.3	TU Measurements & Topography		■	■	■	■	■								
	4.4	TU Building Energy Project		■	■	■	■	■			■					■
	4.5	TU Communication, Culture and Citizenship F2					■	■				■	■		■	
5	**5.1**	TU Applied mathematics	■	■	■			■								
	5.2	TU soil Mechanic		■	■		■	■								
	5.3	TU Structures		■	■	■		■								
	5.4	TU Construction Techniques 1		■	■	■	■	■								
	5.5	TU homogenization	■	■		■	■	■								
	5.6	TU Communication, Culture and Citizenship A3					■	■				■	■		■	
6	**6.1**	TU Probability & Statistics	■		■	■										
	6.2	TU Road & Hydrology		■	■	■	■	■								
	6.3	TU technical Construction 2		■	■	■	■	■								
	6.4	TU Numerical resolution of a civil engineering problem		■	■	■	■	■		■						
	6.5	TU Enterprise Management							■	■			■			
	6.6	TU Communication, Culture and Citizenship F3					■	■				■	■		■	
	6.7	TU internship					■	■	■				■			■
7	**7.1**	TU Numerical Resolution Methods	■	■	■	■	■	■								
	7.2	TU Prestressed concrete		■	■	■	■	■								
	7.3	UE Masterpieces		■	■	■	■	■								
	7.4	TU Foundations and Processes		■	■	■	■	■								
	7.5	TU Communication, Culture and Citizenship A4					■	■				■	■		■	
8	**8.1**	TU Hydraulic		■	■	■		■								
	8.2	TU Integrated project		■	■	■	■	■		■				■		■
	8.3	TU Project Management and Management			■		■	■	■				■	■		
	8.4	TU Communication, Culture and Citizenship F4					■	■				■	■		■	
	8.5	Optional TU: Construction structure		■	■	■		■								
		Bridges & roads		■	■	■		■								
		Eco-building & Energy Efficiency		■	■	■		■			■					
9	**9.1**	TU QHSE applied to Civil Engineering			■			■	■	■	■					
	9.2	TU Pathology, maintenance and rehabilitation of buildings		■	■	■	■	■								
	9.3	TU New Technologies and Optimization		■	■	■		■			■			■		
	9.4	Optional TU: Construction structure		■	■	■		■								
		Bridges & roads		■	■	■		■								
		Eco-building & Energy Efficiency		■	■	■		■			■					
	9.5	TU Law and regulations							■	■						
	9.6	TU Preparation for professional life							■	■			■	■	■	
10	**10.1**	TU Professionalization		■	■	■	■	■	■	■			■	■		■

3.2 Program structure for integration of CDIO skills across 5 years of study

The set-up of the skills referential was the first step leading to the review of the different components of the curricula. The second step was based on CDIO referential that led us to arranging skills into corresponding.
An important starting point was the identification of the key CDIO skills; such as teamwork, communication, personal and professional skills, experimentation and knowledge discovery, etc. (Crawley, E.F.2002). We Adapted the ITU (Introduce, Teach, Utilize) concept (Bankel, Berggren &all. 2005) to systematically introduce

various CDIO skills into courses. The general approach taken is described in Table (3), which shows the integration of planning, management, team contribution to the realization of a multidisciplinary project skills across the entire five-years of training through the Units (the corresponding TU names are specified in table 2). The aim is to introduce and teach students specific skills in Year 1 and 2, which are then extensively practiced in Year 3. By Year 4 and 5, students are expected to be able to utilize them. The numbers corresponding to the highlighted cells show the teaching units explained in table (2) allowing the acquirement of the concerned competence.

Tableau 3: Competence: planning, management team contribution to the realization of a multidisciplinary project

Semester 1	Semester 2	Semester 3	Semester 4	Semester 5	Semester 6	Semester 7	Semester 8	Semester 9	Semester 10
1.1	2.1	3.1	4.1	5.1	6.1	7.1	8.1	9.1	10.1
1.2	2.2	3.2	4.2	5.2	6.2	7.2	8.2	9.2	
1.3	2.3	3.3	4.3	5.3	6.3	7.3	8.3	9.3	
1.4	2.4	3.4	4.4	5.4	6.4	7.4	8.4	9.4	
1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	
		3.6		5.6	6.6			9.6	
					6.7				

3.3 Learning outcomes and learning situations

Our students have to acquire different competences throughout their university training. Our reasoning was based on the teaching units and we worked with the architecture and urbanism unit as an example. The aim is to analyze the skills that our students have to acquire and to see if the current learning situations are adapted. The table (4) illustrates the learning situation corresponding to each skill.

Tableau 4: Match between learning situations and skills targeted (earlier version)

Learning outcomes	Theorical course	Tutorials/ group work shop	Practical work	PBL
Assimilate the notions of architecture and town planning, the cities development, its structures and its components.	X			
Acquire a culture on the discipline of architecture (complexity and styles) Understand the different modes of representation of architectural projects.	X			
Understand the various requirements of a sustainable architectural project: functional, technical, environmental and structural.	X			X
Understand the notion of spatial quality (comfort and ambiance).		X		
Master the bioclimatic approach in architecture.				
Read and understand all the details of a plan		X		X
Take into account the economic and social issues in an urban project.				
Elaborate plans with annotations, quotations and distinction of materials		X		X
Realize a design file (stages, documents, actors and roles of both Architect and Engineer ...)		X		
Recognize the different urban regulations in Tunisia.	X			X

The analysis of the current situation revealed a mismatch between learning situations and skills as shown in the highlighted cells. This result led us to review both of them. The learning outcomes should be adapted to the civil engineer profile.

We therefore decided to integrate new learning situations which are **Group Workshops** and visits as well as **new competences** was acquired by this learning situations such us Mock-up production, real case study, etc.

Experiments were contextualized to simulate real-world working environments whereby students are required to work in teams and conduct experiments using planning tools as shown in table (5).

Tableau 5: Match between learning situations and skills targeted (reviewed version)

Learning outcomes	Theorical course	Tutorials	Group Workshops	Visits	PBL
Assimilate architecture and urbanism notions through examples of distinguished projects	X		X		
Acquire a culture on the discipline of architecture (complexity and styles) Understand the different modes of representation of architectural projects.	X		X	X	
Understand the various requirements of a sustainable architectural project: functional, technical, environmental and structural.				X	
Take into consideration and apply the notion of spatial quality (comfort and ambiance) in the building					X
Understand and produce an architectural plan (standards, composition of a presentation panel ...)		X			X
Manipulate the reading tools of the various graphic documents (line quality, orientation, annotation, materials ...)		X			X
Produce mock up			X		X
Take into account the different economic and social issues in an urban project.	X			X	
Explore the basics of the HQE High Environmental Quality (targets and process)		X			X
Experiment teamwork and presentation techniques as well as organizational and planning tools		X	X	X	X
Realize a design file (process, documents, actors and roles of both Architect and Engineer ...)	X	X			X
Real case study		X	X		X
Recognize the different urban regulations in Tunisia.	X		X	X	

3.4 Assessment methods

- **Evaluate skills rather than knowledge**

The skills based learning approach leads to the assessment of student achievement across complex situations requiring complex production (De Ketele J.M. & Gerard F. M 2005). Standard assessment methods are not adapted. Other validation approaches, formative or summative, should be adopted, respecting reliability and effectiveness requirements.

The point is that in traditional assessment ways we evaluate knowledge rather than skills, these methods cannot be considered as pertinent. With the new evaluation method, we aim at evaluating skills with adapted methods

The table (6) attests the adequate way to judge whether a student has been able to acquire the skills targeted in the architecture and urbanism unit.

Tableau 6: Assessment methods adopted for different skills

Learning outcomes	Oral assessment	Written Exam	MCQ	Presentation + Report	Project
Assimilate architecture and urbanism notions through examples of distinguished projects	X				
Acquire a culture on the discipline of architecture (complexity and styles) Understand the different modes of representation of architectural projects.				X	
Understand the various requirements of a sustainable architectural project: functional, technical, environmental and structural.					X
Take into consideration and apply the notion of spatial quality (comfort and ambiance) in the building					X
Understand and produce an architectural plan (standards, composition of a presentation panel ...)				X	X
Manipulate the reading tools of the various graphic documents (line quality, orientation, annotation, materials ...)				X	X
Produce mock up					X
Take into account the different economic and social issues in an urban project.		X	X		

Explore the basics of the HQE High Environmental Quality (targets and process)			x	x	x
Experiment teamwork and presentation techniques as well as organizational and planning tools				x	x
Realize a design file (process, documents, actors and roles of both Architect and Engineer ...)	x	x	x		
Real case study				x	x
Recognize the different urban regulations in Tunisia.	x		x		

3.5 Projects and visits

Training of civil engineering students is based on active pedagogy, we are adopting problems and projects based learning approaches. Students and teachers are now led to gradually break away from the teacher-centred culture of knowledge transfer and move to a student-centred culture of ownership.

In the civil engineering field, the experience and contact with the real world are the best ways to acquire the know-how, we therefore increased the number of projects throughout the training course considering the level of knowledge acquired by our future engineers. The projects use the skills acquired in the related courses, the table (7) describes the implemented projects.

Tableau 7: projects implemented through university cursus

Project	Semester	Project specifications
Urban development and sustainable development project	1	Students have a real case study, they pick one space in the plan and produce mock ups with proposed solutions by considering the sustainable development aspect
Study and criticism of a building	2	Students make civil plans for existing constructions, they criticise them , and they choose an item such as building or bridge and give specification of its actual state
Associative and collaborative project	3	Students join an association or institution to carry out humanitarian action
Sustainable Construction and Environment Project	3	students apply the principles, issues and actions of sustainable development in an environmental project
Programming Project	4	The students program on a software the approach of solving a technical problem
Energy buildings project	4	students make energy appraisal and study energy efficiency in the case of new buildings and rehabilitation of existing buildings
Numerical resolution of a civil engineering problem Integrated Project	5	Students refer back to their conceptual designs, their architectural design and structural and geotechnical engineering design. They evaluate and modify their designs according to the skills acquired in the courses
Integrated design building project	8	Students with collaboration of professional and academic coaches search for possibilities of innovation and problems solving in civil engineering and related other fields.

Before the reform project, students benefited from several site visits throughout the training simply on the one hand the visits were not part of the teaching units and secondly they were not gratified with ECTS. Among the recommendations of the CTI, all activities should be rewarded by ECTS.

From the current academic year, civil engineering students participate at least to 4 visits per year of training that are henceforth planned as part of the teaching units and a debriefing and an MCQ are used to assess students' required learning outcomes.

3.6 Personal and interpersonal and professional skills in the training

*"The teaching of personal, interpersonal, and professional skills (PIPS), and product, process, and system building skills should not be considered an addition to an already full curriculum, but an integral part of it. To reach the intended learning outcomes in disciplinary knowledge and skills, the curriculum and learning experiences have to make dual use of available time. Faculty play an active role in designing the integrated curriculum by suggesting appropriate disciplinary linkages,(*CDIO Standards).

The Personal and Interpersonal and Professional Skills (PIPS) must take part of all the courses because an engineer is supposed to acquire them in knowledge and know-how at the same time, we established the parts of Basic sciences, Engineering Sciences and Personal and Interpersonal and Professional Skills in every course.

The figure (2) illustrates the evolution of the different skills through all the training cursus.

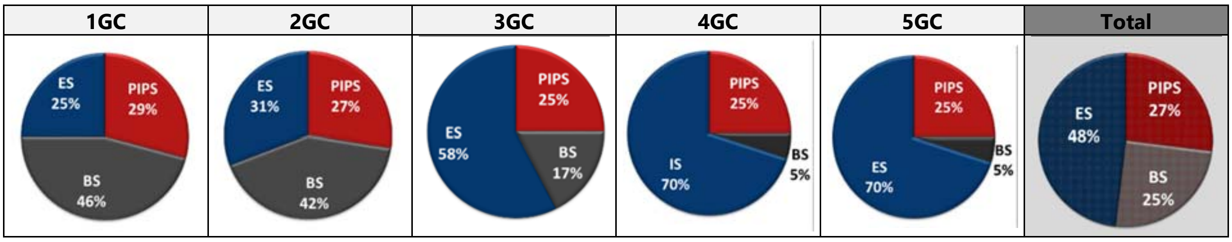

Figure 2: Evolution of skills through the 5 years of training

4 Experience feedback and criticism

Our feedbacks was observed through all steps of the project and even during the writing of this article;

- The involvement of the teachers of the department was essential, it contributed to the success of the project, there was an improvement in the relations between the different members of the team as each contributed on his side in updating the Civil Engineering curricula.
- For their part the students were sceptical about updating the curricula, information meetings were planned with them, and we finally had positive feedbacks, they appreciated that the training program presented all the necessary justifications on the various plans, and this has given rise to comfort and confidence because of the transparency in the results and the visibility in the process.
- The professionals were invited to ESPRIT and took part of a work meeting where we presented the result of the project, they welcomed the approach and expressed their appreciation and some even suggested to take part in the training in the courses where the presence of professionals was required.
- However, several points remain to be improved; the results could have been different if the panel of professionals was wider.
- It has also been found that classical civil engineering is in high demand in the civil engineering field, something that could be very specific to Tunisia, especially with the constant technological advancement in the world, this could even limit our future engineering's chances of work at the international scale; we therefore decided to integrate courses of innovation and new technologies to curricula.

5 Conclusion

Our work, first and foremost, was an attempt to challenge reflection on Civil Engineering Curricula at ESPRIT according to CTI referential and CDIO standards. Our approach surely contains some failures, we are aware of it. One just have to remember from what situation we started. We had a study plan that was developed by the intuition of the experts who proposed it.

In our educational meetings we wanted to change and improve the programs but we did not have tools or scientific justification to do so. The standards of the CTI and the CDIO process were for us the pieces that structured and completed the puzzle. It was a kind of revelation for us. Suddenly everything became clear: our strengths, our weak points, what we had to do, what we should add, what we should eliminate, what we should change, etc.

We did not follow the CDIO approach to the letter, we were inspired by it and what we applied is the CDIO philosophy. Now project-based learning has a remarkable place in study plans, learning situations are established in coherence with the objectives to be attained and the evaluations have become less subjective and have gained in measurability and specificity. The curricula have become intelligible by our students and teachers.

The documentation produced during this process has become a repository for us that is used to justify new recruitments to the department and ongoing improvements to the curriculum. In the future, we intend to bring more rigor when using CDIO standards, and set up a continuous review process each year with the benefit of feedback.

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EPIC: Making Multinational Student Projects Happen

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Abstract

EPIC (Improving Employability Through Internationalization and Collaboration) is an Erasmus+ 3 year Strategic Partnership, which explores how blended learning can support multinational and interdisciplinary student projects. In this way it searches to combine the flexibility and cost-effectiveness of virtual collaboration with the benefits of physical meetings for establishing the collaboration. It is carried out in collaboration between eight European universities and two companies. This paper describes the experiences from the first year, where seven different projects with a total of 25 students were carried out during spring 2018: The projects differ in terms of group sizes, student workloads, and academic levels. Even though the projects are different, a similar structure is defined throughout the semester: In particular, all students follow a short virtual course before the semester starts, then all students and supervisors meet for a one-week seminar in February. From there the collaboration is mainly virtual, with the possibility for each group to meet one additional time. By the end of May a joint report has to be submitted. This paper describes how the projects were set up and executed, along with evaluation results and experiences. Overall, all stakeholders found it to be a good experience, but also with some challenges: A main contribution of the paper is the discussions of two of the most challenging aspects, namely, how to facilitate that the students actually work together when evaluated according to their home university rules as well as how to facilitate supervision in a setup like this, which is more complex than usual problem based learning projects.

Keywords: Interdisciplinarity, Blended learning, Problem Based Learning, Teamwork, Internationalisation.

1 Introduction

Students that graduate today are educated for a global labour market, and companies and projects are often set up across borders. Employability is getting higher on the agenda in higher education and especially in engineering education (Small, Shacklock, & Marchant, 2017; Craps, Pinxten, Saunders, Cruz, & Langie, 2017). It is therefore necessary to equip the students with the competences that enable them to operate under these circumstances, including skills to work in multinational teams, skills to work in close collaboration with industry, and skills to work together across disciplines. This is also in line with the policy of the European Commission (European Commission, 2011), and builds well upon the well-known Problem Based Learning (PBL) model (Kolmos et. al, 2004). The ERASMUS+ EPIC (Improving Employability Through Internationalization and Collaboration) project searches to develop a way to provide the students with these skills through working together on projects across disciplines and countries and in collaboration with companies. It builds upon a good experience from the ERASMUS+ COLIBRI project (COLIBRI, 2018) which showed that students, teachers and companies find that working on smaller multinational student projects is very beneficial for the students. In the case of COLIBRI, the learning activity was organised as a joint 5 ECTS course, including both seminars and virtual work. This approach, while receiving good evaluations from all stakeholders, did not offer the companies the same value as larger projects with a higher workload for students, and it also required many ad-hoc solutions to ensure that all students had the project recognized in terms of ECTS points.

In EPIC these shortcomings are avoided by offering the collaborative projects based on existing student projects, which are transformed into collaborative projects through EPIC: For instance, semester projects, thesis projects or even smaller research projects. In EPIC the students work together on a joint problem to develop a joint solution. There is a requirement of a joint EPIC hand-in that covers both the learning process and the content of the project, but otherwise hand-in and examinations are done according to the rules of each institution, reflecting the learning objectives of their students. Also, timing of e.g. project start and finish is done according to the home university rules, meaning that the students do not always start or end at the same time. While this does indeed solve the challenges stated above, it requires a very careful design of projects, supervision and support to ensure that the collaboration actually happens.

Another approach to international student projects was taken by e.g. the Technical University of Munich in 2009 through the GlobalDrive project, an initiative that is still ongoing. It was initiated by the institute of Automotive Technology (FTM). Each year, 3 - 4 students from FTM start an individual project together with a foreign team. A foreign team is selected from the globalDrive consortium spread among 9 universities all over the world. Similar to EPIC, the industrial partners are also involved and the kickoff is always done at a foreign partner university. This is the place where all students and supervisors get to know country and life abroad. At the end of the semester, there is a multi-week stay of the whole team in Munich to finalise the project activities. In contrast to EPIC, the sole research focus is on automobile industry and the whole project is driven by FTM (GlobalDrive, 2018). Other works within the field focus on particular aspects of the setup, e.g. on how IT tools support collaborative learning, e.g. (Reis et.al, 2018) and (Weiman et.al, 2013), or the pedagogical aspects of student participation in globally distributed project teams (Bartel-Radic et. al, 2015). The latter study is based on only virtual collaboration. Some of the challenges they experience with respect to e.g. communication and conflict handling is exactly what EPIC searches to address during the physical seminars.

In this paper, we focus on discussing the project work and supervision, and in particular addresses two of the challenging aspects: how to facilitate that students actually work together when their work is evaluated according to the guidelines of their home university, and the related question of how to facilitate supervision in such an environment. It extends the previous contributions in (Pedersen & Jensen, 2018) through focusing more on how the project work was supported through various learning resources, training materials and supervision. We will refer to the previous contribution for further details on how EPIC and the student projects are setup. The paper is structured as follows: First we provide a brief overview of the setup of the EPIC project and its organisation in Section 2, then present the first year cycle in Section 3, the evaluation methods and results in Section 4, discussion in Section 5 and the conclusion in Section 6.

2 EPIC setup

In this section we provide a short description of the EPIC setup. This is described in further detail in our previous paper as well (Pedersen & Jensen, 2018), and on the EPIC website (EPIC, 2019). EPIC is an Erasmus+ Strategic Partnership with eight universities and two companies, presenting countries from all over Europe: Universitat Politècnica de Catalunya (Spain), Saxion University of Applied Sciences (the Netherlands), University of Stavanger (Norway), Abdullah Gul University (Turkey), Hamburg University of Technology (Germany), Riga Technical University (Latvia), UTP University of Science and Technology (Poland), Aalborg University (Denmark), Atene KOM (Germany), Auvik Networks (Spain). The universities represent widely different teaching traditions, from a focus on “classical lectures” to a strong focus on PBL – any many in-between. To be able to do project work in this diverse setting, it is crucial to support the whole process from defining projects and problems, to seminars and evaluations. To do this, a number of materials are developed:

- Training materials for students, which combine online materials with materials used during the seminar(s). The main focus of this material is to support the collaboration process, and special effort is made to ensure that the materials are actually used in practice, e.g. through the provision of templates for project work.
- Training materials for teachers. These are mainly online materials, but also materials used during the teacher training of the seminar. One of the main tasks of this material is to clarify the roles of the different supervisors involved, but also to give the supervisors tools for working with companies and in interdisciplinary and multinational settings. Aspects of virtual collaboration are also important.
- Guidelines for companies, which will both encourage companies to participate in the project and provide them an overview of different roles a company can play also depending on their willingness to invest resources/time. The guidelines also support supervision and describe different kinds of supervision and supervisor roles, and how to handle challenges and unforeseen situations. Finally, advice on how to ensure that the student projects create value for the companies is provided. This is important also to ensure that companies will participate in the future.

- A public online data bank with learning resources for the projects. The purpose is to support that the students can find relevant knowledge for their project work when they need it. It is not so much materials produced by us, but rather pointers to material of good quality, which is available from other sources.
- A framework for setting up project proposals and projects. This is necessary to handle the complexity in matching industry interest with the students' learning objectives, and to ensure that all project groups are multinational and with the right fields of studies represented.
- A description of methods to assess and document the students' learning. This is also important for the students, as it helps them to understand the learning objectives and workload of each student, and to use this information to define the role of each student in the project. It also presents peer assessment as a tool for evaluating the contribution of each student throughout the project period.

The project is running for three years, starting in September 2017, and each year a cycle is repeated that allows for testing, evaluation, and adjustment of the approach: A planning meeting is held in September, followed by a preparation phase October-January, where the materials are prepared and students selected. In fact, some students start their project work already in January. In February the projects are really starting with a 5-day seminar for all students and supervisors, which includes both student centred activities and teacher training activities. The virtual project work runs from February until July, where each student group also has the option of a second physical meeting. July-August is the evaluation phase. EPIC is co-funded by the Erasmus+ programme of the European Union, which made it possible for the students to participate free of charge.

3 The first year cycle

In this section we describe the experiences from the first year of EPIC and discuss some of the experiences that led to adjustments during the second year. The timing of the study activities for the first year is illustrated in Figure 1. As it can be seen, both start and finish time for the project work varies a bit from university to university: This is something the students need to consider when planning their work. The joint project hand-in deadline was set to June 1, which was close to some of the earliest local deadlines. However, some groups all had later deadlines, and were granted a later joint project hand-in as well.

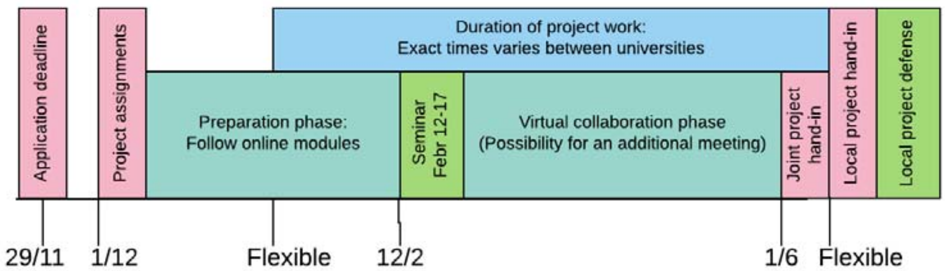

Figure 1 Timing of the project work during the first year of EPIC.

3.1 Project setup and student selection

Each university developed project proposals together with companies, and offered these to the students across the consortium. Then the students selected a project when applying for EPIC. However, some adjustments had to be made to ensure that all projects that were done had students from multiple countries represented. Eventually, seven projects were chosen, with a composition of the groups ranging from two students (from two countries) to nine students (from four countries). A total of 25 students participated in the first year. Table 1 provides an overview of the participants of the largest project with nine students, to show the diversity of the participants.

Table 1: Overview of the EPIC Honeyjar project

Type of Thesis	ECTS	Duration	Focus of the report	Joint part	Other comments
Semester project (5 students from DK). **2nd semester.**	15	Feb-May	System development, technical aspects.	EPIC report, Plan of Action, joint system development.	An additional physical seminar was organized in Barcelona (UPC) in order to discuss with their UPC supervisor, and to present and get feedback from the industry partner Auvik Networks.
Project of Smart Solutions Semester (6th semester) **(2 students from NL)**	24	Feb-June	Business aspects	EPIC report, Plan of Action, joint system development.	
Project work (1 student from Turkey) (6th semester)	8	Feb-May	Technical aspects: Machine learning	EPIC report, Plan of Action, joint system development.	
Project work (1 student from Poland) (6th semester)	5	Feb-May	Technical aspects: System architecture	EPIC report.	

There are some inherent challenges especially when it comes to the students' selection of projects and subsequent allocation of students to projects. In particular, the students from different institutions have different selection deadlines, and when they do not know if they are accepted for their EPIC project this can make it impossible for them to apply for other priorities. On the other hand, it was not possible to confirm all projects until the last students had applied, as it was not clear whether the requirement of having students from at least two countries per project would be fulfilled. This led to some students being accepted very late in the process, an uncertainty that would be good to avoid. For the second year, the application process started earlier, and the project proposals were grouped into themes where students then had to select themes instead of specific projects. In this way, it would at least minimize the chance of having only one student assigned to a project, and therefore awaiting confirmation.

3.2 Preparing students and supervisors

For the first year, students and supervisors had to prepare themselves for the project by studying the blended learning materials mentioned in Section 2 before the project seminar. These focus mainly on PBL, team work, conflict resolution and distance collaboration. For supervisors, the main focus was on supervising students, virtual collaboration, and collaboration with companies.

3.3 The project seminar

The project seminar is where the students get the chance to meet face-to-face with each other and their supervisors for the first time. The duration of the seminar is five full working days, which is also partly due to the fact that this is the minimum duration according to Erasmus+ rules. The seminar for the students is combined with a teacher training seminar for the teachers, but the programs are integrated: Most of the time supervisors are working together with the students, but during some time slots the students work on their projects, while the teachers meet for lectures and workshops regarding supervision.

The seminar is a mix of workshops, group work in the project groups, supervisor meetings and interaction, as well as other project-related activities such as sessions where students present their work and receive feedback from both other students and other supervisors. The program is designed for the students to achieve these goals at the end of the week: a clear project scope and idea of the outcome, a clear overview of how the different students are contributing to this also according to their own learning objectives, a clear project plan, and a collaboration agreement among the groups. The different activities throughout the week are designed to support these goals, with the content shifting throughout the week from focus on teambuilding and collaboration, over tools for problem analysis, to intensive work in the groups towards having a strong project plan at the end of the week.

The majority of the project work is carried out during the virtual collaboration phase. The collaboration and communication were organised differently between the different groups, reflecting that there is a big difference between being two students and nine students. Throughout the virtual collaboration phase there would be regular supervisor meetings with the EPIC supervisor, and peer assessments would be carried out three times during the project to facilitate discussions in the group. A collaboration platform was offered to the students, but almost all groups chose to use other tools/platforms instead, and we did not enforce using a specific platform. The collaboration worked well, but without one communication/collaboration platform it was hard to have an overview of the different groups – this was in the hands of the supervisors. Also, supervisors involved in multiple groups found it challenging that each group was using a different system/platform. In the following year, we will use a single platform for all communication, and also do more to make the students use it. We believe this is best done by having the platform available from the moment the student gets on board, by using it as an information channel even before the project seminar, and by ensuring that it is also used during the seminar, so that it becomes well established as the communication channel of choice.

3.4 The blended learning seminar

The blended learning seminar was an offer to those project groups who wanted a second meeting during the semester, usually around half way into the projects. The geography and timing can vary between the groups, and to minimize travel expenses each group would meet in the country of one of the institutions involved in that particular project.

3.5 Finalising the project work and hand-in

All groups handed in both the projects at their home universities and the joint EPIC report, which consists of one part reflecting on the learning experience of EPIC, and one part to describe the overall problem, how they approached it, and what solution(s) they reached. The groups seemed to overcome the challenge of different timings of hand-in well.

4 Evaluation methods and results

Before presenting the evaluation and results, the methods for data collection will be explained. These methods reflect that data were collected throughout the project period, and more thoroughly after project hand-in.

- Each day of the project seminar, evaluations forms were used to evaluate all student activities during the day in terms of relevance, quality and own participation. The data collected were quantitative, with space for comments.
- At the end of the project seminar, an electronic survey was used to evaluate the seminar (students, teachers, company representatives). The data collected were mainly quantitative, with space for comments. We also asked the students for their motivations for joining EPIC (the options were collected during a plenum session at the beginning of the seminar). The seminar survey was repeated after the blended learning seminar.
- During the virtual collaboration phase, data were collected in two ways: Quality Committee meetings were held approximately every two weeks, with at least one representative per group. The objective of the meetings was to address quality issues, but the comments also provided valuable insights to the progress of the projects, and the challenges experienced by the students. Moreover, all groups performed peer assessments 2-3 times during the project. The main objective of the peer assessment was to support the group work, but these forms also provided good insights into the progress of the students.
- At the end, a final electronic survey was distributed to students, teachers and company representatives, evaluating their experiences, their personal outcome, and their evaluation of the teaching methods used, including the supporting materials. Again, a combination of quantitative evaluations and comments.
- An in-depth interview was held with company representatives, but this falls outside the scope of this paper.

Figure 2 illustrates the answers of the motivation study, confirming that the results are in line with the objectives of EPIC: To enable students to work on real-life projects in a multinational and interdisciplinary setting.

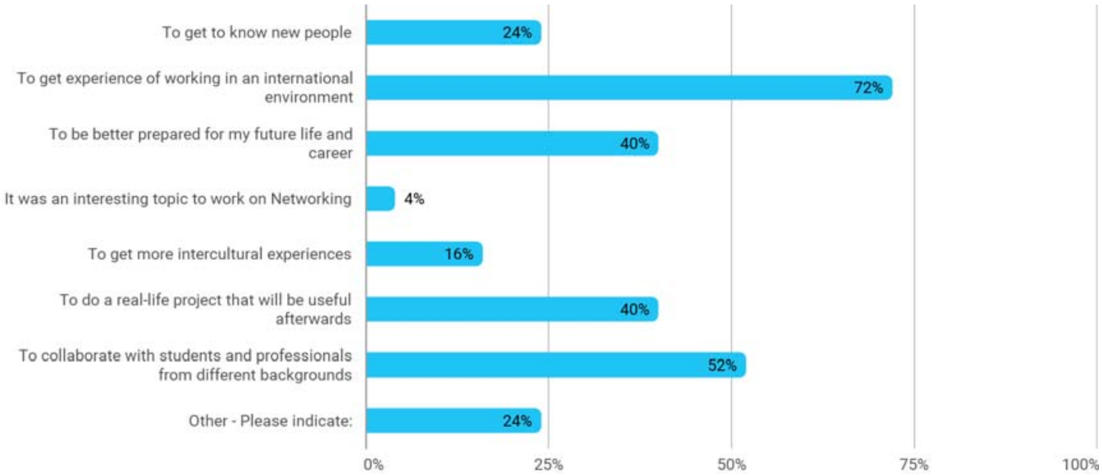

Figure 2: Students motivations for joining EPIC.

The overall evaluation and evaluations of the seminars were already presented in (ETALEE, 2018), so here we just summarize the most important numbers. The evaluations were based on a scale 1-5, where 1 is "Not at all" and 5 is "Very much". When counting the positive replies, we see how many responded either 4 or 5.

- 88% of the students and 90% of the teachers found that EPIC had been a good experience.
- 80% of the students and 90% of the teachers found that EPIC will help students in their future career.

The evaluations of the seminars were based on a scale with four levels: "Bad", "Not so good", "Good" and "Excellent".

- 100% of the students found that the project seminar had helped them to prepare for the upcoming project work to an either good (36%) or excellent (64%) extent.
- 96% of the students found the project seminar to be overall good (44%) or excellent (52%).
- 96% of the students found the project work during the project seminar to be either good (32%) or excellent (64%).
- 96% of the students found that the other academic activities during the project seminar were either good (64%) or excellent (32%).

For the blended seminar, all students answered all questions with either "good" or "excellent". 75% answered "excellent" to how well the seminar helped in the project work, and 67% "excellent" to the seminar overall.

These evaluations are positive, but we notice that for the project seminar the project work receives a better score than the other academic activities, which are there to support the project work. It is also interesting to see that the blended seminars receive such good evaluations. The students commented that these were so productive because they would at this stage have a good understanding of the topic, yet still enough time to work with the outcomes of the seminar.

For the project seminar, the daily evaluations demonstrate that we might have been too ambitious when designing the different workshops, and actually provided too little time for the students to work in the groups, either independently or together with their supervisors. While we encouraged the students to seek advice from all the supervisors/teachers present at the seminar this did not happen as often as we would have liked: We believe that in coming seminars it would be beneficial to facilitate this more actively. We also observed that the different groups worked very differently: Having a programme where the timing works for both 2 students working together on their master thesis and 9 students working together on projects with different workloads and levels is challenging. The students expressed that they felt somewhat unprepared for the project seminar with respect to their topics. This is something we also could see in the way the projects progressed, since many groups had to do major revisions of the plans and scopes in the weeks following the seminar. If the students were better prepared with respect to the subjects and division of work in groups, they might have been able to make more robust plans during the seminar. For the second year, the students were encouraged to meet virtually before the seminar (which required that project groups were decided earlier), and we also made a catalogue describing the background of all participating students and teachers.

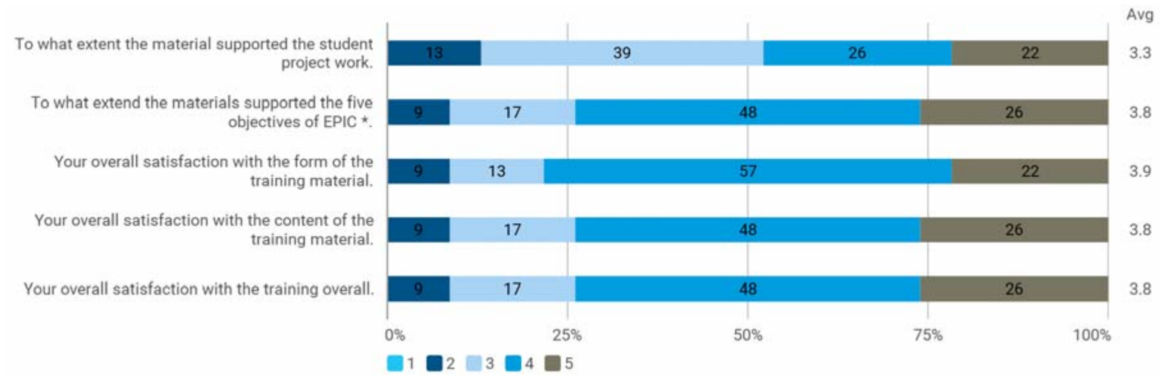

Figure 3: Students evaluation of the teaching materials for students. 1="Not at all", 5="Very much".

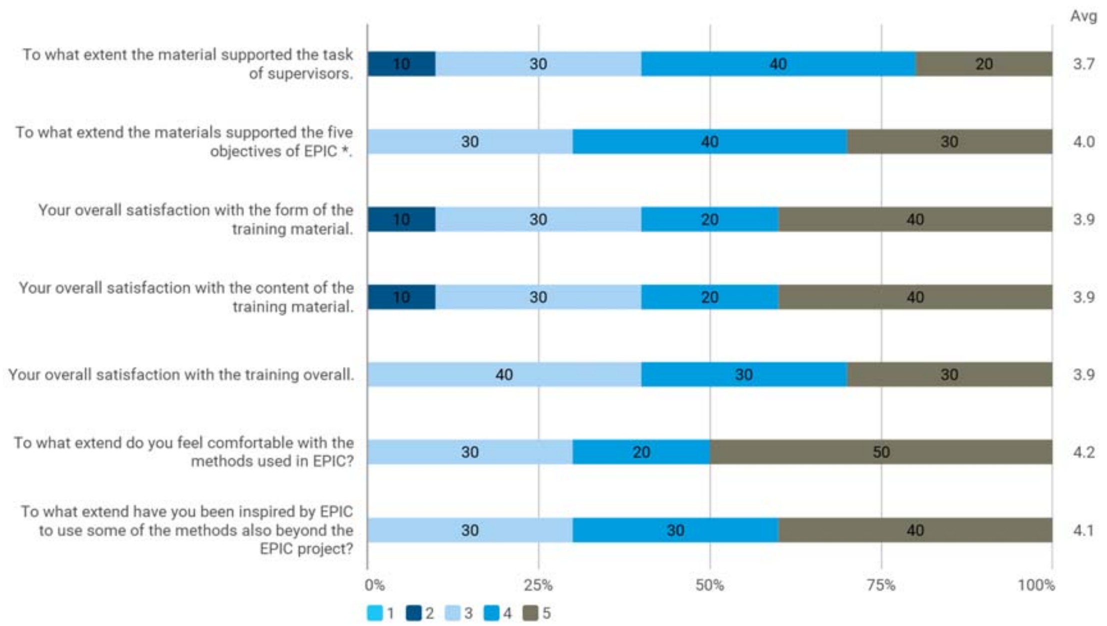

Figure 4: Teachers evaluation of the teaching materials for teachers. 1="Not at all", 5="Very much".

As described in Section 2, one of the pillars to support the project work is the materials for training students and teachers. These evaluations can be seen in Figures 3-4. Again, the evaluations are positive overall, but also with room for improvements. For students, the comments indicate that the materials were too generic, which we believe can be solved by making e.g. assignments that are more project related. If this is done in the project groups, this could also help the groups get to know each other even before the project seminar.

Through the comments collected both throughout the project and at the end, two particular challenges were identified. First, in some groups it was challenging to actually work together instead of "just" splitting the work into subprojects, which would make it hard to write a coherent joint report at the end. Second, some students experienced challenges with respect to supervision, especially if the advice from overall and local supervisors were not in line. This raises central questions for the EPIC approach, which is treated more in-depth in the discussion.

5 Discussion

In general, students and teachers were happy with the results and outcomes, but there are also focus areas for the second year. In particular, we have chosen to focus on making the students better prepared even before the project seminar, and to streamline the process of making project proposals and student selections. Another focus point is to integrate the supporting teaching material better with the project work. We would like to further discuss two central questions, which are critical in order to further promote the approach taken in the EPIC project: Namely how to facilitate that the students actually work together even when evaluated according to (different) home university rules, and how to facilitate supervision in such a diverse environment.

5.1 How to ensure that the students actually work together

This question is central for the EPIC project, since we have chosen an approach where existing study regulations are not altered, and therefore the students are evaluated according to (different) home university rules. Depending on the home university rules and traditions, there is a risk that the students feel that the time spent on collaboration and coordination is not properly rewarded compared to spending the time on getting in deep with e.g. their thesis topics. There is also a risk that the projects are simply divided into subprojects, where the students are essentially working independently from each other, until the subprojects are merged in the end with some joint conclusions. We find that the following considerations can be a help in motivating the students to work together:

- It is important that both students and supervisors are aware of the learning objectives when scoping the projects in the groups and deciding upon roles and tasks of individual students. This can help them see how the work of individual students can benefit from the collaboration. When diving tasks and roles, it is important that each student can see both how he/she contributes and how he/she benefits from the work of the other members of the group.
- It is also recommended that students and supervisors go through the learning objectives together at an early stage of the project and see how the work in EPIC can help fulfil the learning objectives. Sometimes there are broad formulations included, e.g. such as "professional development".
- In a student project within the EPIC framework, there will often be multiple supervisors involved, which can be a challenge. If the academic supervisor, who is responsible from the local university, is not supporting the joint project work – e.g. due to lack of insights – then it is just too likely that the students will be drawn in different directions. This underlines the importance of being explicit about the roles of the different supervisors, and of providing all supervisors an overview of the overall joint project. If possible, all supervisors should attend the project seminar.
- The three aforementioned points deal with alignment between the project work and the learning objectives of each student, and in EPIC this is facilitated through the document produced by each group specifying the learning goals, tasks and workloads of each student. It is created during the project seminar, but projects will always change over time. It is therefore important that this alignment is done throughout the project period, not just in the beginning.
- Finally, we would mention that the best way to support such collaborative projects is to create study regulations which in one way or the other make it possible to reward it in the learning objectives. Also, we notice that the regulations in terms of possible collaborations vary from university to university: In some institutions, it is allowed to make joint reports or joint parts of reports between students from different universities (of course subject to proper academic referencing etc.), where in other cases students must submit individually.

5.2 How to facilitate supervision in such a diverse environment

Supervision in collaborative student projects such as EPIC is characterized by different cultures, different traditions, multiple stakeholders, and multiple supervisors from both industry and academia. Also, each university has their own tradition with respect to supervision and supervisor roles; agreeing on a common set of guidelines is made difficult also by the fact that often these traditions are linked to different requirements in study regulations. Yet, the supervisors play a major role in the success of a collaborative student project. The following considerations are in our opinion helpful when it comes to providing good supervision of collaborative student projects:

- It is important to discuss mutual expectations between students and supervisors, including supervisor roles. There are so many implicit understandings of supervisor roles and different cultures for dialogue between professors and students that we recommend to make a written contract (supervisor agreement) as precise as possible, and also to evaluate and revise this along the way. Ideally this should cover all the involved supervisors.

- The roles of different supervisors were not always clear to the students and supervisors. This especially happened when there were more persons from the same university involved, i.e. different "EPIC contacts" and supervisors, but also between the main supervisor of the EPIC project and the local supervisors. For instance, the largest group with students from 4 different countries had one "main" supervisor who was responsible for the whole group (and acted as local supervisor in one country), as well as three local supervisors for the students from other countries. This has led to a clear and written definition of supervisor roles. It includes four roles: EPIC supervisor (supervising the overall group), Industry Supervisor (supervisor from the company), Local Supervisor (EPIC contact person) and Academic Supervisor (the local supervisor with specific topic-knowledge – can be the same as the Local Supervisor).
- With respect to the roles of supervisors, it was discussed among the partners whether it is a good idea that the EPIC supervisor of the project and the local supervisor can be the same, without any clear conclusions: It is important though to handle the risk that the students who are also locally supervised by the EPIC supervisor becomes the "leaders" of the project and that supervision of the overall group does not go through the local group of students.
- Having multiple supervisors can be a valuable source of inputs, and many good discussions happen when supervisors have different opinions. On the other hand, there is a risk that the students feel they get contradictory advice. This can be more difficult to handle in a virtual collaboration situation, where the supervisors might not meet the students at the same time, than in a traditional setting where everyone can meet around the same table. Therefore, it is important that the supervisors coordinate their supervision efforts throughout the project timespan.

6 Conclusion

This paper described how multinational, interdisciplinary student projects based on real-life problems from companies are established within the Erasmus+ Strategic Partnership EPIC. The idea is to make the projects happen within existing study rules and regulations, i.e. within the scope of existing learning activities of the participating universities: In this way, the approach becomes scalable even outside of the consortium. Moreover, the amount of travelling is reduced through a high degree of virtual collaboration, which is important for the approach to be sustainable after the Erasmus+ funding expires. This paper presents the evaluations made after the first of three yearly cycles of the project, which are overall positive, but we have identified some focus areas to adjust for the coming years. Moreover, the paper includes a discussion of two key challenges in the project, namely how to ensure that students actually collaborate even when the learning objectives differ depending on the home institution of the student, and how to facilitate good supervision of students in such a diverse environment.

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Engineering Students Within and Beyond the Classroom - FlexSim case study

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Abstract

The paper sheds light on the importance of involving students in their learning by examining the process through which the acquisition of, one complementary yet unfamiliar learning tool, FlexSim software is transformed into a prolific learning and teaching experience. The simulation software has been purchased to allow electro mechanical engineering students further practice on the theoretical aspects of one of their courses. Through assigning an undergraduate student the task of exploring the software as part of his summer internship, he has not only developed personal hard skills, but also transformed an individual self tutoring experience into an engaging group experience through teaching, coaching, and assessing other learners.

Keywords: Active Learning; Engineering Education; PBL; Student Engagement.

1 Introduction

Industrial Systems Simulation (ISS) is a problem-solving course that addresses undergraduate engineering students major in electro mechanics. It introduces simulation, and modelling concepts pertaining to the development of industrial manufacturing systems. Thus, Esprit School of Engineering needed to acquire simulation software to allow students further practice on the theoretical aspects of the course. The inconvenience was that the software was left unexplored since it was acquired without any prior training. Thus, an undergraduate student was requested to work on the software, determine its various components, and handle a case study using it.

The paper sheds light on the importance of involving students in their learning by transforming fairly known software into a prolific learning and teaching experience. Through assigning an undergraduate student the task of exploring the software as part of his summer internship, he has not only developed personal hard skills, but also transformed an individual self tutoring experience into an engaging group experience that involves teaching, coaching, and assessing other learners.

2 Review of the literature

Given the ineffectiveness of the traditional lecturing model of teaching, innovative pedagogical models involving active learning, and employing case-based, problem-based, and project-based methodologies, have been introduced to the engineering classroom (Cochran, 2009; Goodnough, 2006; Armacost & Lowe, 2003, Michael, 2006; Muñuzuri et al., 2016).

Active learning (AL) is a learning approach that aims at engaging learners in the learning process by inviting them to play a proactive role in the acquisition of knowledge and the development of their skills and attitudes (Keyser, 2000). AL leaning is ensured through higher order cognitive tasks such as analysing, synthesising, and evaluating (Renkel, et al., 2000). The learners, who are placed at the center of the approach, are the ones to determine their pace of learning, the suitable learning methods, and the strategies to deploy (Nicol et al., 2017; Prosser & Trigwell, 2014; Taylor et al., 2012) . The teacher plays the role of the facilitator whose main tasks include; providing guidance and motivation (Nicol et al., 2017; Gilboy et al., 2015), providing learners with real-life like situations, and challenging tasks; and devising activities that ensure collaboration between learners.

The premise behind using the Problem-Based Learning (PBL) framework is to prepare learners to be equipped with the needed skills in an ever changing market. It aims at constantly challenging learners introducing them to real-life like situations that can stimulate their conceptual understanding, and sharpen their ability to respond and take actions. PBL does not require learners to regurgitate knowledge. It rather urges them to achieve knowledge through dedicated learning and immersion in an environment that requires them to use their knowledge (Albanese & Mitchell, 1993; Ross, 2006). PBL develops problem-solving, critical thinking, and self directed learning (Putnam, 2001). Learners will be capable of recognizing, exploring, synthesizing, and presenting findings (Duch, Groh, & Allen, 2001). According to McLeod and Savoy (2009), when implementing PBL, the learner undertakes four different learning phases:

1) activation of prior experience,
2) demonstration of skills,
3) application of skills, and
4) integration of these skills into real-world activities.

This paper showcases the benefits of implementing PBL within an engineering classroom and presents the various assessment methods that were deployed.

3 Model and Implementation

The following section details the process by which the learning experience of FlexSim, the software modelling, has started as a self-directed learning practise ensured by an undergraduate and been transformed into a teaching experience that comprises different groups of learners locally and internationally.

3.1 Self-directed learning

For his summer internship report, an undergraduate student, major in electro mechanical studies, was instructed to work on FlexSim (http://www.flexsim.com/), the simulation software for analyzing and optimizing industrial systems. He was provided with all the documentation, resources, and tutorials that had been already provided with the software upon its purchase. The student had a time span of two months to master 15 models. He met his supervisor on a weekly basis reporting his progress. The instructor provided guidance, assistance, and feedback.

Following the two months self-instruction experience, the learner was invited to provide peer learners and a group of professionals with a 3-hour training. The learner, now becoming a coach and an instructor, provided his tutees with a case study and asked them to practice on using FlexSim implementing all the information he had delivered.

The learner provided written guiding instructions, and a summary serving as teaching material, or documentation for any learner who would like to use FlexSim in the future.

3.2 Peer tutoring and national challenges

Opting for a problem solving active teaching method, the main instructor used FlexSim as a core part of his Industrial Simulation course. The question pertains to encouraging students to learn problem solving skills through real-world industrial applications. The course was designed to introduce system modelling and simulation techniques (Petri nets). The learning outcomes are; providing realistic estimate of how a system works and evaluating the effects of certain systems taking measurements.

The 21 hour course was delivered to a total of 150 students, and was divided into two main phases; 12 hours covering all theoretical aspects related to the course, and 9 hours for implementing FlexSim. The course was evaluated through a challenge set between a total of 30 teams of 4/5 students, and a final written exam.

The first challenge (first edition) consists in using FlexSim to work on a case study. The preparation for the challenge took 2 weeks. Groups were then invited to present their work in front of a jury of teachers and industry professionals. The audience included all remaining groups with an estimated number of 125 fellow students. The challenge took place in two consecutive days.

During the competition, students put their modeling and analysis skills to the test on various topics proposed by industrial local partners—assembly lines of aircraft components, bottling lines, calibration services for quality control, gas station operations, and more. A similar challenge was organised the following year (second edition). Esprit winning group of this inter class competition was selected to participate in a national challenge comprising groups from two different universities; namely ISET Rades, and the University of Bizerte. Groups of participants were mixed in order to allow for equity since Esprit students had had enough time to learn and practice on FlexSim. Besides, they had documentation detailing how the software works.

The national challenge aimed at encouraging learners to learn from interacting with each other, and to endow Esprit students with the coaching/teaching skills by explaining, and instructing their peers. Students' performance was assessed by a jury of teachers and industrials.

3.3 The International Process Simulation Challenge

From December 14-16, 2018, bbw University of Applied Sciences (bbw Hochschule, https://www.bbw-hochschule.de/) hosted the first International Process Simulation Challenge. The event was held as part of the German Academic Exchange Service (DAAD)-sponsored German-Arab short-term measures program, where bbw University of Applied Sciences invited engineering students and staff from their Tunisian partner university, ESPRIT, to Berlin. 9 coaching positions were provided to students who showed interest in coaching German students on FlexSim. Students provided a total of 16 hour coaching divided into 4 sessions, and provided further guidance throughout an online forum (Figure 1).

The nine ESPRIT students/coaches spent the first half of the weekend training students from bbw University of Applied Sciences' International Technology Transfer Management (ITTM) Master's program on how to use FlexSim. The aim was to enable German students to construct industrially suitable models reflecting what they had been taught.

Once the ITTM students had fair mastery of the software, they were given a modelling challenge to solve in eight teams of four. Teams did not consist of mixed multinational students. It was only the 32 German students who were coached that participated in the challenge.

The team with the best solution would win internships at one of two partner firms that were supporting the event. FlexSim provided the licenses for the weekend, and also gave the winning four ITTM students year-long access to the student version of the program to further sharpen their skills in process simulation modelling.

The students were given the task of optimizing a refrigeration manufacturing plant. Several steps were involved—from preparing the refrigerator tank, handling defective fridges and quality control, to packaging and dispatch. The participants were required to create a production line based on conveyers and then use the dashboard to identify:

- occupancy rate of the product assembly
- non-compliant products
- number of refrigerators stored in the finished product storage area

Finally, the students were asked to give a four-minute explanation of the model they had created and answer any questions from the audience.

"The intensive three-day nature of the challenge gave all the participants a solid grounding in the process modelling software in a compact amount of time," said Prof. Dr. Uwe Kaschka, Director of the ITTM Master's Program at bbw University of Applied Sciences. "It provided the students with a strong basis for improved employability, since such a modelling skill set would be advantageous to companies they employ."

For both the German and Tunisian students, the challenge "gave them an introductory experience similar to the kind of intercultural and inter-communicational environments they will be greeted with when they enter the workforce."

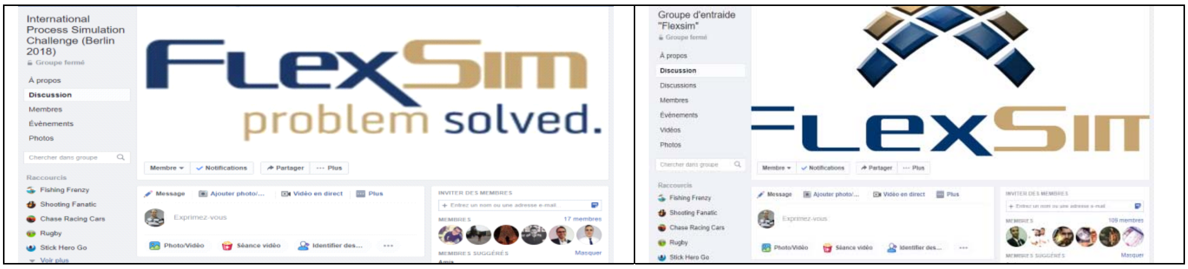

Figure 1. Online forum

An overview of the various trainings and competitions is presented in figure 2 below.


First training (summer internship's validation)


First edition of the challenge (Esprit)


Second edition of the challenge (Esprit)


Third edition of the challenge (with the participation of others schools)


International challenge (Germany)

Figure 2. An overview of trainings and competitions

4 Assessment methods

The following section outlines the various methods for assessing learners' performance.

4.1 Self-directed learning

Regarding the assessment of the learner's self-directed learning, it was established by the supervisor and a jury of teachers using a grid. The grid aimed at assessing the learner's communicative skills as well as his knowledge acquisition of the software. The evaluation consisted in scoring the student's performance focusing on two elements; performance and presentation. Regarding performance, the jury members assessed the student's communicative skills (verbal, non-verbal, written), while presenting, explaining (verbally and in report writing), and handling questions. For the second element, which was presentation, the focus was put on the pedagogical approach, the clarity, relevance, and accuracy of the delivered content (material, data, case study, simulating models, etc).

4.2 National Challenges

Groups' performance was assessed using a grid with the criteria set to be;

- The functionality of the model : 10%
- The accuracy of the model (in respect to the proposed industrial case): 10%
- Aesthetics, design and communication: 20 %
- Creativity: 30%
- Dashboard relevance 30%

Following the competition that was set internally between groups of Esprit students, and the one set to regroup Esprit students and groups from the two other universities, all participants were asked to evaluate the experience by responding to a questionnaire. The questionnaire included a question about their global satisfaction, knowledge acquisition, team work, and event conditions (logistics, rooms, timing, etc)

4.3 The International Process Simulation Challenge

The international challenge was assessed using the same grid as used in the national challenges and as indicated in the previous section.

Also, in order to assess their experience, competing teams were invited to answer a survey questionnaire

the 1st

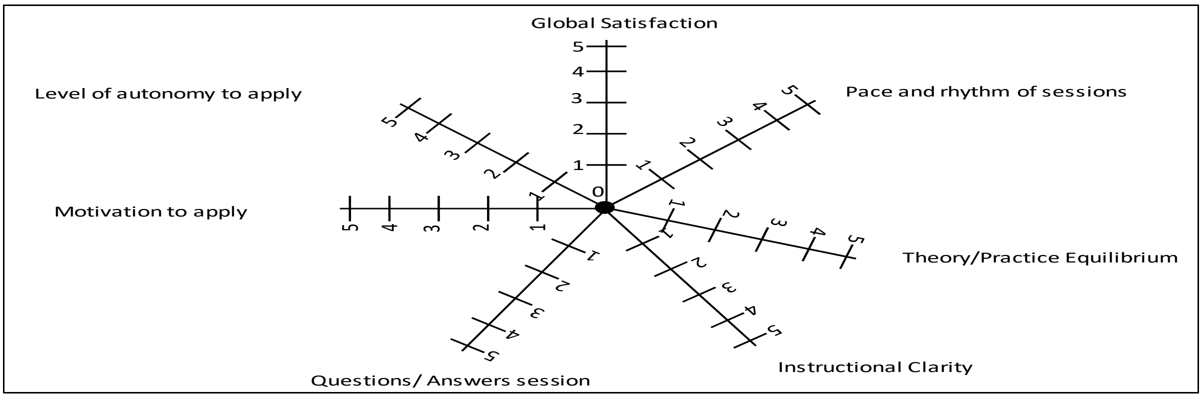

Figure 3. Questionnaire elements

In the second scaling question, participants were asked to indicate their degree of satisfaction with regard to the tutoring/training session that preceded the competition. The evaluation criteria are presented in Table 1 below.

Table1. Evaluation Grid (tutoring training)

Evaluation Criteria	---	--	-	+	++	+++
Has the training (workshop) met your expectations?						
Do you think you have acquired knowledge, competencies, know-how?						
What do you think of the pace and the duration of the different parts?						
Are you satisfied with handed documentation?						
Are you satisfied with the teaching methodologies that have been deployed?						
What do you think of the coaches' communicative skills?						
Have the coaches impact positively the learning environment?						

German students' were also asked to provide further remarks or suggestions as indicated in Table 2 below

Table 2. German students' feedback
It was a bit fast but very productive. Maybe make 3 full days on another opportunity.
Its great opportunity to learn different software.
Seminar was very nice but duration can be raised so that students can spend time with masters and learn more things
Event was very nice and wish could have couple more days
Too short time of workshop
Everything was good. Keep it up!
It was a good presentation. I learnt so many things that I won't able to learn by myself. Hope you guys bring this competition again in next year.
Needed some more clearance of topics from the coaches
Learnt a lot, lot of knowledge was shared with students. Was really good experience, continue with same intensity and same motivation.
The people were too good and attentive they tried to help us the best they could but they were not able to understand English that good. So if there's a provision for translate then that will be awesome.
Its great opportunity to learn different software.
Everything is perfect
No suggestions
Need to give more time to teach and to prepare the competition
Good efforts to teach us. but still need some more improvements from our side as well as yours
Good
Give some time for getting use to software
Too short program Try to provide correct files in challenge

Jury members were also requested to expression opinions regarding the competition and teams' performance. They were asked to evaluate their level of satisfaction on a scale ranging from 1-3 (3- Very satisfied 2- Satisfied 1-Unsatisfied). The elements of assessment are the following

- Methodology
- Clarity of information & instruction
- Communication
- Questions/ Answers session
- Discipline
- Tutoring / Training
- Mastery/use of the software
- General impression

5 Results and implications

In this section, the results of the various assessment methods used and their implementations are reported.

5.1 Self-directed learning

The assessment of the learner shows an enhanced attainment level, and a good level of communication, as well as analysis, explanation, and discussion skills. At the end of the internship, the student was able to handle 15 modules and provide a valuable simplified documentation set as a reference for other learners to follow. The result gives further evidence of the importance of putting the learner at the center of the learning process and enabling them to handle the learning/teaching task.

5.2 National Challenges

Besides the evaluation grid that was used to assess students' final output (, i.e. implementing FlexSim), students were invited to report their global satisfaction, knowledge acquisition, teamwork, and event organization. Results are shown in figure 4 below.

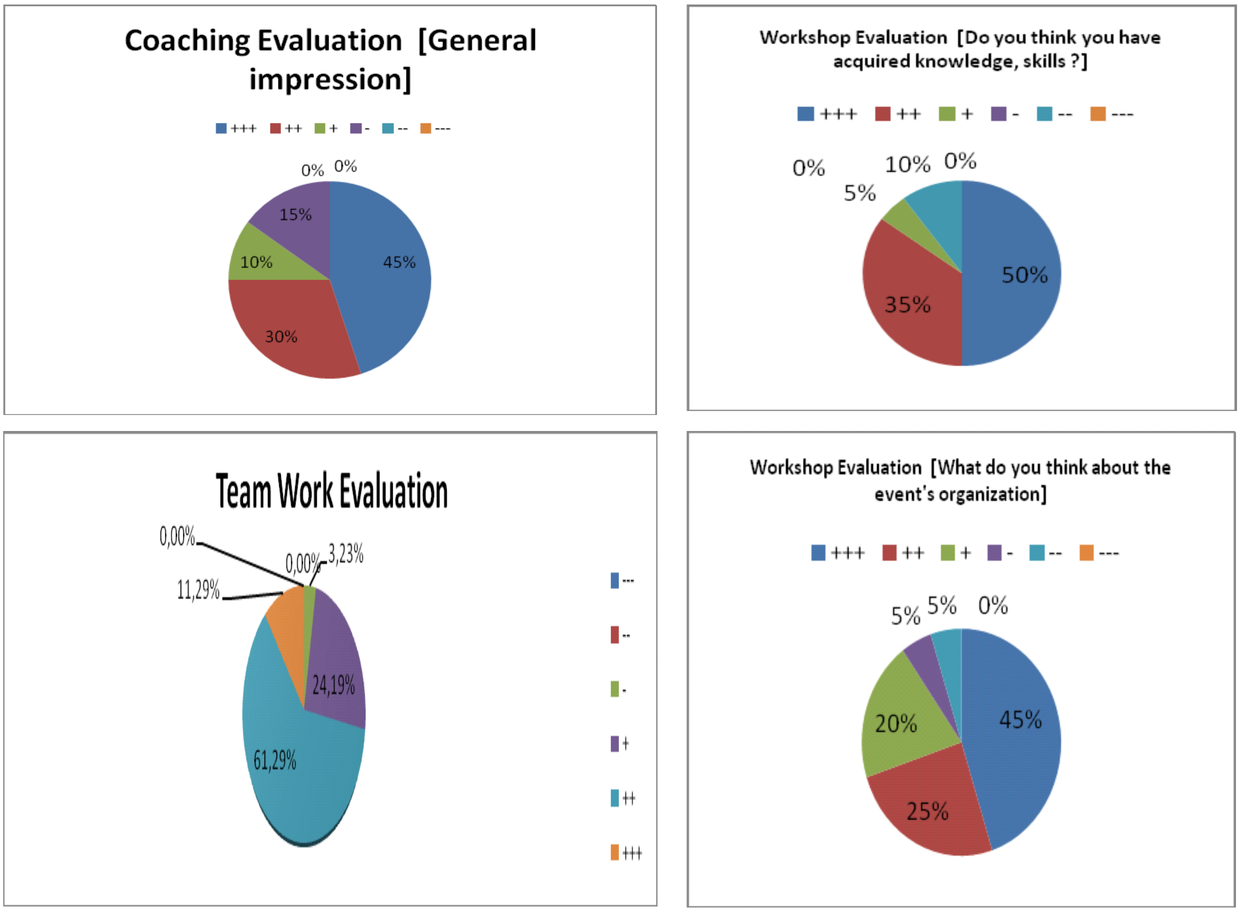

Figure 4. Results of the questionnaire

The results reveal a greater satisfaction on the part of the learners. They showed 61.29% appreciation of working within teams and 50 % for knowledge acquisition. Esprit students are accustomed to team work as it is a vital part of all their courses which are either problem-based or project-based. The results may confirm that of the literature. It is stated that team work may involve self and peer tutoring. It enhanced learners' communicative as well problem-solving, analytical skills to cite a few. The competition set between the various groups, with the aim to present a simulation system, fosters students' dedicated learning through immersion in a problem-solving case. It guarantees that the learners undertake the four different learning phases as stated by McLeod and Savoy (2009) ;1) the activation of prior experience, 2) the demonstration of skills, 3) the application of skills, and 4) the integration of these skills into real-world activities.

5.3 The International Process Simulation Challenge

Regarding the international challenge experience, similar results to the national challenges are reported (Figure5).

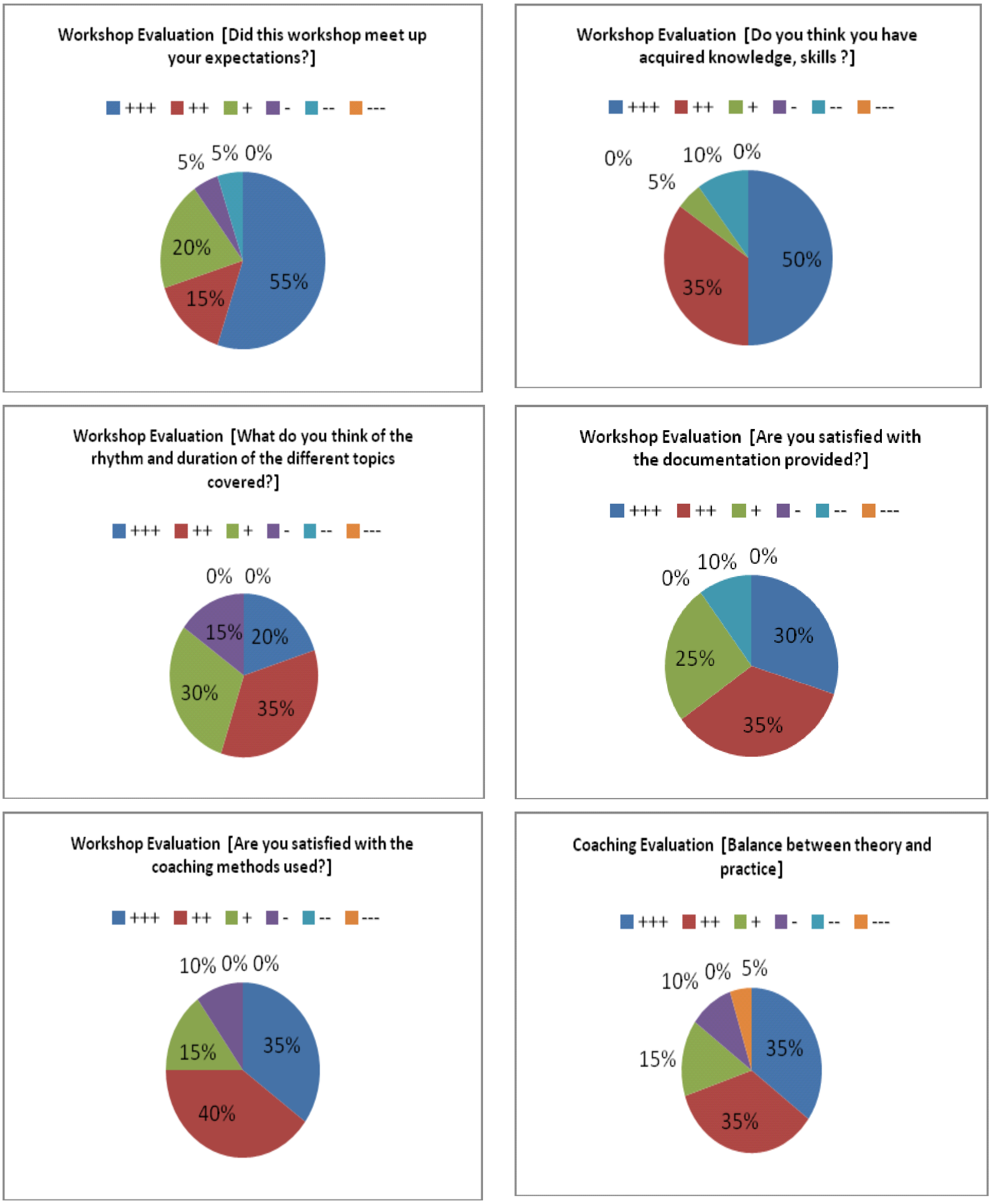

Figure 5. Questionnaire answers

The results varied between very satisfied and satisfied reflect German students' overall satisfaction with the experience. Their comments on record and off record reveal that the problems that they faced pertain to first language problems since Tunisian students coaches and German candidates needed to use a 3rd foreign language (i.e., English) to communicate. In both groups, not all students master English. The second problem that the German candidates reported is related to time constraints. They preferred to be given more time to learn FlexSim.

Bringing a problem-solving case outside of the classroom by means of a competition makes the benefits of the approach, and the methodology reach a wider range of learners. While acknowledging the importance of involving learners within teams, and inviting them to solve real work related problems, and the advantages that can result from both, the individual performance and attainment in ISS module cannot be guaranteed. Due to time, and class size constraints, students' mastery of the software could not be assessed individually. The summative assessment of the module indicated that students did not reach the same level of mastery.

6 Conclusion

The paper reports the benefits of using active learning in enhancing engineering students' learning self-directed learning, problem solving, and critical thinking skills. Esprit experience with FlexSim Simulation Software proves that students can learn independently and can be entrusted with the task of instructing and coaching others. The experience started with a self-directed learning of the simulation software, and then developed into a coaching competitive context where students engaged cooperatively in learning aspects of the software while performing in teams. Esprit students' mastery of the software enabled them to coach other peers in an international context.

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Engaging Engineering Students in Learning through Peer and Group Teaching

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Abstract

The paper showcases the paramount significance and the effectiveness of involving engineering students in their learning process through peer and group teaching. It details a one term experience in which undergraduate electro mechanical engineering students took turns in instructing and coaching their peers as well as a group of professionals on a variety of innovative advanced tools. The main aim from the experience is to implement a locally fairly acknowledged method gaining popularity worldwide. The newly adopted method of peer teaching results in allowing students to actively engage in an innovative enjoyable learning environment, enhancing attainment, and acquiring new sets of skills.

Keywords: Active Learning; Engineering Education; Pedagogy; Peer teaching

1 Introduction

Research has proven that peer teaching is amongst the effective learning methods in engaging pedagogies that place the learner at the heart of the learning process which can be inquiry- based. Students tend to learn from each other through social interactions (Vygotsky, 1978). They engage in a co-construction process of meaning following their involvement in shared activities, in which they enact dialogues with peers to solve a problem or acquire schemata (Barrett, 2001; Barrows and Tamblyn, 1980; Woolfolk, A., 2004).
In this paper, a new approach of a course delivery approach combining peer tutoring and problem solving within an engineering classroom is presented. Conceiving, Designing, Implementing and Operating Project (CDIO) is a 42-hour one term module that deals with advanced theoretical concepts and notions, with an aim to combine conceptual and practical knowledge. The teacher faces many challenges when designing and delivering the course. These challenges consist in:

- selecting the items of the subject matter or content, simplifying intricate tools and notions,
- integrating research based data or introducing new methods or updating existent course,
- implementing a learner centred approach in teaching,
- respecting time constraints,
- dealing with the lack or scarcity of resources, and lack of students' motivation and reluctance to participate in the various activities, etc

In order to overcome these hardships, the teacher decided to entrust undergraduate electro mechanical engineering students with the teaching task. Divided into groups of 5- 6, students were instructed to take turns preparing in-class and out of the class workshops on an x part of the subject, or a fairly known but never taught industrial engineering tools, covering all its various aspects, researching all its elements by collecting data from professionals and the literature, and delivering presentations to their peers and a group of senior graduates, teachers, and professionals. Workshops and presentations were followed by discussion and feedback sessions. The teacher's role consisted in monitoring students' work pre-, during, and post presentations, providing assistance, guidance, and assessment.

The aim behind adopting a peer teaching method for course delivery is twofold:

a) it engages students in their learning process as they become responsible of their own learning and that of their peers, and

b) it endows them with the skills (communicative, personal, and disciplinary) needed to integrate in the marketplace.

2 Literature Review

An extensive body of research has dealt with the effectiveness of peer tutoring or peer instruction in creating the most suitable of learning environments. Peer instruction consists in inviting students to play a teaching role providing instruction and guidance to other students who are usually younger in age or less capable (Colvin, 2007; Magin and Churches, 1995). Students are expected to share the same knowledge background, intentions, and skills. This entails that peer tutoring creates a non threatening safe environment for the learners (Power and Dunphy, 2010).

The theoretical premises of peer tutoring or learning draw from Vygotsky's social cognitive development theory, which postulates that learning takes place in a collaborative social environment where a learner actively engages with others in shared activities and dialogues in order to construct meaning, draw patterns, develop skills, and independently perform tasks (Vygotsky, 1978). Johnson, Johnson, & Smith (1998) suggest that learners sharing a complex task, and aiming to achieve a common goal, tend to help, assist, support, encourage, and promote the success of one another. Forman & Cazden (1986) further advance that learners provide accommodation for each other the same way an adult provides it to a child.

Peer tutoring has been well-recognized as an instruction method. It improves the learning experience in general, more specifically learner's perceptions about themselves, and their attitude towards their learning. It is reported as a motivational tool that fosters performance, self-efficacy, self-confidence, retention, understanding, collaboration, networking, team work skills, leadership skills, interest in discipline, and academic success, (Brown, & Poor, 2010; Colvin, 2007; Crouch, Watkins, Fagen, & Mazur, 2007; Mazur, 1997; McNall, 1975; Mynard & Almarzouqi, 2006; Powers, Sims-Knight, Topciu, & Haden, 2002; Smith et al., 2005). Peer mentoring requires a senior and more capable student to act as a facilitator whose role is to devise, and develop facilitating approach and activities.

The benefits do not only concern the learner, but extends to include the teacher who will not face the same working load or unmotivated learners (Brown, & Poor, 2010; Colvin, 2007; Zou, Ko, & Mickleborough, 2012).

3 Model and implementation

Peer tutoring usually involves tutors that are senior or more capable teaching other students. In this paper, we present a case where peer tutoring is handled by a group of students delivering the course to their peers. The model that was adopted portrays all types of learning resulting from peer instruction inside and outside of the classroom (Figure1).

It incorporates:

i. learning resulting from self-instruction as students need to cover separately the same subject and individually their part of the workshop, and presentation

ii. learning resulting from peer instruction within the same team by means of assistance, questioning, and guidance

iii. learning resulting from peer instruction among tutoring teams by means of questioning, responding, presenting feedback and assessment

iv. learning resulting from interacting with the main instructor by means of assistance, feedback, and assessment

v. learning resulting from delivering the subject to a group of professionals by means of questioning, and feedback.

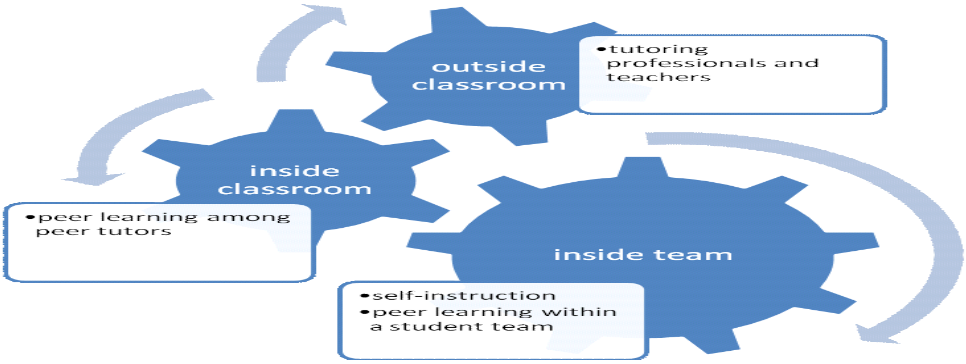
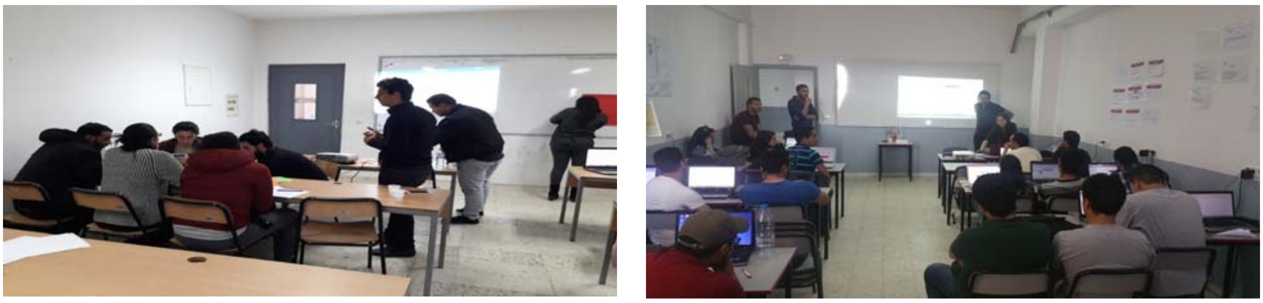


Figure 1. The adopted learning model

The model was implemented within a 42 hour module entitled CDIO Project. The module covers aspects related to advanced industrial engineering tools and is delivered within a problem-based framework. Its main learning outcome is studying and designing a scientific and technical project unfolding Electromechanics bases**.** Divided into 6 groups of 5 students, all thirty students were invited to deliver a workshop on fairly known industrial engineering tool or a presentation on a conceptual/practical aspect already selected by the main instructor. Their task was to share the knowledge they had already acquired, and to transform it into teachable material. Among the tools and techniques that were suggested to students, we can cite:

- Design of Experiments (DoE)
- PMI/PMBOK (Project Management Institute/ Project Management Body Of Knowledge).
- Industry 4.0
- Statistical Process Control (SPC)
- Measurement Systems Analysis (MSA)
- Lean Six Sigma

During the first session, the teacher explained the project framework, aims, and the requirements. Randomly, students chose the tools and techniques to study and implement and were allocated time to conduct literature review and consult professionals seeking guidance. The teacher constantly provided each group with guidance, assistance, and formative assessment (discussion, reflection, group presentations). Team students' final output consisted in a written report, a workshop, or a presentation outlining all the various aspect of the concept or the tool they acquired (Figure2). Their summative assessment, which encompasses a report, and a final presentation/workshop, was handled by their main instructor and a jury. The following section outlines the assessment method.



PMI/PMBOK training — Statistical Process Control training

Figure 2. Training sessions

4 Assessment method and results

4.1 Formative assessment

Formative assessment includes discussions, reflections, and group presentation. Besides receiving regular feedback from their teacher, tutoring groups received feedback from their tutees. In order to evaluate their performance after delivering workshops and presentations, tutoring groups and tutees were invited to answer questionnaires describing their learning/teaching experience.

4.1.1 Among peers

Upon attending presentations, and workshops, tutees evaluated the tutoring groups' performance. The evaluation was carried by means of a questionnaire. Tutees were presented with 6 questions concerning:

i. their global satisfaction with the presentation/workshop,
ii. their tutors' ability to present, convince, and explain concepts and tools
iii. their tutor's communicative skills
iv. their tutors' ability to present a theoretical framework and link it to a practical case study
v. their tutor's answers following questions, and or feedback, and
vi. their satisfaction with the peer tutoring approach.

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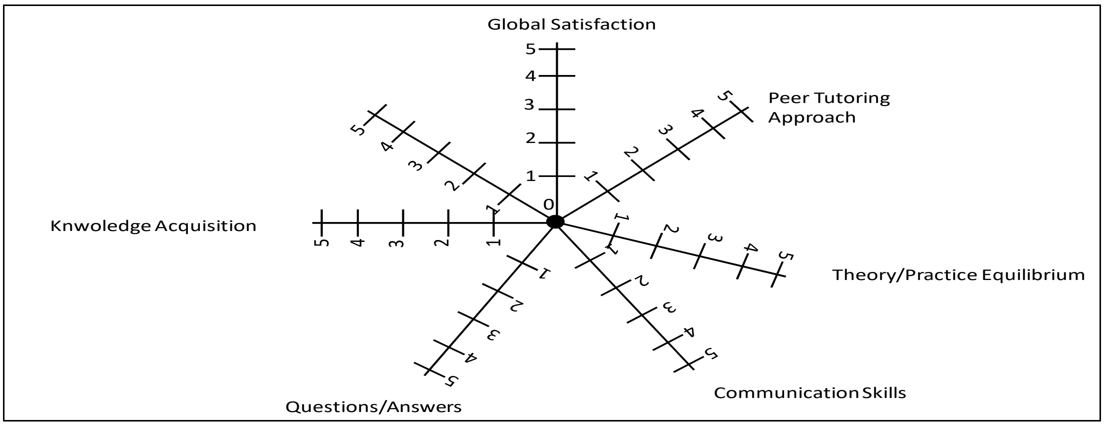

Figure 3. The questionnaire elements

The results are presented in the following charts (Figure 4). Tutees showed a global satisfaction of near 62 % of the delivered presentations or workshops. Also, they showed satisfaction with the communicative skills of their tutors during presentations and their ability to handle questions and discussions. Regarding knowledge acquisition, and the balance between the presented theory and the implemented case study, respondents expressed the following percentages 65 % and 47.1 % respectively. Tutees showed also satisfaction with the new teaching approach displaying 31% of satisfaction.

As previously stated, the literature cites many benefits arising from peer tutoring, among which the enhancement of communicative skills and the level of attainment as reflected in tutors' capabilities to handle discussions, and provide answers. Still, tutees' answers may reflect their reluctance about their peers' ability to handle the teaching role. Their answers may show their uncertainty about the content presented by their tutoring peers, or their peers' suitability to teach. The results may also demonstrate students' competitiveness toward each other as group students, who took turn presenting, are aware that their work is 40% of the final mark assigned to their course.

Students managed to cooperatively and actively engage in the various presentations. Still, they have always shown their need to direct towards the main instructor either to solve a conflict, confirm a theory, or further explain an aspect of the presentation or the workshop. Though they are accustomed to active learning, students tend to show resistance towards independent learning.

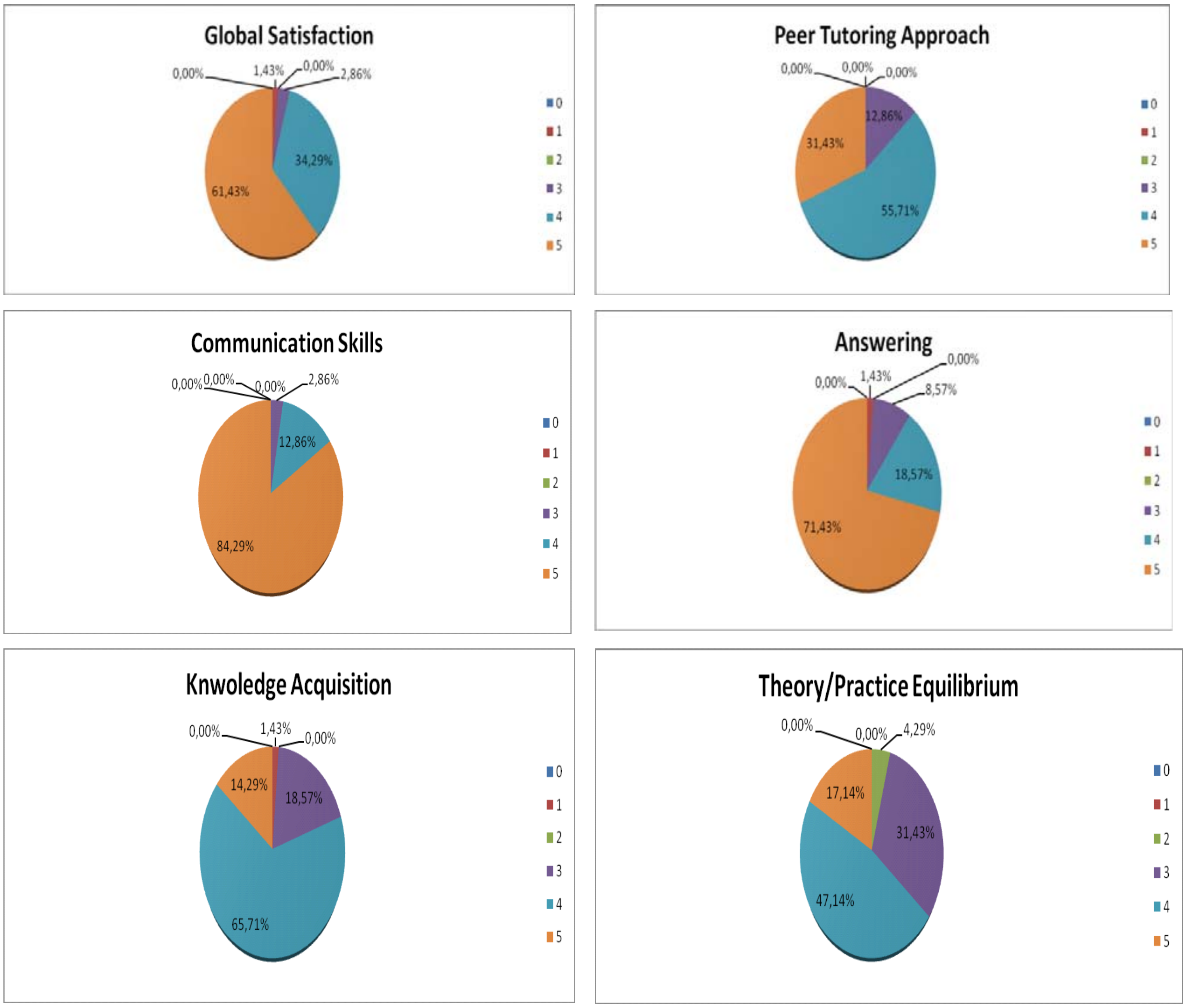

Figure 4. Questionnaire results

4.1.2 Within tutoring teams

By the end of the course, during the 15th week, tutoring teams were instructed to report on their experience, their satisfaction with the teaching approach in general, the set of skills they have acquired, and the shortcomings.

A reflective sheet (think aloud protocol) was distributed comprising a scale question on students' level of satisfaction with the new teaching approach, and a set of reporting questions about the positive, the negative sides of the approach, and suggestions.

The chart below (Figure 5) shows a high satisfaction level with the peer teaching approach (about 96 %).

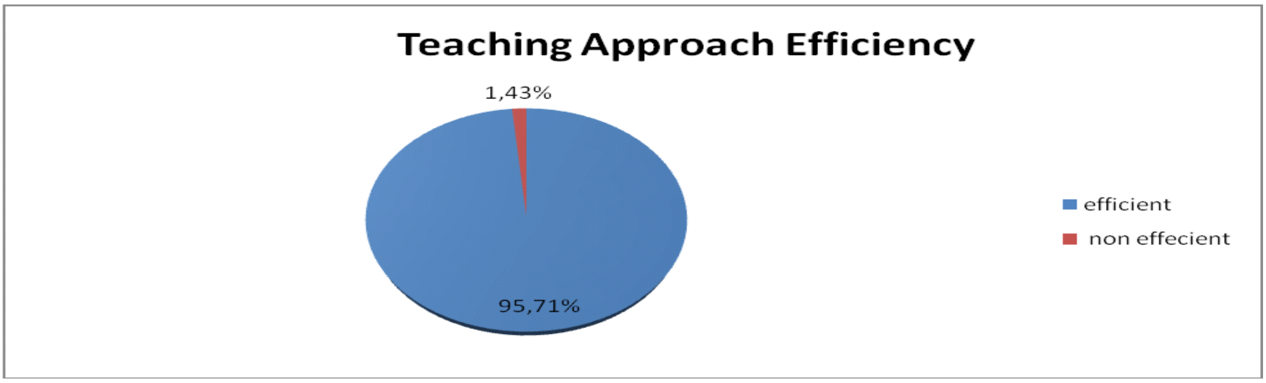

Figure 5. Questionnaire result

Students' answers on the positive sides and the negative sides were regrouped in table1. They were classified according to the common positive or negative sides cited in the literature. Students reported that the experience enhanced their motivation towards learning, their self-confidence, their communication skills and cooperation within and outside of the team.

However, students expressed concerns about time constraints, and planning. They expressed a need for additional time in order to grasp difficult notions, and prepare suitable simplified activities, examples, or case studies. They could not effectively estimate the time needed to finish their presentations or workshops. Students also reported facing difficulty when teaching because they lacked the necessary teaching skills.

Students' suggestions related to allowing more time for preparation, and getting training on teaching techniques.

Table 1. Tutors' views and reflections

Benefit (as identified in literature)	**Sample statements**
Attitude towards learning	I think I have full mastery of the area I taught and I can teach it as an expert I learnt so many things that I won't able to learn by myself. I learnt a lot, lot of knowledge was shared with students
Self-confidence	I can face a big audience of professionals and experience
Communication	I think I know how to present appropriately and explain in a simplified way
Teamwork	We learned teamwork and helped each other
Cooperation	I was able to cooperate in everyone of the teaching group
Time constraints	We needed more time to grasp the concepts and to develop our case study Activities took more time than expected. We couldn't finish on time
Difficulty of peer teaching	It was difficult for me to become a teacher and to teach a group of undergraduate engineering students and especially professionals

4.2 Summative assessment

Peer tutoring experience was also evaluated by professionals, and a group of teachers using an evaluation grid. The evaluation consisted in scoring teams' performance focusing on two elements; learners' performance and presentation. Regarding performance, the jury members assessed students' communicative skills (verbal, non-verbal), while presenting, explaining, and handling questions. For the second element, which was presentation, the focus was put on the pedagogical approach, the clarity, relevance, and accuracy of the delivered content (material as well as data).

The grid assigned each rubric under the two headings; performance and presentation different scores. Each element (performance vs. presentation) was scored 10 points maximum. Thus, the final mark should range between 0-20 points (maximum). Summative assessment was a requirement for succeeding in the CDIO project module.

5 Implications

The brief case study of peer teaching provides evidence that this approach is effective as it engages students in their learning process, and makes them responsible of their own learning and that of their peers. It enhances autonomy, and empowers students with a set of skills, among which problem-solving, team work, and communication.

However, the experience seems daunting for some students as they have no prior experience teaching others, or they still face problems related to team work in general as reluctance to participate or engage in any activity.

6 Conclusion

The paper presented an innovative teaching/learning method consisting in introducing the peer tutoring experience to the engineering classroom throughout a module based on problem solving such as CDIO. The paper details the experience and the methodology used for its assessment. It shows that the experience has its positive sides related to enhancing students' overall performance, and acquisition of skills. Nevertheless, issues related to time constraints, and planning, lack of supervision and lack of prior knowledge need to be considered. Further research is needed in order to address these shortcomings.

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Trello as Virtual Learning Environment and Active Learning Organiser for PBL Classes: An analysis under Bloom's Taxonomy

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Abstract

Trello is a cloud app based on Kanban concept and also available for desktop mobile devices. The app has plenty of boards that help projects' development under SCRUM concept. Trello is not originally designed as a Virtual Learning Environment (VLE) but it is recurrently adopted by one of the paper authors as a VLE for Project-Based Learning (PBL) classes development. It is also used as a formative assessment platform. The present research brings a case study under Trello point of view about a PBL class from a specialisation program named Creativity & Innovation where students chose to develop a project related to a vegan pizza bike entrepreneur in a Brazilian Applied Science Institute. The students from this PBL class came from distinct study areas like Graphic Design, Business Administration, Social Communication, and Journalism as well as Production Engineering since the program has an interdisciplinary character. Active Learning was the core learning approach taking PBL as a framework for it. According to the methodology, the students collaboratively identified the steps for project development from the "pizza bike" to the business areas related to it. For instance: visual identity, digital marketing, financial and accountability, manufacturing, etc. After that, the students supported by a tutor proposed teams for each areas identifying team tasks. From the beginning until the last activity, Trello as a VLE was disruptively essential for project organisation as well as their project success. A model based on Bloom's Taxonomy and other authors were proposed for the results analysis and it was possible to conclude that Trello as an innovative VLE and PBL organiser seemed to be positive from the author´s/tutor´s perception to the students' feedback and project results.

Keywords: Active Learning; PBL; Trello; Cloud Education; Bloom's Taxonomy; Virtual Learning Environment.

1 Introduction

Project-based Learning (PBL) is an active learning approach and philosophy that brings a multitude of interdisciplinary process and students' curricula gain. According to (Stoicoiu & Cain, 2014) the PBL as a learning approach can improve students' communication, individual growth, lifelong learning and team-work. All of them are desired skills by the job market. These skills are explored by students in their PBL experiencing since the projects try to resemble real life. And, much closer the project is of the real life, more opportunities students have to develop these skills (Stoicoiu & Cain, 2014).

Despite these advantages for students' curricula, PBL approach promotes a learning related to the project process that is usually hard to follow and control. For this reason, the absence of process operationalisation methodologies (e.g. SCRUM) can be a risk for the PBL effectiveness. Not always process operationalisation methodologies (POM) are full-adopted during classroom project development. In some cases partial-adoption of these methodologies are associated to a virtual or physical learning environment allowing a minimum control of the project process.

In this way the PBL was taken as active learning approach in the Entrepreneurship & Innovation Program of the Instituto Federal Fluminense. This paper aims to describe and analyse the results from a case study related to the Trello adoption as Virtual Learning Environment (VLE) in a PBL classroom of this program. Bloom taxonomy will be used to discuss the results obtained.

This paper is organized in six sections. The first section introduces the objectives of the paper. A short background related with PBL and Bloom taxonomy is presented in section two. Third section reviews the Trello for Education tool and SCRUM methodology. Study context is described in section four. Section five presents the main outcomes and finally, the last section wraps-up some final conclusions.

2 Background

This section brings the subjects related to the present research: Project-based Learning (PBL) as pedagogic framework, Trello as Virtual Learning Environment (VLE) & SCRUM thinking and Bloom's Taxonomy as an element of analysis model.

2.1 PBL & Bloom's Taxonomy

Project-Based Learning is an active learning methodology considered as student-centred approach. Student-centred approaches are different from teacher-centred approaches since these last ones are common in conventional teaching/learning practices and student-centred approaches referred to the result of transformational teaching/learning where the teacher assumes a role of a coach and a mentor and peer-to-peer networks among students are formed, emphasing the balance in the team and individual performance (Zhang, Zimmerman, Mihelcic, & Vanasupa, 2008). Being a student-centred approach, PBL has characteristics such as the Inductive Learning, meaning that basic material is introduced as soon as the need is established in the context of a question, problem or project assignment.

PBL also implies other learning approaches such as Collaborative and Cooperative Learning which calls for students interaction and working in a group to learn, apply course materials and work in structured assignments or projects under conditions that assure their interdependence, individual accountability, periodic face-to-face interaction, appropriate development and use of interpersonal skills and self-assessment of group work (Felder & Brent, 2006). Flipped-classroom is another learning approach identified in the PBL context since instructional content is delivered to the students outside the classroom and, usually, by themselves (Flumerfelt & Green, 2012).

For PBL development, students should use communication and information means such as blogs (Vicente, Mattarredona, & Alves, 2014), Facebook, Asana, Trello, or others web tools (Bittencout, Pimentel, Lago, & Santos, 2010). According to (Harmer, 2014), the key features of PBL models are: 1) learning by doing; 2) real world problems; 3) role of the tutor; 4) interdisciplinary; 5) collaboration and group work; 6) an end product.

PBL has been implemented globally in different academic years with interesting results (Alves, Moreira, Fernandes, Leão, & Sousa, 2017; de Graaff & Kolmos, 2007; Guerra, Ulseth, & Kolmos, 2017; Lima et al., 2017; Pereira & Barreto, 2016). PBL provides competences such as communication skills, leadership, project management, problem solving, among others that according to various studies and reports on the labour market are valued by employers value (Alves, Leão, Moreira, & Teixeira, 2018; ASME Board on Education, 2012; Jollands, Jolly, & Molyneaux, 2012; Santos, Simon, Guimarães, Amorim, & Vieira Junior, 2017; UNESCO, 2010).

Such competencies are not achieved in the traditional teacher-centred approaches which, normally, use tests and exams to evaluate students' competencies that are typically the competencies of the lower levels of Bloom's taxonomy (Bloom, 1956). These competencies of lower levels of a six-level scale are: ability to memorise facts, procedures and descriptions; and the ability to describe in other words facts and concepts; of interpreting and extrapolating. PBL supports the high-order levels this taxonomy: apply, analyse, evaluate and create. Bloom's Taxonomy consists in a framework of cognitive skills that help students and teachers in the learning process. This framework provides a hierarchy of critical thinking levels represented by keywords and its related student's action (verbs) as detailed in Table 1, Dimension 3 in Outcomes section. Authors like Ekren & Keskin (2017) and Stone (2004) have been developing and adapting Bloom's Taxonomy for specific models related to learning researches.

Additionally, PBL is also used as an educational strategy to improve students' attitudes towards science, technology, engineering and mathematics (STEM) as well as their achievements (Capraro, Capraro, & Morgan, 2013; Han, Capraro, & Capraro, 2015; Kezar, Gehrke, & Samantha, 2017; Tseng, Chang, Lou, & Chen, 2013). Concerning/Regarding projects development based on conceiving products such as robots, students are capable to collaborate, program and construct in a team setting (Eguchi, 2016). This was observed in the Hispanic students in US classrooms by (Han, Capraro, & Capraro, 2016) and in the sustainability concepts learning of Civil Engineering undergraduates students by Fini, Awadallah, Parast, & Abu-Lebdeh (2018). As so, it has a positive impact in the communication and collaboration skills and their entrepreneurship spirit is stimulated (Alves & Eira, 2015). Students make PBL an effective way to teach STEM in an integrated and meaningful way (Berry, Chalmers, & Chandra, 2012).

PBL is an active learning methodology capable of providing the competencies for 21st Century that, according to Fonseca (2017) are : complex problem solving; critical thinking; creativity: people management; coordinating others ?; emotional intelligence; judgement and decision making; service orientation; negotiation and cognitive flexibility.

2.2 Trello (VLE) and SCRUM

Trello is currently part of the Atlassian Company portfolio (Cannon-Brookes, 2017), but was released in September 2011 in the applications session at TechCrunch Disrupt, being its conception strongly inspired by the Kanban method (Finley, 2014). Since its launch, it has been gaining more and more fans because of its flexibility of use and dynamism in different contexts.

Although not mandatory, Trello is based on japanese Kanban concept and can act as a virtual environment for the SCRUM application that is one Agile method. Kanban is a method based on a visual system for work management. (Kabanize, 2019; Digite, 2019). SCRUM consists in framework used for project management and can be a useful thinking framework for PBL and also Trello (Sutherland & Schwaber, 2017).

Considering the academic universe and its multidisciplinary approaches, Trello has been an alternative of use in the learning environment, by incorporating a platform that allows collaborative and interactive work, promoting the sharing of knowledge and experiences.

Teachers can use their structure, among other possibilities, to help in the application of the PBL methodology in their classes, following the interaction of the groups, the progress of the work and evaluating the performance of the class with transparency. Some application examples of Trello working in a PBL environment could be consulted in Cervino (2015a, 2015b).

3 Study Context

In Brazil it is very usual a kind of post-graduation course related to a certification/specialisation in general knowledge fields (*lato sensu*) and not related to a Master nor a PhD. This section describes the study context and methodological approach for the research developed among students from a specialisation course in multidisciplinary subject of Management, Design & Marketing in a Brazilian public university. The Project-Based Learning (PBL) experiment happened in the context of a specialisation program named Creativity & Innovation where students chose to develop a project related to a vegan pizza bike entrepreneur based in the food truck business tendencies. The program goal was to promote technical entrepreneurship knowledge among the students as well as skills related to creativity, teamwork, conflict management, risk management and more.

The project was developed during a whole academic semester. For this time the program's tutor suggested to the students to adopt specific digital tools related to project business control named Trello. Usually this development step is not requested by the tutor since the students are free to adopt any tool they want. In this context, students usually choose a chat platform like Whatsapp group that decreases the team capability to control the project processes.

Trello features were previously explained to the 26 active-enrolled students. The students integrate a multidisciplinary class since are all graduated in some of professional fields like: Production Engineering, Business Management, Graphic Design, Marketing, Communication, Journalism and others according to the certification course multidisciplinary subjects?.

After the how-to-do step about Trello, the students were tutor-guided to include tasks related to the project on brainstorm creative group discussion technique. The students got totally free to include data in Trello according to their organising ideas. The students were free to decide how to think about project's tasks as well as organise these tasks in Trello, the teacher's role was to promote short interventions to provoke or direct students if they forgot something important or were following a very different way from those that would obviously lead to better results.

SCRUM concept (Sutherland & Schwaber, 2017) was briefly presented to the students and a card was created suggesting how to adopt the Sprint's "To Do", "Doing" and "Done" lists to the project development.

The students proposed 10 main Trello's lists according to major project's steps identified by them: a) Administração (management), b) Comunicação (communication), c) Produção (production), d) Redação Facebook (Facebook Writing) , e) Atividades chave (key tasks), f) Proposta de Valor (value proposition), g) Relacionamento com o Cliente (customer relationship), h) Fonte de Renda (income source), i) Estrutura de Custos (product cost elaboration). Part of these lists are presented in Figure 1.

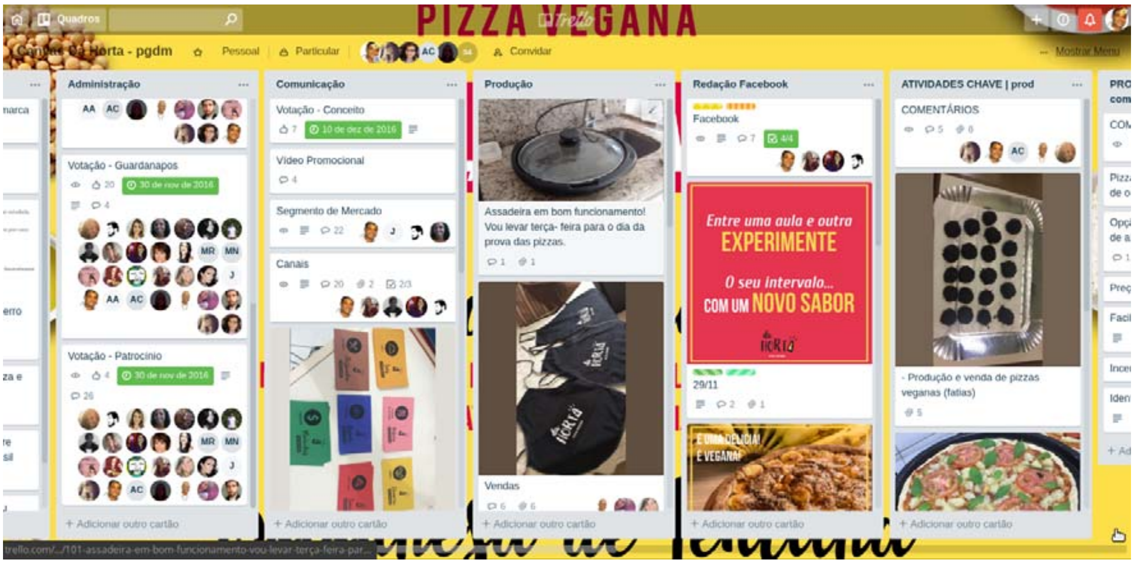

Figure 1: Major project's steps

For each project's task the students created a card in one related list above and include as member the related student task owner. As an example, the card "Relacionamento com Cliente" (customer relationship) in Communication list. Other cards/tasks had all project participants included like "Votação - Patrocínio" (Voting - sponsorship) in Management list.

4 Outcomes

The research's methodology development consists in an exploratory approach based on a set of parameters collected from different authors intending to arise quantitative data about three dimensions according to the Table 1, related to PBL aspects, VLE aspects and learning aspects. Furthermore, a qualitative analysis is proposed detailing aspects from Table 1 aspects.

Dimension 1 is adapted from PBL aspects and criteria from Mansur & Alves (2018) research. Dimension 2, brings criteria adapted from Mezzari (2011) and Norman and Schmidt (2000). It arises aspects that can confirm Trello effectiveness as VLE and project organiser. Dimension 3 aims to identify students learning level according to Bloom's Taxonomy (Krathwohl, 2002).

Table 1 – PBL, VLE and Bloom's Taxonomy aspects on PBL

Dimension 1 – PBL Aspects		
Academic Course Year	Academic year program in the course context	2
Duration (months)	Program duration over a period of time	6
Supporting Courses	Courses related to the PBL program	1
Assessment Tools	Different assessments related to the project	4
Students Dimension	Number of students / teams related to the project	27
Teachers / Coordinators	Teachers / coordinators related to the project	1
Infrastructure	Infrastructures allocated to the project	3
Project Tasks	project's tasks self-proposed by students	39
Flipped-classroom	Delivered instructional content, often online, outside of the classroom	10
Knowledge Acquired	Number of knowledge areas interdisciplinary dealt by the students	6
Dimension 2 – VLE Effectiveness		
Number of Cards	Total number of cards created in VLE	92
SCRUM Cards	Number of Cards related to SCRUM	0
Subjects arose	Project related subjects arose by students	16
Student's Interaction	Average of different cards accessed by project members	8
Project Milestones	Cards from students for Project Planning discussion / Total of cards	72
Theoretical Issues	Number of Cards related to academic themes arose by the PBL	61
Theoretical interest	Students interactiveness in cards related to theoretical material	1
Dimension 3 - Learning Evidences according to Bloom's Taxonomy		
Remember	Evidences (number of cards) of students retrieving relevant knowledge from long-term memory (Recognising, Recalling)	25
Understand	Evidences (number of cards) of students determining the meaning of instructional messages, including oral, written, and graphic communication. (Interpreting, Exemplifying, Classifying, Summarising, Inferring, Comparing, Explaining)	20
Apply	Carrying out or using a procedure in a given situation. (Executing, Implementing)	27
Analyse	Evidences (number of cards) of students breaking material into its constituent parts and detecting how the parts relate to one another and to an overall structure or purpose. (Differentiating, Organising, Attributing)	6
Evaluate	Evidences (number of cards) of students making judgments based on criteria and standards. (Checking, Critiquing)	9
Create	Evidences (number of cards) of students putting elements together to form a novel, coherent whole or make an original product. (Generating, Planning, Producing)	6

Some dimension's criteria demand extra detail. In dimension 1, the highlighted assessment instruments were self-assessment, peer-assessment in the checkpoints related to the project task as well as to the final presentation presented in Figures 2 and 3

Figure 2 - Assessment Instruments

The students made use of three types of infrastructure: the institute’s facilities (classroom and external area) and areas outside the institute (student’s home). The project tasks were conducted outside-classroom and were fully/completely developed. The classrooms became a weekly coaching meeting,, while the project’s tasks were developed by the students in their own home and continually in a flipped classroom strategical learning approach. Some evidences are flyers and folders, cooking aprons and pre-baked pizza dough developed and made by the students out of classroom time.

Figure 3 – Flipped Classroom evidences

In the context of a flipped classroom, the students had the opportunity to deal interdisciplinarily with technical academic fields like Marketing, Accountability, HR, Business Management, Cooking, Graphic Design.

In dimension 2, 72 of 92 cards created in Trello by the students were project’s milestones like subjects vote of tasks discussion or checkpoint. It represents 76% (almost 80%) of total cards created and it is an indicative of the great autonomy and student knowledge self-production. Despite this promising results only one cards indicated students’ interest in theoretical reading. The list of theoretical references were created with some cards content like: Trademark registration, How to deal with project’s uncertain, What to do when your client says: It is expensive!. For a total of six subject-cards only one named How to calculate statistical sample pattern deviation resulted in some card interaction by the students.

While the last two dimensions brought empirical and observational data, dimension 3 brought an analysis related to a traditional and famous model named Bloom’s Taxonomy. According to this model, the PBL experience related in this research reached the six levels of learning since the most basic like student’s remembering skill until the most complexity level related to the creating student’s skill. Remember level evidences are found in cards where students could brought previous knowledge to deal with a problem. For example, the card like Pizza Wrap demanded previous knowledge related to graphic design program, while the card customer relationship demanded knowledge related to the marketing program. The Understand level is evidenced in cards available in the Notes list where students are demanded to confirm their understanding about tasks deadlines and specific procedures. Create level is evidenced by cards that represent organising, planning, scheduling for a new product or project step proposition. For example, the card Questionnaire where the students elaborated and validated the market research for the vegan pizza flavours as well as/and also the flavour-testing day organised by them to eliminate the pizza flavour previously suggested and non-real tested.

5 Conclusion

Usually, there are not specific analysis tools for PBL learning evidencing. For this reason, it seems to be satisfactory the innovative model presented in this research intending to clarify this aspect. The model can be and must be improved since it is a first version of it. While dimension 3 is the most consistent since it is based in a consecrated theory (Bloom's Taxonomy), dimensions 1 and 2 can be reconsidered/rethought and deepened. Despite that, the model in its whole was conclusive as a tool to bring evidences of PBL effectiveness and Trello adoption as VLE, as well.

Dimension 1 made PBL effectiveness measuring possible. Adaptations where made from the original model since Mansur & Alves (2018) did not consider evidences from Trello. Criteria like Flipped-classroom evidences and Knowledge Acquired are evidences of it.

Dimension 2 evidenced the Trello adoption effectiveness. Despite being based in related researches, the model is brand new/ an innovation in the present study since it had never been proposed before. From its gathered data it is possible to verify that Trello was useful as a task organising tool for PBL classes as VLE scaffolding students to plan, gather and organise their own learning process. Regarding SCRUM thinking, it was evident that the basic knowledge/contents exposed to the students were not a suitable path to make them go deeply in this set of management project practices. The only thing mentioned about SCRUM in Trello was the card explaining how to create the sprint step for process categorising. For next experiments it is suggested that SCRUM concepts be more detailed explained. Other suggestions are experimental researches about how students deal with SCRUM+Trello (as VLE) in two scenarios where SCRUM concepts are previously explained: a) SCRUM mandatorily adoption in PBL and SCRUM as non-mandatory organiser tool.

From the proposition of Bloom's Taxonomy as an analysis tool for PBL effectiveness, Dimension 3 brought evidences that the students have covered/reached the six Bloom's learning categories. These findings were made easier since Trello cards were important elements to identify important aspects like students capabilities of summarising, executing, organising, checking, criticizing and create and assess elements related to their own learning process.

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The role of the dummy student to encourage idea generation

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Abstract

Students are often using social networks during their project-work to meet course requirements instead of face-to-face interaction. An exceptional student profile was designed and put into an online collaborative platform as a dynamic dummy to incentive idea generation by online blogs, and to mitigate the lack of brainstorming sessions. The study was made in four groups of students developing real engineering projects. Twenty-one students were surveyed, then student's perceptions were processed by thematic analysis. Additionally, the student's participation and ideas quantification were tracked and compared with dummy participation. Results indicate that the student's interaction among them increases, as it is positively associated with dummy participation. The collaboration between the groups also increased. Finally, results were compared with previous experiences.

Keywords: Problem-based learning; Creativity; Idea generation; engineering skills, innovation; Engineering Education.

1 Introduction

Creativity in Engineering has been taking relevance throughout the years. Industry claims for more creative engineers to take advantage of competitors (Global Engineering Deans Council - GEDC, 2015; World Economic Forum, 2016). Creative engineers must find novel solutions, introducing better performance to their design and changing traditional ways to conduct projects. One way is by using newly available technologies to increase professionals' performance in job places. Those technologies include other than traditional tools based on IT technologies and customisable online collaboration networks that have become popularised through the years in the engineering design process and project management.

The idea of working using the internet or remote communication is not new. Nowadays, the 4G industry's workplaces request increasing online practical and multidisciplinary tools to improve communication and to integrate experts into several areas of knowledge. Besides, with the globalisation, companies have been moving to on-cloud solutions, incorporating collaboration and cooperation for the stakeholders. In consequence, competent engineers must change their minds and ways to do projects, moving towards online collaboration for the engineering processes.

To make narrower the gap between the professional practice and the academy, teachers should incorporate online tools for their educational practices, but in particular, for the project-work, encouraging learners to develop skills in the engineering process with online collaboration or cooperation. Since any project often includes activities of idea generation, and since creativity is relevant for problem-solving, this study explores idea generation among the students during an academic project-work in PBL by using a dummy student. This dummy student was to stimulate collaboration in an online engineering platform. In this study, creativity is view as a holistic process for the project-work in a PBL course of Engineering. Findings were obtained from statistics and from open-ended questions to the participants. Data were analysed by Thematic Analysis supported with quantitative data.

2 Background for foster creative ideas

Creative ideas are the seed for innovative projects in engineering. To develop a project in engineering, engineers give ideas for several purposes such as sharing information, for solving and findings problems, and for propose procedures to the project work. Despite ideas are useful, often an idea is considered creative if it is novel and useful at the same time. A novelty idea implicates something new concerning the field of knowledge, but different from previous knowledge in that field. Moreover, an idea is also creative when it moves from one field to another. In turn, the value of a creative idea depends on the discipline and cultural context (Csikszentmihalyi, 1988). A useful idea is identified when it could be applied to a solution to a problem and need (Amabile, 1983; Driver, 2008; Sternberg, 1997).

Creative ideas can produce individually or in a group. The first involves the cognitive and psychological aspect of an individual. The group generation of creative ideas involves the social participation of a group of individuals sharing information or knowledge. To share information groups usually use brainstorming sessions or through a more elaborate process of collaboration involving communication skills and behaviour dynamics (Jaques, 1991; Jaques & Salmon, 2007; Sawyer, 2008).

2.1 Fostering creativity

Creativity ideas are encourage using diverse strategies including training (Ma, 2006; Mansfield, Busse, & Krepelka, 1978; Scott, Leritz, & Mumford, 2004), group-work climate (Amabile & Gryskiewicz, 1989), group composition (Gocłowska & Crisp, 2014; Leung, Maddux, Galinsky, & Chiu, 2008; Taggar, 2001), IT technologies (Cybulski, Keller, Nguyen, & Saundage, 2015; Oldham & Da Silva, 2015), modelling, mentoring. However, the concept of brainstorming seems popular to use in solving problems (Amabile & Pillemer, 2012). Brainstorming was introduced by Osborn since 1939 meaning brain to storm a creative problem (Osborn, 2009) in face to face sessions.

2.2 On-line Collaboration

Brainstorming, first proposed by Osborn, is a Traditional technique of idea generation wich involving small notes and coordination, almost always during any meeting. However, current methods have introduced non-face interventions in its practices, taken advantage of Social Networks has been using to do communication, sharing information, conduct projects, assign task and outcomes. Some reports show that online-instrument offers advantages over face to face intervention, increasing participation against diversity in the ideas (Pissarra & Jesuino, 2005). In turn, virtual media foster idea generation over written notes when the electronic media are available and easy to use (Michinov & Primois, 2005).

3 Method

Twenty-one students of a course of Automation of Manufacture Process (AMP), from a Mechatronic Engineering program, were part of this study. During the course, students had to work in one real project. The group of students was split into four groups. Students were requested to use a different collaborative commercial on-cloud platform called 3DExperience to work in the project (Dassault Systèmes, 2018). Despite the full use and applications of the platform for developing the project, this study was focused just on the idea generation stages. Data were collected asking the students, and from platform reports. Those collected data were processed using Thematic Analysis (Braun & Clarke, 2006) supported with a statistic of platform participation.

3.1 Course description

The AMP is a project-based learning (PBL) course. Students enrolled in the course have to work 12 hours per week, for 16 weeks, while they apply previous knowledge to their project-work and learn from some lectures on specific topics. There are five subjects to apply to do the project: programmable logic controller, electro-pneumatics, robotics, digital factoring and cost analysis. Students in the workgroup have to solve a real problem through the project while the teacher asks them about some specific task, from a handed project report at the end of the course. It is expected that the project evidence learning outcomes and develops innovation in the manufacturing process.

This study took place during the first semester of 2018. Students worked in four groups doing four projects: a packing line of a filter factory, a line to make brushes, a line to paint coffins and a plastic production. During the project, students made use the 3Dexperience platform management apps and sharing ideas among the four projects and co. Each project had a facilitator to support students.

The 3D experience platform made its debut in this course. That is, students and facilitator used it for the first time, implicating uncertainty in some of its advantages. Traditionally, ways to do the project included group meeting, task assignments between the students and individual work. However, share ideas had been doing by face to face meetings, networks and cloud drivers. In this new online tool, students had to move all of their practices to this new platform.

3.2 Idea generation provocation

The dummy student was used to stimulate idea generation at the platform level. Sharing idea generation online is an advantage of the collaborative platform because participants could increase it, through blogs and online activities. For the AMP course, it was a new way to does their academic projects. Students were training in the use of the platform in short sessions including ways to share ideas. Since at the beginning of the project, students did not use the platform to share ideas, returning to the traditional way to do. In consequence, the manager of the platform created a fake, unknown student profile or dummy, who incentives student participation in it.

3.3 Data collection

Data were collected by anonymous survey available online. The survey consisted of three open-ended questions about idea generation by using the 3DExperience platform. The survey was in Spanish because it is the mother language of the student. The questions translate into English were: (1) Do peer participation encourage your participation at the 3DExperience platform? (2) Do idea generation of someone in the platform stimulates your ideas? and (3) Do someone participation stimulates your own participation? Also, the students had not known about the dummy student in the blog's of the platform to avoid bias in the survey answers.

Besides, the statistics of the 3Dexperience helped to establish the relationship between the dummy participation and student intervention in the project-work.

4 Results

Statistics indicate students' frequency of participation and ideas during project-work (Figure 1). That statistic was taken from the 3DExperience platform since the start of the 14-week course. The darkest line in the figure shows the moments when the dummy student participates giving ideas. The lightest line considers the total of the students' participation by date but excluding the dummy student. Hence, the vertical line indicates the number of accesses of the participant, while horizontal indicates dates. Note that the last is for 14 weeks.

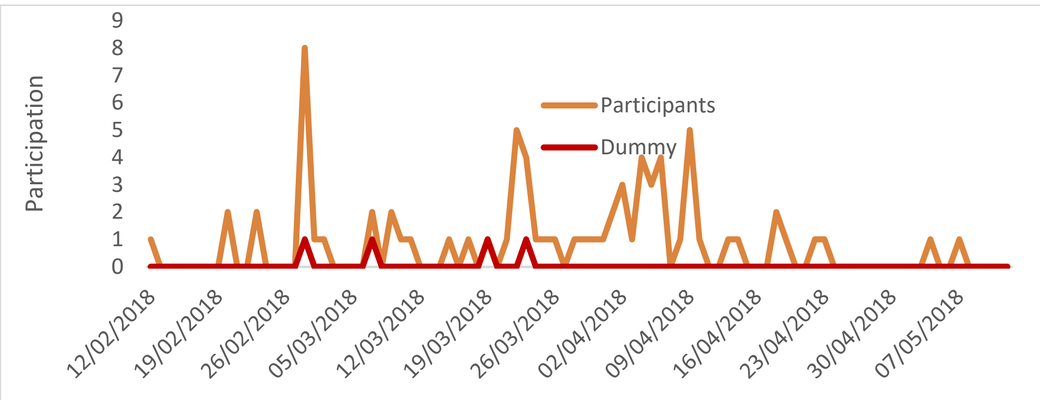

Figure 1. Idea generation participation at the platform during the semester. Adapted from 3DExperience platform

Figure 2 shows the total of access of the participants, the dummy and the facilitator in the same period of Figure 1. The graph is taken from the platform as well. The bars indicate the total participation taking in account visits during the period if a participant makes any contribution in the blog either writing something, answering or asking questions or opening underlying files of information. This bars in the figure do not include participant read-only blog operations. The facilitator has the highest participation because in the idea generation and blogs into the platform he has to answer questions often for the whole group, including the dummy.

The facilitator, who was always reviewing the platform, appears at the top with 110 visits. The dummy, who was also operated by the facilitator, appears in the second place with 68 visits. The participation of the students was diverse, showing a trend curve. The highest participation of a student was 64 visits, while some students had low participation on the platform, almost null.

The online survey was sent to the whole group of 19 APM students. Then, 14 answers were collected from the students, taking 967 words for the analysis. The names and gender of the participants were anonymised and imported to Nvivo 11 to be analysed by Thematic Analysis. After analysis, three main groups were obtained according to students' perception: usability of the platform, peer participation and generation of ideas with the dummy participation, i.e. dummy generation. (Figure 3).

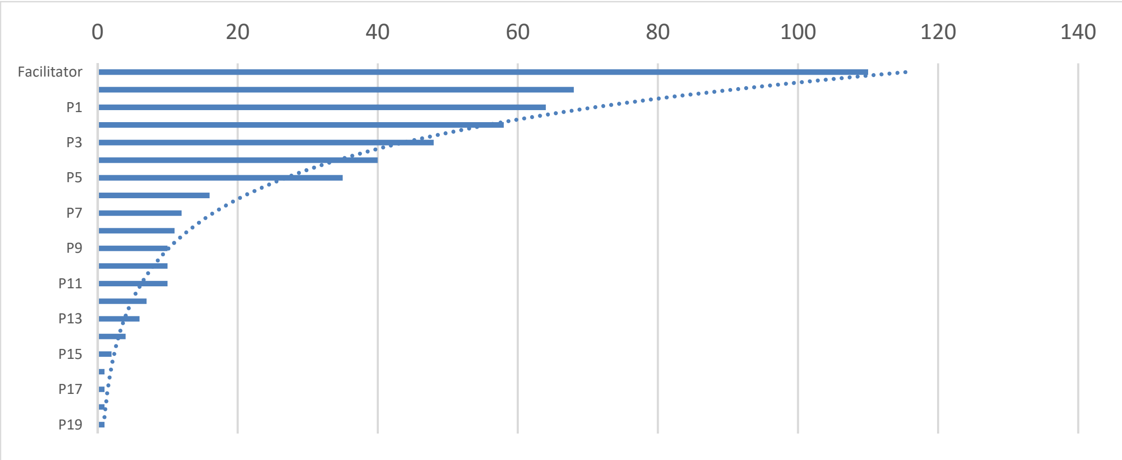

Figure 2. Reading frequency of the idea generation.

5 Discussion

The new platform is a challenge for the students since several engineering processes could be done there. Students were introduced in it just in few hours. Thus, it was expected that at their first glances they feel threatened by the amount of information and procedures to learn. Although early training was given to start to use the apps inside of the platform, changing students' traditional ways to do things requests transformative learning. According to Rogers (1969), individuals prefer to keep traditional manners to learn when they feel some threat. The students mentioned such a complexity in the survey.

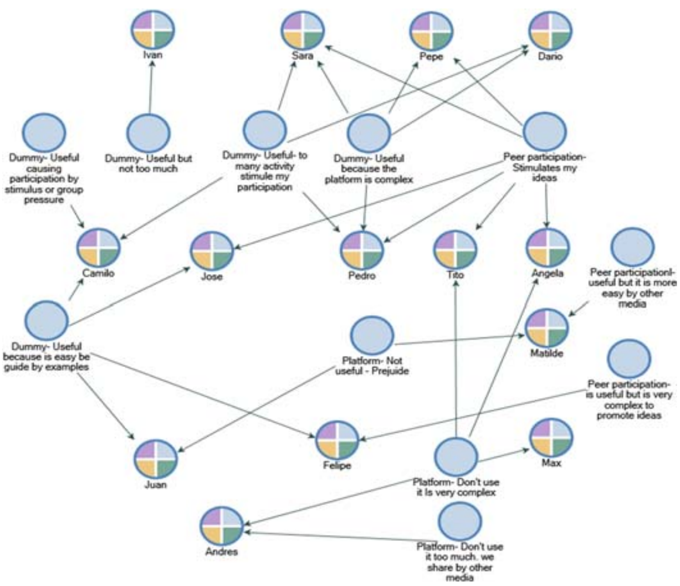

Figure 3. Students' perception about the idea generation in 3DExperience. Made by the author using Nvivo 11(QSR, 2015)

As soon as complexity is identified, it is possible to use an intensive training at the beginning of the course or looking for alternative solutions. During the course, the concept of learning by doing (Dewey, 1938; Kilpatrick, 1918) was applied to start using the platform for the first time. However, the students were afraid, and they turned down to use it. Thus, the dummy student was introduced as an active member of the platform to stimulate the students' participation freely. Since it was not known by the students', they saw his intervention just as if he was another student from an additional project in the course. As a result, students' participation was activated regarding idea generation. When the dummy participation was down, also the students' participation was down (Figure).

The statistics evidence a rise-up of participation after the dummy student wrote questions and ideas on the platform during three moments in the semester (Figure). While his intervention motivated student's participation, more students' participation motivates, in turn, more participation in sharing ideas. In this regard, some students stated.

"There were times of the semester where there was a lot of activity and that encourage me to work." (Camilo- Original in Spanish)

"Yes, it shows that it is not so complicated to use the tool" (Pepe- Original in Spanish)

The students found useful the examples of ideas given by the student dummy to encourage his or her own idea generation. While students want to learn by themselves how to write ideas, they are stimulated by another participant activity. As mentioned before, his/her participation stimulates others to participate in more ideas.

"Yes. They help to know the format of how to ask questions or how to answer them. In addition, the teacher's build correction on them. I can notice those corrections and apply them in mine. (Sara- original in Spanish)

"Sometimes we feel sorry for asking something, an idea or doubt. But when someone else has the initiative to do it, he encourages others to do the same". (Pedro- original in Spanish)

Students' perception of complexity seems not to be reduced due to participation in the platform by the others. For example, Tito and Ana state that the platform is complex, but they recognise that peer participation is stimulated by ideas. However, they claim for more training to participate.

In fact, (given ideas in the platform) it is a factor that prohibits. However, it is necessary to have a more immersive learning platform (Angela- original in Spanish)

"Maybe because of the lack of knowledge of the whole platform we use other tools that are easier to use (Tito- original in Spanish)

Likewise, Juan and Felipe found satisfactory the use of the examples given by participants, but they seemed to be reluctant to use the platform by its level of complexity (Figure 3).

The dummy student encourages share ideas and participation of students in the platform. Stimulation happens in several manners. First, the fact is that students had scarce training, the dummy student had a role of guiding indirectly in how to use the platform, as an example exercise does for a topic in a lecture or book. Thus, students could learn by doing and for imitation. Second, group members push their mates to participate, answering questions and sharing information regarding the project. The more is the participation, and the more is the demand to use it. Last, continuous participation could decrease the threat to new learning; that is, other participations let the student think about how easy it is to use the platform. Figure 3 was obtained by TA and showed the aspects above mentioned.

6 Conclusion

The notion of using a dummy student to enhance idea generation in the online project work could be valuable. The study found that when a student participates online in a structured way, others start to participate. Sharing ideas online stimulates more ideas. However, doing it with new applications demanding additional mental strength from students could unmotivate them.

The participation in sharing ideas online through the collaborative took place without previous training. The platform is complex to use due to the full range of application in it. However, the result of this study brings evidence that despite that complexity, they could begin a process of ideation for the project-work, with limited knowledge and skills. Since that complexity is a threat to learning acquisition, rejection to use it could happen. So it is recommended using the previous training to diminish that perception of the complexity to use a new app for the project work.

The role of the dummy student is to be a media to put dynamics examples it those areas where the students could be weak during the project work. Since this study is a case, it is recommended to do more studies about the dummy concept to facilitate the implementation of new online tools and learning strategies. A dummy student could be used to encourage not only idea generation but also collaboration and cooperation. Moreover, the dummy student could make a whole project to enhance all project-tasks, facilitating the use of the platform for the project work.

This paper only shows the idea generation stage of the research, which will continue to assess the final product in terms of creativity.

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Challenges and Opportunities of the Adoption of Collaborative, Multidisciplinary, Project-Based Approaches: The Case of NMSPCAM Project

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Abstract

Many higher education institutions, namely engineering and applied sciences schools have been adopting innovative, active learning methodologies, not only to respond to contemporary world challenges, but to prepare students to be professionals capable of responding to the demands of the new society. One of methodologies that has gained acceptance over the last decade is project-based learning (PjBL), which is believed to empower the development of cognitive skills, important for the training of future engineers, such as knowledge transfer, critical thinking and metacognitive strategies, fundamental for a better response to the current labour market needs. PjBL approaches often require a collaborative, multidisciplinary context, because the focus is on real world problems, which need to be analysed at the light of, and to bring together, contributions from different knowledge fields. In this article we present the adoption of the PjBL methodology within NMSPCAM project, whose main aim is to develop new media solutions (e.g. digital games and videomapping projections) aiming at raising awareness and value cultural heritage in Viana do Castelo, Portugal. The project was conceived and developed as a multidisciplinary cooperative project-based learning program, and the outcomes comprise contributions from different degree levels (Technical Superior Courses, Bachelor's and Master's), and different programmes (Computer Graphics and Multimedia Engineering, Education, Tourism and Arts) offered by two Polytechnic Institutions in the North of Portugal (Instituto Politécnico de Viana do Castelo and Instituto Politécnico de Bragança). Initial results show that a multidisciplinary, cooperative PjBL context can be a valuable experience, with both opportunities and challenges for students and teachers. On one hand it is highly demanding on integrating all participants involved, namely curricula and teaching methods, as they differ according to each HEI's framework. But, on the other hand, it represents a unique and enriching experience, offering students conditions to the development of problem-solving, teamwork and lifelong learning skills, as well as technical knowledge, beyond that of individual achievement.

Keywords: Engineering Education, Active Learning, Multidisciplinary approach, PjBL

1 Introduction

At present, in society in general, there is an increasing demand for skilled and well-educated engineers who can develop new solutions through innovation, and this has pushed universities to seek solutions to meet these requirements. Higher education institutions (HEIs) in general, and Applied Sciences Schools in particular, as is the case of IPVC (Viana do Castelo Polytechnic Institute) face the challenge of being capable to implement learning methodologies that can enhance students' engagement and motivation within Engineering Education (Løje et al., 2017). Programmes often show an increasing focus on innovation and entrepreneurship, and more active methodologies are emphasized, meeting the needs of employers. Most of these sound methodologies are of a collaborative nature, widely acknowledged in the literature as University-Business Cooperation (UBC) activities. UBC involves the collaboration between universities (Polytechnics included) and organisations in general, either businesses or other institutions, often with the support of governmental organisations, for mutual and societal benefit. UBC can simultaneously help universities to face the problem of decreasing public investment and helping businesses to gain and maintain their competitive advantage in today's dynamic international markets (Davey et al., 2011). UBC has become one of the top priorities for governments, higher education policies, education systems enabling universities and businesses to work together in the creation of cooperation initiatives that can provide relevant results for both (Lima et al., 2015; Hasanefendic, Heitor & Horta, 2015). UBC creates mutual benefit for all parties involved, contributing to the economic development at regional and national level (Bramwell et al. 2012), as well as meeting the demands of the labour market (Plewa et al., 2013), providing local businesses with access to research breakthroughs and helping them with problem-solving, by increasing the employability of students (Gunasekara, 2006). For Universities, the collaboration with industries and public organisations is also significant for curriculum development, in order to get inputs for development of new educational programs or for the revision of existing curricula (Lima et al., 2014).

Hasanefendic et al. (2015) debated the relevance and role of high education institutions (HEIs), such as the public polytechnics that should promote practice-oriented research, often designated as problem-based or project-based approaches. These practices can be integrated in UBC initiatives which respond to goals from different stakeholders through formal or informal collaborative mechanisms (Hasanefendic et al., 2015). The authors have also highlighted the relevance of short-term project-oriented research as a motor towards the institutional credibility, through the engagement of local and external organizations and their commitment in training together, within the higher education systems, students that represent the next labour force.

The aim of this paper is to present the NMSPCAM project (Alto Minho Cultural Heritage Supported by New Media), aiming at raising awareness and value cultural heritage in Viana do Castelo, through new media solutions (e.g. videomapping projections and digital games), and to discuss its characteristics (opportunities and challenges) as a context of multidisciplinary, cooperative, project-based learning (PjBL) program. Although much has been written about active learning and PjBL approaches, it has not been found in the literature examples of projects of this kind, addressing a multidisciplinary PjBL context, whose outcomes comprise contributions from students and teachers from 2 different HEIs, and students from 6 different courses.

Following sections include: Section 2 presenting a brief review of the literature about PjBL with an emphasis on the challenges and opportunities, when adopted by HEIs as a learning context; In Section 3 we describe NMPSCAM project, discussing the conditions that framed its implementation as well as the conditions for success. Section 4 discusses de results and provides conclusions.

2 Project based learning (PjBL) approach

Although there is debate around what project-based learning (PjBL) is, its fundamentals are suggested as curricula being developed around problems/specific situations, and not disciplines; being interdisciplinary and integrated, with a greater emphasis on cognitive and transversal skills. PjBL approaches' environment favours work in small groups, tutorial instruction, active and student-centred methodologies; and learning outcomes focus on skills development and motivation, abilities for lifelong learning (Newman et al. 2001).

Within a PjBL approach, students address and resolve problems and issues, and the entire learning process is developed around real world problems and activities, enabling students to acquiring a set of skills that are not only important to the success of the approach but to their performance as future professionals (Donnelly, R. Fitzmaurice, M., 2005). The PjBL experiences are a powerful experience for students, when compared to more traditional approaches, because provides a closer link to their professional context, and the opportunity to develop key competences (Lima, et al., 2014). Some studies also indicated that PjBL is superior to traditional lecture format with regard to the understanding of course content and retention of information (Klegeris and Hurren, 2011).

2.1 Collaborative project-based learning

Collaborative project-based learning often adopts a multidisciplinary approach, using real world problems to articulate theory and practice, and bringing together the appropriate knowledge and skills, from different areas and backgrounds (Donnelly, and Fitzmaurice, 2005). Teachers from various areas of knowledge as well as companies from outside the university, are often involved, and the projects can be used to develop problem-solving, teamwork and lifelong learning skills as well as producing a level of technical knowledge, beyond that of individual achievement (Hmelo-Silver, 2004).

2.2 Benefits and challenges of PjBL multidisciplinary approaches, to the students and the overall context

PjBL has several clear advantages over the more traditional lecture- and seminar- based course delivery techniques. Some of the benefits that have been previously identified include increased retention of information; an integrated knowledge base (rather than discipline bound); the development of lifelong learning skills; an exposure to real-life experience, increased interaction between students, HEIs and institutions; and an increase in overall students' motivation (Hmelo-Silver, 2004; (Klegeris and Hurren, 2011; Lima, et al., 2014).

PjBL experiences provide students with guided learning, through solving complex, real world problems and helps constructing extensive and flexible knowledge, and key competencies for their professional context, such as transversal competencies. It is designed to help students construct an extensive and flexible knowledge base; develop effective problem-solving skills, to develop self-directed, lifelong learning skills; become effective collaborators; and become intrinsically motivated to learn (Lima et al., 2014).

The necessity of gathering knowledge from a wide range of sources allows students to see how knowledge is a useful tool for problem solving. Multi and interdisciplinary problems should help build extensive and flexible knowledge because information is not learned in isolation; it is based on the integration of several knowledge areas (Lima et al., 2014).

In spite of the acknowledged benefits, the transition from a traditional approach to a PjBL approach can be associated with feelings of frustration and uncertainty. The outcomes in the form of grades are important to the student in their perception of PjBL (Alessio, 2011).

Interdisciplinary learning contexts are challenging, both for the students and teachers not only in the development of learning products, including both tangible and intangible elements, as well as in the assessment (Grant, 2011; Hill and Hannafin, 2001). In order for the students to understand what is expected from them, and how they can contribute to the overall context, teachers need to be more explicit about the required elements of projects and about transfer of knowledge and skills between disciplines and domains (Grant, 2011). Moreover, throughout the learning experience, increased emphasis needs to be placed on registering students' development processes, in order to help the teacher to recognize competencies and easing the evaluation process (Grant, 2011).

3 The NMSPCAM project

Our cultural heritage has a very important value both in the cultural and educational dimensions. This knowledge supports a more comprehensive understanding of our identity. Also, as a visitor/tourist, knowing the local cultural heritage of the visited places has a very important value to the understanding of the differences and to give a proper context to the touristic experience. New media, such as video mapping and digital games, have the ability to present the users with new forms of content and new experiences (Anderson, et. al., 2010). These new media can expectedly be more attractive and provide higher levels of engagement of the users with the content (Froschauer et. al., 2012). The use of immersive technologies such as virtual environments and augmented reality has proven to be a clear advantage in communicating cultural heritage to the public at large. These new forms of experiencing cultural heritage have demonstrated complementary to tools and practices based on tangible goods such as museums, exhibitions, books or other visual content (Mortara, et. al., 2014). Taking into account that game-based approaches to learning have shown high efficacy levels, with consistent player engagement, serious games, or digital games designed for educational objectives (Freitas & Maharg, 2011), seem a highly adequate tool to propose cultural content in an engaging way for learners.

This project intends to use new media such as video mapping projections and digital games in order to make known the local cultural heritage. For a chosen theme selected within the local cultural heritage, a concept narrative will be developed. This concept will be the support for a videomapping projection and for the development of a game. The target audience of the project is diverse. The projection is directed to the population in general and also tourists. The developed game is targeted to students of the primary school, which will have the opportunity to learn their local cultural heritage by means of different and innovative means, which is generally well accepted by within these ages. Both of these two new media areas are potentially very attractive to the target audiences. The project will evaluate the societal impact of this experiment and in its several dimensions (e.g. student and tourists).

The completion of this project will integrate skills and enhance synergies, bringing together teachers, researchers and students from diverse scientific areas, around a set of specific activities, promoting and enhancing a network of polytechnic schools through the sharing of human and material resource. It builds on the value of symbolic capital rooted in the culture of the region, in architectural and cultural heritage, as opportunities for cultural development of its inhabitants and particularly in this case, the students of the 1st cycle of basic education. In addition to this project, is possible to verify an economic appreciation opportunity, through tourism activities, but also in terms of the development of technologies that improve the use and availability of such heritage.

The main activities established for the project development are broad spectrum, being transversal to multiple domains. The impact and benefits are diverse, depending on the participants and the beneficiaries. The tourists will benefit from the cultural richness of the region participating in the project, and from the video mapping which will allow an attractive and immersive experience allowing the learning about the chosen thematic. Also, primary schools (from 1st cycle) will beneficiate from an innovative way of imparting knowledge to their students, through the use of new audio-visual projection technologies and an interactive experience from a digital game. It is important to note that these students (3rd year, primary school) are driven to the discovery of their country, and particularly in the region where they live. They study the past of the local environment in which they live: history, local heritage, customs and traditions (food and crafts), local and regional symbols. Other beneficiaries of this project are the inhabitants of the municipalities, who will have cultural content about their regions.

3.1 Project Implementation

The NMSPCAM project has several goals related to the development of activities based on experience (experience or practice based research) enabling the organization of groups of researchers, involving both teachers and students from various scientific domains (including Information Technology, Multimedia, Education, Tourism and Arts), from 3 schools belonging to 2 polytechnic institutes (Viana do Castelo and Bragança). The project also involves a company dedicated to the production of digital content and the collaboration of the local authorities (municipality), as well as primary schools where part of the . The main objective of the project is to develop new media digital content about the local cultural heritage and present it to the population in general, tourists and children from primary school and two of the main objectives of this project are based on the following:

- To use a video mapping projection technique to give life to a facade of building/monument of a city (Viana do Castelo) to tell a story about a previously chosen cultural heritage theme;
- To create interactive experiences in the form of digital games for children of the primary school. Storytelling of the games is based on the same thematic of the projection. The game intends to be used as an innovative tool to learn about the local heritage and culture.

Thus, higher education students are beneficiaries as they will be active agents participating in the research and development of tasks associated with this project, in a project-based research and learning approach. In order to accomplish the objectives of the project, the research work plan is divided in several activities, such as:

1. Identification of the theme
2. Identification of the site for the projection
3. Creation of audiovisual narrative
4. Videomapping production
5. Design and development of an educational game
6. Videomapping projections
7. Implementation of the project with students of the 1st cycle
8. Results Evaluation

In (Table 1) are indicated several outcomes which result from the participation of higher education students on the NMSPCAM project.

In activity 1, 24 students from the Arts and Technology (Light, Sound and Image) course had participated, resulting in several reports with useful information to identify the themes related with cultural heritage, to be developed in the following activities. In activity 2 was identified a site for the videomapping projection. Nineteen students from the Master in Integrated Design had participated with the production of scripts and storyboards to be used in activity 3, to create the audiovisual narrative. Six students from the Web Design and Multimedia course and from Computer Graphics and Multimedia Engineering course produced several videos and motion graphics, to be used in activity 4. In activity 5, 43 students from Computer Graphics and Multimedia Engineering course and from Digital Games Design course, have participated, resulting in the production of different assets, such as illustrations, images, audios, etc. and some game prototypes. In activity 7, one student of the Master's Degree in Preschool and Primary Teacher Education (1St Cycle) had participated and his main outcome was a master thesis. Activity 8 is being implemented together with Tourism degree students, which will assess perception of local stakeholders about the potential impacts of visitors flows.

Table 1: Main outcomes from NMSPCAM project.

School	Levels	Courses	Subjects	Semester	Duration of PjBL (Weeks)	Nº of Students	Outcomes	NMSPCAM Activities
IPVC-ESE	CTeSP[1]	Arts and Technology (Light, Sound and Image)	Design and Digital Visualization History of Culture and Arts	3	16	24	Reports	Activity 1
IPVC-ESTG	CTeSP	Web and Multimedia Development	Web and Multimedia Project	3	16	2	Video	Activity 4
IPVC-ESTG	Bachelor	Tourism	Project	6	16	5	Assessment of impacts of videomapping activities	Activity 8
IPVC-ESTG	Bachelor	Computer Graphics and Multimedia Engineering	Multimedia Technologies	6	16	8	Motion Graphics, Videos, Digital Games Prototypes	Activity 4 Activity 5
ESaCT-IPB	Bachelor	Digital Games Design	Extra-Curricular	2	15	8	Several Assets (Illustrations, Images, Audio)	Activity 5
ESaCT-IPB	Bachelor	Digital Games Design	Documents of Design & Storyboard	4	15	18	Several Assets (Illustrations, Images, Audio)	Activity 5
ESaCT-IPB	Bachelor	Digital Games Design	Audio	5	15	17	Several Assets (Audio)	Activity 5
ESaCT-IPB	Bachelor	Digital Games Design	Projects	6	15	5	Several Assets (Illustrations, Images)	Activity 5
IPVC-ESTG	Master	Integrated Design	Multimedia Tools Applied to Project	1	8	19	Scripts e Storyboards	Activity 3
IPVC-ESE	Master	Preschool and Primary Teacher Education (1St Cycle)	Thesis	3, 4	32	1	Master Thesis	Activity 7

[1] Higher education degree that combines both vocational and academic qualification. Similar to UK's Foundation Degree or French's Brevet de Technicien Supérieur (BTS).

In order to materialize this project, it has been important the strong articulation between teachers from different schools, different scientific areas, as well as students from different courses and different levels of teaching, which allowed to enrich the development of skills, in order to develop the NMSPCAM project under the PjBL methodology.

It should be noted that many of the activities depended on the well development of previous ones. Thus, during the execution of the project, the time spent with each activity was a relevant issue, since the following activity was dependent on the previous. Additionally, there was a need for articulation between the participants in each activity (teachers and students) to ensure that the final product was not a sum of products, but a single product developed by several collaborators, at different periods of time.

3.2 NMSPCAM as Multidisciplinary PjBL Approach – Oportunities and Challenges

The challenge to implement this project is enormous for several reasons. The main challenge, as a learning context, is to manage a diversified team composed of several institutions and scientific fields of knowledge, being one of the primary difficulties to reach a common perception and understanding of its goals and objectives, by all those taking part in the implementation of the project. As in this case it involved teachers and students from several institutions and scientific area, challenges are also identified in what concerns the match of curricula objectives and methodologies with the project aims. Teachers needed to adapt their work, not to a priori list of established goals, but to the objectives of the project. Additionally, assessment methods often need to be revised, and adapted, to include more student-centred approaches, reflect the learning experience as a whole, including traditional knowledge, but also the transversal competencies, required, and stimulated by the project.

Different teams, from different schools were responsible for the identified set of tasks and activities, which were all interrelated and interdependent. Therefore, all teams had to be aware of the implications of their performance, affecting the outcomes and success of the next in row activities.

From another perspective, the multiplicity of scientific domains involved in the project, (Information Technology, Game Design, Multimedia, Education, Tourism and Arts) and the need for a close collaboration evidenced that it was necessary to establish an appropriate mechanism for communication between all participants (researchers, students of various courses of 3 schools from 2 polytechnic institutes and the business partner in the project), during the duration of the project. The project implementation timeline, its articulation with the school's calendars and the moments when the subjects take place were also amongst the difficulties encountered.

As previously indicated one of the beneficiaries of the project are the students of primary schools and thus another challenge is to address this approach within the context of primary schools.

An interesting opportunity though (and at the same time a challenge), is related with the fact that several students from the polytechnic institutions involved in the project, are from several different study programmes, as for instance:

- CTeSP in Arts and Technology (Light, Sound and Image)
- CTeSP in Web and Multimedia Development
- Bachelor in Computer Graphics and Multimedia Engineering
- Bachelor in Digital Games Design
- Bachelor in Tourism
- Master in Integrated Design
- Master in Preschool and Primary Teacher Education (1st Cycle)

Although the analysis of the students' perception and level of satisfaction with the conditions and benefits of taking part in a PjBL experience are still being investigated (through a quantitative, survey-based approach), the outcomes can already be anticipated as being mostly positive. Not only these students had to work in teams within their own degree context, as they had the additional challenge of contacting with students and teachers from the different disciplines involved. Naturally, these students benefitted from a richer, and far more demanding learning experience, enabling the development of transversal skills as team work, responsibility, time management, amongst others, which will be valued when entering professional contexts.

Several tasks of this project are being accomplished by means of project-based learning methodologies and/or project classes from the programme's curricula. More advanced or long-term research will be allocated to internships and/or final projects or master thesis projects.

4 Conclusion

This paper presents a brief contextualization of the NMSPCAM project and diagnosis of the conditions for implementation, addressing in particular the opportunities and challenges as a project-based learning approach. Overall, the context of this project can be considered as innovative, as the implementation of the project in educational context through the PjBL approach involved several subjects from various scientific areas, 3 higher education schools from two different HEIs, and various levels of education, and consequently a planning and implementation process, integrating all stakeholders. This articulation enhanced the communication beyond the actors of the same scientific area and different scientific areas, providing the development of transversal competences, indispensable for the training of future professionals.

The complexity that arises from the number of participants and from their diversity has been challenging but proved to be rewarding and enriched the overall experience. From the experience of the PjBL approach in project execution, it was verified the need to timely redefine the curriculum and planning of the subjects, in order to ensure the execution of the chronologically defined tasks in the project, besides ensuring that the learning was achieved by the students.

One of the aspects that still need of further work, being an on-going process, is related with assessing how effective the experience has been in what was its major goal, to extend the different target groups' knowledge of cultural heritage by means of desirably attractive and engaging content. Data collection is taking place and results will soon be made available.

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Potentialities of Using an Online Platform to Learn Mathematics in Engineering

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Abstract

In engineering courses, basic formation is maintained over the time, with a strong component in basic sciences, predominantly in the area of mathematics. However, several technological and socio-economic changes have interfered in the development of the society, which today is known as the knowledge society. It is possible to communicate in increasingly favourable conditions in terms of speed, quantity, accessibility and credibility of the information that is communicated. Consequently the construction of knowledge is continuous. From a very early age the students have access to information in a variety of ways. Higher education institutions have to accompany today's more competitive and ever-changing global society. Thus, it is necessary to develop teaching methodologies, namely at the level of higher education. In this article we intend to share innovative pedagogical practices, supported by the use of information technologies, in an educational context, namely, through the use of online platforms to support the learning of mathematics, at the higher education level, in engineering courses. Two approaches will be presented: one consists in the previous exploration of the programmatic contents, in an online platform, before they are presented in a classroom context. And, the other is the exploitation of the contents in the online platform, after the teachers introduce them in the classroom. The results demonstrate that the use of online platforms have contributed to the construction of knowledge. Moreover, it was possible to verify that the previous exploitation of the contents in the online platform facilitates the development of the students' autonomy. It was also verified that the use of the platform in an educational context stimulates the interest and have motivated the students to study more and, consequently, impelled to a greater school performance.

Keywords: Teaching Mathematics for engineering; Online Platform; Engineering Education; Innovative Practices.

1 Introduction

The engineering courses have a well-defined curriculum structure, based on a solid scientific structure (such as mathematics, physics, chemistry and biology) that enables engineering graduates to apply it to general models and allows them to prospect, design, plan, execute, control, operate, manage, maintain, communicate, lead, innovate, test and audit systems, components, processes, products and services (Guedes, 2010). Additionally, the Order of Engineers Institution (Portugal) considers essential in the education of an engineer to have a strong mathematics background. Thus, it is important to develop autonomy in students, throughout the academic formation, stimulating the critical spirit and the self-regulation to develop proposed tasks. Considering the actual large-scale technological development, mainly in information technology, it is possible to establish communications in a formidable quantity, speed and credibility. Thus, we live in a Society already known as the Knowledge Society (Pérez, 2000; Adell, 1997), since knowledge is the primordial strategic factor of wealth and power. The information is increasingly very accessible and consequently the construction of knowledge is continuous. In this context, the educational model must be more dynamic and to appeal to debate and reflection, transforming information into knowledge (Roldão, 2000). For (Warnock, 2003) the dogmatic teacher will give place to the dialoguing teacher. The accommodated student should give place to the proactive student in the construction of his own knowledge, in the interaction with it and evoking the technologies as mediators in this process. Some studies have registered the positive impact of information technologies on both teaching and learning processes, since they allow the implementation of more student-centered teaching strategies (Junior & Coutinho, 2009) with an increasing autonomy with respect to the teacher. Learning can be understood as the process that leads to the acquisition and development of skills, involving knowledge, attitudes and values, and behaviour change. And, in this way, supports the preparation of future engineers to the challenges of the increasingly competitive global work world. Some studies allow verifying the advantages of using online technologies (Youssef & Dahmani, 2008; Pais, Cabrita & Anjo, 2011;

Araújo & Cabrita, 2014), namely virtual learning environments, generators of new spaces for competences development, relevant to the students training. However, according to (Cerqueira et al, 2017) teachers still use the technologies in a basic way, in their teaching activities, by just sending study resources or storing them as a repository to interact with the students. Although the teacher is aware of the importance of using new technologies in the classroom, he still faces the challenges of associating pedagogical content with technological instruments. This reinforces the idea that is necessary a permanent search for developing the skills and techniques necessary to learn how to use ICT to teach with a really significant use of digital technologies in the classroom (Silva, Prates & Ribeiro, 2016).

2 Methodology

An empirical study was carried out, between 2010 and 2014, concerning the M@t-Educate With Success (pM@t) platform, developed in the School of Technology and Management of the Polytechnic Institute of Viana do Castelo (Araújo et al, 2010). The main objective of that study was to evaluate the influence of previous platform exploration, in the development of mathematical knowledge, skills, autonomy and interest for the area, by higher education students. Subsequently, in 2015/2016 academic year, the possibility to use this platform was shared with other institutional colleagues, in order they may use it in an educational context. With the objective of sharing the pedagogical experiences, based on the exploration of contents available in the pM@t platform, before and after it be used in a teaching context, by the teacher, it was decided for the analysis of the two studies, which resulted from a mixed research with a multi-methodological approach, using as data collection techniques the knowledge measurement tests, subject final grades, students surveys and interviews conducted with the teachers (this last technique was used only in the second study). In the first study, the assessment of students' knowledge was done through the use of evaluation tests, having a dual purpose – a diagnostic evaluation and later the evaluation of students' progress, by comparing it with a post-test results. In the second study the final grades of the subject in that academic year, were considered, and also the final grades of the subject in the previous academic year. Thus, the objective is to obtain a more reliable final result of the reality or a better understanding of the phenomenon under analysis, since according to (Yin, 2005), a larger diversity and integration of methods produces a larger confidence in the results and any conclusion will be much more convincing and anchored.

3 Different Approaches to the pM@t Platform in Engineering Courses

This platform has been the target of some studies, in an educational context, in particular in engineering courses. Although there are different strategies of using an online platform in an educational context, we present below two different approaches to its implementation in engineering courses. One was the prior exploration of the course contents in the online platform, before they were introduced in the classroom context and the other approach was the exploration of contents in the platform, after the teacher taught them.

3.1 Exploration of the pM@t Platform Before the Contents be Taught

This approach was implemented to a Mathematics student group, of the 1st year of a Food Engineering Degree, of a Higher Education Institution of the North of Portugal, in the academic year of 2010/2011. The approached thematic was Integral Calculus of the Mathematics subject. In the first class of this subject, the students were elucidated that, weekly, they would have to respond to the tasks proposed in the week Study Guide (SG). As this proposed tasks considered that students explore the contents available in the pM@t platform, before the teacher teach them in the classroom, students could explain their difficulties and to indicate the reasons why they did not resolve the proposed tasks. In the following week, in the classroom, the topics already pre-explored by the students were discussed. Additionally, some tasks of different nature, related to those contents, were discussed in order the teacher may evaluate the ability to apply the constructed knowledge, through the autonomous and self-regulated exploration of the pM@t platform.

3.2 Exploration of the pM@t Platform After the Contents be Taught

This other approach, resulting from sharing the platform with other teachers of the higher education institution, was implemented in the Integral Calculus thematic, in the Mathematical/Mathematical Analysis subject.

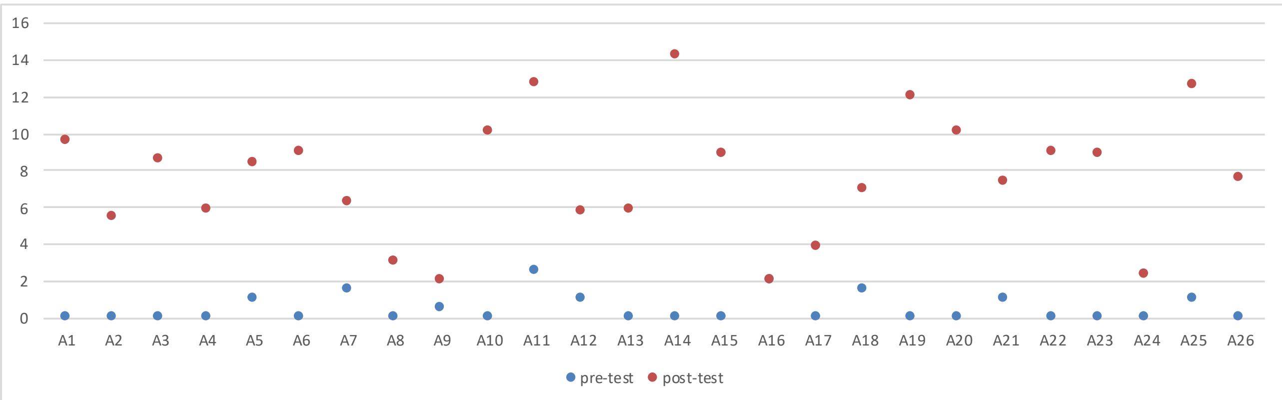
Students from seven engineering degrees were involved in this study, namely: Civil Constructions (Civil and Environmental Engineering), Electronic Engineering and Computer Networks, Informatics Engineering, Materials Engineering and Technology, Renewable Energy Systems Engineering (Daytime and evening classes), Agronomy, Agronomy Engineering, Environment Engineering, Environmental Science and Technology, Food Science and Technology and Food Engineering. Six students were involved in this study implemented in the 2015/2016 academic year. With this approach, the contents were introduced supported by the pM@t platform, in a classroom context. And, regardless of the classroom content approach, at the end of the theoretical-practical classes, students were asked to perform the tasks that the student should explore and try to solve Dynamic Guides (DG) available in the platform. These DG consist of a set of tasks about certain contents, which the student must perform through which will getting feedback on their performance. Thus, these DG allow the student to explore the contents by performing the tasks. Additionally, the students were informed that the platform stores their navigation through the menus and files available, allowing the teacher to know which contents the students had explored and for how long. In the subsequent practical classes, the proposed tasks were also discussed and other tasks available in the platform were discussed.

4 Analysis and Discussion of Results

In this section the data resulting from the implementation of the two approaches will be presented and discussed.

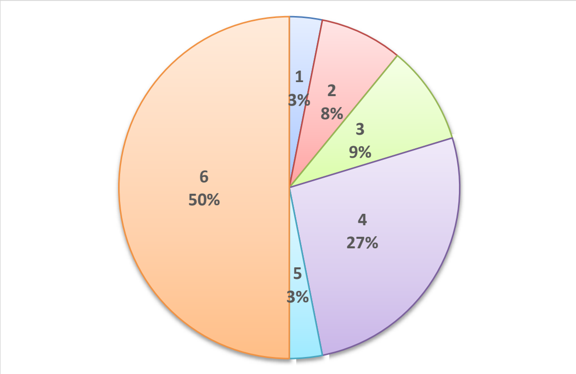
4.1 Exploration of the pM@t Platform Before the Contents be Taught

In the Mathematics subject, in whom the study was implemented, 38 students were enrolled on it. From those 38 students, only 26 (65% of the enrolled students) underwent the evaluation and 10 obtained a grade higher than 9.5 (0 to 20) although all but one of the students obtained a better classification in the second test (Graphic 1).



Graphic 1: Results of the pre-test and post-test.

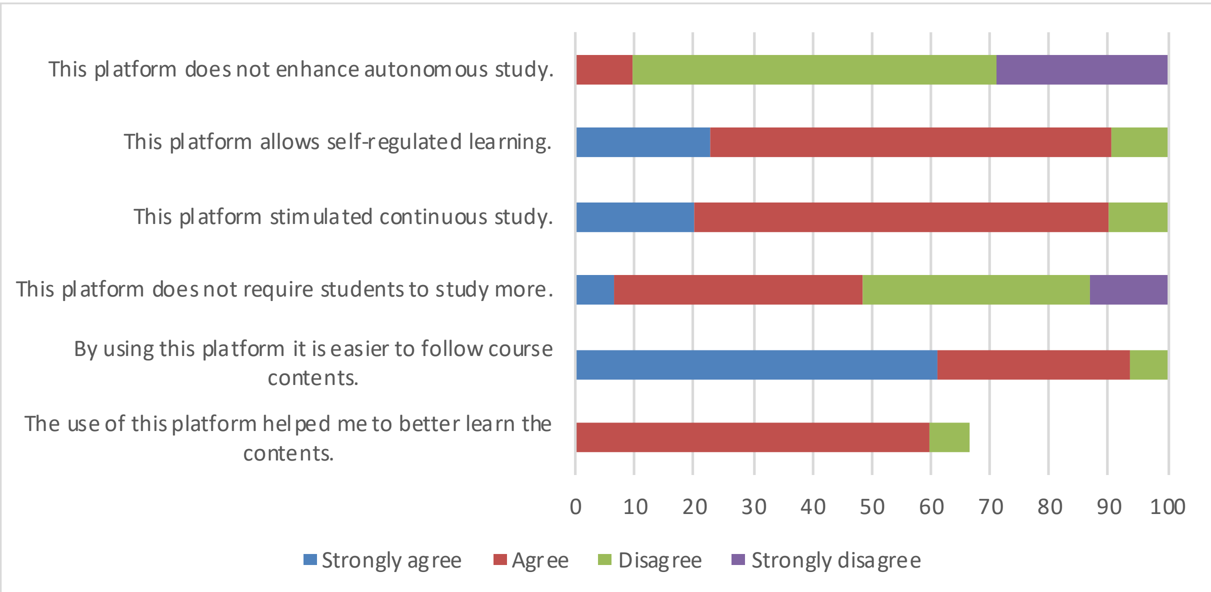
Through the analysis the relative gains, it is verified that, in average terms, there was a relative gain from the pre-test to the post-test of 35.72%. From the 32 students who answered the survey about the pM@t platform and the methodology adopted, which involved an exploration of the contents before being introduced in the classroom, almost all students (94%) accessed the platform from home, 75% used it weekly for less than two hours. Considering the access speed to the platform (Graphic 2) on a scale that varies from 1 (very slow) to 6 (very fast), 50% of the respondents rated it very fast.



Graphic 2: Access speed to the pM@t platform in 2010/2011 academic year.

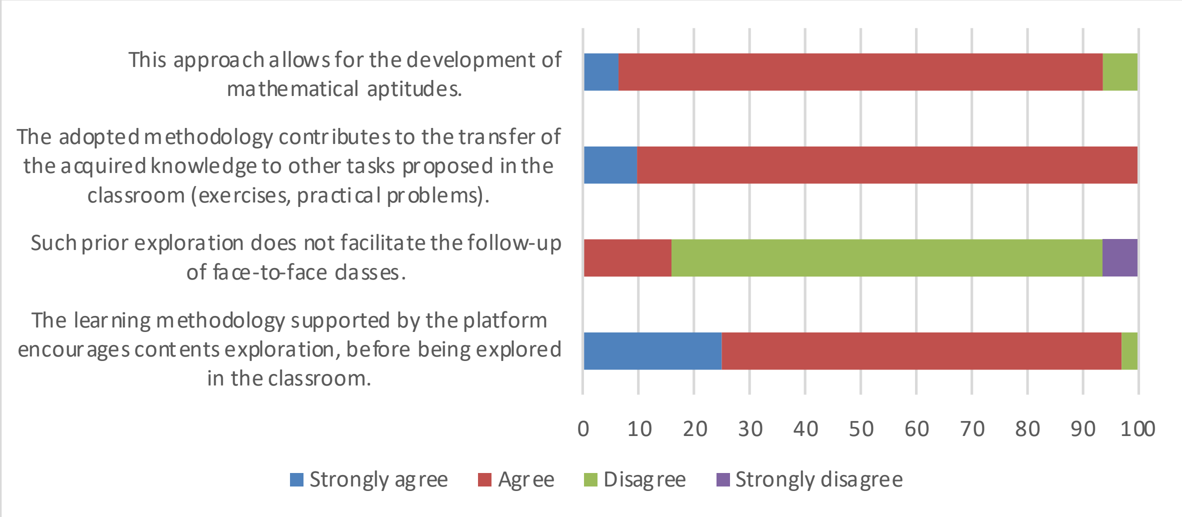
Using the survey about the platform, in order to better understand it, as an instrument to support learning, six statements were prepared, which the student could classify according with 4 possible values: Strongly Agree, Agree, Disagree and Strongly Disagree (Graphic 3). From the analysis to the students' answers it is verified that a large majority of the students, 90%, agree that this platform allows to self-regulate the learning and stimulates to the continuous study. Also, approximately 21% of the students strongly agree with that. However, the percentage of students who consider that this platform forces them to study more is identical to those who consider that it does not force them.

More than 90% of the students Agree with the statements "the use of this platform helped me to better learn the contents" and "by using this platform it is easier to follow course contents", with approximately 33% and 61% Agree and Strongly Agree, respectively. Observing the remaining answers, 90% of the students consider that this platform facilitates the autonomous study.



Graphic 3: Classification of the pM@t platform.

Concerning the statements about the adopted methodology, in which the contents were discussed in the classroom, after the students had explored them in the pM@t platform, it is verified that all students considered that the methodology contributes to the transfer of the acquired knowledge to other tasks proposed in the classroom (exercises, practical problems) (Graphic 4). However, 6% disagree that this approach allows for the development of mathematical aptitudes, and 6% strongly agree. The remaining respondents (88%) rated this item with the agree value.

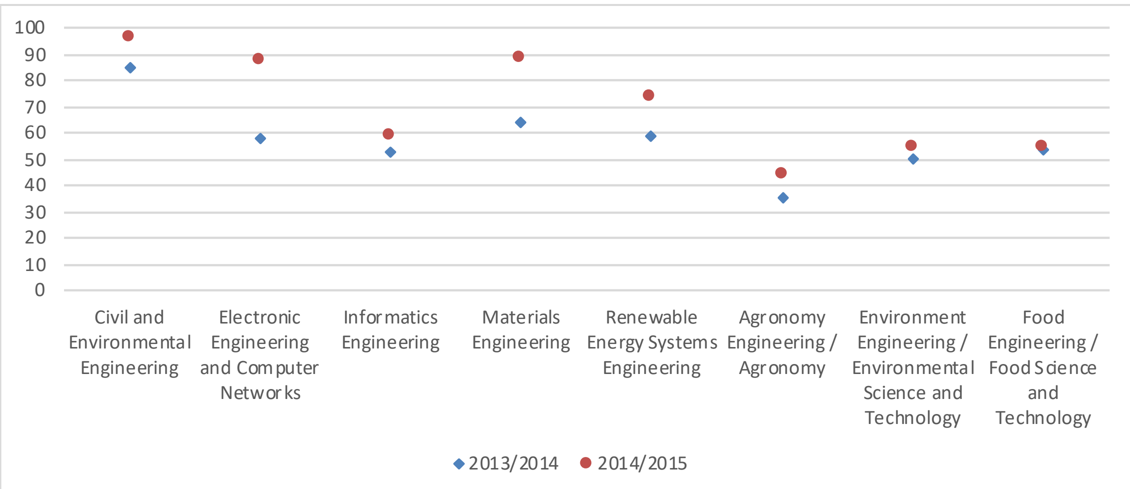


Graphic 4: Evaluation of the methodology adopted.

Most students, 97% of the respondents, consider that the learning methodology supported by the platform encourages contents exploration, before being explored in the classroom, with 25% strongly agree. Regarding the statement "Such prior exploration does not facilitate the follow-up of face-to-face classes", 6% strongly disagree, 77% of respondents disagree and 16% agree.

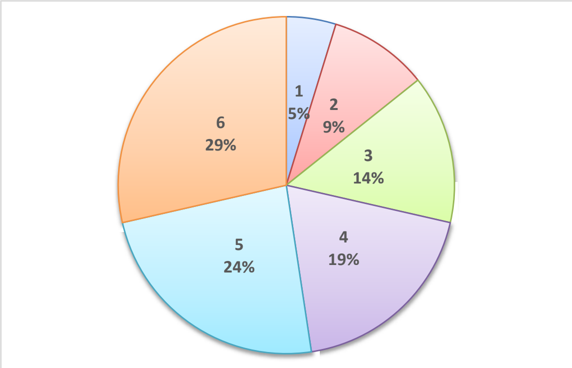
4.2 Exploration of the pM@t Platform After the Contents be Taught

The subjects that supported the study here described had 504 students enrolled on it and about 60% attended the classes. However, only 144 students did register in the platform and 153 accessed it. From the 329 students evaluated in the Mathematics and Mathematical Analysis subjects, 68% obtained approval. It should be noted that the number of students evaluated, 65% of those enrolled, is approximately equal to the number of students who actually attended the classes. Considering the final classifications of the students enrolled in the subjects of this study, in the academic year in which the study was applied and also the students from the previous academic year (in which the platform was not used) it is possible to verify that, in all courses, the percentage of the number of approved students, compared with the number of students evaluated, is higher than in the previous academic year (Graphic 5).



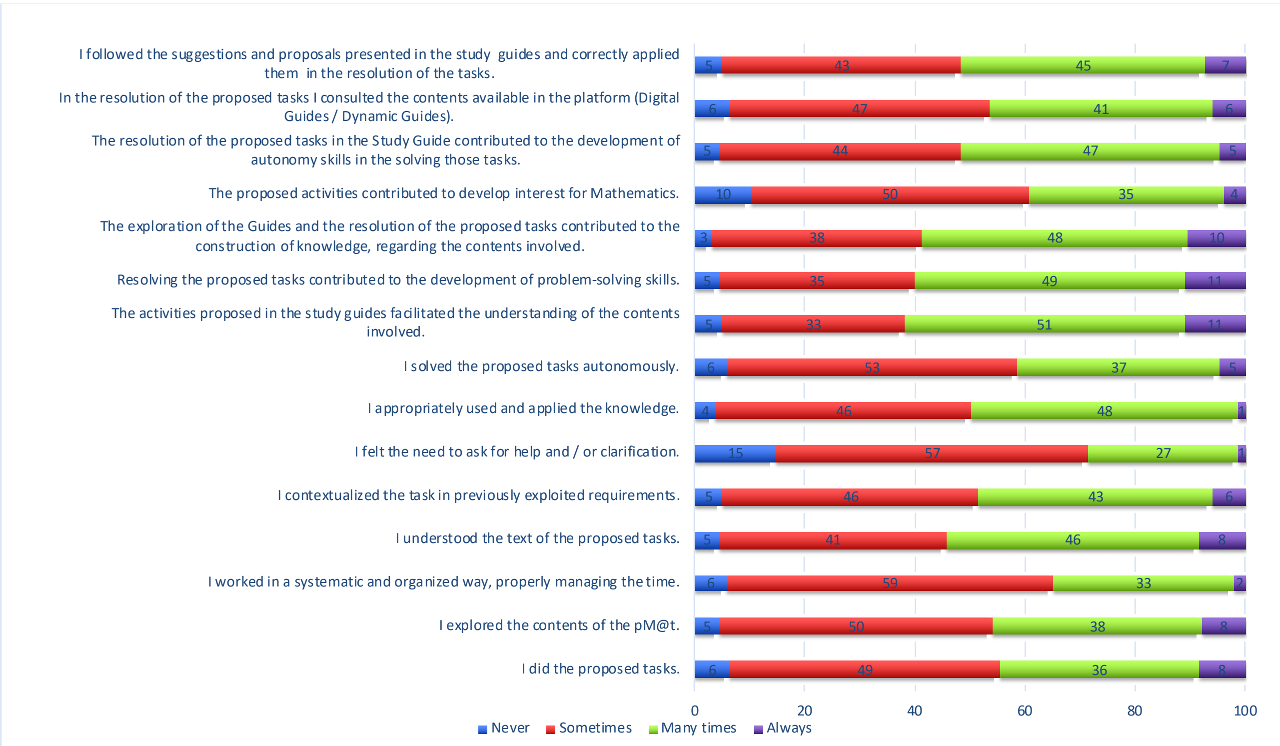
Graphic 5: Percentage of students approved over assessed in the 2013/2014 and 2014/2015 school years.

In order to understand and evaluate the use of the platform by the students, the answers to the student's surveys about the platform were analysed. A number of 155 students answered in a total of 329. The access to the platform from home/residence was done by about 50% of the students surveyed and 46% accessed the platform at school (mostly (82%) for less than 2 hours a week). With regard to the access speed to the platform (Graphic 6) on a scale from 1 (very slow) to 6 (very fast), 53% of the respondents rated it as more than 4 and 29% rated it as very fast.



Graphic 6: Access speed to the pM@t platform in 2014/2015 academic year.

In the survey about the pM@t platform 16 statements were listed, related to the study, supported in the use of the platform, that each student should classify as Never, Sometimes, Many times or Always (Graphic 7). From the analysis to the responses to the survey it is verified that 50% indicated sometimes explore and 46% indicated many times or always. This means that there has been interest in content exploitation, through the pM@t platform, being in accordance with the accesses registered in the platform.



Graphic 7: Classification of the pM@t platform.

Regarding the resolution of the tasks, almost all students (about 95%) chose between sometimes / many times / always, in relation to the statements: "I worked in a systematic and organized way, properly managing the time"; "I understood the text of the proposed tasks"; "I contextualized the task in previously exploited requirements"; "I appropriately used and applied the knowledge"; "I solved the proposed tasks autonomously";

“The resolution of the proposed tasks in the Study Guide contributed to the development of autonomy skills in solving those tasks“; “In the resolution of the proposed tasks I consulted the contents available in the platform (Digital Guides / Dynamic Guides)" and “I followed the suggestions and proposals presented in the study guides and correctly applied them in the resolution of the tasks”. Thus, 95% of the respondents considered that the activities proposed in the study guides facilitated the understanding of the contents available. And, the resolution of the proposed tasks contributed to the development of problem solving skills, with about 60% indicating many times / always. These indicators allow us to conclude that, for the great majority of the students, this platform can contribute to self-regulate the learning of Mathematics.

Almost all students (97%) considered that the exploration of the guides and the resolution of the proposed tasks contributed to the construction of knowledge related to the contents involved, with about 60% indicating many times / always. However, concerning if the proposed activities contribute to develop interest for Mathematics, 10% indicated never, versus 4% who indicated always. The most registered option was sometimes (50%).

Considering on the opinions collected from the teachers involved in the project, three aspects stand out:

1. This methodology allows the coordination of different rhythms of study and different levels of knowledge. The exploration of the contents in the platform and the accomplishment of directed tasks, allows the students to do a more autonomous work, that can be developed individually or in group, which is indispensable to its progression in the process of acquisition of knowledge;
2. Moreover, this teaching methodology allows teachers to be more willing to clarify, individually, the doubts of each student;
3. The third referred aspect was that the platform could and should be improved to include more content that would allow a more dynamic work on a wider range of topics.

5 Conclusion

The information and communication technologies that teachers and students have at their disposal are fundamental tools to change and improve the quality of education. To achieve this, teachers and students must have knowledge about how to use them. Students who currently have a strong aptitude for the use of technological means have adhered to use the pM@t platform, facilitating a greater involvement in the proposed tasks and, consequently, empowering the construction of knowledge at their own pace, taking a more active attitude in their learning process. Teachers also pointed out as a strong advantage the use of the platform in educational context, to enable students to explore the contents at their own pace. That provided a greater awareness of student’s difficulties and the possibility of helping them to overcome them. The teachers also recognized that the pM@t platform allowed the exploration of issues/difficulties that in traditional classes might not be so noticeable.

The results obtained allowed to conclude that in both approaches – whether exploring the platform before the contents be taught in the classroom, or exploring the platform after the teacher introduced the contents – the use of the pM@t platform allowed the teaching/learning process become more dynamic. Students were more involved in the proposed tasks and, consequently, they built knowledge at their own pace, taking a more active attitude in the learning process. This fact is supported by the students' responses to the survey, indicating that the platform has many times or always contributed to the construction of mathematical knowledge as well as to a greater involvement of the students in the resolution of tasks.

When the results and opinions of teachers and students, who participated in the implementation of the project, are analysed, it is verifiable that a future extension of the platform to support new contents would be a good contribution to the teaching/learning process, in higher education, namely in mathematics training for engineering courses. Considering the relevance of solid foundations in engineering courses, particularly in mathematics, and by the fact that the problem of school failure continues to be a reality in this area, it is considered that by sharing strategies that can enhance pedagogical approaches and practices, that allow students to become more involved in their own learning process, can contribute to the development of skills needed by future engineers. Moreover, still exists some resistance of teachers to use new methodologies involving ICT, and in this sense it is important to continue to explore and disseminate pedagogical practices, including the use of emerging technologies.

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Introducing Scrum in a PBL context

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Abstract

Agile Project Management methodologies have increased their popularity over the years in many different contexts. This paper describes a project developed in cooperation with industry in the Integrated Master degree in Industrial Engineering and Management at the University of Minho. The main goal of this project was to introduce Scrum within student' teams involved in a Project-Based Learning (PBL) activity on fourth year, in order to improve their planning and management capabilities. A group of 5 students from the fifth year of the same degree was created to support the PBL teams so that they could learn and become autonomous in using Scrum. This project was developed in four weeks and during this time, the students were inquired in order to understand the initial and final perceptions of the use of the Scrum in the various Development Teams. The analysis of the results demonstrated that the initial concerns with this framework were related with the amount of time they would spend to plan their work. However, the final results showed that Scrum really helped in the definition and distribution of tasks among the members, in the organization and management of the team as well as in the accomplishment of deadlines.

Keywords: Scrum; Project Management; Project-Based Learning (PBL); Agile Methods.

1 Introduction

Project Management and projects themselves have become more complex over the last decades. The global competition existing in the actual market and the quick technological and environment business changing, requires new approaches in the area of Project Management (Popova, Kryvoruchko, Shynkarenko, & Zéman, 2018). As the market needs changes, the professional competences required to deal with it, technical and transversal changes too. Over the years, some universities have been trying to adapt their traditional teaching methods to new ones aiming to better link theory with practice, in order to bring to their students, the opportunity to have a work experience in real industry context. University of Minho is one of the universities that are affording to its students new teaching and learning approaches like Project-Based Learning (PBL) (Alves & Leão, 2016). In the fourth year of its Integrated Master degree in Industrial Engineering and Management course, a PBL project is been carried out in Integrated Project II in Industrial Engineering Management (IPIEM II) curricular unit, where the students are divided into teams to solve real company problems, involving knowledge acquired in the other curricular units. These teams, during one semester face several problems regarding communication, deadline accomplishments, balanced work assignment, data organization and goals setting (Dinis-Carvalho et al., 2019).

Agile Project Management has been increasing its popularity over the last years in many different contexts, as it tries to build the right development environment, engaging people in projects, being flexible and simple, overcoming planning and communication problems, promoting team integration and mainly exploring the concept of inspect and adapt team's work as soon as possible, so they can answer quickly to the fast changes of the market (Kalenda, Hyna, & Rossi, 2018).

This paper describes a project developed in cooperation with Lean Projects and Teams Management (LPTM) and IPIEM II curricular units. One team from LPTM assumed the role of an Agile Team, and each member performed as Scrum Master, for the teams that were developing their PBL project in the previous year of the course. This Agile Team, among one month, tried to share their agile experience with the other teams, in order to help them to overcome their difficulties in setting goals, planning work, communicating and monitoring their performance and progress and also to ensure that after one month, the teams would be capable of practicing Scrum by themselves.

The paper is structured as follows: Section 2 – Literature Review about Team Management and Scrum as an agile framework. Section 3 – Project Description, explaining the project context and its goals. Section 4 – Scrum adapted to PBL, describing the adaptation of Scrum to this particular project. Section 5 – Methodology, reporting all the steps, practices and tools that the Agile Team performed during this project and finally the Section 6 – Results, where is made an analysis of the questionnaires sent to the students in order to understand their opinion regarding this experience with Scrum.

2 Literature Review

According to Špundak (2014), Project Management is applied in today's business world to a variety of different projects. They can be traditional or agile. Traditional project development focused on individual work, in which there were specialized skills, larger teams and low customer involvement. The customers didn't use to collaborate with the teams during the project development and, consequently, there was the risk of the result not being in accordance with the customer requirements (Lindsjørn, Sjøberg, Dingsøyr, Bergersen, & Dybå, 2016).

Over the past decades, agile methods became popular in the software industries world-wide due to the facility to respond with agility to change (Hoda & Murugesan, 2016). Nowadays, agile is being increase and applied to different projects in different contexts. These methods emphasize that there should exist a collaborative work between teams and customers, and that team members should work closely together and communicate between them frequently (Lindsjørn et al., 2016). In 2001, a group of 17 members founded what they call Agile Manifesto. This approach is based on four fundamental values like: individuals and interactions over processes and tools; working software over comprehensive documentation; customer collaboration over contract negotiation; responding to change over following a plan (Beck et al., 2001). Agile differs from the traditional approach by doing the project in iterations and, therefore, reducing and eliminating uncertainty (Fernandez, Daniel & Fernandez, John, 2009).

One of the most popular agile development methods is Scrum (Schwaber & Beedle, 2002). This framework has an iterative and incremental approach (Schwaber, 1994) and is designed to add energy, focus, clarity and transparency to project teams (Sutherland, Viktorov, Blount, & Puntikov, 2007). For Schwaber (1994), this framework lets developers devise the most ingenious solutions throughout the project, as learning occurs and the environment changes. Scrum is characterized for its own roles, ceremonies and artifacts. The person responsible to ensure that the agile practices are performed in the right way by the team it is known as Scrum Master (SM). The SM resolves impediments for the Development Team (DT) facilitates all the agile ceremonies during the sprint and establish the bridge between The Product Owner (PO) and the Development Team. The PO, is the person inside the project that translate de requirements of the stakeholders/clients into work to be done by the Development Team. The Product Backlog construction, prioritization and grooming it is its responsibility. The Product Backlog it is a list of things that have to be done during the project to achieve the clients requirements (Schwaber & Sutherland, 2017).

These "things" can be described as Epics, Features or User Stories, depending the level of the maturity of the Backlog. Epics are the higher level of Product Backlog items, representing the main goal that can be achieved by getting done a group of Features. On the other hand, Feature as its denomination indicates, represent some feature that the product needs to have. A Feature includes a group of User Stories. Last but not least, an User Story it is some kind of work that have to be done, within one sprint, for having some functionality of the product ready to use or to be evaluated for the client. This creation of the Product Backlog is denominated as "story telling" once we are telling a story, starting with a really abstract content (Epic) and ending with a specific level (User Stories).

During the sprints, there are typically moments where all the team sit together to manage and evaluate their work. These moments have the designation of Scrum Ceremonies which include: Sprint Planning, Sprint Review, Sprint Retrospective and Daily Standup Meeting. In the Sprint Planning, the PO shares with the team their Product Backlog, already prioritized, presents his expectations, and suggests a Sprint Goal. After that, the team evaluates the User Stories presented by the PO and defines the effort needed to get them done. Then, the team confirms and agrees to which User Stories they will be committed for that sprint and the Sprint Backlog is defined. Sprint Review ceremony takes place in the end of sprint. This ceremony is where the PO evaluates if the team achieved or not the Sprint Goal and if the User Stories were done or not. For last, the Sprint Retrospective is a moment where the team reflects on what went well, and what didn't go so well during the sprint, so they can avoid the same mistakes the next time or think in a different way of doing something. In this ceremony, the SM also tries to extract from the team some improvement suggestions. The Daily Standup Meeting occurs every day, and the team updates the state of its work answering the following questions: What have you done in the previous day?; What are you doing now?; Are some impediment that are blocking your work? (Sutherland, 2014).

3 Project Description

Every year at the University of Minho, students who are in the fourth year of the Integrated MSc in Industrial Engineering and Management develop a Project Based Learning in a real context during the first semester. This project constitutes the curricular unit "Integrated Project in Industrial Engineering and Management II" (IPIEMII) and students must integrate all the technical skills they acquire from the other 5 curricular units (Integrated Production Management, Manufacturing Systems Organization II, Production Information Systems, Ergonomic Study of Workstations and Simulation). A space is provided to each team so that the students can meet and work together in this project during the semester.

Students are separated in teams of 9-11 elements and then allocated to different companies. The companies define the area they wish a problem to be solved, but if they don't have anything planned the teams can choose an area to improve it. So, each team will deal with a different real situation and, during the semester, they should analyse and diagnose the existing problems at the company, plan improvement actions and, if possible, implement them. Along the project, teams go through some control points to demonstrate the progress of their work.

Since these teams have a considerable number of elements, there are some problems related with team and project management in this context, such as: incompatibility schedules, unfair division of tasks among the members, lack of communication, little clarity about what each element must do and postponement of tasks to be performed closed to the delivery date. To overcome these problems, it became necessary an approach that allowed a better management of the teams as well as the organization and planning of all the tasks that arise during the project.

This article portraits the application of Scrum as a project management framework, in 8 teams who developed the PBL project in 2018, with the help of a group of students who were in the fifth grade of the same course. This group of students had already experienced the previous PBL project, having also knowledge and experience regarding the use of Scrum, since they used it to manage themselves during their project. Thus, these students were in charge of accompanying and giving assistance to the teams in the use of Scrum during the first month, in order to ensure that they were autonomous enough to continue using it by themselves.

Therefore, the main goal of this article is to describe the Scrum introduction practice in a PBL approach and to analyse the perception of students regarding the use of this framework among the project.

4 Scrum adapted to PBL

Scrum framework is increasing its popularity over the years, due to its flexibility to adapt to many different contexts. In this project, Scrum was also adopted with some variations of the standard framework to better fit the PBL context.

4.1 Roles

The main roles in Scrum were also applied here, being Scrum Master, Product Owner and Development Team.

Scrum Master: The Agile Team was constituted by 5 elements that performed the role of SM. Their main goal was to teach the good practices of Scrum to all the members and support the teams during the planning and development phase of the project, so that everyone would stay focused in accomplishing their goals and become autonomous in the planning and management of time and resources. The SM was responsible for the facilitation, orientation and leadership of the Sprint Planning meetings, Sprint Review and Retrospective.

Product Owner: PO was responsible for the curricular unit in which the project takes place. He, alongside the team of assistant professors (Stakeholders), accepted or rejected deliveries that occurred monthly and at the end of every sprint.

Development Team: DT was responsible for the planning and development of its project. The creation of the Backlog, through Epics and User Stories, was the team's responsibility, as well as the Sprint Backlog. Although there was a plan of deliveries to be met, the team was completely free to develop, design and plan their work.

4.2 Artifacts

4.2.1 Scrum Board

For a better visual management of the weekly planning of each sprint, the team of Scrum Masters introduced, in each DT, the practice of the application of a physical and visual board so that they could plan and monitor their project. The dynamic process of the board lead to the constant update of the team's work, allowing all the members to stay updated about the state of the task of each colleague.

The *Ideias* column was used to group post-its representing ideas that emerged during the sprint and that the team wanted to discuss later. Posteriorly, for each Epic that was described in Product Backlog, the respective User Stories were associated and divided into different tasks. During Sprint Planning, the team committed to fulfil certain User Stories and, consequently, their tasks were passed to the "Sprint" column. Each task was assigned to one or more team element, and in this task, his/her picture was placed so that everyone could quickly identify who was working on that. Whenever the task was completed, it should be moved to the *Feito* column.

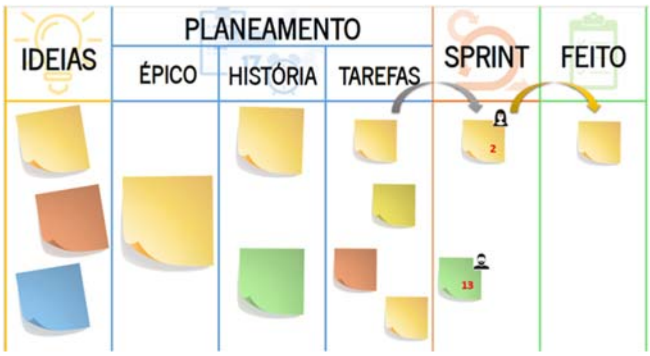


Figure 4 – Scrum Board

The lower part of the board represents an aid to the Review and Retrospective ceremonies. The *Em espera* column represents all tasks that were not completed during the sprint due to external reasons that didn't depend on the team. The Burndown Chart column was used to monitor the team's work during the sprint and can be described in the next topic. Finally, in the *Restrospetiva* column, the team could report some improvement suggestions to be discussed during the Sprint Retrospective, as show Figure 2.

Figure 5 - Lower part of Scrum Board

4.2.2 Burndown Chart
The Burndown Chart was used in order to monitor the cadence of the work performed by the team. Whenever the team realized the Sprint Planning, the sum of the task's punctuation was represented in the y axis whereas the days available for work were represented by the x axis. The diagonal line represents the ideal velocity that the team should work. Whenever a task was fulfilled, its score was withdrawn. If they stayed on top of that line implied that the effort was not being sufficient and whenever it was down it represents that they work at a speed higher than expected. However, it is necessary to recall that the team did not display 100% of their time in the project due to other curricular obligations. For that reason, the burndown did not look as a common burndown, and the line stayed at the top for 2 or 3 days, and only decreases in the days that the team was available to work in the project.

4.3 Ceremonies
The Sprint Ceremonies performed during this project were also an adaptation of the standard ceremonies of the Scrum framework.

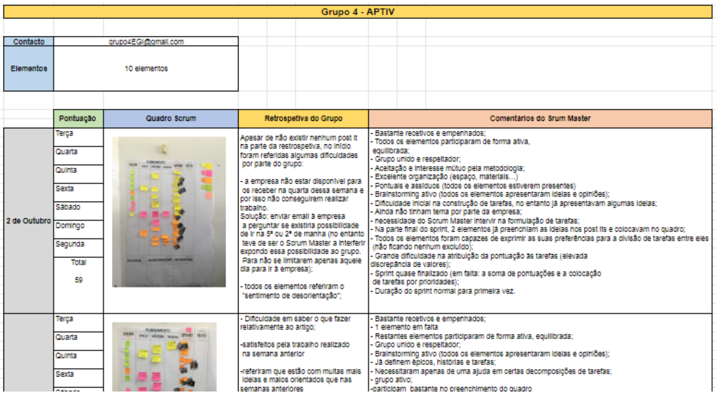
4.3.1 Sprint Planning
During Sprint Planning the team planned the work to be done through the sprint. Although they have a backlog of Epics and User Stories, these items were not written using the standard rules to write User Stories, and for that reason there was not acceptance criteria, or a detailed description. In this meeting, the team decided which User Stories would be included in Sprint Backlog and added the necessary tasks. After this step, the team punctuated all the tasks assigned to that sprint, using Scrum Poker application, with Fibonacci sequence, in order to quantify relatively the work that could be done, and consequently they could monitor their velocity through the project.

4.3.2 Sprint Review
Sprint Review ceremony occurred before the Sprint Retrospective. In this meeting the team evaluated the work that was or not done during the Sprint, depending on the approval of the work by the teachers. Every time a task was considered as "Done", they passed to the *Feito* column of the board. After all the committed tasks were evaluated, the team proceeded with the sum of the punctuation of all the tasks that were done, obtaining the velocity of the team in that sprint.

4.3.3 Sprint Retrospective
The closure of the Sprint was represented by the performance of the Sprint Retrospective. In this moment, the team discussed with transparency what went well and what did not go so well during the sprint. Also, each element could give some creative solutions, in order to achieve a continuous improvement.

5 Methodology
The implementation of a Project Management methodology begun with the presentation of Scrum to all the PBL teams, by a group of students from fifth grade who had already used it on the previous year in their project. All procedures were explained and exemplified to better understand all the dynamics associated to Scrum.

Then over four weeks, the group of Scrum Masters followed all that teams on the initial phase of the PBL project. As there weren't enough Scrum Masters, the group started by randomly select one SM for each team every week to avoid that the same element of the group had always more than one team to meet with. Usually, these meetings were held on every Tuesday mornings as it was the only compatible schedule between the teams and the Scrum Masters. In these sessions, the teams were guided to perform all the Scrum ceremonies mentioned above. However, before this, each SM should consult the performance report file regarding to the teams that they were responsible for each week. This file was created because it was essential that everyone in Agile Team were aware of the current situation of the teams which they were going to meet with. So, after each meeting, the SM should register in the file represented in Figure 6, the score obtained in the end of Sprint Planning and some notes about the retrospective of the previous sprint. Besides this, there was also a column to insert some comments related to the main difficulties felt by the teams during the several ceremonies of Scrum, so that a right support could be given at some specific stage of this framework in the next meeting.



Grupo 4 - APTIV	
Contacto	grupo4EGI@gmail.com
Elementos	10 elementos

	Pontuação	Quadro Scrum	Retrospetiva do Grupo	Comentários do Srum Master
2 de Outubro	Terça Quarta Quinta Sexta Sábado Domingo Segunda Total 59		Apesar de não existir nenhum post it na parte da restrospetiva, no início foram referidas algumas dificuldades por parte do grupo: - a empresa não estar disponível para os receber na quarta dessa semana e por isso não conseguirem realizar trabalho. Solução: enviar email à empresa a perguntar se existiria possibilidade de ir na 5ª ou 2ª de manha (no entanto teve de ser o Scrum Master a interferir expondo essa possibilidade ao grupo. Para não se limitarem apenas aquele dia para ir à empresa); - todos os elementos referiram o "sentimento de desorientação";	- Bastante recetivos e empenhados; - Todos os elementos participaram de forma ativa, equilibrada; - Grupo unido e respeitador; - Aceitação e interesse mútuo pela metodologia; - Excelente organização (espaço, materiais...) - Pontuais e assíduos (todos os elementos estiverem presentes) - Brainstorming ativo (todos os elementos apresentaram ideias e opiniões); - Dificuldade inicial na construção de tarefas, no entanto já apresentavam algumas ideias; - Ainda não tinham tema por parte da empresa; - necessidade do Scrum Master intervir na formulação de tarefas; - Na parte final do sprint, 2 elementos já preenchiam as ideias nos post its e colocavam no quadro; - Todos os elementos foram capazes de exprimir as suas preferências para a divisão de tarefas entre eles (não ficando nenhum excluído); - Grande dificuldade na atribuição da pontuação às tarefas (elevada discrepância de valores); - Sprint quase finalizado (em falta: a soma de pontuações e a colocação de tarefas por prioridades); - Duração do sprint normal para primeira vez.
	Terça Quarta Quinta Sexta		- Dificuldade em saber o que fazer relativamente ao artigo; -satisfeitos pela trabalho realizado na semana anterior -referiram que estão com muitas mais ideias e maios orientados que nas semanas anteriores	- Bastante recetivos e empenhados; - 1 elemento em falta - Restantes elementos participaram de forma ativa, equilibrada; - Grupo unido e respeitador; - Brainstorming ativo (todos os elementos apresentaram ideias e opiniões); - Já definem épicos, histórias e tarefas; - Necessitaram apenas de uma ajuda em certas decomposições de tarefas; - grupo ativo; -participam bastante no preenchimento do quadro

Figure 6 - Performance report file of one team

In order to manage the team's expectations and perceptions regarding the use of the Scrum, all team members were assessed with a total of two online questionnaires. The first one during the initial phase of the project, after an initial contact and presentation of the framework to the teams. The goal of this questionnaire was to evaluate the teams' knowledge about project planning methodologies, the difficulties experienced in their implementation, and the benefits expected during the implementation of Scrum. To this end, open-ended questions and closed-ended questions were used, in which the following statements refer only to the first survey:

- Have you used any project management methodology before? If so, which ones?
- Have you ever heard of Scrum in previous years? If yes, how?
- After presenting the Scrum, do you think it will be useful in carrying out your project?
- How do you think Scrum can help you?

The second survey was exposed to the teams after their last contact with the team of Scrum Masters. This was intended to study the impact that the Scrum had on the teams during an initial planning phase of a project and how it aided in the resolution of conflicts and problems in the teams. Closed and open questions were used, in which it was intended to evaluate more succinctly the following:

- Do you think Scrum is being useful in the development of your project?
- At the time of the retrospective were you always sincere?
- What is the most important moment at Scrum?
- State the strengths of Scrum.
- Do you think the Scrum Master role was important in weekly project planning? (If yes / no, why?)
- Do you feel that you could take on the Scrum Masters role?
- Do you think that your team can be autonomous in the application of this methodology?
- Do you intend to continue using Scrum in this project?

Finally, in a comparison of the initial and final perception of the team elements to the intervention of the Scrum Masters team and the interaction with the Scrum, it was intended to evaluate and compare the following questions that were evidenced in the two questionnaires in an open and closed response format:

- Do you think that the group tasks were distributed in a balanced way by all elements of the group and previous work?
- Have you ever felt overwhelmed during a project?
- Have you ever felt that some element of the group worked more compared to you or the rest of the group in previous work?
- In the previous projects have you already witnessed situations of conflict between the different elements of the team?
- If YES, what were the reasons for the conflicts?
- Do you think the timing of the retrospective helped to discuss/resolve the conflict?
- What are the negative points/difficulties that point to this methodology?
- Do you think the Scrum Master role was important in weekly project planning? (If yes / no, why?)
- Do you feel that you could play the Scrum Master?

- Do you think that your team can be autonomous in the application of this methodology?
- Do you intend to continue using Scrum in this project?

In both surveys we obtained valid answers, and in a total of 75 students, 45 answered the first survey and 41 answered the second survey. This collected data only reflects the 4 weeks in which the Scrum Masters team developed their project. Following the departure of the team, the Development Teams would have to present full autonomy to act independently and play the role of Scrum Masters.

6 Results

According to the observation made by the Scrum Masters and the responses to the surveys, it is possible to extract data regarding the initial and final perceptions of the use of the Scrum in the various Development Teams.

Regarding the first survey and after obtaining 45 valid answers, about 96% of the respondents stated that they never had any previous contact with Project Management methodologies and 87% never had any information related to the Scrum framework. However, after the Scrum Masters team have introduced and presented this new approach to teams, 98% of respondents stated that Scrum would be useful when developing the project. When confronted with the possible benefits of using this framework, they showed that strengths are fixed in allocating tasks equally; managing the time in the accomplishment of tasks; improving self-managing team skills; establishing priorities; improving communication between the various elements of the team.

On the other hand, they demonstrated concerns about the amount of time that they expected to spend planning their work; that the moment of retrospective is not carried out with total sincerity and that there is an added difficulty in integrating into the dynamics of the group.

After the fourth week of the Scrum Masters team intervention, the obtained results in this second moment of inquiries regarding conflict management, planning and division of tasks in an equitable manner by the various team members, differed greatly from the first survey, opinion wise. There has been a significant improvement in results as students feel less overwhelmed, tasks and roles are better defined, and consequently certain conflicts have been avoided.

Regarding the final perception and evaluating a total of 41 valid answers, 98% affirm that Scrum is a useful framework to aid in the development of the project and 95% affirm that the most important moment of this cycle is without doubt the Sprint Planning. After using this planning practice, they mentioned that Scrum assisted in the distribution of tasks by the diverse elements of the group; organization of the team; time management; visual management of tasks; task definition and milestones.

The feedback regarding interaction with the Agile Teams was quite positive, as it helped in the introduction of the framework and essential concepts in the teams; to maintain focus and calm for problem solving and meeting objectives; in the orientation and organization of the team; in group dynamics and processes.

However, after the departure of the team of Scrum Masters, the teams expected to assume full control over the planning and development of the project. As such, about 90% of the respondents assumed that their team could be autonomous in the application of this framework and that after the Agile Team finished the follow-up they intended to continue using Scrum.

Some excerpts from student reports were extracted that highlighted the importance of the Scrum Master role played by older students. Three testimonials selected as examples are:

> *"No doubt. Taking into account the initial difficulties of adapting to the methodology, the Scrum Master was essential to accelerate the familiarization process with Scrum and also to teach and guide in the indicated way (student 1). "*
>
> *"Primordial, we can apply the methodology correctly as soon as possible (student 2)".*
>
> *"It helped to understand the concepts of division of tasks, helped to maintain an order initially and helped mainly to give lights to launch next steps (student 3)."*

"Because the Scrum Master helped in keeping the group calm and keeping the group performing the necessary tasks (student 4)."

7 Conclusion

This paper described the introduction practice of Scrum framework, in teams developing a project in PBL context, with the contribution of an Agile Team constituted by students with already some knowledge about agile methods. During four weeks, this Agile Team expected to introduce and develop agile practices within the other Development Teams, so that they could become autonomous in planning and improve the capability of managing themselves by using Scrum.

The main goal of the project was achieved, once in the beginning, it was shown some resistance from the students to adopt this framework. Although, over the time, the teams started to recognize the benefits of this approach and when the Agile Team left the project, the majority of the students affirmed that they would continue using Scrum until the end of the PBL project and that they felt confident in assuming the role of Scrum Master. Some of the benefits identified by the teams were that Scrum helped in the definition and distribution of tasks, time and visual management and also in the accomplishment of deadlines.

The interaction between students from different curricular years was an interesting aspect. For the Agile Team, this project was mentioned as an opportunity to share their experience with other teams, as well as to develop soft skills and experience new challenges. For the Development Teams, this represented a big support, once the members of the Agile Team had already been involved in the PBL project in the previous year and were aware of the difficulties about this kind of project.

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PAEE/ALE'2019 Full Papers Submissions (Portuguese)

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Self-Evaluation and pairs adopting Project-Based Learning: Perception of students in the course of administration in a Higher Education Institution

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Abstract

The teaching and learning process with the adoption of active teaching methodologies requires reconsideration of the evaluation process, considering that the change of behavior permeates the learning of the traditional format. A differentiated format should contemplate evaluation as an instrument of planning and control for the development and training of learners, based on these innovative strategies. The aim of this article is to analyze the learning experience through the students 'self - evaluation and their peers' evaluation in the Marketing course of the Administration course of the Federal University of Rio Grande do Norte, based on cases for teaching and learning based on projects - PjBL. The research is characterized as a case study, quantitative and descriptive, through the application of a questionnaire, with 28 students who studied the discipline, adopting the descriptive statistics. The results showed that, in relation to the questions of self-evaluation and evaluation of the pairs in the subject, an average of 4.26 was obtained in the two evaluation models, demonstrating the perception of personal progress in the development of their competences and of their colleagues in the class. In addition, the fact that the same note average was attributed in the two evaluation modes denotes a social control among the pairs. The item that obtained the lowest indexes, 3 and 2.81, was about the difficulty of carrying out the self-assessment process, and may be related to the fact that the students are not that much familiar with this evaluative model.

Keywords: Project-based learning; Self-evaluation; Peer evaluation; Management teaching and learning.

Auto Avaliação e Por Pares adotando a Aprendizagem Baseada Em Projetos: percepção de alunos do curso de Administração de uma Instituição De Ensino Superior

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Resumo

O processo de ensino aprendizagem com a adoção de metodologias de ensino ativas exige reconsideração do processo avaliativo, considerando que a mudança de comportamento perpassa o aprendizado do formato tradicional. A avaliação como instrumento de planejamento e controle para o desenvolvimento e formação dos educandos, baseado em estratégias inovadoras, deverá contemplar um formato diferenciado. O artigo tem como objetivo analisar a experiência de aprendizagem por meio da auto avaliação dos alunos e avaliação de seus pares na disciplina de Marketing, do curso de Administração da Universidade Federal do Rio Grande do Norte, com base nas metodologias adotadas na disciplina: sala de aula invertida, casos para ensino e aprendizagem baseada em projetos - ABPj. A pesquisa caracteriza-se como um estudo de caso, quantitativo e descritivo, por meio da aplicação de um questionário, com 28 alunos que cursaram a disciplina, adotando-se a estatística descritiva. Os resultados demonstraram que em relação às questões de auto avaliação e avaliação dos pares na disciplina, obteve-se uma média 4.26 nos dois modelos avaliativos, demonstrando a percepção de um avanço pessoal no desenvolvimento das suas competências e de seus colegas, na disciplina. Ademais, o fato da mesma média de nota ter sido atribuída nos dois modos avaliativos denota um controle social entre os pares. O quesito que obteve os menores índices, 3 e 2.81, foi sobre a dificuldade de realizar o processo de auto avaliação, podendo estar relacionado ao fato dos alunos não terem tanta familiaridade com esse modelo avaliativo.

Palavras-chave: Aprendizagem Baseada em Projetos; Autoavaliação; Avaliação por pares; Ensino Aprendizagem em Administração.

1 Introdução

Recorrentemente, estudos vêm apontando à valorização das habilidades e competências em detrimento ao conhecimento puramente tecnicista em meio ao ambiente complexo que se desenvolve. A insuficiência do modelo tradicional em abarcar essa nova necessidade faz com que o debate a respeito das estratégias de ensino e aprendizagem na área da Administração sejam crescentes (SCHMITZ, 2013; LUCENA et al., 2016; BOAVENTURA et al., 2018).

Esta feita, as instituições de ensino, enfrentam o desafio de implementar modelos de ensino que estejam de acordo com seus orçamentos, ao mesmo tempo sejam mais eficazes e gerem um nível de envolvimento que resulte no desenvolvimento das suas habilidades. Estudiosos da educação vêm recomendando a Aprendizagem Baseada em Projetos (ABPj) como alternativa para alcançar esses fins (LABOY-RUSH, 2011; BENDER, 2015; BOAVENTURA et al., 2018).

Segundo Bender (2015), a Aprendizagem Baseada em Projetos se apresenta como um modelo de ensino que permite ao aluno confrontar os problemas e questões concretas de sua realidade que considere relevante e significativo, decidindo cooperativamente como deve abordá-lo e, assim, de forma colaborativa busquem soluções para aquele dilema e refletindo sobre as atividades que foram realizadas, por conseguinte, desenvolvendo diversas de suas habilidades.

Em razão de a autoavaliação ter se tornado essencial enquanto habilidade do século 21, nos projetos de ABPj, competências interpessoais e intrapessoais, precisam ser desenvolvidas, ao passo que são indispensáveis para a aprendizagem ao longo da vida e sociedade baseada na informação e no conhecimento.

A ABPj se caracteriza, entre outros, pela sua forma de avaliação diferenciada dos modelos tradicionais, que trazem avaliações retrospectivas objetivas e/ou discursivas. No entanto, a utilização do modo tradicional como sendo o único tipo de avaliação, sem qualquer modelo autoavaliativo, deixa recorrentemente, de contemplar aspectos metacognitivos, como uma compreensão mais aprofundada. As autoavaliações e as por pares quando feitas de forma numérica, tendem a ser mais reflexivas, pois auxiliam os alunos a quantificar seus esforços no projeto (BENDER, 2015).

A fim de analisar a experiência de aprendizagem por meio da autoavaliação dos alunos e avaliação de seus pares foi realizado um estudo de caso de ensino na disciplina de Marketing de um curso de Administração da Universidade Federal do Rio Grande do Norte.

2 Aprendizagem Baseada em Projetos e modelos avaliativos

A aprendizagem baseada em projetos é uma forma ativa de ensino centrada no aluno que é caracterizada por autonomia dos alunos, inversão da sala de aula, investigações construtivas, estabelecimento de metas, colaboração, comunicação e reflexão dentro das práticas do mundo real. A ABPj desenvolve habilidades meta cognitivas e cooperativas, a cooperação e a criatividade que são essenciais para a resolução de problemas e a aprendizagem no século 21. Além disso, meta cognição, pensamento de ordem superior e prática reflexiva, desempenham um importante papel na avaliação e no sucesso do processo de aprendizagem (BENDER, 2015; ALVES et al.; KOKOTSAKI, MENZIES, WIGGINS, 2016)

Para Bolella e Cesaretti (2017) a sala de aula invertida (SAI), uma das prerrogativas da ABPj, conecta vários conceitos educacionais, incluindo a aprendizagem ativa, significativa e colaborativa. Geralmente se converte a leitura ou instruções em um vídeo ou em outro formato digital, em sintonia com os atuais estudantes altamente conectados com novas tecnologias e recursos digitais. O tempo de sala de aula é reestruturado, sendo utilizado para a realização de atividades, atribuições práticas e ajuda direcionada, as quais devem ser obrigatórias e envolver aprendizado interativo, exceto palestras. O ganho significativo no tempo destinado à prática orientada e independente ou a atividade de laboratório com o uso de sala de aula invertida, ultrapassa 100% de aumento, quando comparado o tempo de práticas do modelo tradicional de ensino (ZUBER, 2015; BOLELLA, 2017). Essa inversão da sala de aula, proporciona um maior contato com a prática e ainda uma maior interação entre os alunos, para Bender (2015) essa maior relação interpessoal pode auxiliar nos processos de auto avaliação e ainda na avaliação dos pares.

Além disso, a autoavaliação e avaliação por pares tende a provocar a autocrítica e senso de responsabilidade. Essas capacidades são construtivas e permitem o desenvolvimento de maior criticidade, tanto na análise dos seu próprio desempenho quanto no desempenho dos demais, competências úteis durante a vida profissional (RIBEIRO, ESCRIVÃO FILHO, 2011)

Em relação a avaliações ativas de diversas formas, experiências similares que fizeram uso da aprendizagem baseada em problemas, os resultados demonstram que o rendimento dos grupos foram, em geral, compatíveis com as notas obtidas nas demais formas de avaliação, a saber, auto avaliação, avaliação pelos pares e diferentes avaliadores (ARAÚJO E ARANTES, 2009; RIBEIRO, ESCRIVÃO FILHO, 2011; FREZATTI et al., 2016).

A comparação de modos de avaliação ativa em relação às competências transversais adquiridas a partir da percepção dos alunos em um projeto, foi medida no curso de Engenharia Elétrica da UFJF quando na utilização de metodologias ativas de aprendizagem. Todos os estudantes assinalaram melhora em desenvolver trabalho em equipe, 90% manifestaram aprimoramento na capacidade comunicativa enquanto que um pouco mais de 60% manifestaram estímulo à liderança (PINTO et al, 2013).

Continuamente, de acordo com os achados de Mansur e Alves (2018), os resultados obtidos nas autoavaliações em uma experiência de aprendizagem baseada em projetos foram similares às notas obtidas nas demais vias de avaliação. Isso corrobora com a explicação de Bender (2015) que indica a existência de uma espécie de controle social realizado pelos alunos, impedindo benefícios indevidos com notas maiores.

3 Metodologia

O estudo constitui-se uma pesquisa descritiva de natureza quantitativa, sendo assim, ela visa descrever as características relacionadas à experiência de aprendizagem por meio da auto avaliação dos alunos e avaliação de seus pares ou, ainda, o estabelecimento de relações entre variáveis (PRODANOV; FREITAS, 2013). Compreende ainda um estudo de caso, que constitui uma abordagem metodológica de investigação especialmente adequada quando procuramos compreender, explorar ou descrever acontecimentos e contextos complexos, nos quais estão simultaneamente envolvidos diversos fatores.

Os sujeitos de pesquisa foram os discentes da disciplina de Marketing 2, no período de 2018.2, no turno matutino do curso de Administração da UFRN, os quais formaram equipes por afinidade e realizaram um projeto relacionado à confecção de um plano de marketing, O número de alunos inscritos na disciplina representavam um universo de 31 alunos. Foi enviado um questionário para todos os alunos que cursaram a disciplina no período 2018.2, depois do final da disciplina e fora das atividades avaliativas. Foi facultado aos alunos a participação e explicado que os dados, caso aceitassem, não trariam nenhum tipo de identificação pessoal, o índice de retorno das respostas foi de 90%, atingindo assim uma amostra não probabilística por conveniência de 28 alunos, que participaram assim, de forma voluntária, da pesquisa. Collis e Hussey (2005) argumentam que o tipo de amostragem utilizado também pode ser considerado natural, uma vez que o pesquisador tem pouca influência na composição da amostra, o que no caso se deve ao fato de que apenas determinados alunos, que cursaram a disciplina no período, estão envolvidos com o fenômeno estudado e também disponíveis para o estudo.

O questionário foi dividido em duas dimensões, a saber: auto avaliação e avaliação dos pares. A respostas estão compreendidas numa escala psicométrica que a variável era a percepção sobre o desempenho dos alunos na atividade com valores quantitativos de 1 a 5 e com relação crescente, ou seja em uma escala de 1 a 5, 1 representou baixo desempenho e 5 seria um alto desempenho (BERMUDES, 2016). A análise dos dados foi realizada, utilizando-se da estatística descritiva para compreender as respostas dadas pelos alunos.

Por se tratar de um trabalho inicial, o questionário formado não havia sido validado por modelos anteriores, mas sim por aprimoramento de instrumentos avaliativos em disciplinas de períodos anteriores e pelos estudos de Amaral et al. (2008); Schimitz (2013); Alves e Eira (2015); Lucena et al. (2016); Soares, Alves e Targino (2017); Freitas e Odelius (2018). Das quais foram identificadas como sendo: Pensamento Analítico; Resolução de Problemas; Inovação; Trabalho em equipe; Liderança; Comunicação; Colaboração; Autoanálise; Autocontrole; Automotivação; Autoconhecimento; Capacidade de organização pessoal e conhecimento técnico que no caso foi sobre gestão de marketing.

Quanto à análise dos dados, foi construída uma tabela no excel que foi categorizada por afirmativa e separada cada nota por aluno. Para isso foram analisadas as médias atribuídas por alunos pra si e aos outros a fim de identificar características salientadas na literatura.

4 Análise dos Resultados

No primeiro bloco de questões relativas ao desempenho individual e a iniciativa dos alunos dentro do grupo de trabalho, foram analisadas 15 afirmações, conforme pode ser visualizado no quadro 1.

Analisando os resultados apresentados, percebeu-se que das afirmativas apresentadas, comparando-se os dados da autoavaliação com os da avaliação dos pares, as avaliações que obtiveram resultados mais críticos foram nos itens: concentração no trabalho e a dedicação dos membros da equipe. Seguida da habilidade de liderança e da capacidade de motivação do grupo.

No sentido contrário, a avaliação do grupo é mais crítica do que a autoavaliação nos quesitos relacionados a habilidades intrapessoais, como a dificuldade na autoavaliação a requisição de ajuda aos colegas e a capacidade de ouvir os colegas.

QUADRO 1 - MÉDIAS E VARIAÇÕES DO DESEMPENHO INDIVIDUAL POR AFIRMATIVA

AFIRMATIVAS	**Auto Avaliação**	**Avaliação dos pares**	**Variação entre as Notas**
1. Compreendi claramente o que tinha que fazer no trabalho	4.54	4.57	-0.029
2 . Estive o tempo todo atento e concentrado durante a realização do trabalho	3.88	4.31	-0.439
3. Ouvi e procurei compreender ideias e opiniões dos meus colegas	4.96	4.69	0.264
4. Apresentei ideias novas enriquecendo o trabalho do grupo.	4.29	4.31	-0.014
5. Encorajei os colegas a participarem no trabalho	4.00	4.10	-0.099
6. Ajudei colegas quando foi necessário	4.46	4.39	0.070
7. Pedi ajuda a colegas quando foi necessário	4.58	4.36	0.220
8. Aceitei a ajuda de outros colegas	4.58	4.64	-0.055
9. Senti entusiasmo durante a execução do trabalho	3.83	3.91	-0.076
10. Tive capacidade de escutar o outro, apresentando flexibilidade necessária para aceitar as idéias divergentes da minha e capacidade de negociação.	4.58	4.60	-0.012
11. Tive capacidade em me comunicar (entrar em contato para realizar as tarefas, por exemplo) com os outros integrantes do grupo.	4.67	4.50	0.163
12. Tive uma postura de liderança favorecendo a execução das tarefas.	3.83	3.96	-0.125
13. Participei das aulas e dos encontros extra-aulas e das atividades online com o grupo	4.17	4.23	-0.065
14. Tive dificuldade para realizar a minha auto avaliação.	3.00	2.81	0.195
15. Considero que evolui durante o processo educacional.	4.46	4.49	-0.029

As duas constatações anteriores refletem o perfil da turma pesquisada, alunos do curso de Administração que hora se punem por não serem suficientemente líderes, no entanto de modo mais agressivo, criticam os colegas por não conseguirem desempenhar tarefas que exigem uma maior autonomia.

Deste modo, entende-se que quando calcula-se os resultados da avaliação de todos os alunos, a média de todas as diferenças entre as autoavaliações e as avaliações por pares, a diferença média das notas foi de 0.04. Ademais, a média de 4.26 foi quantificada na percepção dos alunos, tanto na autoavaliação quanto na avaliação por pares. Esse resultado sinaliza concordância com os achados de Mansur e Alves (2018), na forma de que os alunos tendem a atribuírem notas próximas a si, às das indicadas pelos colegas. Isso corrobora a ideia de controle social entre os membros do grupo apontada por Bender (2015).

Associado a isso, vemos que nenhuma das notas, nem das auto atribuídas quanto das avaliadas pelos pares conseguiram atingir o nível de excelência. Entende-se assim que esse resultado pode ser considerado como sendo positivo, visto que é mais um indicativo de desenvolvimento da autocrítica e do senso crítico de maneira abrangente por parte do alunado.

Quando na análise individual das afirmativas, a fim de compreender como foi o processo de desenvolvimento dos alunos, podemos depreender que, de modo geral, os alunos pesquisados percebem melhora nas suas habilidades. A fim de ratificar os achados, foi ainda analisado a segunda dimensão do questionário exposto no quadro 2.

QUADRO 2 - AVALIAÇÃO DO DESEMPENHO POR GRUPO

AFIRMATIVAS	**Discordo totalmente**	**Discordo parcialmente**	**Não concordo, nem discordo**	**Concordo parcialmente**	**Concordo totalmente**
1. Todos compreendemos e conseguimos realizar o que tínhamos de fazer	0	0	0	21	7
2. Estivemos todos atentos, concentrados e entusiasmados no trabalho	0	0	4	23	1
3. Colaboramos uns com os outro durante a execução do trabalho	0	0	0	12	15
4. Expressamos nossas opiniões durante o desenvolvimento do trabalho	0	0	0	3	25
5. Conseguimos resolver dificuldades na execução das tarefas durante o trabalho	0	0	1	10	17

Algumas habilidades foram desenvolvidas apesar do reconhecimento dos alunos, mesmo com a não obtenção de notas de destaque. Um exemplo disso seria a inovação (quadro 1), que é uma importante habilidade e foi percebida como exercitada pelos alunos mas sem uma ênfase que chame atenção, apresentando uma média muito próxima entre a percepção do próprio aluno e dos demais participantes, sendo de 4.29 e 4.31, respectivamente.

Outras das habilidades desenvolvidas, tiveram um reconhecimento mais explícito pelos alunos de maneira que deram pontuações de forma geral mais altas. As habilidades interpessoais como cooperação, colaboratividade e comunicação tiveram as médias de notas mais altas, pela percepção dos alunos. O trabalho em equipe é desenvolvido, ao passo que o contexto da vida real lhe conduz às interações comuns ao convívio social, isso corrobora com a literatura quando Bender (2015) e Alves et al. (2016) sinalizam a importância do trabalho feito em equipes colaborativas. Além disso, Pinto et al. (2013) também verificou melhora nessas habilidades, mediante resultados de autoavaliações e discussões em equipe.

Uma das habilidades intelectuais mais complexas, o pensamento de ordem superior, possibilita aos alunos a compreensão da realidade a sua volta. Para Bender (2015) e Lucena et al. (2016), o caráter absorto da ABPj proporciona um ambiente de desenvolvimento da capacidade de raciocínio e na análise e resolução de problemas. Os alunos demonstraram boa compreensão dos passos da disciplina sempre questionando e estabelecendo relação entre o que era requisitado e o que era realizado. Isso evidencia uma maior significação do conhecimento apreendido. Como forma de confirmação dessa afirmativa, a avaliação realizada pelo grupo também traz uma inclinação dos participantes a ratificarem a compreensão das atividades e ainda em confirmarem o sucesso na realização do projeto explicitando a superação das dificuldades encontradas ao longo do trabalho, evidenciando o exercício da habilidade de solução de problemas.

Uma habilidade intrapessoal que exige reflexão e senso crítico é a empatia. Esse quesito, entendido aqui como a expressão das afirmativas 3 e 10, do quadro 1, respectivamente a compreensão de ideias e opiniões dos colegas e a capacidade de escutar o outro, apresentando flexibilidade necessária para aceitar as idéias divergentes e negociá-las, tiveram médias bem avaliadas pelos alunos. O indicador da afirmativa 3 obteve média 4.96 na autoavaliação e 4.69 na avaliação por pares enquanto o indicador da afirmativa 10 atingiu média de 4.58 na autoavaliação e 4.60 na avaliação por pares. Em Pinto et al. (2013), a habilidade de lidar com diferentes visões e saber conciliá-las colocou-se como necessária na avaliação dos alunos.

De forma geral, os alunos ficaram engajados no projeto, não necessariamente nas interações em sala de aula, mas se reunindo em horários especiais e ainda desempenhando as atividades relativas ao projeto, atribuindo notas com uma média de 4.61. Para Bender (2015) a ABPj causa um efeito motivador diante dos alunos, pois quando se envolvem diretamente no aprendizado, tendem a ter um aumento do seu interesse pelas atividades da disciplina.

Nada obstante, os alunos não se sentiram especialmente entusiasmados para realizarem o projeto. Apesar da média 3.83 nas autoavaliações e 3.91 na avaliação por pares serem notas relativamente altas, essa foi uma das piores médias da avaliação como um todo. Isso corrobora com a avaliação do grupo quando existe alguma inclinação dos alunos em concordarem apenas parcialmente que estavam concentrados e entusiasmados com o projeto.

Esse foi o quesito que mais chamou atenção, pois obteve a menor média, 3 nas autoavaliações e 2.81 na avaliação por pares. Esse achado evidencia que os alunos têm problemas na mensuração de seus próprios esforços e no reconhecimento de seu desenvolvimento. Isso de certa forma vai de encontro aos achados de Bender (2015) que afirma que o ambiente de ABPj auxilia a auto reflexão. Ademais, apesar de ser a menor média apreendida, a percepção não obteve implicações operacionais, não pode se considerar ainda que existiram problemas reais na autoavaliação visto que todos conseguiram desenvolver a atividade avaliativa e as médias encontradas, de forma geral, na autoavaliação não tem uma discrepância alta em relação às avaliações entre os pares.

O quesito que trata da evolução geral dos alunos serviu como um mecanismo de feedback a mais para entender se eles haviam compreendido seu desenvolvimento. De maneira geral, os alunos reconhecem que evoluíram seus aprendizados durante a disciplina atribuindo média 4.7 nas avaliações.

É perceptível que a metodologia gerou desenvolvimento de habilidades conforme destacado nos itens relacionados a capacidade de concentração e compartilhamento de ideias, entretanto a falta de intimidade com esta forma de ensino contribui para algumas dificuldades por parte dos alunos, como é possível ver na baixa pontuação relativa a execução da autoavaliação. Ficando claro que a maior aproximação dos alunos com as metodologias ativas, pode aguçar o senso crítico, possibilitando uma maior capacidade de reflexão, tanto sobre o conteúdo desenvolvido na disciplina, como e sobre o seu próprio desempenho.

E ainda, apesar da dificuldade expressada em realizar a autoavaliação, de forma geral os resultados obtidos nas autoavaliações se aproximaram dos alcançados nas avaliações por pares. A maior discrepância entre as avaliações do quadro 1 foi o item 2 seguido do item 3, com índices de -0.439 e 0.226, respectivamente, que ainda assim não se constituem em diferenças significativas. Isso nos dá pistas sobre a efetividade da aplicação desses tipo de avaliação frente à adoção de metodologias de ensino ativas.

5 Conclusão

O trabalho objetivou entender melhor como era a percepção dos alunos sobre os modelos ativos de avaliação apresentados a eles ao fim da disciplina e como os resultados dessas avaliações diferiam entre si. Foi constatada uma aproximação entre os resultados dos índices das avaliações com maior variância atingindo -0.439.

E ainda, os resultados apontaram para uma a percepção de um avanço pessoal no desenvolvimento das suas competências e de seus colegas na disciplina uma vez que obteve-se uma média 4.26 nos dois modelos avaliativos. Essa média igual denota um controle social entre os pares o que confirma a literatura. O quesito que obteve os menores índices, 3 e 2.81, foi sobre a dificuldade de realizar o processo de auto avaliação, podendo estar relacionado ao fato não terem familiaridade com esse modelo avaliativo.

A partir de impressões iniciais dos dados coletados, os alunos tiveram problemas de liderança ao longo da disciplina. Como modo de circularidade, recomenda-se investigar como a liderança foi desenvolvida por meio do contexto do projeto, pela autoavaliação e pela avaliação dos pares a partir de uma entrevista.

No mais, seria interessante o aprofundamento da relação entre as avaliações por pares e autoavaliações além de outras estratégias avaliativas, em estudos posteriores, de modo a enriquecer e fundamentar o uso de diversas formas de avaliações das metodologias ativas. Com isso, poderão ser delineadas relações comparativas entre o resultado dessas duas avaliações e outras, contemplando suas discrepâncias e concordâncias, limitações e potencialidades.

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Rubrics as a Way of Improving Assessment Practices in Fashion Design

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Abstract

The present paper refers to the reviewing of the assessment tools used for grading the products required for graduation in Fashion Design at Centro Universitário Iesb.

Having as a starting point for the investigation the positionings from both teachers and students collected during the end of the second semiannual cycle of 2018 and based on the objectives established in the institution's curricular guide, the assessment tool's first update proposal was developed based on the utilization of Rubrics.

Such assessment tool offers rich possibilities concerning improvement of both grading and learning processes, stimulating objectivity and clarity in regards to the stablishing of criteria for learning assessment, performance standards and post assessment feedback.

The present work is a register of the process through which Rubrics adequate for the assessment of institutional learning objectives, as well as for answering both teacher's and student's positionings were developed.

Keywords: Design; Fashion; Assessment; Rubrics.

Rubrics como Forma de Aprimoramento de Práticas Avaliativas em Design de Moda

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Resumo

O presente trabalho trata da revisão das ferramentas de avaliação de produtos exigidos para obtenção de diploma no Curso Superior Tecnológico em Design de Moda do Centro Universitário Iesb.

Partindo de posicionamentos obtidos tanto de docentes quanto de alunos ao final do ciclo de avaliação do segundo semestre de 2018 e baseado na Proposta de Plano Curricular (PPC) da instituição, desenvolveu-se uma proposta inicial de atualização da avaliação de aprendizagem final do curso com base na utilização de Rubrics.

Tal ferramenta de avaliação oferece possibilidades ricas de melhoramento dos processos tanto de avaliação quanto de aprendizagem, favorecendo a objetividade e clareza no estabelecimento de critérios avaliativos, níveis de desempenho e processo de *feedback* pós avaliativo.

Registra-se por meio do presente trabalho os Rubrics desenvolvidos, adequados aos objetivos de desenvolvimento de habilidades da instituição, bem como de expectativas educacionais de docentes e alunos.

Palavras chave: Design; Moda; Avaliação; Rubrics

1 Introdução

A avaliação educacional ocupa um espaço de extrema importância nos processos de formação, sendo responsável por aferir os resultados do processo de aprendizagem bem como por fornecer ao estudante um instrumento de aprimoramento contínuo através de um ciclo PDCA. Ao apresentar-se como instrumento de aferição de resultados, a avaliação educacional evidencia a visão da instituição de ensino com relação às competências consideradas necessárias para o adequado exercício de uma ocupação e da cidadania. A importância dos modelos de avaliação da aprendizagem é evidenciada pelo elevado número de reflexões em desenvolvimento presentes na bibliografia científica a respeito de como, quanto, quando e porque se avaliar em cada situação de ensino/aprendizagem.

Os processos de avaliação ganham especial destaque quando da utilização de metodologias inovadoras de ensino/aprendizagem, tais como a Aprendizagem Ativa e a Aprendizagem Baseada em Projetos .

O trabalho de conclusão de curso (TCC) em design de moda exigido pelo Iesb (Instituto de Educação Superior de Brasília) possui caráter projetual, exigindo que os alunos investiguem e respondam à questão de criar a partir do zero uma coleção de moda. A semelhança dos projetos em engenharia, a complexidade do projeto e, por consequência, da sua avaliação, vem da grande variedade de conteúdos simultaneamente presentes, bem como da presença de habilidades tanto técnicas quanto criativas a serem aferidas. Como será melhor detalhado adiante, o aluno deve desenvolver trabalhos de planejamento, pesquisas, orçamento, design gráfico, design de produto, escrita acadêmica, confecção, ilustração e comunicação, tornando a avaliação do projeto de forma enriquecedora e clara um desafio ao docente.

Nesse contexto, os Rubrics aparecem como uma ferramenta tanto de avaliação quanto de ensino (Jonsson, Svigby, 2007) com potencial de melhorar o processo de aprendizagem e de avaliação no contexto de projetos de moda.

O presente artigo documenta a experiência de adaptação da ficha de avaliação utilizada até o semestre 2/2018, no modelo grelha de avaliação, para o formato de Rubrics.

2 Contextualização

O Curso Superior Tecnológico em Design de Moda do Centro Universitário Iesb oferece formação superior voltada para atender, em especial, ao mercado de moda da capital brasileira e cidades de sua região de influência econômica. O Plano Pedagógico do Curso (PPC) propicia a constante revisão dos processos avaliativos afirmando que "a Instituição entende que há uma relação fundamental, porém rompida, entre avaliação e (re)planejamento, que precisa ser resgatada, pois é isto que lhe dá o sentido transformador. A avaliação deve ter caráter de acompanhamento do processo, fazendo parte da realização interativa" (Iesb, 2016).

A formação do curso envolve 1790 horas de aula distribuídas ao longo de 4 anos. A cada semestre letivo são oferecidas 120 vagas a serem divididas em turmas de até 50 alunos para disciplinas teóricas e 30 para disciplinas práticas.

São realizadas, em todas as disciplinas, ao menos duas avaliações, com a possibilidade de realização de avaliações em formatos diversos conforme proposta do docente. No caso das disciplinas teóricas, uma das avaliações é obrigatoriamente uma prova nos moldes do Exame Nacional de Desempenho de Estudantes (Enade).

Ao final do curso, os alunos devem desenvolver um Trabalho de Conclusão de Curso (TCC), de forma individual ou em dupla, que ateste suas competências para o desempenho de sua atividade profissional no mercado de trabalho da moda.

2.1 Avaliação do Trabalho de Conclusão de Curso (TCC)

O Centro Universitário Iesb, em seu Curso Superior Tecnológico (CST) em Design de Moda utiliza três produtos para a avaliação de qualidade do Trabalho de Conclusão de Curso (TCC): 1) um Memorial Descritivo; 2) um Dossiê e; 3) uma coleção de vinte looks (termo utilizado no meio da moda para uma vestimenta completa, seja de peça única ou não), sendo cinco destes confeccionados e apresentados.

O Memorial Descritivo é um documento escrito em formato de monografia que deve conter os itens objetivo, justificativa, metodologia adotada, análise de mercado, público, tendências, tema criativo, descrição conceitual (como o tema se traduz em produto), cartela de cores e materiais.

O Dossiê é um material impresso que busca comunicar as questões exploradas no Memorial Descritivo de forma visualmente atraente e coerente para o público consumidor não especializado, além de trazer o chamado mapa de coleção, que mostra os *looks* desenvolvidos em forma de ilustração criativa e as fichas técnicas de cada produto que compõe os *looks* confeccionados.

Por fim, cada aluno apresenta uma Coleção, formada por cinco *looks* confeccionados, selecionados dentre os vinte desenvolvidos no decorrer do semestre, para que sejam avaliadas as habilidades relacionadas ao desenvolvimento de produtos que evidenciem sua identidade com a coleção e adequação ao público alvo, mas também apresentem execução e acabamento consistentes com os padrões de qualidade desejados.

A ferramenta de avaliação utilizada é a Ficha de Avaliação de TCC (Figura1), que é disponibilizada para os alunos sempre no início do semestre.

No final do 2/2018, em reunião de avaliação do curso, verifica-se a necessidade de ajustes do processo de avaliação de TCC, para adequar os resultados aos objetivos previstos no Plano Pedagógico do Curso (PCC): "a formação de profissionais capazes de elaborar e gerenciar projetos que visem o desenvolvimento de produtos de moda factíveis, por meio da aquisição de competências voltadas ao planejamento e ao gerenciamento do processo criativo, considerando fatores estético-funcionais, econômicos, técnico-produtivos e sustentáveis." (Iesb, 2016)

MEMORIAL DESCRITIVO	PO	PA	PC
1. Conformidade com o guia e formatação.			
2. Clareza, linguagem, coerência com os objetivos e metodologia utilizada.			
3. Justificativa do tema, pesquisa e referencial teórico.			
4. Manual de identidade visual.			
5. Assiduidade e comprometimento com as orientações.		x	x
DOSSIÊ	**PO**	**PA**	**PC**
1. Diagramação e projeto gráfico.			
2. Coerência com o tema.			
3. Completude dos itens cobrados.			
4. Ilustrações.			
5. Caderno Técnico			
COLEÇÃO	**PO**	**PA**	**PC**
1. Aspectos de linguagem: identidade, unidade, equilíbrio e consistência.			
2. Coerência da coleção com o tema.			
3. Coerência da coleção com macro e microtendência.			
4. Número de looks apresentados.			
5. Acabamento e confecção das peças			
6. Adequação na escolha dos materiais e texturas.			
7. Caimento.			
8. Inovação.			

Figura 1. Grelha de avaliação utilizada no semestre 2/2018 (PO: Professor Orientador; PA: Professor Assistente; PC: Professor Convidado).

As principais observações por parte do corpo docente são relacionadas aos produtos apresentados não serem factíveis (fatores estético-funcionais e técnico-produtivos). Por parte dos alunos as observações dizem respeito ao orçamento final do projeto, que consideram muito elevado (fator econômico e sustentáveis). Tais observações destacam aspectos da atuação profissional, ligados à precificação, planejamento do produto e da operação.

No presente trabalho, busca-se o aprimoramento do processo de avaliação, partindo-se da Ficha de Avaliação de TCC, mantendo-se a clareza de critérios já presente ao passo que se define os níveis de performance de forma detalhada, permitindo ao aluno aprender o que constitui um adequado produto e guiá-lo ao longo do projeto semestral.

3 Metodologia e resultados

Para atender aos objetivos descritos no item anterior, o presente trabalho partiu de uma identificação das habilidades a serem aferidas pelo TCC, passou pela correlação de tais habilidades com parâmetros de aferição a serem utilizados na avaliação, definiu critérios de qualidade para o cumprimento de cada parâmetro, identificou ferramenta de avaliação (Rubrics) adequada ao modelo proposto e executou a migração da ferramenta anteriormente utilizada para o novo modelo.

3.1 Habilidades e parâmetros de aferição

Cada um dos três produtos utilizados no processo de avaliação (Memorial Descritivo, Dossiê e Coleção) busca aferir se o aluno desenvolveu determinadas habilidades, consideradas essenciais para o exercício profissional segundo o PPC, ao longo do curso, utilizando-se parâmetros de aferição definidos pelo corpo docente.

A seguir, apresenta-se as relações entre habilidade e parâmetros de aferição para os produtos Memorial Descritivo (Tabela 1), Dossiê (Tabela 2) e Coleção (Tabela 3).

Tabela 1 – Relação entre parâmetros de avaliação e habilidades (memorial descritivo)

Memorial Descritivo Habilidades	Parâmetros		
	Conformidade e formatação	Clareza e linguagem	Justificativa e tema
Dominar a escrita e pesquisa acadêmicas	X		
Comunicar efetivamente por meio de texto		X	
Prospectar e analisar problemas a serem explorados			X
Pesquisar e analisar tendências de mercado e público			X
Associar tema criativo e desenvolvimento de produto		X	

Tabela 2 – Relação entre parâmetros de avaliação e habilidades (dossiê)

Dossiê Habilidades	Parâmetros			
	Diagramação, impressão e encadernamento	Coerência com tema e público	Ilustrações	Caderno Técnico
Produzir diagramação gráfica	X			
Realizar comunicação visual efetiva	X	X	X	
Ilustração		X	X	
Desenvolver desenho técnico				X
Elaborar ficha técnica de produto				X

Tabela 3 – Relação entre parâmetros de avaliação e habilidades (coleção)

Coleção Habilidades	Parâmetros			
	Aspectos de linguagem	Coerência com o tema	Coerência com as macro e micro tendências	Construção das peças
Unidade, identidade e consistência entre si	X			
Coerência com o tema criativo escolhido		X		
Coerência com as tendências estudadas			X	
Adequação ao público alvo escolhido	X	X	X	X
Adequado acabamento e processo de confecção				X
Adequada escolha de materiais para a construção	X			X

Um quarto parâmetro de avaliação, "Assiduidade nas Orientações", sem correlação direta com as habilidades descritas, é incluído na avaliação do Memorial Descritivo. Tal parâmetro diz respeito às habilidades de respeitar horários, cumprir compromissos e gerir o tempo disponível, consideradas gerais pelo PPC (Iesb, 2016, p.67).

3.2 A escolha por Rubrics

O trabalho buscou desenvolver a ficha de avaliação utilizada até o segundo semestre de 2018, fazendo a adaptação dos critérios de avaliação do formato de grelha de avaliação para o formato característico de Rubrics.

O termo Rubrics refere-se à ferramenta de classificação que divide o trabalho do aluno em suas partes componentes e objetivos, além de proporcionar uma descrição detalhada do que constituem níveis aceitáveis ou não aceitáveis de performance em cada componente (Stevens; Levi, 2005). Embora específicos por produtos, as Rubrics apresentam uma estrutura matricial padrão, na qual, cada linha corresponde a um parâmetro a ser avaliado, para o qual são propostos quatro níveis de avaliação de qualidade (Excelente, Avançado, Médio e Iniciante), dispostos em colunas. Nas células formadas pelo cruzamento da linha (parâmetro) com cada coluna (níveis de qualidade) são descritos os critérios de avaliação.

Tabela 4. Estrutura matricial padrão dos Rubrics

Parâmetro Avaliado	Excelente	Avançado	Médio	Iniciante
Parâmetro 1	critério 1.1	critério 1.2	critério 1.3	critério 1.4
Parâmetro 2	critério 2.1	critério 2.2	critério 2.3	critério 2.4
...	...	...	...	...
Parâmetro n	critério n.1	critério n.2	critério n.3	critério n.4

É importante ressaltar que as Rubrics não são o objetivo da avaliação. Trata-se apenas de uma ferramenta para aferição de resultados de projeto e de aprendizagem, cabendo ao docente, de acordo com o plano curricular institucional, definir cada habilidade a ser aferida e o que constitui cada nível de performance. Embora os rubrics pareçam ser principalmente utilizados para aferir o conhecimento a respeito de conteúdo (Jonsson, Svigby, 2007), não existe na sua essência nada que impeça sua utilização para aferição de processos psicológicos ou sociais, sejam estes avaliados pelo professor, por colegas ou pelo próprio aluno.

Vale também detalhar brevemente a relevância de tal ferramenta para um momento no qual as práticas avaliativas têm se tornado mais complexas, passando de uma medida de rendimento com base nos resultados e voltada para o conhecimento (Scallon, 2004) para um conjunto de habilidades técnicas, psicológicas, críticas, afetivas e mais (Fernandes, 2007).

Nessa emergente perspectiva de avaliação, "o aluno é avaliado com base em standards de desempenho (avaliação criterial), não havendo comparação com os seus pares nem dependendo da posição que ocupa no grupo (avaliação normativa). Há uma explicitação das expectativas de aprendizagem a atingir em cada nível, tal como sugerido no âmbito de uma avaliação criterial" (Barbosa, 2012).

Os Rubrics correspondem às expectativas sobre as avaliações colocadas acima, estabelecendo os standards, permitindo avaliação individual e até mesmo auto avaliação e explicitando as expectativas por meio da descrição minuciosa do que consiste cada habilidade a ser avaliada bem como dos erros cometidos.

No tocante a impactos da utilização de rubrics como ferramenta de avaliação, observa-se que os rubrics podem melhorar a confiabilidade da pontuação em avaliações de desempenho. Para possuir essa confiabilidade, os rubrics devem ser analíticos, específicos e acompanhados de treinamento para o formato de avaliação (Jonsson, Svigby, 2007).

3.3 Adequação da Ficha de Avaliação

Além da estrutura matricial padrão de Rubrics, uma última coluna foi acrescentada, destinada a "comentários do avaliador". O objetivo é oferecer a oportunidade de maior detalhamento pelo avaliador a respeito do que motivou o nível de desempenho assinalado, bem como de maior compreensão do aluno acerca das habilidades que precisam ser melhor desenvolvidas.

Cabe ao avaliador assinalar o nível de qualidade para cada parâmetro e, na coluna final, deixar orientações que permitam ao aluno compreender suas potencialidades e fragilidades – sob o ponto de vista dos avaliadores – e, através delas, identificar suas oportunidades e ameaças no mercado de trabalho, cumprindo de tal forma o papel da ferramenta da avaliação como indutor de um processo de aprendizagem e de desenvolvimento de habilidades contexto de projetos de moda.

Ao fazermos um paralelo com o campo da engenharia, fica claro o papel da Rubric como agente de inclusão do processo de avaliação em um ciclo PDCA (Plan, Do, Check, Act) de melhoria contínua.

A seguir, apresenta-se os Rubrics propostos para avaliação de Memorial Descritivo (Figura 2), Dossiê (Figura 3) e Coleção (Figura 4).

MEMORIAL DESCRITIVO					
	Excelente	**Avançado**	**Médio**	**Iniciante**	**Comentários do Avaliador**
Conformidade e formatação	A formatação ABNT foi seguida e o trabalho contém todos os itens solicitados.	O trabalho contém no máximo 1 erro de categoria de formatação (ex: espaçamento de linhas ou fonte bibliográfica) OU no máximo 1 item incompleto/ausente.	O trabalho contém no máximo 3 erros de categoria de formatação (ex: espaçamento de linhas ou fonte bibliográfica) OU no máximo 2 itens incompletos/ausentes.	O trabalho contém 4 ou mais erros de categoria de formatação (ex: espaçamento de linhas ou fonte bibliográfica) E/OU mais de 2 itens incompletos/ausentes.	
Clareza e linguagem	A linguagem utilizada é adequada, com bom uso de termos técnicos. Os textos são bem embasados, organizados e de fácil compreensão.	O trabalho apresenta 1 dos seguintes erros: (a)a linguagem utilizada é pouco adequada, (b)há falha(s) no uso de termos técnicos, (c)os textos são pouco embasados, (d)os textos são pouco organizados ou de difícil compreensão.	O trabalho apresenta 2 dos seguintes erros: (a)a linguagem utilizada é pouco adequada, (b)há falha(s) no uso de termos técnicos, (c)os textos são pouco embasados, (d)os textos são pouco organizados ou de difícil compreensão.	O trabalho apresenta 3 ou mais dos seguintes erros: (a)a linguagem utilizada é pouco adequada, (b)há falha(s) no uso de termos técnicos, (c)os textos são pouco embasados, (d)os textos são pouco organizados ou de difícil compreensão.	
Justificativa e tema	O trabalho está adequadamente justificado, demonstrando ser baseado em pesquisa de necessidades e de público. As pesquisas estão corretamente apresentadas e o tema escolhido complementa a comunicação e processo criativo.	O trabalho possui 1 dos seguintes erros: (a) fracamente justificado, apresentando falhas na pesquisa de necessidades e de público, (b)as pesquisas estão incorretamente apresentadas, (c) o tema escolhido não complementa a comunicação e processo criativo.	O trabalho apresenta 2 dos seguintes erros: (a) justificativa fraca, apresentando falhas na pesquisa de necessidades e de público, (b)as pesquisas estão incorretamente apresentadas, (c)o tema escolhido não complementa a comunicação e processo criativo.	O trabalho apresenta 3 dos seguintes erros: (a) justificativa fraca, apresentando falhas na pesquisa de necessidades e de público, (b)as pesquisas estão incorretamente apresentadas, (c)o tema escolhido não complementa a comunicação e processo criativo.	
Assiduidade nas orientações	O aluno possui no máximo 1 falta.	O aluno possui 2 faltas.	O aluno possui 3 faltas.	O aluno possui 4 ou mais faltas.	

Figura 2 – Rubric para avaliação do Memorial Descritivo

DOSSIÊ					
	Excelente	**Avançado**	**Médio**	**Iniciante**	**Comentários do Avaliador**
Diagramação, impressão e encadernamento	A diagramação está adequada, assim como a encadernação e a impressão. O Dossiê Apresenta bom acabamento.	A diagramação contém 1 dos seguintes erros: (a)imagens com baixa resolução, textos ilegíveis, grandes espaços em branco, falta de margem para impressão, uso prejudicial de cores, (b)apresenta impressão de má qualidade, (c)utiliza papel inadequado, (d) oDossiê presenta acabamento falho.	A diagramação contém 2 dos seguintes erros: (a)imagens com baixa resolução, textos ilegíveis, grandes espaços em branco, falta de margem para impressão, uso prejudicial de cores, (b)apresenta impressão de má qualidade, (c)utiliza papel inadequado, (d) oDossiê presenta acabamento falho.	A diagramação contém 3 ou mais dos seguintes erros: (a)imagens com baixa resolução, textos ilegíveis, grandes espaços em branco, falta de margem para impressão, uso prejudicial de cores, (b)apresenta impressão de má qualidade, (c)utiliza papel inadequado, (d) oDossiê presenta acabamento falho.	
Coerência com tema e público	O Dossiê utiliza elementos gráficos claramente ligados ao tema escolhido, além de organizá-los de forma adequada às preferências de seu público.	O Dossiê utiliza elementos gráficos nebulosamente ligados ao tema escolhido OU os organiza de forma falha às preferências de seu público.	O Dossiê utiliza elementos gráficos nebulosamente ligados ao tema escolhido E os organiza de forma falha às preferências de seu público.	O Dossiê utiliza elementos gráficos não ligados ao tema escolhido E/OU os organiza de forma claramente inadequada às preferências de seu público.	
Ilustrações	As ilustrações trazem referências visuais, estilísticas ou narrativas adequadas ao Dossiê, além de terem sido executadas de forma tecnicamente correta e permitirem o entendimento da roupa ilustrada.	As ilustrações contém 1 dos seguintes erros em 3 casos ou menos: (a)não trazem referências visuais, estilísticas ou narrativas adequadas ao Dossiê, (b)execução ténica incorreta, (c)não permitir o entendimento da roupa ilustrada.	As ilustrações contém 1 dos seguintes erros em mais de 3 casos: (a)não trazem referências visuais, estilísticas ou narrativas adequadas ao Dossiê, (b)execução ténica incorreta, (c)não permitir o entendimento da roupa ilustrada.	As ilustrações contém 2 ou mais dos seguintes erros: (a)não trazem referências visuais, estilísticas ou narrativas adequadas ao Dossiê, (b)execução ténica incorreta, (c)não permitir o entendimento da roupa ilustrada.	
Caderno Técnico	Os desenhos técnicos apresentam execução adequada e a ficha contém todas as informações solicitadas preenchidas corretamente.	O Caderno técnico apresenta 1 dos seguintes erros em 3 casos ou menos: (a)desenhos técnicos com erro de proporção, (b)de detalhamento, (c)de espessura de linhas, (c)de diferenciação frente/costas, (d)de falta de legenda, (e)faltam informações relevantes na ficha técnica.	O Caderno técnico apresenta 1 dos seguintes erros em mais de 3 casos : (a)desenhos técnicos com erro de proporção, (b)de detalhamento, (c)de espessura de linhas, (c)de diferenciação frente/costas, (d)de falta de legenda, (e)faltam informações relevantes na ficha técnica.	O Caderno técnico apresenta 2 ou mais dos seguintes erros: (a)desenhos técnicos com erro de proporção, (b)de detalhamento, (c)de espessura de linhas, (c)de diferenciação frente/costas, (d)de falta de legenda, (e)faltam informações relevantes na ficha técnica.	

Figura 3– Rubric para avaliação do Dossiê

COLEÇÃO					
	Excelente	**Avançado**	**Médio**	**Iniciante**	**Comentários do Avaliador**
Aspectos de linguagem	A coleção contém em sua totalidade os seguintes itens: unidade (as peças dividem entre si elementos visuais ou de composição e construção o bastante para serem laramente pertencentes a um conjunto), equilíbrio (os elementos de identidade da coleção estão distribuídos de forma equilibrada, tornando todas as peças da coleção importantes para o conjunto) e consistência (a coleção tem um objetivo e identidades claro, não se perdendo em diversas direções narrativas, técnicas ou estéticas).	A coleção contém, exceto em 3 ou menos *looks*, 1 erro dentre os seguintes itens: (a)unidade (as peças dividem entre si elementos visuais ou de composição e construção o bastante para serem laramente pertencentes a um conjunto), (b)equilíbrio (os elementos de identidade da coleção estão distribuídos de forma equilibrada, tornando todas as peças da coleção importantes para o conjunto), (c)consistência (a coleção tem um objetivo e identidades claro, não se perdendo em diversas direções narrativas, técnicas ou estéticas).	A coleção contém, em 4 *looks*, 1 erro dentre os seguintes itens: (a)unidade (as peças dividem entre si elementos visuais ou de composição e construção o bastante para serem laramente pertencentes a um conjunto), (b)equilíbrio (os elementos de identidade da coleção estão distribuídos de forma equilibrada, tornando todas as peças da coleção importantes para o conjunto), (c)consistência (a coleção tem um objetivo e identidades claro, não se perdendo em diversas direções narrativas, técnicas ou estéticas).	A coleção contém 2 ou mais erros dentre os seguintes itens: (a)unidade (as peças dividem entre si elementos visuais ou de composição e construção o bastante para serem laramente pertencentes a um conjunto), (b)equilíbrio (os elementos de identidade da coleção estão distribuídos de forma equilibrada, tornando todas as peças da coleção importantes para o conjunto), (c)consistência (a coleção tem um objetivo e identidades claro, não se perdendo em diversas direções narrativas, técnicas ou estéticas).	
Coerência com o tema	A coleção é em sua totalidade claramente ligada ao tema criativo escolhido. O aluno fez uso de elementos visuais derivados de seus estudos do tema, além de demonstrar uma interpretação própria e embasada a respeito do mesmo.	A coleção é, exceto em 1 *look*, claramente ligada ao tema criativo escolhido. O aluno fez uso de elementos visuais derivados de seus estudos do tema, além de demonstrar uma interpretação própria e embasada a respeito do mesmo.o	A coleção é, exceto em 2 *looks*, claramente ligada ao tema criativo escolhido. O aluno fez uso de elementos visuais derivados de seus estudos do tema, além de demonstrar uma interpretação própria e embasada a respeito do mesmo.	A coleção é em 3 ou mais *looks* pouco ou não ligada ao tema criativo escolhido.	
Coerência com as macro e micro tendências	A coleção é em sua totalidade claramente ligada às tendências estudadas. O aluno fez uso de narrativa visual ou de adequação de produto em acordância com a macrotendência, além de apresentar em seus produtos os elementos apresentados na seleção de microtendências.	A coleção é razoavelmente ligada às tendências estudadas. No entanto, o aluno fez uso de narrativa visual ou de adequação de produto em desacordo com a macrotendência OU apresentou em seus produtos, com exceção de até 2 os elementos apresentados na seleção de microtendências.	A coleção é razoavelmente ligada às tendências estudadas. No entanto, o aluno fez uso de narrativa visual ou de adequação de produto em desacordo com a macrotendência OU apresentou em seus produtos, com exceção de até 4 os elementos apresentados na seleção de microtendências.	A coleção tem pouca ou nenhuma relação com as tendências estudadas. O aluno fez uso de narrativa visual ou de adequação de produto em desacordo com a macrotendência E não apresentou em seus produtos os elementos apresentados na seleção de microtendências.	
Construção das peças	A construção das peças apresentadas é adequada em sua totalidade. Os produtos apresentam correta escolha de materiais e aplicações, correta escolha e execução de técnicas de modelagem, costura e beneficiamento. As peças apresentam portanto aspecto profissional e aparente durabilidade (de acordo com o projetado).	As peças possuem, em 2 casos ou menos, até 2 dos seguintes erros: (a)escolha inadequada de materiais ou aviamentos (que implica em caimento defeituoso, conflito entre materiais,, etc.), (b)escolha inadequada de técnica de execução (erros de adequação em costura, estampa ou beneficiamentos diversos), (c)modelagem inadequada para a obtenção do modelo projetado (resultando em forma inadequada das peças ou vestibilidade prejudicada), (d)execução técnica inadequada.	As peças possuem, em 3 ou mais casos, até 2 dos seguintes erros: (a)escolha inadequada de materiais ou aviamentos (que implica em caimento defeituoso, conflito entre materiais, etc.), (b)escolha inadequada de técnica de execução (erros de adequação em costura, estampa ou beneficiamentos diversos), (c)modelagem inadequada para a obtenção do modelo projetado (resultando em forma inadequada das peças ou vestibilidade prejudicada), (d)execução técnica inadequada.	As peças possuem 3 ou mais dos seguintes erros: (a)escolha inadequada de materiais ou aviamentos (que implica em caimento defeituoso, conflito entre materiais, etc.), (b)escolha inadequada de técnica de execução (erros de adequação em costura, estampa ou beneficiamentos diversos), (c)modelagem inadequada para a obtenção do modelo projetado (resultando em forma inadequada das peças ou vestibilidade prejudicada), (d)execução técnica inadequada .	

Figura 4 – Rubric para avaliação da Coleção

4 Considerações Finais

O presente trabalho partiu da manifestação de inquietações tanto de corpo docente quanto de alunos do CST em Design de Moda do Centro Universitário Iesb. Os posicionamentos levaram a uma investigação acerca de métodos para otimização dos processos de avaliação de aprendizagem.

A utilização de rubrics permite um grande grau de transparência por parte do avaliador, definindo de forma clara tanto o que constitui um trabalho excelente quanto os fatores que prejudicam o trabalho. Permite também ao aluno fazer sua auto avaliação e desenvolver com objetividade o mapeamento de habilidades que desenvolveu mais ou menos. Por fim, a utilização de rubrics tem potencial de reduzir a variação nas aferições por diferentes professores, promovendo o estabelecimento de critérios representativos de todo o corpo docente e instituição.

O desenvolvimento de um produto de moda (coleção) apresenta estreita correlação com as fases de concepção, detalhamento e produção de um produto em engenharia, seja ele um edifício, um veículo, um equipamento ou um novo material. Assim, o processo de construção de rubrics aqui apresentado e as conclusões obtidas após a sua aplicação, servirão de base ao desenvolvimento de ferramentas de avaliação nos cursos de engenharia.

Pretende-se a continuação da presente trabalho ao longo do ano de 2019, uma vez que a primeira aplicação da avaliação aqui desenvolvida será feita ao final do primeiro semestre do mesmo ano (julho). As seguintes etapas da investigação envolverão a aferição dos resultados da aplicação da avaliação proposta, com metodologia a ser explorada em trabalhos seguintes.

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Focus on content to focus on competencies: Impacts on Engineering curricula

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Abstract

In this paper we analyze the teaching model based on competencies and the changes provoked in Engineering courses, ranging from new ways of conceiving formation, new approaches of Teaching and Learning and also new evaluation and assessment strategies. The change proposed by the 1999 Bologna Project and, in Brazil, the discussion on the National Curricular Guidelines for Engineering courses, dated 2002, on the objectives of the undergraduate courses, points in a different direction in higher education design courses. Besides the legal aspects discussed in these proposals, there is a change on focus in the construction of the curricular matrices of the courses. Historically, Engineering courses were built from the knowledge necessary for the professional exercise, which led to focus on the minimum contents that student should have. What is perceived in the discussions is that focus changes to the Engineer's competencies, that is, in addition to establishing what the student should know, establishes what he/she should do with acquired knowledge. Documents are concerned with establishing technical skills and transversal skills: communication, teamwork, problem solving, adaptability to new technologies and new market scenarios. This also leads to a change in the way courses are constructed, conducted and assessed. Regarding the classes, to change the focus of the contents to the projects, in the laboratories change the focus of the scripted classes in favor to experimentation. If we are used to assess knowledge, we now need to broaden the assessment by addressing other aspects such as participation in project design and construction, how experiments are conducted, and what concepts and conclusions have been reached. This also leads to a change in the way courses are constructed, conducted and also in forms of assessment. Regarding the practical classes, changing focus from contents to projects, in the laboratories change the focus from scripted classes to classes that favor experimentation. If we are used to assess knowledge, we now need to broaden the assessment by addressing other aspects such as participation in project design and construction, how experiments are conducted, and what conclusions they have reached.

Keywords: Assessment; Skills; Curricula; Project-based Learning.

Do foco em conteúdos para o foco em competências: Impactos nos currículos de Engenharia

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Resumo

Neste artigo analisamos o modelo de ensino baseado em competências e as mudanças provocadas nos cursos de Engenharia, que vão desde novas formas de conceber a formação, novas abordagens de Ensino e Aprendizagem e também a necessidade de novas estratégias de avaliação. A mudança proposta pelo Projeto de Bolonha de 1999 e, no Brasil, a discussão em torno as Diretrizes Curriculares Nacionais para os cursos de Engenharia, datada de 2002 (CNE, 2002), sobre os objetivos dos cursos de graduação, apontam para uma outra direção na concepção dos cursos superiores. Além dos aspectos legais discutidos nessas propostas, há uma mudança de foco na construção das matrizes curriculares dos cursos. Historicamente, os cursos de Engenharia eram construídos a partir dos conhecimentos necessários ao exercício profissional, o que levava ao foco nos conteúdos mínimos que o estudante deveria ter. O que se percebe nas discussões é que o foco muda para as competências do Engenheiro, ou seja, além de estabelecer o que o estudante deve conhecer, estabelece o que ele deve fazer com o conhecimento. Os documentos se preocupam em estabelecer as competências técnicas e também competências transversais: comunicação, trabalho em equipe, resolução de problemas, capacidade de adaptação às novas tecnologias e novos cenários de mercado. Isso leva também a uma mudança na forma como os cursos são construídos, conduzidos e também nas formas de avaliação. No que tange às aulas, mudar o foco dos conteúdos para os projetos, nos laboratórios mudar o foco das aulas roteirizadas para aulas que favoreçam a experimentação. Se estamos acostumados a avaliar conhecimentos, precisamos agora ampliar a avaliação, abordando outros aspectos como a participação na elaboração e construção de projetos, a forma como os experimentos são conduzidos e a que conclusões levaram.

Palavras chave: Aprendizagem por Projetos, Avaliação; Competências; Currículos.

1 Introdução

Muitos desafios têm sido colocados às Universidades, que têm o propósito de formar os profissionais no século XXI. Sem prescindir dos conhecimentos técnicos necessários, outras competências são essenciais na formação, como leitura, escrita, comunicação oral, visão crítica.

As Universidades, de uma maneira geral, foram estruturadas como difusoras de conhecimentos e, por consequência, criou-se uma cultura de que as matrizes curriculares sejam focadas em conteúdos necessários a serem aprendidos pelos alunos. Porém esse modelo tradicional já não atende às exigências do mercado de trabalho no século XXI. Neste artigo pretende-se apresentar uma reflexão a respeito das razões que levaram a essa mudan.ca de foco, bem como apontar pistas para uma construção efetiva de currículos em cursos de Engenharia, e as implicações práticas em sala de aula e nos demais ambientes educacionais.

A discussão sobre esse modelo vem pelo menos de meados da década de 1990 (Camacho & Legare, 2016) apontando a necessidade de uma formação ampla, de cidadãos ativos e com sólida base de conhecimentos. Essa nova maneira de enxergar os cursos superiores trouxe uma série de consequências, inclusive na forma de elaborar os currículos, mudando o foco dos conteúdos para as competências, ou seja. ao invés de se preocupar com o que os alunos devem saber ao final do curso, o objetivo é estabelecer o que os alunos serão capazes de fazer com o conhecimento. Este é o conceito central de competência. O ensino baseado em competências é capaz de, ao mesmo tempo, desenvolver os conhecimentos e as competências sócio-emocionais necessários ao estudante que se prepara para a vida profissional (Camacho & Legare, 2016).

2 Contexto

No Brasil, as Diretrizes Curriculares Nacionais para os cursos de Engenharia trazem explicitamente a recomendação de que as matrizes curriculares sejam focadas em competências e não mais em conteúdos, apesar de ser ainda um processo em constante e calorosa discussão. No entanto, ainda há um longo caminho a percorrer, visto que a concepção de cursos e aulas ainda são elaboradas a partir de conteúdos. Professores e gestores. percebem que a educação deve ser um processo de construção baseado em desafios, sem tolher a criatividade, e que os métodos tradicionais de abordagem de conteúdos não garantem que o estudante consiga, ao final do curso, aplicar de forma correta os conhecimentos e se adaptar às constantes mudanças tecnológicas a que somos submetidos.

Esses mesmos gestores, coordenadores e professores não se adaptaram completamente à nova concepção, embora percebam a sua necessidade, e ainda buscam alternativas, algumas já bem sucedidas, de criar aulas, dinâmicas de trabalho (seja com alunos ou entre professores de diferentes áreas de conhecimento), desafios e processos avaliativos adequados a uma proposta pedagógica que cumpra os objetivos de formação profissional a que a universidade se propõe.

Algumas abordagens já desenvolvidas têm como objetivo mostrar caminhos para que uma proposta pedagógica consistente possa ser construída a partir das reflexões do corpo docente e dos gestores. Não há uma receita pronta e acabada, mas um processo ainda em construção.

O primeiro ponto de um planejamento é o estabelecimento de objetivos claros, que incluem o desenvolvimento de conteúdos e competências, bem como o grau de profundidade de aprendizado que deve ser atingido pelos estudantes buscando que a avaliação seja condizente com os objetivos e o grau de profundidade desejado (Boulton-Lewis, 1995)

O elemento essencial na construção de um currículo baseado em competências é a indicação clara dos objetivos de aprendizagem, que deve nascer das competências profissionais que se desejam desenvolver, em uma disciplina, unidade curricular ou mesmo no curso completo. A figura 1 abaixo ilustra a forma como é proposta uma abordagem baseada em competências traçando objetivos a partir de competências gerais

Figura 1: Construção de cursos ou disciplinas baseados em competências

Nessa forma de planejamento, os objetivos gerais (do curso ou da disciplina) formam o grande arco superior e leva em consideração os conhecimentos prévios dos alunos, que, via de regra, não são uniformes e únicos, mas devem ser compreendidos e tidos como referência para o desenvolvimento das sequências (ou etapas) a serem executadas. Uma vez estabelecidos os objetivos gerais, os objetivos intermediários são estudados de forma a construir a sequência para se atingir os objetivos finais, daí se organizar a sequência de etapas intermediárias (que podem variar em número, de acordo com os objetivos e o tempo necessários.

Uma vez que os objetivos ficam claros, essa abordagem traz mudanças não só na forma de elaborar currículos, mas, principalmente, na forma de conduzir o processo de ensino e aprendizagem, modificando a forma como as aulas são preparadas e ministradas, na condução das práticas em laboratórios e na aplicação do processo de avaliação (Annala & Makinen, 2011).

A questão: "o que os alunos devem ser capazes de fazer ao final do curso (ou disciplina)" está no centro da elaboração de um currículo baseado em competências. No caso específico dos cursos de Engenharia, as competências técnicas e profissionais, estabelecidas, no Brasil, pelas diretrizes curriculares, devem estar em consonância com as demandas do mercado de trabalho e as necessidades da sociedade.

2.1 Aulas

No modelo tradicional, as aulas são tidas como o "centro" das atividades das Universidades e precisam passar por um processo de profundas modificações se se pretende de fato construir um currículo por competências. Foco no aluno, uma expressão muito em voga, precisa ser concretizado de maneira verdadeira. A começar pelos espaços de aprendizagem, a sala de "aula", que precisa ser reelaborada, tirando o professor do "palco" e as cadeiras enfileiradas e alinhadas para um espaço de real construção de conhecimento, com maior participação e responsabilidade dos alunos. Além disso, o uso da tecnologia permite hoje que a aprendizagem aconteça de diversas formas e nos mais variados (Camacho, op cit)

Para isso, o professor precisa lançar mão de ferramentas metodológicas que permitam a interação, a reflexão e a construção do conhecimento de maneira significativa e que o aluno possa perceber seu crescimento e se responsabilize por sua aprendizagem.

Também deve-se considerar que a carga horária atribuída a uma unidade curricular não deve ser atribuída somente pela quantidade de horas dispendidas em sala de aula, mas levar em consideração uma estimativa da carga de trabalho que o aluno tem durante o curso. Isso pode incluir atividades *on line*, em projetos, desafios extra-curriculares, estudos em grupo ou individuais, o que amplia a visão de aprendizagem para além da sala de aula somente. Assim, a visão de muitos cursos, construídos sobre uma carga horária somente baseada em sala de aula deixa de ser relevante e também exige uma mudança de postura por parte das instituições de ensino, que precisam oferecer espaços alternativos de aprendizagem, como laboratórios, espaços abertos de atividades (do tipo "*fab labs*").

2.2 Laboratórios

Usualmente baseado em roteiro estabelecidos para que se chegue a um resultado previsto, os laboratórios não constituem hoje um modelo de experimentação. A bem da verdade, são ensaios para comprovar a teoria (considerada mais "importante") e não experiências.

Práticas de laboratório que permitam ao aluno, de fato, experimentar estimulam a pesquisa, o pensamento científico e a busca criativa de soluções mas podem, eventualmente, conduzir ao erro, que não deve ser entendido como algo negativo. O processo reflexivo das razões que levaram ao erro são muito mais eficientes para o aprendizado do que a mera repetição de procedimentos "seguros".

O desenvolvimento do raciocínio científico em todos os níveis, mas em particular no nível superior, aumentam no estudante a compreensão da ciência, dos conceitos científicos e de como esses conceitos são desenvolvidos e modelados. As práticas desafiadoras em laboratórios oferecem aos alunos essa oportunidade, além de desenvolver a capacidade de observação crítica e anal[itica (Edelson, Gordin, & Pea, 1999).

Problemas e perguntas abertas colocadas de maneira correta são muito mais desafiadoras e motivadoras do que a condução restritiva através de roteiros (Marques & Garcia, 2017). Os roteiros conduzem a um resultado pré estabelecido, que normalmente não faz muito sentido ao aluno, ao passo que questões abertas levam a um processo aberto (*open end*) que favorecem o aprendizado mais sólido dos conceitos científicos (Edelson, op cit.).

As oportunidades criadas nesse tipo de condução das aulas de laboratório são o desenvolvimento da observação, teorização, modelagem e construção de conceitos científicos. Neste ponto ressalta-se o papel do professor como o formulador das questões e auxiliando os alunos na elaboração das conclusões a partir dos fatos observados.

Na concepção curricular baseada em conteúdos, as aulas roteirizadas fazem sentido (ao professor, mas não necessariamente ao aluno) à medida em que os conteúdos são abordados, embora isso não signifique que o aluno, ao simplesmente ver o fenômeno acontecer, tenha de fato observado e compreendido adequadamente os conceitos e o método científico envolvidos naquele ensaio. Numa abordagem baseada em competências, os laboratórios são peças essenciais na construção das habilidades relacionadas à observação científica, compreensão de fenômenos, e na modelagem dos mesmos.

2.3 Avaliações

Avaliações são etapas essenciais num processo educativo e devem ser compreendidas como parte da aprendizagem (Fernandes, 2011). Alinhadas com os objetivos e que levem à reflexão (Biggs & Tang, Teaching for Quality Learning at University, 2011), as avaliações podem ser classificadas como sendo formativas ou somativas. Embora com papéis diferentes (avaliação da aprendizagem a primeira e para aprendizagem a segunda) essas avaliações se complementam e devem ser colocadas com o mesmo objetivo.

Somativas são avaliações de aprendizagem que compreendem as "medidas" de conhecimentos e competências e devem ser feitas em momentos de controle para que se tenha uma ideia do desempenho até aquele momento. Além de ser pontual, acontecendo num momento específico, a avaliação somativa é graduada pela atribuição de notas ou conceitos classificatórios. As provas e exames são exemplos de avaliações somativas, embora não sejam as únicas formas de se fazer esse tipo de avaliação.

As avaliações formativas, por outro lado, constituem momentos de avaliação para as aprendizagens e também de reflexão. Como afirmou Fernandes (2011, op. cit): "*A avaliação formativa está associada a todo o tipo de tomadas de decisão e de formas de regulação e de autorregulação que infuenciam de forma imediata os processos de ensino e aprendizagem*". Sob esta ótica, o estudante passa a ser corresponsável pela sua aprendizagem.

A figura 2 abaixo ilustra, dentro do planejamento do curso, os momentos de avaliações formativas e somativas. As avaliações formativas são um processo contínuo e distribuído ao longo do curso enquanto que as avaliações somativas são pontuais, em momentos pré determinados. Em ambos os casos, os processos de *feedback* são importantes no sentido de criar no aluno a sua autonomia e seu processo de auto-regulação.

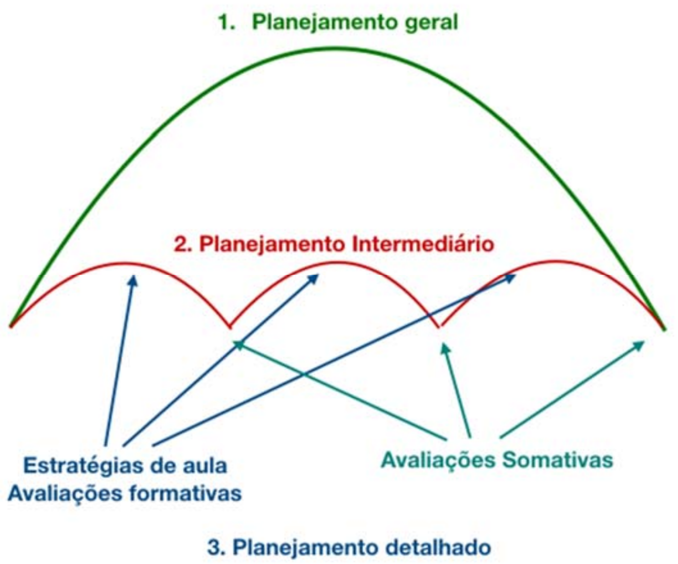

Figura 2: Momentos de avaliações somativas e formativas

Em um currículo baseado em competências saber avaliar, conhecer as avaliações, seus propósitos e as formas de aplicação é um fator determinante no sucesso de sua implantação (Watson, 1994). As estratégias são várias e devem buscar, juntamente com os objetivos, as evidências de aprendizagem, ou seja, o que o avaliador deve observar para emitir o julgamento de avaliação. Três aspectos básicos que devem ser observados no processo de avaliação:

1. Avaliação periódica e continuada. Momentos de controle durante o desenvolvimento do curso, através de testes, simulações ou descrições.

2. Auto avaliação. Pode ser aplicada tanto individualmente quanto ao grupo e em vários momentos, com quesitos objetivos que promovem a reflexão e a auto-regulação por parte do estudante.
3. Avaliação final. Que deve ser o mais objetiva possível, levando em conta os objetivos pré-estabelecidos (e que devem ficar claros aos alunos desde o início do processo).

Assim, as avaliações formativas e somativas entrelaçam-se e complementam-se. Organizar o procedimento avaliativo é uma tarefa complexa, que envolve várias particularidades e é um fator que não pode ser desprezado nem colocado em segundo plano.

3 A abordagem por projetos

Desde que estejam colocados de forma a ajudar a atingir os objetivos de aprendizagem, os projetos são uma forma muito motivadora de aprendizado. Esses projetos, no entanto, devem cumprir uma tarefa além da motivação. Os projetos, quando inseridos na perspectiva da aprendizagem, concatenados aos objetivos do curso ou do semestre são um complemento importante na construção do conhecimento, através de problemas interdisciplinares, que relacionam conteúdos e conceitos já desenvolvidos ou ainda em desenvolvimento, e contribuem no fortalecimento de competências de gestão de projetos e pessoas, organização do tempo e de tarefas, análise crítica dos problemas, estimulando a criatividade na busca de soluções.

O acompanhamento e avaliação constante dos projetos durante sua execução, a inserção de habilidades relacionadas à gestão de projetos são formas de garantir os conhecimentos e as competências necessárias ao profissional do século XXI. À medida que os projetos vão se sucedendo, novas ferramentas de acompanhamento e gestão devem ser apresentadas aos alunos, como organização de tarefas, cronogramas, controle e checagem da execução.

Como normalmente os projetos são executados em grupos, a avaliação deve lançar mão de diversos instrumentos, como diário de bordo (forma de acompanhamento contínuo do processo), apresentação de *banners,* seminários e relatórios, avaliação por pares. Isso garante uma avaliação contínua e permite correções de rota ao longo do processo.

Na abordagem por competências professor exerce o papel de orientador e também de gestor do projeto. O professor executa um monitoramento permanente, analisando os progressos de cada projeto, apontando problemas, orientando as equipes na divisão e execução das tarefas relacionadas ao projeto, identificando potenciais problemas individuais ou do grupo, e conduzindo os alunos a estudos de conteúdos relacionados ao projeto (que podem ser aulas expositivas, leituras ou mesmo exercícios complementares), apoiando a efetiva comunicação dos alunos, seja nas apresentações ou em relatórios (Van Hattum-Hansen, 2012)

4 Conclusões

Mudar o foco de conteúdo para foco em competências não é uma tarefa fácil, a ser resolvida burocraticamente, e é uma exigência de um mercado de trabalho dinâmico, competitivo e que demanda posturas ativas e inovadoras, que requer da universidade uma ação de transformação da educação, em particular no que se refere aos cursos de engenharia, a ponta de lança da transformação tecnológica. Exige, portanto, uma mudança na postura docente e administrativa. Aulas, laboratórios, projetos, avaliações e a própria estrutura física da Universidade devem ser reelaborados, o que inclui um novo olhar sobre os próprios espaços físicos de aprendizagem.

Essa mudança também implica na centralidade no estudante, o que normalmente é difícil de ser compreendido pelos professores, que têm um papel diferente, mas crucial nesse processo. Ao mesmo tempo que o professor deixa de ser o centro das atenções na sala de aula, a sua atuação demanda novas competências mas não deixa de ser fundamental, uma vez que, pelo excesso de informação, o professor passa a ser o referencial da condução do processo educativo. No planejamento e definição dos objetivos, na orientação de atividades didáticas, sejam elas atividades *on line*, projetos, desafios, experimentos ou mesmo aulas expositivas (que não deixarão de existir por completo, mas terão um outro papel no processo educativo), o professor continuará sendo uma peça essencial na educação. Mas esse papel precisa ser melhor definido e uma orientação ao professor é mais do que necessária, visto que todos nós (os autores incluem-se nesse perfil) fomos formados no modelo tradicional (BIGGS & TANG, 2011).

Também o planejamento de aulas, disciplinas e cursos não mais fica restrito a um professor especialista numa única disciplina que trabalha isoladamente, mas passa a ser um trabalho interdisciplinar e deve contemplar várias atividades como projetos focados em soluções de problemas reais, experimentação para o desenvolvimento de conceitos básicos, desafios, competições.

Toda essa transformação remete também a uma revisão de conceitos. A aula passa a ser vista de maneira muito mais ampla do que a exposição do professor, tornando o aluno muito mais ativo, responsável e participante. As aulas também não se restringem aos momentos de encontro entre professor e alunos e precisam ser compreendidas como o espaço de tempo necessário para se aprender uma unidade curricular ou um tópico de uma disciplina.

A aprendizagem passa a ser medida (avaliada) por vários ângulos, em um processo contínuo e dirigido pelos objetivos de aprendizagem e não focado na reprodução de conceitos e procedimentos memorizados.

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STEM Topics: a course to teach mathematics functions in a contextualized way

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Abstract

This paper reports an active learning experience held in an introductory course of the STEM programs at University of Caxias do Sul. This introductory course, named STEM Topics, is new in the curriculum, in substitution of the Pre-Calculus course, and has as main objectives to reduce evasion, to improve students' performance and help students to develop skills. The classes' methodology was based mainly in the use of case studies, flipped classroom and expository and interactive instruction, along with a semester-long project. Linear, quadratic, logarithm, exponential and trigonometric functions were studied, applying Chemistry and Physics problems, such as nuclear decay, KCl solubility, projectile motion, in order to teach Mathematics in a contextualized scenario so the students could understand the importance of these functions in Science and Technology. The course was offered to four groups, totalizing 257 students. The data collected from midterm and final tests indicate that improvements in the understanding of the applications of Mathematics was made. Data collected during the semester also show that students take a more active role in the learning process when the flipped classroom approach is applied. The results do not show an increase in the number of approbations in the course, however it does show a decrease in the number of dropouts, which may indicate that the course is more attractive to students. The verbalizations about the course's methodology show that most students understand the advantage of an active learning environment where they learn Mathematics while applying it to Physics and Chemistry problems. Observations in the classroom showed that students who had previously made the expected activities had the best overall performance. Further comparisons among students, in a subsequent course, indicate that the methodology adopted for this course improved procedural and attitudinal learning for those who took it in contrast with those in the old curriculum.

Keywords: Active Learning; Mathematics Functions; Case Study; Flipped Classroom; STEM Education; Pre-Calculus.

Tópicos de Ciências Exatas: uma disciplina para ensinar e aprender funções matemáticas de forma contextualizada

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Resumo

Este artigo relata uma experiência de aprendizagem ativa aplicada em uma disciplina introdutória dos cursos de Ciências Exatas, Engenharias e Tecnologias da Universidade de Caxias do Sul (UCS). Esta disciplina introdutória, chamada de Tópicos de Ciências Exatas é nova no currículo, em substituição ao tradicional curso de Pré-Cálculo, e tem como objetivo reduzir a evasão, melhorar o desempenho dos estudantes e auxiliar os estudantes a desenvolver habilidades. A metodologia da disciplina foi baseada principalmente em casos de ensino, sala de aula invertida e aula expositiva dialogada, juntamente com um projeto desenvolvido ao longo do semestre. Foram estudadas funções lineares, quadráticas, logarítmicas, exponenciais e trigonométricas, aplicando problemas de Química e Física, tais como decaimento radioativo, solubilidade de KCl, lançamento de projéteis, a fim de ensinar Matemática em um cenário contextualizado de modo que os estudantes compreendam a importância destas funções nas diferentes áreas da Ciência e da Tecnologia. A disciplina foi oferecida para quatro turmas, totalizando 257 estudantes. Dados coletados nas avaliações indicaram que houve melhora significativa no entendimento das aplicações da Matemática. Dados coletados ao longo do semestre também mostraram que estudantes adquirem uma atitude mais pró-ativa no seu processo de aprendizagem quando a sala de aula invertida é aplicada. Os resultados não mostram um aumento no número de aprovações na disciplina, entretanto mostra um decréscimo no número de desistências, o que pode indicar que a disciplina é mais atraente para os estudantes. Conversas com os estudantes a respeito da metodologia utilizada na disciplina mostrou que a maioria compreende as vantagens de um ambiente de aprendizagem ativa onde eles aprendem Matemática enquanto a aplicam em problemas de Física e Química. Observações e dados mostraram que os estudantes que fizeram previamente as atividades esperadas tiveram os melhores desempenhos de maneira geral. Comparações posteriores entre os estudantes, em uma disciplina subsequente, indicaram que a metodologia adotada para esta disciplina teve um impacto positivo nos processos de aprendizagem e atitude naqueles estudantes que a cursaram em comparação aos estudantes do currículo antigo.

Palavras-Chave: Aprendizagem Ativa; Funções Matemáticas; Casos de Ensino; Sala de Aula Invertida, Educação STEM, Pré-Cálculo.

1 Introdução

Nos cursos de Ciências Exatas, Tecnologias e Engenharias, é possível identificar, com base na análise de rendimento nas avaliações, no número de reprovações, nas taxas de evasão e na aplicação de avaliações diagnósticas, um grande número de estudantes com dificuldades em matemática básica. Essas dificuldades prejudicam o aproveitamento em outras disciplinas, o que justifica a relevância de pesquisar sobre questões relacionadas aos processos de ensino e aprendizagem de Matemática nos estágios iniciais desses cursos (Armstrong & Croft, 1999; Soares, Lima, & Sauer, 2004; Araújo et al., 2007; Gill, O'Donoghue, Faulkner, & Hannigan, 2010; Carr, Bowe, & Fhloinn, 2013; Carr et al., 2014; Nite et al., 2015; Boff, 2017; Boff et al., 2017).

No caso específico das Engenharias, as Diretrizes Curriculares Nacionais ainda vigentes para esses cursos (BRASIL, 2002), bem como o INOVA Engenharia (CNI, 2006) e o Relatório 'Erguendo-se acima da Tempestade' emitido pelo Comitê em Prosperidade na Economia Global (CPGE, 2007), propõem que futuros engenheiros estejam aptos a conceber, projetar, analisar sistemas, produtos e processos; planejar, supervisionar, conduzir experimentos, interpretar resultados, atuar em equipes multidisciplinares, comunicar-se eficientemente, avaliar a viabilidade econômica de projetos e o impacto de atividades da Engenharia no contexto social e ambiental.

Professores, em geral, precisam considerar ações pedagógicas inovadoras no ambiente escolar, concebendo e implementando novas propostas para os processos de ensinar e de aprender. Segundo Booth e Villas-Boas (2014), ensinar em muitas instituições de ensino é ainda sinônimo de apresentação de informações. Nesse tipo de concepção, a ação do professor está focada na exposição de conteúdos, e os estudantes são ouvintes dessas informações. Nesse sentido, é importante no cenário atual, fundamentar estudos e ações para possibilitar a mudança desse paradigma.

Diante dessas necessidades, que estratégias e métodos possuem potencial para desenvolver habilidades requeridas para os futuros engenheiros e profissionais das ciências exatas? Que aspectos da mediação necessitam estar presentes em ambientes de aprendizagem quando o foco for a ocorrência de uma aprendizagem significativa?

Processos de ensino e de aprendizagem, coerentes com esta tendência, necessitam estar focados cada vez mais em ações dos estudantes diante de situações que favoreçam a interação, a colaboração, a troca de conhecimentos e o desenvolvimento de aprendizagens significativas (Ausubel, 2012). Estratégias e métodos de aprendizagem ativa que possibilitem ao estudante construir conhecimentos novos, bem como competências, para lidar de forma adequada com a realidade, parece ser um caminho viável.

Neste artigo, relatamos uma experiência de aprendizagem ativa bem-sucedida aplicada a uma disciplina introdutória dos cursos de Ciências exatas, Engenharias e Tecnologias (STEM, no inglês) na Universidade de Caxias do Sul (UCS), no primeiro semestre de 2018. Esta disciplina introdutória, chamada de Tópicos de Ciências Exatas, é nova no currículo, em substituição ao tradicional curso de Pré-Cálculo, e tem como objetivo principal reduzir a evasão, melhorar o desempenho dos estudantes e auxiliar os estudantes a desenvolver habilidades importantes que irão ajudá-los durante seu curso de graduação e sua vida profissional (Herreid, 1997).

A metodologia das aulas foi baseada principalmente na utilização de estratégias e métodos de aprendizagem ativa, tais como sala de aula invertida, casos de ensino, aula expositiva dialogada, juntamente com um projeto desenvolvido ao longo do semestre. A disciplina de Pré-Cálculo utilizava apenas a metodologia tradicional de aprendizagem para ensinar as funções matemáticas, sem contextualização.

2 Descrição do programa da disciplina

As aulas aconteceram em uma sala de aula especialmente montada para a disciplina (Figura 1), designada para receber 90 estudantes de maneira confortável, com mesas que se encaixam na forma de hexágono, muitos quadros brancos ao longo de três paredes, dois sistemas de reprodução de vídeo e um sistema de reprodução de áudio com caixas de som espalhadas pela sala, e microfones para os professores. O curso foi planejado por um grupo de oito professores, e ministrado por três professores juntos em sala de aula para cada turma, ensinando Matemática, Química e Física. Ao todo a disciplina foi ministrada para 257 estudantes, dos quais, 181 no campus de Caxias do Sul e o restante no campus de Bento Gonçalves.

As funções estudadas na disciplina foram as seguintes: função linear, quadrática, logarítmica, exponencial e trigonométrica, divididas em três áreas. Na primeira área foram apresentadas as funções lineares e quadráticas, na segunda área as funções exponenciais e logarítmicas, e na terceira as funções trigonométricas e o projeto final da disciplina. Ao final da primeira e da segunda área, os estudantes foram submetidos a uma avaliação individual tradicional a fim de aplicar o que aprenderam. A nota final foi calculada por média harmônica a partir de três notas: duas provas individuais e uma nota composta do projeto final e mais as tarefas realizadas ao longo do semestre.

Durante o semestre, uma estratégia e um método de aprendizagem ativa foram escolhidos para pautar a disciplina: sala de aula invertida e casos de ensino. A abordagem pedagógica da sala de aula invertida, onde os estudantes tiveram de realizar atividades de aprendizagem em casa, foi utilizada na forma de tarefas diversas no momento pré-aula e compuseram parte da nota final. Estas atividades eram compostas de leitura de um texto, apropriação de conteúdo assistindo um vídeo, realização de uma simulação computacional ou exercícios, etc. Após a realização, o estudante deveria postar no ambiente virtual uma produção associada, que consistia em um resultado, uma análise, um pequeno parecer, um ou mais gráficos, dependendo do tipo de atividade pedida. Todas as atividades foram posteriormente conferidas pelos professores e analisadas, discutidas ou diretamente utilizadas em sala de aula, seja como introdução, pré-requisito para as atividades de aula, fechamento de algo que foi visto em sala de aula, ou somente como uma atividade extra para melhor entendimento dos conceitos abordados.

Foram utilizados problemas de Química e de Física para aplicação da matemática estudada, na forma de casos de ensino e exemplos de aplicações de exercícios em cenários contextualizados, de maneira que os estudantes pudessem compreender a importância do entendimento dessas funções em Ciência e Tecnologia, uma vez que artigos anteriores têm mostrado que estes métodos promovem o pensamento crítico e maior engajamento por parte dos estudantes (Herreid & Schiller, 2013).

Figura 1. A sala de aula onde a disciplina é ministrada em Caxias do Sul, na Universidade de Caxias do Sul (UCS), Brasil.

Em diferentes momentos da disciplina houve a necessidade de intervenções tradicionais entre os diferentes conteúdos, e nestas situações a aula expositiva dialogada, com métodos interativos de perguntas e respostas, com paradas para resolução de exercícios, foi utilizada em blocos de 20 a 40 minutos. Após o período da aula expositiva, os estudantes realizavam uma série de exercícios e problemas de Física e Química, onde aplicavam o conhecimento de funções e tiravam dúvidas. Os três professores ficavam à disposição dos estudantes para responder as dúvidas, recapitular conceitos mal compreendidos e ajudar na compreensão dos problemas apresentados, e frequentemente, boa parte dos estudantes utilizavam o tempo de modo produtivo.

2.1 Primeira parte da disciplina: função linear e quadrática

Na primeira aula foi realizada a apresentação geral da disciplina, professores, estratégias e métodos de aprendizagem que seriam utilizados, e conceitos de matemática básica e operações elementares, enfatizando na relação entre variável dependente e independente. Ao final da aula, os estudantes receberam atividades de revisão de matemática básica para fazer em casa.

O primeiro caso de ensino foi apresentado na segunda aula, e consistia de um problema de Química de solubilidade de sais, mais especificamente o cloreto de potássio, KCl, intitulado de “A indústria dos fertilizantes e a solubilidade de sais”. Os estudantes se dirigiram para o laboratório após terem realizado a leitura de procedimentos de segurança e de itens básicos que consistem um laboratório de Química, e realizaram as medidas de temperatura em que ocorrem a formação de sais para diferentes concentrações de cloreto de sódio, KCl, em 100ml de água. Após a coleta dos dados, os estudantes realizaram a análise dos mesmos em sala de aula, em grupos de até 6 estudantes, com a finalidade de produzir um gráfico a partir dos pontos gerados.

Tabela 1. Resultados esperados de coleta para o primeiro estudo de caso: Solubilidade do KCl.

Massa KCl (g)	Temperatura (°C)
3,00	6,5
3,25	15
3,50	23
3,75	31
4,00	40

Com este gráfico em mãos, os estudantes responderam algumas questões presentes no roteiro, sendo a questão final a seguinte: ”Qual é a solubilidade média do cloreto de potássio entre 5°C e 15°C? Como essas baixas temperaturas podem afetar no propósito da adubação?”. Para responder tal questão os estudantes tiveram que encontrar o modelo matemático que melhor descreve o comportamento da solubilidade deste sal em função da temperatura. Uma vez que os estudantes identificaram o gráfico (o modelo) como sendo o de uma reta, os professores instruíram os grupos como proceder para encontrar a equação desta função de primeiro grau (Figura 2).

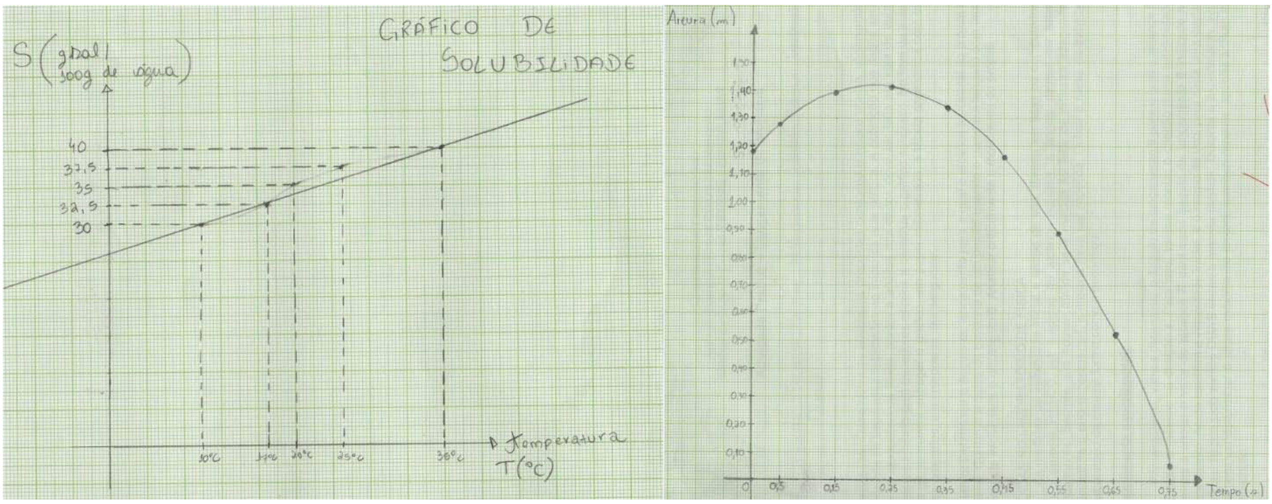

Figura 2. Gráficos produzidos a partir de dados experimentais por estudantes de uma das turmas da disciplina, do campus de Caxias do Sul, para modelar casos de ensino para estudo de funções de primeiro grau (gráfico da esquerda) e funções de segundo grau (gráfico da direita).

O segundo caso de ensino apresentado foi de um problema de Física, envolvendo o lançamento de projéteis, abordando as funções quadráticas, além de conceitos fundamentais da Física. A abordagem da sala de aula invertida foi utilizada previamente à aula de laboratório (momento pré-aula), com o objetivo de que os alunos realizassem uma apropriação (ou revisão) de conceitos básicos referentes às funções quadráticas, após a realização de testes virtuais de um experimento de lançamento de projéteis. A primeira parte da atividade consistiu em uma atividade de simulação computacional para lançamento de projéteis, utilizando para tanto a plataforma PHET Colorado (https://phet.colorado.edu/en/simulation/projectile-motion), onde é possível lançar diversos objetos com um canhão, analisar o alcance, as velocidades, os efeitos da resistência do ar, enquanto modifica parâmetros como a inclinação, velocidade inicial e altura de lançamento. O objetivo era que o estudante fizesse a comparação de resultados obtidos na simulação com resultados posteriormente alcançados em laboratório. Na segunda parte, havia a forte sugestão para que os estudantes assistissem as seguintes vídeo-aulas, da plataforma Youtube listadas a seguir, com o objetivo de apropriação de conceitos básicos referentes às funções quadráticas: 1. Funções – Introdução às funções de 2º grau – Duração: 7min25s (https://www.youtube.com/watch?v=lTWCZkJtSpw); 2. Funções – Resumo dos coeficientes da função de 2º grau – Duração: 7min18s (https://www.youtube.com/watch?v=NO78s8nosZI); 3. Funções – Delta, Bhaskara – Raízes da parábola passo a passo – Duração: 7min07s (https://www.youtube.com/watch?v=LodMxZZXg9w); 4. Funções – como encontrar o vértice da parábola? Duração: 5min34s (https://www.youtube.com/watch?v=0mS5AqRrhxY); 5. Funções – como esboçar uma parábola - Duração: 7min26s (https://www.youtube.com/watch?v=Wg-KGKeiQOY). Para a realização desta atividade foi dado o prazo de duas semanas, de maneira que os estudantes possuíam uma aula presencial entre o início e fim da atividade a fim de tirar dúvidas.

A aula presencial iniciava com uma atividade sugerida em um artigo (Mossmann & Villas-Boas, 2012), onde os estudantes assistiram um trecho do filme "Seis Dias, Sete Noites" (https://www.youtube.com/watch?v=DXCZKglGP68) dando início a uma discussão com o intuito de detectar a veracidade da cena presente no fragmento do filme apresentado em sala, cuja conclusão se daria no final da aula. Entre os objetivos propostos, estavam a análise da independência dos movimentos horizontal e vertical, as grandezas físicas envolvidas e a análise da veracidade levando em consideração as leis físicas envolvidas no lançamento de projéteis (Mossmann & Villas-Boas, 2012).

Depois desta discussão inicial, os alunos foram para o laboratório de Física, com o objetivo de observar o movimento de projéteis, com a introdução dos conceitos de velocidade e aceleração, e coletar alguns dados de lançamentos. Os estudantes analisaram para qual ângulo de lançamento o projétil, uma pequena esfera metálica sólida, teve o alcance máximo, sendo os ângulos analisados 0, 30°, 45° e 60°, e compararam com os resultados da simulação computacional. Para fazer a análise correta eles deveriam observar que a simulação foi realizada com altura inicial zero em relação ao solo, enquanto no laboratório as medidas foram realizadas a partir de uma bancada que possui aproximadamente 1,18m. Os dados para construção de um gráfico de uma parábola foram dados dentro do roteiro, pois no experimento de lançamento não era possível obter os dados necessários para tal. Os estudantes deveriam ser capazes de encontrar a equação de segundo grau que descreve a relação entre a posição vertical ao longo do tempo do projétil com os dados disponibilizados a partir de uma análise dos parâmetros juntamente com um sistema de duas variáveis (Figura 2). Além disso, deveriam observar o movimento do projétil como um todo, a fim de responder à questão levantada no início da aula sobre a veracidade do fragmento do filme.

A maioria dos grupos foi capaz de realizar toda a atividade no período de 2h50min (tempo total de aula) e entregar os resultados das atividades no final da aula, incluindo a finalização da discussão sobre a veracidade da cena do filme.

2.2 Segunda parte da disciplina: função logarítmica e exponencial

Após a primeira avaliação parcial, o assunto trabalhado foi de função exponencial através de um caso de ensino intitulado "Radioatividade na indústria". A primeira parte consistia em uma atividade de sala de aula invertida (momento pré-aula), utilizando a plataforma Khan Academy (https://pt.khanacademy.org) a fim de revisar a função exponencial, onde os estudantes analisaram suas propriedades principais, interpretando o gráfico de funções exponenciais básicas, e aprenderam a identificar regularidades no crescimento exponencial, distinguindo crescimento exponencial de crescimento linear.

Os estudantes foram previamente avisados da necessidade de levar pelo menos um computador portátil para cada grupo de até 6 componentes, para realização de uma atividade computacional em sala de aula. Eles deveriam resolver um problema de radioatividade na indústria, onde uma siderúrgica que utiliza fontes seladas de cobalto-60 no controle de nível de aço líquido nos sistemas de lingotamento contínuo, precisaria substituir a fonte quando a mesma atingir 3,125% de sua atividade inicial. Sabendo a meia-vida do cobalto, os estudantes precisavam construir uma tabela descrevendo a atividade do cobalto-60 do momento em que a fonte foi instalada até o momento de sua troca, representando esse processo em um gráfico da atividade ao longo do tempo, e responder qual seria a porcentagem de atividade após um ano de funcionamento da siderúrgica. Os estudantes exploraram o problema através de um aplicativo do PHET Colorado (https://phet.colorado.edu/pt_BR/simulation/legacy/radioactive-dating-game) chamado de Jogo da Datação Radioativa, onde deveriam datar diferentes objetos utilizando alguns isótopos através de um gráfico mostrado no próprio jogo, e através da equação fornecida no roteiro.

O roteiro para trabalhar as funções logarítmicas seguiu uma lógica semelhante, utilizando a sala de aula invertida, e aplicação do caso de ensino no momento aula, com a diferença que houve uma aula de exercícios entre um momento e outro. Os estudantes tiveram que estudar a respeito do pH previamente à aula de apresentação da função logarítmica seguida de exercícios, definindo pH e apresentando um breve histórico no desenvolvimento deste conceito, relacionando pH de uma substância à escala utilizada atualmente, para apresentar a relação matemática que define o cálculo de pH de uma substância.

O caso de ensino utilizado para trabalhar com as funções logarítmicas foi o uso de soluções ácidas na limpeza e conservação de concreto. Em aula, os estudantes receberam um roteiro onde analisaram dados obtidos a partir de uma titulação de uma alíquota do ácido muriático com hidróxido de sódio na concentração de 1 mol/L. A partir destas informações, calcularam o pH para cada concentração, em seguida construindo um gráfico do pH em função do volume de NaOH utilizado, conforme é possível observar na Figura 3. A atividade tinha como objetivos promover o entendimento de relações logarítmicas e seus gráficos, chegar no modelo matemático, o entendimento de alguns conceitos da Química, tal como neutralização, ponto de equivalência, etc, fazer análises críticas a respeito de procedimentos de limpeza da superfície de concreto. Por fim, os estudantes analisaram um gráfico inverso, da concentração em função do pH, e fizeram a análise do mesmo, aprendendo a relação entre as funções exponenciais e logarítmicas.

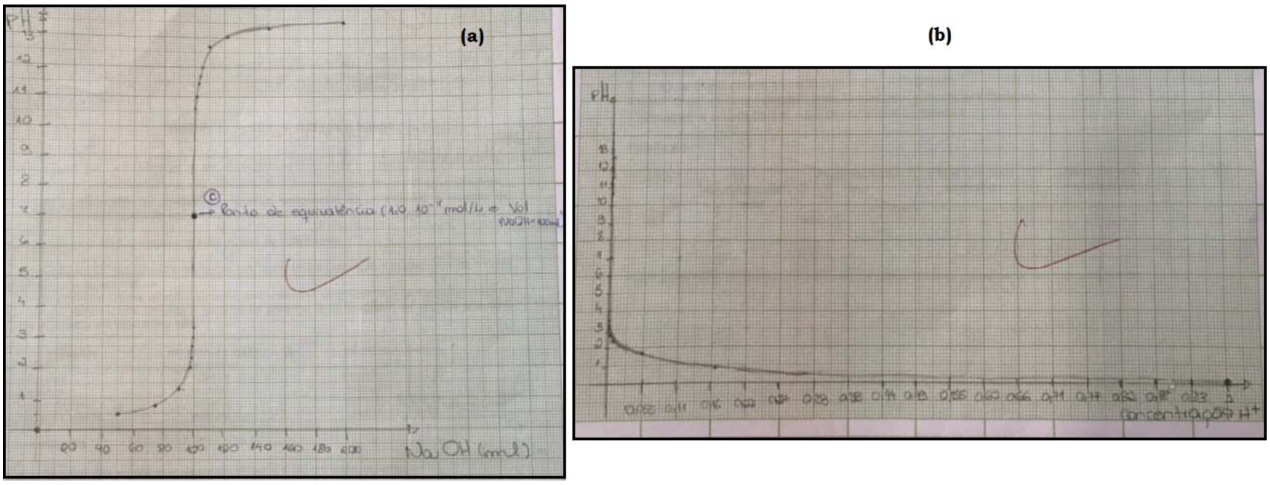

Figura 3. Gráficos produzidos por estudantes na atividade de pH. (a) Gráfico do pH em função do volume de NaOH; (b) Gráfico do pH em função da concentração de H^+.

2.3 Terceira parte da disciplina: funções trigonométricas e projeto final

As funções trigonométricas foram trabalhadas ao longo de três semanas, principalmente através de aulas expositivas dialogadas, iniciando com a sala de aula invertida e utilizando a plataforma Khan Academy (https://pt.khanacademy.org) para revisão das razões trigonométricas no triângulo retângulo, e aplicação das definições de seno, cosseno e tangente de um ângulo agudo para calcular medidas desconhecidas no triângulo retângulo no momento pré-aula. No momento aula, estes conceitos foram revisados a fim de conferir a apropriação por parte dos estudantes, e a partir desta construção, desenvolver o ciclo trigonométrico ou circunferência trigonométrica, as definições de ângulo, unidades de medidas, relações com coordenadas retangulares, mesclando as aulas expositivas dialogadas com a resolução de exercícios.

Ao longo do semestre foi apresentado um projeto para os estudantes, onde o objetivo final era a construção e lançamento de um foguete utilizando garrafa PET para a ogiva, que alcançasse a maior distância possível com o voo mais estável possível. Os estudantes poderiam se reunir em grupos de até 5 estudantes, e deveriam obedecer certos prazos para entrega de relatórios. O projeto foi apresentado em quatro fases:

1. Primeira fase: Formação de equipes, entrega de um relatório contendo introdução com motivação para o tipo de foguete escolhido pelo grupo, projeto para o mesmo e fundamentação teórica.
2. Segunda fase: Construção do foguete e bancada de lançamento, registro e entrega de um diário de bordo sobre os processos de construção.
3. Terceira fase: Entrega de um relatório contendo os eventuais ajustes realizados nos foguetes e bancadas, lançamento com coleta de dados, produção de vídeos do lançamento, análise dos dados e aplicação de cálculos com geração de gráficos.
4. Quarta fase: Produção de uma apresentação final que será realizada para a turma.

Figura 4. Resultados de um grupo da disciplina, (a) de parte da primeira fase, onde era necessário apresentar o projeto do foguete; (b) de parte da segunda fase, da construção da base e do foguete; (c) e parte da terceira fase, gerando gráficos a partir de dados de lançamentos. As datas e formas de apresentação mudaram de uma turma para outra, especialmente se comparamos entre os diferentes campuses, porém a estrutura geral foi muito similar. Na Tabela 2 é possível ver as datas aplicadas em uma das turmas do campus de Caxias do Sul.

Tabela 2. Projeto Foguete: "To infinity and beyond!" – Datas aplicadas em uma das turmas do campus de Caxias do Sul.

Data de início	Data para entregar	Atividade
24-05-2018	14-06-2018	Apresentação do projeto, cronograma e orientações para a primeira parte.
14-06-2018	21-06-2018	Orientações para a segunda parte.
21-06-2018	28-06-2018	Orientações para a terceira parte.
28-06-2018	05-07-2018	Orientações para apresentação.
05-07-2018		Apresentações finais dos resultados.

Mais de 80% dos estudantes se engajaram no projeto, em sua maioria relataram que gostaram de trabalhar no mesmo e aprenderam onde aplicar conceitos estudados, gerando trabalhos com qualidade superior ao usualmente visto em estudantes de primeiro semestre.

3 Análise de dados

Dados coletados a partir de testes realizados ao longo do semestre indicam que houveram melhorias no entendimento das aplicações da Matemática nas Ciências Exatas, indicando também que os estudantes tiveram papeis mais ativos no processo de aprendizagem quando os métodos de aprendizagem ativa foram aplicados. No entanto, os resultados não mostraram aumento no número de aprovações no curso, quando comparado com a disciplina de Pré-Cálculo. Contudo, mostraram que o número de cancelamentos e desistências diminuiu, indicando que esta disciplina se mostrou mais atraente para os estudantes. A verbalização a respeito da metodologia da disciplina mostrou que a maioria dos estudantes entendem a vantagem de um ambiente de aprendizagem ativa onde aprendem Matemática enquanto aplicam em problemas de Física e Química. A análise dos dados de desempenho dos estudantes também mostra que os estudantes que realizaram as atividades do momento pré-aula da sala de aula invertida tiveram as melhores notas na disciplina, e de maneira geral, que, embora, a realização das atividades não tenha garantido aprovação, a não-realização das atividades indica fortemente a reprovação.

No final da disciplina, foi aplicado um teste de percepção da disciplina, onde os estudantes responderam um questionário utilizando o 'Google Forms', a respeito das estratégias e dos métodos utilizados ao longo do semestre. Foi possível observar que muitos estudantes ainda possuem resistência quanto à adoção de novos métodos. No entanto, a percepção de acima de 60% dos estudantes que responderam ao questionário foi bastante positiva, enfatizando como crítica o grande número de alunos em sala de aula nas turmas que possuíam mais de 60 estudantes.

Na comparação desta disciplina com a equivalente anterior (a disciplina de Pré-Cálculo), existe a percepção subjetiva que o número de cancelamentos foi menor (este dado não foi disponibilizado para confirmar a percepção), sendo de somente 5% do total de matriculados inicialmente, e objetivamente é possível ver na tabela, a seguir, que o número de reprovados por nota ou por falta é relativamente menor do que dos últimos 6 anos, apesar da diferença não ser estatisticamente relevante.

Tabela 2. Desempenho dos alunos de Pré-Cálculo versus alunos de Tópicos (2018).

Ano	Reprovação por falta e conceito	Aprovados
2011	44,2%	55,8%
2012	46,3%	53,7%
2013	51,7%	48,3%
2014	49,2%	50,8%
2015	47,4%	52,6%
2016	52,1%	47,9%
2018 (TCE)	44,3%	55,7%

Foram coletados dados de engajamento nas atividades de TDEs, utilizando as notas e entregas dos mesmos, e notas finais de uma disciplina subsequente, Dinâmica Translacional e Rotacional, comparando estudantes que completaram a disciplina de Tópicos de Ciências Exatas, com estudantes que não fizeram previamente esta disciplina. Os resultados indicam que estudantes que completaram previamente a disciplina baseada em estratégias e métodos de aprendizagem ativa se engajam mais e com mais qualidades nas atividades extraclasses, obtendo assim melhores resultados de aprovação. Entre os estudantes que previamente completaram Tópicos, 21,6% reprovaram em Dinâmica, enquanto que dentre os alunos que não completaram Tópicos previamente, 36,1% reprovaram em Dinâmica. O número de cancelamentos e desistências está em torno de 6,5%, e reprovações totais, em 25%, que são índices menores do que os índices da disciplina de Mecânica Newtoniana, do currículo anterior, cuja média de reprovações e desistências era maior do que 50%.

Os índices de aprovação na disciplina estão diretamente relacionados com o engajamento dos estudantes nas atividades extraclasses, com forte relação entre a aprovação e o engajamento. Os estudantes que não se engajam nas atividades, reprovam na disciplina, enquanto que os estudantes que se engajam em todas ou quase todas atividades são em sua grande maioria aprovados (índices maiores do que 90%).

4 Considerações Finais

As observações em sala de aula e a análise das notas mostraram que os estudantes que fizeram as atividades esperadas do momento pré-aula da sala de aula invertida tiveram o melhor desempenho geral, não apenas em resultado numérico, mas principalmente comportamental. Comparações realizadas no semestre seguinte ao da realização do curso, com o resultado de uma disciplina subsequente, mostraram que a metodologia adotada melhora o engajamento dos estudantes no processo de aprendizagem em contraste com os estudantes do currículo antigo, que não possui esta disciplina. Este estudo não é uma análise completa do fenômeno analisado, mas, com os resultados obtidos, foi possível evidenciar que a metodologia traçada para esta nova disciplina possui potencial para promover aprendizagens significativas, diminuir a evasão e aumentar os índices de retenção.

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The Teaching of Mechanical Energy Conservation Mediated by the Use of Active Learning Methodologies

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Abstract

For many reasons, being a teacher, especially in sciences and technology one, has become a major challenge in the last few decades. The increasing devaluation of teaching as a profession in Brazil, the lack of incentive and funding for experimental classes, and the growing demotivation of students make teaching more difficult in this area. The present paper presents an alternative for teaching Mechanical Energy and its conservation. The planning and development of the lessons are guided by the Theory of Meaningful Learning of David Ausubel and involves the construction of a Potentially Meaningful Material by the students, as a way to instigate them and make rise the interest and motivation to learn this subject, in particular, and Physics, in general. The classes were elaborated and implemented in a 1st-year high school class at SESI High School Albino Marques Gomes, located at Gravataí, Rio Grande do Sul, Brazil. The students were encouraged to build soap box cars and, based on their use, to investigate the mechanical energy present in their movement and the conservation of this energy during the cars descent movement; such analysis was done using the video analysis software Tracker. With the application of this didactic sequence, good results were obtained, as well as an observed evolution in students' learning of energy concepts, as well as their engagement and their involvement during the realization of the project. From the analysis of the results, it is understood that the teaching proposal to be presented has great potential to promote Meaningful Learning.

Keywords: Active Learning; Teaching of Mechanical Energy Conservation; Meaningful Learning.

O Ensino da Conservação de Energia Mecânica Mediada pelo Uso de Metodologias Ativas de Aprendizagem

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Resumo

Por diversas razões, ser professor, especialmente de física, tornou-se um grande desafio nas últimas décadas no Brasil. A crescente desvalorização da profissão docente no Brasil, a falta de incentivos e de financiamentos para execução de atividades práticas de boa qualidade e a crescente desmotivação dos alunos tornam o ensino de física cada vez mais difícil. O presente trabalho apresenta uma estratégia de ensino tematizando o conceito de Energia Mecânica e de sua conservação. O planejamento e o desenvolvimento das atividades didáticas são norteados pela Teoria da Aprendizagem Significativa de David Ausubel e envolvem a construção, pelos alunos, de um Material Potencialmente Significativo. O objetivo primeiro dessa abordagem é instigar os alunos e promover o interesse e a motivação para aprender este assunto, em particular, e física, em geral. As aulas foram elaboradas e implementadas em uma turma de 1° ano de Ensino Médio da Escola SESI de Ensino Médio Albino Marques Gomes, situada na cidade de Gravataí, Rio Grande do Sul, Brasil. Os alunos foram orientados a construir carrinhos de lomba e, a partir da descida dos mesmos em um declive existente no pátio da Escola, investigar a Energia Mecânica presente no movimento e, a partir disso, verificar a conservação ou não dessa Energia durante a descida, fazendo a análise do movimento filmado através do software de análise de vídeos Tracker. Com a aplicação desta sequência didática, obteve-se bons resultados, uma vez que se observou um engajamento dos alunos com a atividade que resultou na apropriação do conceito de energia de forma bem mais eficaz do que em aulas expositivas tradicionais sobre essa matéria. A partir da análise dos resultados, conclui-se que a proposta de ensino aqui apresentada tem grande potencial para promover uma Aprendizagem Significativa.

Palavras-chave: Ensino de Física; Conservação de Energia Mecânica; Aprendizagem Significativa; Metodologia Ativa de Aprendizagem.

1 Introdução

O ensino de física, bem como a educação em geral, têm encontrado sérias dificuldades em nosso País o que tem resultado em baixos índices de nossos estudantes em rankings internacionais de avaliação, tais como o PISA. Uma das razões para esse baixo desempenho parece estar fortemente associada à desmotivação desses estudantes com as propostas pedagógicas propostas pelas escolas. Os estudantes parecem não ver sentido no que estudam no ambiente escolar e, por consequência, acabam não percebendo a conexão entre o que estão estudando e o que vivem em seu cotidiano, bem como têm dificuldade em perceber a conexão entre os diferentes componentes curriculares, o que acaba sendo muito desmotivador.

Além disso, a maioria das escolas brasileiras desenvolve seu trabalho ainda em um modelo de ensino tradicional, o que é espelhado na organização das salas de aula onde as mesas são dispostas em fileiras, permanecendo um aluno atrás do outro, voltados para um quadro negro onde o professor apresenta os conteúdos e desenvolve exercícios de sua matéria sem estabelecer uma correlação com outras disciplinas do mesmo currículo (Saviani, 1999) nem com o cotidiano do aluno. Dessa forma, as escolas orientam seus professores a seguir um currículo ditado pelos conteúdos a serem desenvolvidos durante cada ano letivo e pelas provas, como o Exame Nacional do Ensino Médio (ENEM) e os vestibulares, que condicionarão o caminho acadêmico dos alunos, privilegiando uma aprendizagem enciclopédica, em que a memorização se faz mais presente do que uma aprendizagem significativa.

Tudo isso nos leva a crer que o desenvolvimento dos conteúdos não deve ser pré-determinado em detalhe, e sim programado através de um tema central, partindo da realidade dos alunos e sem perder a meta de promover a aprendizagem em temas específicos.

No caso específico dos professores de física, esses se deparam com ainda mais dificuldades no ensino pela falta de laboratórios bem equipados, pela indisponibilidade de recursos tecnológicos, pela desvalorização da carreira docente (Costa & Barros, 2015) e pelo pouco tempo de planejamento das aulas, já que muitos lecionam em mais de uma escola. Observando essas dificuldades que os professores enfrentam diariamente na tentativa de obter êxito, muitos autores vêm propondo diversas alternativas e estratégias para oportunizar aos alunos um ensino de qualidade.

A aprendizagem dos conceitos da área da Mecânica – apesar de ser introdutória – está longe de ser simples, e o seu ensino pode se tornar complicado. Percebe-se isso quando, por exemplo, se comparam as situações idealizadas descritas nos livros e as respectivas equações - com variáveis muitas vezes simplificadas ou desprezadas - com os cenários de experimentação, pois os resultados experimentais e teóricos nem sempre convergem.

Considerando os aspectos acima elencados, surgem as perguntas norteadoras deste trabalho: Como apresentar uma alternativa para o ensino de Energia Mecânica e sua Conservação baseada na metodologia ativa da experimentação? De que maneira incluir o uso das Tecnologias de Informação e Comunicação (TIC) como estratégia para uma aprendizagem significativa?

A atividade descrita a seguir sugere uma sequência didática na qual os alunos constroem um aparato para experimentação como sendo um Material Potencialmente Significativo e utilizam as TIC para coleta e análise de dados, para a consolidação e apropriação dos conceitos de Energia Mecânica. O aporte teórico utilizado é a Teoria de Aprendizagem Significativa de David Ausubel. Nessa perspectiva, o aluno se torna foco principal da aprendizagem e seus conhecimentos prévios, chamados subsunçores pelo teórico, são um dos principais elementos para a construção do seu aprendizado.

2 Referencial Teórico

De acordo com a teoria ausbeliana, a Aprendizagem Significativa ocorre quando novos conceitos são ancorados, de maneira não arbitrária e substantiva, em uma estrutura cognitiva pré-existente no aprendiz – a qual o Autor denomina subsunçores (Ostermann & Cavalcanti, 2011).

Nessa perspectiva, a aprendizagem significativa se dá quando o aprendiz consegue atribuir significado àquilo que está observando durante seu processo de aprendizagem. Dessa forma, a assimilação cognitiva da novidade se dá a partir de alguns fatores considerados essenciais: o conhecimento prévio do aluno, a condição potencialmente significativa do material e dos recursos pedagógicos utilizados pelo professor e a predisposição do aluno para o aprender.

Segundo Ausubel (1978 apud Moreira, 2016) "Se tivesse que reduzir toda a psicologia educacional a um só princípio, diria o seguinte: o fator isolado mais importante que influencia a aprendizagem é aquilo que o aprendiz já sabe. Averigüe isso e ensine-o de acordo".

A partir disso, mapear os conhecimentos prévios do aprendiz e planejar o ensino de acordo com essa estrutura cognitiva preexistente identificada é considerado indispensável.

Para completar, a pré-disposição do aluno para o aprender é fundamental. Quando o Autor evidencia que, para ocorrer de fato a aprendizagem significativa, o aluno deve estar pré-disposto a aprender, destaca que independentemente de quão potencialmente significativo seja o material pedagógico utilizado, se a intenção do aprendiz for simplesmente memorizar conteúdos, tanto o processo de aprendizagem como seu produto serão mecânicos (ou automáticos) (Moreira, 2011).

2.1 Metodologias Ativas

As Metodologias Ativas são aquelas centradas nos alunos. Ao utilizar metodologias ativas de ensino, o professor torna-se um mediador, um orientador para o aluno, tirando-o da condição de ouvinte e fazendo com que ele tenha mais participação no processo de aprendizagem (Almeida, 2018). Nessa metodologia, o professor auxilia o aluno a realizar pesquisas e a refletir sobre como solucionar problemas. Os alunos se tornam responsáveis pelo seu processo de aprendizagem.

As metodologias ativas também têm o potencial de despertar a curiosidade, à medida que os alunos se inserem na teorização e trazem elementos novos, que talvez não tenham sido considerados nas aulas ou na própria perspectiva do professor. Quando o professor acata, analisa e valoriza as contribuições dos estudantes, ele estimula o sentimento de engajamento, percepção de competência e de pertencimento, além da persistência nos estudos, entre outras. (Berbel, 2011).

Outra etapa que caracteriza a aprendizagem centrada no aluno é a da apresentação das suas conclusões aos colegas e ao professor. Essa é uma etapa muito importante na construção do conhecimento científico, pois, ao expor o que fizeram, como resolveram o problema proposto pelo professor, tanto para os colegas, como para o próprio professor, os alunos têm a oportunidade dedesenvolver um raciocínio metacognitivo que os leva a tomarem consciência de suas ações e a justificar para si mesmos o porquê dessas ações. É nessa etapa que se solidificam as discussões realizadas nos grupos, levando-os a tomarem consciência das relações entre as variáveis do fenômeno físico estudado (Carvalho et al. 2010).

2.2 O Uso de TICs no Ensino de Física

O uso das Tecnologias de Informação e Comunicação (TICs) no Ensino de Física se torna indispensável na realidade atual. Um dos maiores desafios da educação é preparar os estudantes para a realidade de um mundo cada vez mais globalizado, criativo, dinâmico, móvel e tecnológico, onde as inovações transformaram a maneira como as informações são apresentadas. Nesse aspecto, observa-se uma falta de sintonia entre a realidade da vida cotidiana e o ambiente escolar. Na escola, os componentes curriculares se apresentam fragmentados e, fora dela, temos uma realidade multidisciplinar, em constante transformação. A sociedade tem demandado cidadãos qualificados para essa nova realidade, o que exige jovens mais preparados para essa imprevisibilidade e para esse dinamismo das atuais relações socioeconômicas (Sanches, 2017).

Além disso, o uso das TICs na educação básica têm se apresentado como fonte motivadora para o aprendizado do aluno, recomendando seu uso como ferramentas que contribuam para o ensino, principalmente em áreas do conhecimento que envolvam avanços tecnológicos, como é o caso das ciências exatas.

O avanço do conhecimento na área tecnológica propicia aos alunos uma maior interatividade e agilidade na busca pelo saber científico. Agilidade, velocidade de comunicação e praticidade fazem parte da rotina dos estudantes de hoje em dia e, muitas vezes, essas características não são acompanhadas nas estratégias pedagógicas utilizadas ou devido à falta de recursos físicos ou pela incapacidade de investir em tecnologia, tornando a aprendizagem menos atraente para os alunos (Andrade, 2016).

3 Metodologia de Ensino-Aprendizagem

3.1 Experimentação

As atividades experimentais têm grande importância na aprendizagem das ciências, constituem uma metodologia de ensino reconhecida na comunidade científica e entre os professores, com resultados comprovados em muitas investigações (Neves & Caballero & Moreira, 2006) e, em última instância, quando possíveis de serem implementadas, representam um teste de validade de toda e qualquer teoria científica. Portanto, considera-se que essas atividades são essenciais para que os alunos compreendam as inúmeras equações matemáticas e grandezas físicas encontradas nos livros didáticos e nas aulas expositivas na área das ciências.

Usualmente, em física, os professores apresentam o conteúdo com pouca ou nenhuma contextualização, demonstram alguns exemplos numéricos e oferecem uma lista de exercícios para que os estudantes apliquem as mesmas equações em diferentes contextos. Esse processo não traduz o que de fato é a proposta da física como ciência e corrobora para uma "aprendizagem mecânica, na qual novas informações são memorizadas de maneira arbitrária, literal, não significativa" (Moreira, 2011, p. 226), de simples fixação e resolução de equações matemáticas.

O fato de as atividades experimentais já estarem nos currículos escolares há muitos anos não significa que os professores tenham familiaridade com essas atividades. Na maioria das vezes, as atividades de laboratório são extremamente estruturadas com guias do tipo "receitas de cozinha", em que os alunos seguem os planos de trabalho previamente elaborados, seguindo os passos do guia; portanto, o trabalho deles se caracteriza pela execução de tarefas e muito pouco pela troca de ideias significativas sobre o fenômeno estudado (Carvalho et al., 2010).

Uma alternativa pedagógica consiste, então, em estruturar as atividades de laboratório como investigações ou problemas práticos mais abertos, que os alunos devem resolver sem a orientação imposta por um roteiro fortemente estruturado ou por instruções verbais do professor (Borges, 2002). Para a aprendizagem, parece ser mais eficaz incentivar o aluno a investigar o fenômeno estudado experimentalmente e, na sequência, instigar o aluno com questionamentos a respeito do experimento realizado.

Outro aspecto positivo com relação à experimentação é a possibilidade de fomentar o desenvolvimento das habilidades de metrologia através da manipulação de ferramentas e de instrumentos de medida pelos alunos. Laburú (2005) apresenta esse aspecto como sendo de grande eficácia quando utilizado por professores de ensino médio ao se depararem com a escolha dos experimentos que irão trabalhar com seus alunos.

Há uma classificação das atividades investigativas, proposta por Tamir (1991, apud Borges, 2002) em quatro níveis. No nível 0, o qual corresponde aproximadamente ao extremo de problema fechado, são dados o problema, os procedimentos e aquilo que se deseja observar/verificar, ficando a cargo dos estudantes coletar dados e confirmar ou não as conclusões. No nível 1, o problema e os procedimentos são definidos pelo professor, através de um roteiro, por exemplo. Nesse caso, cabe ao estudante coletar os dados indicados e obter as conclusões. No nível 2, apenas a situação-problema é dada, ficando para o estudante decidir como e que dados coletar, fazer as medições requeridas e obter conclusões a partir deles. Finalmente, no nível 3 o nível mais aberto de investigação o estudante deve fazer tudo, desde a formulação do problema até chegar às conclusões.

A sequência didática aqui apresentada baseia-se na utilização da atividade experimental como metodologia ativa central, utilizando como estratégia pedagógica a experimentação mais aberta, na qual é fornecido aos estudantes apenas o questionamento-desafio, ficando com eles a responsabilidade de planejar, pesquisar, construir, experimentar, analisar, concluir e expor suas conclusões. Essa proposta se afasta da tradicional, tendo como objetivos principais motivar, instigar e promover uma aprendizagem significativa através da promoção da curiosidade nos alunos para aprender, a partir da prática, conceitos como Energia Mecânica e sua Conservação.

3.2 Descrição da Aplicação da Sequência Didática

O primeiro encontro com os alunos teve por objetivo investigar os conceitos prévios sobre energia. Para tanto, os alunos foram instigados a refletir sobre o significado de energia e expor suas opiniões, enquanto a professora mediou a discussão com questionamentos sobre o conceito. Após essa discussão inicial, em que os alunos foram expondo suas considerações, foi solicitado que eles pesquisassem sobre o conceito físico de energia, e mais precisamente, sobre o conceito de Energia Mecânica.

Já nesse primeiro encontro, foi sugerida a proposta da construção de "carrinhos de lomba" para a investigação da Energia Mecânica e sua Conservação através da análise do movimento desses carrinhos em um terreno com inclinação (lomba). Para fomentar a autonomia do fazer desses alunos e suas habilidades de pensamento científico, crítico e criativo, foi proposta a tarefa de construirem carrinhos de lomba. A turma foi, então, dividida em grupos de, no máximo, seis alunos para que iniciassem os estudos e respectivos projetos dos carrinhos.

De forma a contemplar a discussão sobre sustentabilidade ambiental, foi sugerido a reutilização de materiais descartáveis.

Na primeira aula, foi discutido o tema energia e apresentada a proposta da sequencia didática.

No segundo encontro, propôs-se a realização de um teste de conhecimentos prévios a fim de identificar com maior acuidade as concepções prévias dos alunos acerca do assunto Energia e sua Conservação. Para responder ao questionário, os alunos utilizaram os tablets que a escola disponibiliza e seus próprios telefones celulares. O teste foi previamente enviado para os e-mails dos alunos – frequentemente essa ferramenta é utilizada nas aulas – e foi respondido na plataforma online gratuita *Google Forms*.

As questões respondidas pelos alunos foram analisadas pela professora e pode-se identificar muitos equívocos de concepção acerca do tema. Esses equívocos revelaram que alguns alunos acreditavam que objetos parados não possuem energia, outros demonstraram confusões entre o conceito de energia e o de força ou entre o conceito de energia e de velocidade.

A partir dessas respostas, o encontro seguinte foi direcionado à exposição e à discussão dos conceitos, na perspectiva da mecânica newtoniana. Para ilustrar, foram apresentados aos alunos alguns dos diversos tipos de energia, tais como: mecânica, elétrica, térmica (que é o somatório das energias potenciais e cinéticas das moléculas e átomos que constituem o corpo) e química, enfatizando os conceitos referentes à Energia Mecânica (Energia Cinética, Energia Potencial Gravitacional e Energia Potencial Elástica) e sua unidade no Sistema Internacional de Unidades (Joule).

Houve muitos questionamentos e discussões acerca das formas em que a energia se apresenta. Alguns alunos se surpreenderam por entender que é possível armazenar energia em um corpo e que esse pode utilizar essa energia, posteriormente, para se mover, por exemplo. A seguir, foram apresentadas o equacionamento matemático que permite quantificar as energias cinética e potencial gravitacional, uma vez que esse assunto seria necessário para a atividade a ser desenvolvida com os carrinhos de lomba.

Em seguida, nesta mesma aula, foi feita a exposição das ideias de conservação de energia e de sistemas conservativos através de contextualização com ocorrências diárias e situações-problema. Situações como o movimento de uma criança em um balanço em uma praça e de um adolescente com um *skate* em uma rampa em forma de U foram levantadas para promover a reflexão e discussões. Nesse encontro também foi apresentado aos alunos o questionamento-desafio a ser resolvido após o experimento com os carrinhos de lomba: "O movimento de descida de um carrinho de lomba pode ser caracterizado como um sistema conservativo?". A partir deste desafio, organizados em grupos, os alunos foram formulando hipóteses e anotando-as para posterior análise. Na ocasião, a maioria sugeriu que o movimento seria conservativo, provavelmente em função dos exemplos discutidos previamente ou pelas pesquisas realizadas, assim eles não cogitaram uma possível variação de energia durante a descida dos carrinhos.

Já com as equipes formadas, os alunos decidiram que tipo de carrinho cada equipe iria construir e organizaram a distribuição de tarefas, decidindo aqueles que, em cada equipe, ficariam responsáveis por trazer os materiais e as ferramentas necessárias para a construção dos carrinhos.

Os encontros seguintes foram destinados à construção dos carrinhos de lomba. Os alunos trouxeram materiais necessários e algumas ferramentas, tais como: martelo e serrote. Eles puderam utilizar, também, ferramentas disponíveis na escola (furadeiras, parafusadeiras e serras). Foram momentos de muita integração e de cooperação entre os alunos. Cada um ficou responsável por diferentes etapas da construção e pôde-se perceber a autonomia deles na tomada de decisões e na concepção de alternativas para a construção do artefato.

O desenvolvimento de habilidades manuais com as ferramentas e também as de mensuração pôde ser percebido. A maioria dos alunos levou para a escola materiais reutilizáveis: tábuas de madeira, pedaços de armários e de prateleiras, *skates* quebrados, rodas de carrinho de mão, restos de tinta. Os alunos que não conseguiram sucatas para utilizar optaram pela compra dos materiais necessários. Pôde ser observada também a interação com os pais dos alunos que forneceram ideias a eles de como proceder com a construção. Meninos e meninas trabalharam juntos no desenvolvimento dos carrinhos, mostrando respeito e igualdade nas tomadas de decisões. A seguir, as figuras 1, 2 e 3 mostram os períodos de construção dos carrinhos.



Figuras 1, 2 e 3: Alunos construindo os carrinhos de lomba.

Com os carrinhos prontos, o encontro seguinte foi destinado à realização do experiment. O registro foi feito através de filmagem feita pelos próprios alunos, utilizando seus *smartphones*. Antes de iniciarem as atividades com os carrinhos, os alunos coletaram alguns dados dimensionais: comprimento e massas dos carrinhos, massas dos alunos-pilotos. Essas medidas foram utilizadas na posterior análise quantitativa da atividade.

As descidas com os carrinhos foram efetuadas no patio da escola. O tipo de carrinho construído e de roda utilizada, foram critérios utilizados para escolher o melhor terreno para fazer o teste. Os carrinhos com rodas de diâmetro maior foram testados em uma rampa de grama, para evitar deslocamentos muito rápidos. Os carrinhos com rodas de diâmetro menor foram testados na rampa pavimentada de acesso ao estacionamento da escola.

Cada grupo foi responsável pela filmagem da descida do seu carrinho. Todos foram orientados a posicionar o equipamento de filmagem (*smartphones*) perpendicular à lateral das rampas e a tomar o cuidado de manter a câmera imóvel durante a filmagem. As descidas deveriam iniciar no ponto mais alto das rampas e sem impulsos iniciais, deixando que apenas a força gravitacional os fizesse acelerar. Antes de cada descida, os alunos se prepararam colocando os equipamentos de proteção, tais como: joelheiras, cotoveleiras e capacetes, conforme mostra a Fig. 4.

Figura 4. Aluna pronta para iniciar o movimento do carrinho.

Após as descidas serem registradas em vídeos pelos alunos, os próximos encontros foram dedicados à análise dos dados através do *software Tracker*. Para realizar a análise, foi mais conveniente separar os alunos em grupos menores, duplas ou trios. Cada pequeno grupo utilizou um dos *notebooks* da escola para iniciar a análise dos vídeos feitos por eles nas aulas anteriores. Através do programa, os alunos puderam analisar o movimento quadro a quadro da filmagem e puderam, por meio dos dados fornecidos pelo software, obter a energia mecânica.

Foi solicitado aos alunos que calculassem as energias (potencial gravitacional e cinética) em dois pontos distintos da descida, de preferência no início e no final do movimento, a partir dos valores de velocidades e de alturas fornecidos pelo programa e, também, da massa medida por eles antes das descidas. Foi solicitado também que os alunos calculassem a Energia Mecânica nesses dois pontos utilizando as equações apresentadas em sala de aula. Finalmente, foi solicitado que os alunos fizessem a comparação desses resultados com as suas previsões iniciais e verificassem se o experimento havia se comportado como um sistema conservativo.

Os encontros seguintes foram dedicados à elaboração das apresentações que cada equipe deveria fazer para os demais colegas, durante aula destinada especificamente para essa finalidade. Eles elaboraram essas apresentações através de *slides*mostrando seus cálculos de Energia Mecânica no início e ao final do movimento e responderam o questionamento inicial da professora: "O movimento de descida de um carrinho de lomba pode ser caracterizado como um sistema conservativo?".

Esse momento foi produtivo em termos de auto avaliação, pois os alunos puderam perceber os seus próprios progressos com relação aos conceitos vistos e experimentados.

Todos os grupos obtiveram concluíram que o experimento realizado não era um sistema conservativo. Em todos os cálculos apresentados pelas diferentes equipes foram observados uma perda de dez a vinte por cento da energia mecânica inicial. As hipóteses iniciais dos alunos previam uma conservação de energia mecânica e, como isso não ocorreu, pois o sistema perdeu energia, os alunos tiveram que pesquisar e propor explicações para essa redução. As justificativas foram dadas em função das forças dissipativas, a maioria dos alunos apontou o atrito e a resistência do ar como fatores principais da perda de energia no movimento observado.

Para avaliar a evolução/confirmação dos conceitos estudados sobre energia, o teste inicial sobre concepções de energia foi disponibilizado aos alunos por e-mail no aplicativo *Google Forms*. Nessa atividade, foi possível observar o entusiasmo dos alunos ao responderem com mais confiança e propriedade as perguntas. Na segunda aplicação do teste, foram acrescentadas duas questões ao final do questionário, para se ter uma avaliação dos alunos com relação à atividade experimental realizada e se eles a consideraram eficaz para o aprendizado de Energia Mecânica.

3.3 Resultados Obtidos

A avaliação da aprendizagem se deu em todo o processo, mais precisamente nos dois momentos finais, quando os alunos apresentaram aos colegas suas conclusões com relação à atividade e na reaplicação do teste de concepções sobre Energia Mecânica e sua Conservação.

Todas as equipes chegaram à conclusão que o movimento dos carrinhos não representava um sistema conservativo, o que divergiu em muitas de suas hipóteses iniciais. Muitos deles previram que o movimento seria conservativo, baseados em situações e exemplos descritos em livros, mas acabaram concluindo que o valor da Energia Mecânica no início do movimento era maior do que o seu valor no final. Foi solicitado a eles, então, que sugerissem causas para a diminuição do valor da energia. As equipes apontaram a presença de forças dissipativas - a resistência do ar e demais atritos - como causadores da redução da Energia Mecânica.

Durante as apresentações, foi bastante visível a aprendizagem dos alunos sobre Energia Mecânica, mostrando-se capazes de diferenciar bem os dois tipos de Energia Mecânica presentes no movimento e como a Energia Potencial Gravitacional ia se transformando em Energia Cinética a cada intervalo de tempo da descida dos carrinhos. Do ponto de vista da aprendizagem, revelaram ter havido interação não literal e não arbitrária dos novos conceitos com o conhecimento pré-existente, gerando novas compreensões e conseguindo, assim, mostrar que houve aprendizagem significativa acerca do tema proposto.

Com relação à aplicação dos testes de conhecimento, todos os alunos que responderam ao questionário inicial apresentaram, na reaplicação do questionário, ao final da atividade, um aumento no número de acertos. Cabe ressaltar que, inicialmente, os alunos tiveram bastantes dúvidas ao responder o questionário apresentado, principalmente nas questões de conservação de energia, pois o conceito que eles tinham de energia era frequentemente confundido com os de força e de velocidade. Dos 22 alunos que responderam ao questionário na segunda aplicação, 20 identificaram a contribuição eficaz da atividade para a aprendizagem.

4 Considerações Finais

Este trabalho versa sobre o planejamento, o desenvolvimento e a aplicação de uma sequência didática para o ensino de Energia Mecânica e sua Conservação no 1° ano do Ensino Médio de uma escola localizada no município de Gravataí, no Rio Grande do Sul.

Utilizando, como base de sustentação teórica, a teoria de Aprendizagem Significativa de David Ausubel, foram considerados os conhecimentos prévios dos alunos avaliados através da aplicação de um teste de concepções. A partir disso, a atividade pedagógica foi desenvolvida e aplicada de acordo com esses conhecimentos visando gerar novas compreensões.

Os alunos construíram carrinhos de lomba e, utilizando vídeos das descidas, analisaram a Energia Mecânica presente no sistema. Ao final, puderam concluir que a situação analisada não se tratava de um sistema conservativo do ponto de vista mecânico, pois a Energia Mecânica no início do movimento era maior do que no final.

A sequência didática apresentada incluiu a utilização das TICs como ferramenta para a alfabetização científica e tecnológica, que se mostraram também como instrumento motivador para a aprendizagem.

Após a avaliação da sequência didática e a reaplicação do teste de concepções, foi possível concluir que a atividade cumpriu com o seu propósito, o de consolidar uma aprendizagem significativa do conceito de Energia Mecânica e de sua Conservação.

A atividade experimental aqui apresentada pode ser utilizada não somente como estudo da conservação de energia, mas também como tema motivador na construção dos conceitos primordiais de posição, velocidade e aceleração, para o ensino de construção e interpretação de gráficos e cálculos da cinemática, assim como leis da mecânica newtoniana, estudo de aerodinâmica, estabilidade e rotações. Além disso, pode ser uma potente ferramenta para trabalhar de forma interdisciplinar com a área da matemática na análise de funções.

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Proposal of a Self-Assessment Model for an undergraduate course: Case study applied to the Production Engineering course of the University of Brasília

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Abstract

The professional profile of the engineer of the 21st century must adhere to the new demands of the market, which changes with each technological evolution. The area of Education requires an adjustment in the engineer's curriculum, since it is necessary to train engineers capable of acting in a changing world. This article aims to structure and apply a self-assessment model in the Production Engineering course at the University of Brasília, in order to identify possible gaps and to address them in a way that improves quality in teaching. The Self-assessment Model was developed based on researches that determine the minimum quality requirements that graduation courses must present, as well as the quality indicators evaluated by MEC, SINAES, ENADE, etc. A case study was adopted as a research strategy, with a qualitative approach, of an exploratory nature, and the technique used for the data collection was given through questionnaires. The aim of this study was to capture the perception of faculty and students regarding the course, based on discussions of quality issues in higher education, using the CPA as a valuable source of information. The results of the questionnaires were compiled and treated through tools such as Pareto diagrams, Ishikawa diagram and 5W's1H, and show that one of the strengths highlighted by the student body is the adoption of the PBL methodology in the course applied to the disciplines of Projects of production systems (PSPs), and the weak point was the absence of the method of evaluation of these disciplines. It was also possible to show that the proposed Performance Degrees were very close to each other when compared to faculty and students. The generated action plan serves as input for the redirection of the pedagogical political project of the course.

Keywords: Self-evaluation model; Higher Education Evaluation; *Problem Based Learning*.

Proposta de um Modelo de Autoavaliação para um curso de graduação: Estudo de caso aplicado ao curso de Engenharia de Produção da Universidade de Brasília

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Resumo

O perfil professional do engenheiro do século XXI deve estar aderente às novas demandas do mercado, que se modifica a cada evolução tecnológica. A área da Educação requer uma adequação no currículo do engenheiro, uma vez que é necessário formar engenheiros aptos a atuarem em um mundo em constantes mudanças. Este artigo tem como objetivo estruturar e aplicar um Modelo de Autoavaliação no curso de Engenharia de Produção da Universidade de Brasília, a fim de identificar possíveis lacunas e tratá-las de maneira a propiciar melhoria da qualidade no ensino. O Modelo de Autoavaliação foi desenvolvido com base em pesquisas que determinam os requisitos mínimos de qualidade que os cursos de graduação devem apresentar, assim como os indicadores de qualidade avaliados pelo MEC (Ministério da Educação), SINAES (Sistema Nacional de Avaliação da Educação Superior), ENADE (Exame Nacional de Desempenho de Estudantes), etc. Adotou-se um estudo de caso como estratégia de pesquisa, com abordagem qualitativa, de caráter exploratório, e a técnica utilizada para a coleta de dados se deu por meio de questionários. O estudo visou captar a percepção do corpo docente e discente a respeito do curso, baseado nas discussões de temas concernentes à qualidade em educação superior, utilizando-se da CPA (Comissão Própria de Avaliação) como valiosa fonte de informações. Os resultados dos questionários foram compilados e tratados por meio de ferramentas tais como diagramas de Pareto, diagrama de Ishikawa e 5W´s1H, e mostram que um dos pontos fortes destacados pelo corpo discente é a adoção da metodologia PBL no curso aplicada às disciplinas de Projetos de Sistemas de Produção (PSPs), e já como ponto fraco foi destacado a ausência do método de avaliação dessas disciplinas. Foi possível mostrar também que os Graus de Desempenho propostos foram muito próximos um do outro quando comparado o corpo docente e discente. O plano de ação gerado serve como input para o redirecionamento do projeto político pedagógico do curso.

Palavras-chave: Modelo de Autoavaliação, Avaliação de Curso Superior; Aprendizagem Baseada em Problemas.

1 Introdução

Em virtude do crescente número de Instituições de Ensino Superior (IES) e a consequente oferta ao mercado de novos cursos, faz-se necessário que as IES atendam requisitos básicos propostos pela área de Educação, com foco na melhoria de seu desempenho, para oferecer à população um ensino de qualidade.

De acordo com Saeki & Imaizumi (2013), cabe às universidades atender ao desafio de formar profissionais com visão diferenciada, que possam responder às diferentes demandas provenientes de instituições governamentais, públicas ou privadas. O ensino na área tem sido objeto de interesse e debate crescente. Dessa forma, a inovação nas práticas educacionais na formação desses profissionais passa a ser prioritária, visando aperfeiçoar o processo de ensino-aprendizagem, bem como os métodos utilizados na avaliação dos cursos nas IES.

Ao refletir sobre a importância do papel da avaliação não somente nas IES, mas também nos cursos de graduação, Krüger (2013) afirma que qualquer instituição que queira se manter atuando com qualidade no mercado atual deve adaptar-se às mudanças, buscar e implementar novos conceitos no ambiente interno e desenvolver estratégias para alcançar o sucesso. Com os resultados da avaliação em mãos, cabe planejar e colocar em ação as metas que levam a melhoria, propiciando formação de melhor qualidade aos alunos que chegam ao mercado de trabalho em busca da realização profissional.

Este artigo tem como objetivo propor a estruturação e aplicação de um Modelo de Autoavaliação que possa ser empregado pelo curso de Engenharia de Produção da Universidade de Brasília – (EPR/UnB), a fim de identificar possíveis lacunas e tratá-las de maneira a propiciar melhoria para a qualidade do ensino, a partir da percepção do corpo discente (alunos) e do corpo docente (professores), utilizando-se da CPA (Comissão Própria de Avaliação) como valiosa fonte de informações. A seção 2 apresenta os indicadores utilizados pelo Sistema de Avaliação de Ensino Superior no Brasil.

2 Sistema de Avaliação de Ensino Superior

A melhoria qualitativa do Sistema Educacional Brasileiro não prosperou de forma concomitante ao aumento do número de Instituição de Educação Superior (IES). Pelo contrário, a qualidade de muitas instituições decaiu bastante com o advento da competitividade (Consoni & Henriques, 2011). O artigo trata do conceito de qualidade no âmbito educacional, e em especial na Educação Superior. O conceito de qualidade é importante quando pensado na medida das dimensões extrínsecas (extraescolares) e intrínsecas (intraescolares) como fundamentais para a definição e compreensão teórico-conceitual e para análise da situação acadêmica que deve ser entendida de maneira articulada, pois, essas dizem respeito às múltiplas determinações e às possibilidades de superação das condições relativas aos processos de organização, gestão, bem como, aos processos ensino-aprendizagem, tendo em vista a garantia do sucesso dos discentes (Dourado, Oliveira & Santos, 2007).

Neste contexto, o Sistema Nacional de Avaliação da Educação Superior (SINAES) divulga anualmente os indicadores de qualidade das IES. O SINAES é formado por três componentes principais: i) avaliação das instituições, ii) avaliação dos cursos e iii) avaliação do desempenho dos estudantes. O resultado das avaliações do SINAES propicia ao Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira (INEP) o cálculo dos indicadores de qualidade do Sistema Nacional de Avaliação do Ensino Superior: (i) Conceito ENADE; (ii) Conceito Preliminar de Curso (CPC); (iii) Índice Geral de Cursos Avaliados da Instituição (IGC); e (iv) Indicador de Diferença entre os Desempenhos Observado e Esperado (IDD). Por meio de uma comissão de avaliadores externos, investigam-se três grandes dimensões: 1. Organização Didático-Pedagógica; 2. Perfil do Corpo Docente; e 3. Instalações físicas. Ao avaliar essas três dimensões de forma participativa, permanente e global, levando em consideração o papel que as instituições cumprem não só na formação dos seus estudantes e no suporte aos docentes e técnico-administrativos, mas também na contribuição ao desenvolvimento de sua região e do País, o SINAES pretende enraizar uma cultura avaliativa em prol das demandas oriundas da sociedade (Pereira, 2010). Os indicadores utilizados no processo de avaliação das IES são demonstrados na Figura 1.

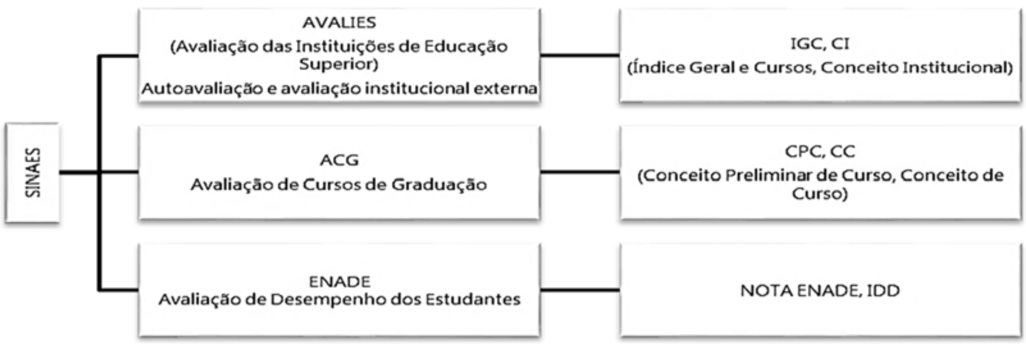

Figura 1. Hierarquia dos Indicadores de Qualidade para as IES

Conforme a Figura 1, os processos e a hierarquia dos indicadores de qualidade que compõe o SINAES, integra as três modalidades principais de instrumentos de avaliação, o AVALIES (Avaliação das Instituições de Educação Superior), o ACG e o ENADE, que são descritos a seguir. O AVALIES é o centro de referência e articulação do sistema de avaliação que envolve duas etapas principais: (i) autoavaliação – coordenada pela Comissão Própria de Avaliação (CPA) de cada IES; (ii) avaliação externa - realizada por comissões designadas pelo INEP, segundo diretrizes estabelecidas pela CONAES. A Avaliação dos Cursos de Graduação (ACG) – avalia os cursos de graduação por meio de instrumentos e procedimentos que incluem visitas *in loco* de comissões externas. A periodicidade desta avaliação depende diretamente do processo de reconhecimento e renovação de reconhecimento a que os cursos estão sujeitos. O conceito ENADE - O SINAES estabelece que os estudantes sejam avaliados pelo ENADE no início e no fim do curso de graduação, caracterizando os alunos ingressantes e concluintes que participam de cada edição do exame. O Exame tem a periodicidade anual e é dividido em grandes áreas de conhecimento, que se repetem a cada três anos. O ENADE é composto pela prova, o questionário de Avaliação Discente da Educação Superior (antigo questionário socioeconômico), o questionário dos coordenadores de curso e a percepção do aluno sobre a prova. A Nota ENADE do curso é a média ponderada da nota padronizada dos concluintes na Formação Geral e no Componente Específico. A parte referente à Formação Geral contribui com 25% da nota final, enquanto a referente ao Componente Específico contribui com 75% (INEP, 2018). Em suma, a composição dos indicadores mostrados na Figura 1 e sua forma de cálculo pode ser melhor visualizada na Tabela 1.

Tabela 1. Composição e fórmula de cálculo dos Indicadores

Indicadores	ENADE (ED)	IDD	CPC	IGC
Composição	Prova (PR), Questionário de Avaliação Discente (QA), Questionário do Coordenador de Curso (QC) e Percepção dos Alunos (PA)	Nota ENADE concluintes (EC) e Nota ENADE ingressantes (EI)	ENADE (ED), IDD e Insumos (infraestrutura, organização didático-pedagógica) (IN)	CPC, Conceito CAPES (CP)
Forma de Cálculo	Nota ED = PR PR é 0,25 Formação Geral + 0,75 Componente Específico	IDD = EC - EI	CPC = 0,3 ED + 0,3 IDD + 0,4 IN	IGC = CPC + CP
Unidade de Medição	Nota (0 a 100) Conceito (0 a 5)	Conceito (0 a 5)	Conceito (0 a 5)	Nota (0 a 500) Conceito (0 a 5)

A seção 3 ressalta o método de pesquisa utilizada e sua estruturação.

3 Metodologia da pesquisa

A pesquisa adotou como estratégia um estudo de caso, para uma melhor compreensão de um fenômeno em seu contexto real, onde investigou a opinião dos docentes e discentes do curso de Engenharia de Produção acerca de requisitos de qualidade para cursos de graduação, dentre eles, indicadores avaliados pelo MEC, a partir de um estudo exploratório. A abordagem da pesquisa foi qualitativa, pois não se preocupou em enumerar ou medir eventos estudados, mas sim descrevê-los com o objetivo de compreendê-los (Ganga, 2012). A técnica utilizada para a coleta de dados foi a aplicação de questionários. Como pontos fortes observados pode-se destacar que as questões são em sua maioria, objetivas, fáceis de pontuar, apresenta facilidade de conversão dos dados para gráficos, as questões são padronizadas e, por isso, garantem a uniformidade. Em contrapartida, observou-se como limitação, a baixa taxa de respostas obtidas, principalmente por parte do corpo discente, além da dificuldade de pontuar questões abertas e da possibilidade de existirem itens polarizados ou ambíguos (Pinto, Scheidegger, Gaudêncio, & Turrioni, 2015).

A fórmula para o cálculo do tamanho da amostra para uma estimativa confiável da média populacional (n) é dada pela Equação 1:

$$n = \frac{Z^2(\text{pq})\,\text{N}}{e^2(N-1) + Z^2(\text{pq})} \qquad Equação\ (1)$$

onde:

n = Número de elementos da amostra (em unidades); N = Número de elementos da população (em unidades);

Z = Intervalo de confiança da pesquisa (em desvios-padrões); são usuais: 90% = 1,65; 95% = 1,96; 99% = 2,58;

e = Margem de erro da pesquisa (em desvio percentual relativo às frequências obtidas); são usuais 10%; 5%; ou 3%;

p.q = Grau de homogeneidade das opiniões da população ("split") / probabilidade de ocorrência do evento "respostas iguais"; são usuais 50/50 ou 80/20.

Foi proposto um Modelo de Autoavaliação a fim de identificar lacunas e propor ações para tratá-las, visando a melhoria da qualidade do ensino para o curso de Engenharia de Produção da Universidade de Brasília. Para isso, foram construídos 3 questionários, um para avaliar a percepção discente com relação ao corpo docente, um questionário para avaliar a percepção docente com relação ao corpo discente, e o último questionário para avaliar a percepção da coordenação e chefia do EPR com relação à estrutura do curso de EPR.

Calculou-se o número de elementos da amostra para a reposta do primeiro questionário, considerando os 514 alunos do curso de Engenharia de Produção, e a partir da fórmula mostrada pela Equação 1, com 10% da margem de erro, 90% de intervalo de confiança, e o "split" usual e constante com valor de 0,210, chegou-se à amostra ideal de 52 questionários respondidos, mas só se obtiveram 15 respostas de estudantes. Com relação ao segundo questionário, para avaliar a percepção docente com relação ao corpo discente, em um universo de 16 professores obtiveram-se 12 respostas, e o último questionário para avaliar a percepção da coordenação e chefia do EPR com relação à estrutura do curso de EPR, obtiveram-se 3 respostas (entre coordenador, chefe e ex-chefe do Departamento), totalizando ao todo 30 questionários respondidos.

Vale ressaltar que os questionários foram desenvolvidos a partir dos indicadores de qualidade avaliados pelo MEC, como o CPC, IGC, CC, ENADE, IDD, CI e CPA, demonstrados na seção 2.

A partir dos dados obtidos pela aplicação dos questionários, propôs-se Digramas de Pareto (Gráficos 1 e 2) para identificar quais esforços deveriam ser priorizados para a melhoria, sob o ponto de vista dos discentes, e foi possível reconhecer os pontos fracos do curso. Foram propostas causas para identificar o que origina o ponto fraco prioritário, por meio do Diagrama de Ishikawa (Figura 5), apoiado nas respostas obtidas com os questionários dos discentes. Fundamentado no resultado da aplicação do modelo e na identificação das lacunas existentes no curso, sob o ponto de vista dos discentes, docentes, coordenação e chefia do Departamento, e com base no sistema de avaliação de ensino adotado no Brasil, elaborou-se um plano de ação 5W1H que pode ser visto pela Tabela 4.

A seção 4 exibe o modelo de Autoavaliação proposto, e a seção 5, os resultados de sua aplicação ao curso de Engenharia de Produção da Universidade de Brasília.

4 O Modelo de Autoavaliação do Curso de EPR da UNB

O Projeto Político Pedagógico do Curso de EPR da UnB apresenta como proposta um diferencial com enfoque nas atividades de "praticar fazendo", que se pauta na metodologia PBL – "*Problem Based Learning*", traduzida como Aprendizagem Baseada em Problemas. De acordo com Dias, Turrioni & Silva (2012), o PBL é sugerido como uma abordagem pedagógica ativa, amplamente estudada e aplicada no ensino das ciências médicas, e que vem sendo aplicada no ensino da Engenharia. Esse método centra-se no aluno e favorece o desenvolvimento de habilidades e atitudes. Através de um processo de análise de dados e informações, é possível verificar a situação em que se encontra a instituição, identificando as fragilidades e as potencialidades existentes. A partir dos resultados das análises, podem ser estabelecidas estratégias e ações para a superação dos problemas, procurando corrigi-los e melhorar ainda mais os indicadores avaliados (Freitas & Fontan, 2008).

A partir do entendimento do contexto do curso de EPR, propôs-se um procedimento para a estruturação do processo de autoavaliação do curso de EPR segundo a percepção de dois importantes atores: corpo docente e corpo discente. A Figura 2 ilustra o relacionamento entre os atores envolvidos e os elementos que contém o modelo, considerando as quatro "Dimensões" compreendidas na estrutura proposta: Organização Administrativa, Instalações, Corpo Docente e Corpo Discente.

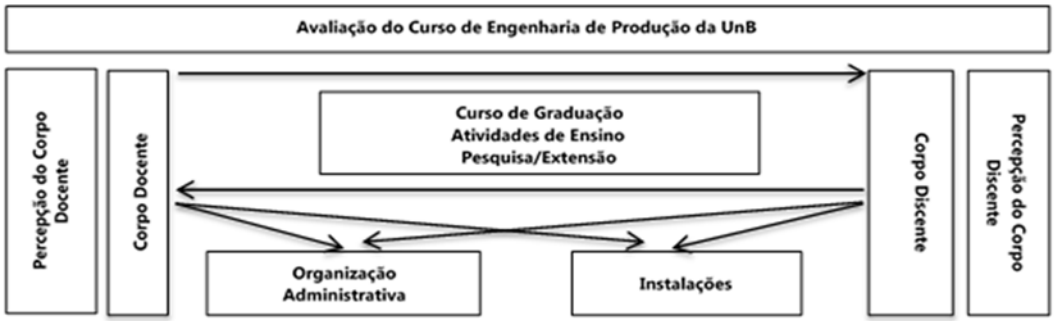

Figura 2. Relação entre os elementos do processo de autoavaliação do Curso de EPR

Desta forma, desenvolveu-se um procedimento a fim de agrupar os julgamentos dos avaliadores (corpo docente, corpo discente, coordenação e chefia), em que GDj (EPR) consiste no Grau de Desempenho de Engenharia de Produção "EPR" à luz do item j, com base nos pesos de 5 a 1 para a quantidade de itens avaliados respectivamente como, "muito bom", "bom", "regular", "ruim" e "muito ruim", e da mesma forma para a escala utilizada de concordância: "concordo totalmente", "concordo", "neutro", "discordo" e "discordo totalmente", a serem aplicados nos muitos itens a serem avaliados. Então, o índice de desempenho de "EPR" à luz do tal critério (GDc) é dado pela Equação 2:

$$\overline{GDc}^{EP} = \frac{\sum_{j=1}^{n} GD_j^{EPR}}{n} \qquad Equação\ (2)$$

Este procedimento objetivou associar o índice de desempenho do curso avaliado a uma das categorias de classificação pré-definidas, comparando-o com o valor dos limites que definem tais categorias, conforme a Tabela 2.

Tabela 2. Categorias e Limites

Categorias	**A**	**B**	**C**	**D**	**E**
Limites	4,50< $\overline{GDc}^{EP}$ ≤5,00	4,00< $\overline{GDc}^{EP}$ ≤4,50	3,00< $\overline{GDc}^{EP}$ ≤4,00	2,00< $\overline{GDc}^{EP}$ ≤3,00	1,00< $\overline{GDc}^{EP}$ ≤2,00
Conceitos	Excelente	Bom	Regular	Ruim	Péssimo

A partir da definição dos elementos que compõem o Modelo de Autoavaliação e a definição do Grau de Desempenho que foram incorporados nas perguntas contidas nos três questionários, a seção 5 apresenta o resultado de sua aplicação.

5 Resultado da Aplicação do Modelo de Autoavaliação

Conforme ressaltado na seção 4, o Modelo de Autoavaliação compreende a percepção dos discentes, docentes, da coordenação e chefia do EPR sobre aspectos relacionados com a avaliação do corpo discente, docente e infraestrutura. A seção 5 tem como objetivo apresentar e detalhar essa percepção.

Após a análise dos 30 questionários respondidos foram observados os resultados mais relevantes das percepções do corpo discente, divididos em não concluintes e concluintes, do corpo docente, da coordenação e chefia, apresentados e detalhados nessa seção. A Figura 3 mostra a avaliação dos alunos nas disciplinas de Projetos de Sistemas de Produção (PSPs), que adotam a abordagem PBL.

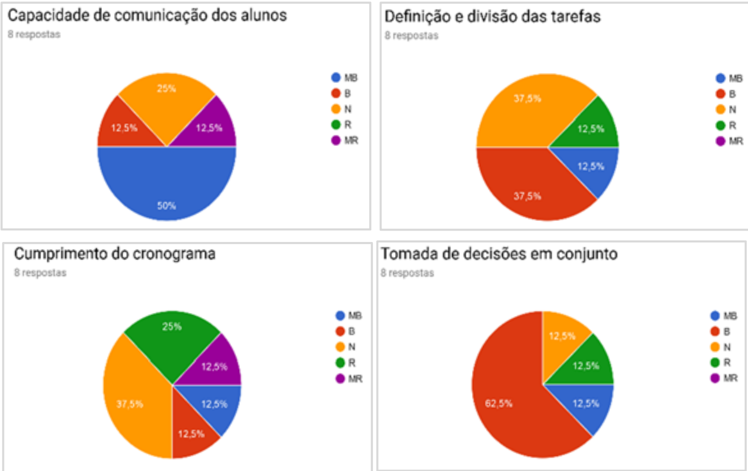

Figura 3 Critério: Atuação dos Alunos nos PSP

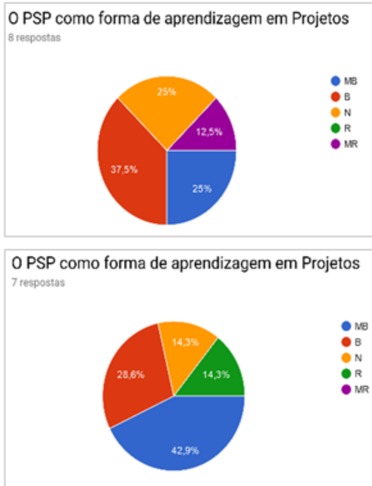

Figura 4. Critério: Metodologias empregadas no Curso de EP

Foram avaliados critérios relacionados à atuação dos alunos nas disciplinas de PSPs (que adotam a metodologia PBL), e os gráficos destacam positivamente em ambas as percepções, concluintes e não concluintes, a capacidade de comunicação entre os alunos, a definição e divisão de tarefas e a tomada de decisões em conjunto. Em contrapartida, 25% dos alunos consideraram como ponto negativo o cumprimento do cronograma proposto na execução das tarefas de projeto.

Ainda com relação às metodologias empregadas no curso de EPR, foi proposto como outro critério a avaliação quanto ao método PBL, como forma inovadora para o curso, tomando como destaque a metodologia empregada nos PSPs como contribuição na formação do Engenheiro de Produção, ilustrados na Figura 4. De acordo com a Figura 4, avaliado pelos discentes, pode-se constatar que com relação ao item que avalia o PSP como forma de aprendizagem em projetos, propiciando o desenvolvimento do aluno nas competências transversais, houve a escolha da opção "Muito Ruim" por pelo menos um aluno não concluinte, enquanto que segundo a percepção dos concluintes para este mesmo item, a maior incidência foi observada na opção "Muito bom". Uma possível explicação para esse resultado é que os alunos não concluintes não apresentam a visão total dos PSPs como disciplinas que buscam uma aprendizagem mais autônoma, porque provavelmente ainda não tenham cursado muitas disciplinas no fluxo de projetos.

Deve-se chamar atenção para a predominância de julgamentos considerados Neutros pelos alunos. Não somente para o critério avaliado, mas para outros, a neutralidade nos julgamentos pode-se caracterizar talvez, pela falta de informações dos alunos sobre os itens avaliados, e as reais funções e objetivos propostos pelo curso de EPR. Baseado nas percepções dos discentes foi possível elaborar os Diagramas de Pareto (Gráficos 1 e 2), e a partir disto, instituir a prioridade a ser dada aos problemas analisados. Com esta técnica, foi possível coletar métricas sobre quantas vezes ocorre cada problema ou causa. O Diagrama de Pareto mostra os problemas e determina sua frequência de ocorrência, resultando em informações necessárias para priorizar os esforços.

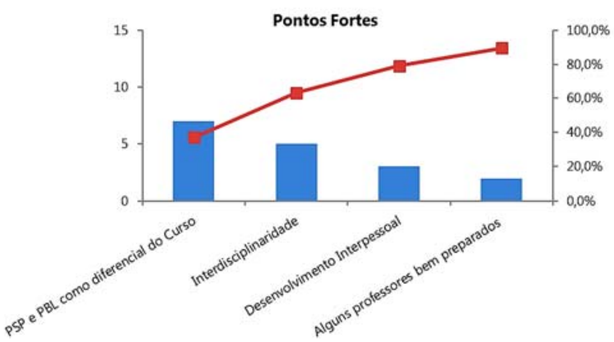

Gráfico 1. Pontos Fracos na percepção do corpo discente

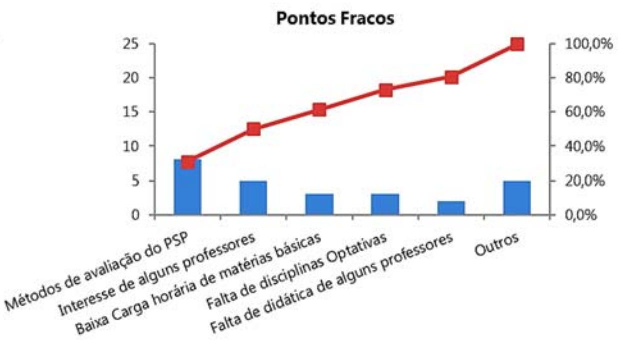

Gráfico 2. Pontos Fortes na percepção do corpo discente

O Gráfico 1 mostra que uns dos maiores pontos fracos do curso, segundo a percepção dos discentes correspondem aos métodos de avaliação dos PSP, o interesse de alguns professores na condução da disciplina ministrada, a falta de disciplinas optativas e também a falta de didática de alguns professores. Segundo a percepção dos alunos, para corrigir estas lacunas encontradas precisa-se de padronização e critérios de avaliação mais objetivos. O Gráfico 2 mostra o reconhecimento dos discentes em relação à metodologia do PBL adotada nos PSP, que foi relatada como fator diferencial do curso de EPR (Engenharia de Produção) da UnB, pois a interdisciplinaridade integra atividades teóricas e práticas, e contribui para o desenvolvimento interpessoal do aluno.

A fim de identificar as causas do maior ponto fraco apontado pelos discentes no Gráfico 1, propôs-se o Diagrama de Ishikawa (Figura 5), o qual relacionou as principais possíveis causas para a falha no método de avaliação dos PSPs, a partir das respostas obtidas com os questionários dos discentes.

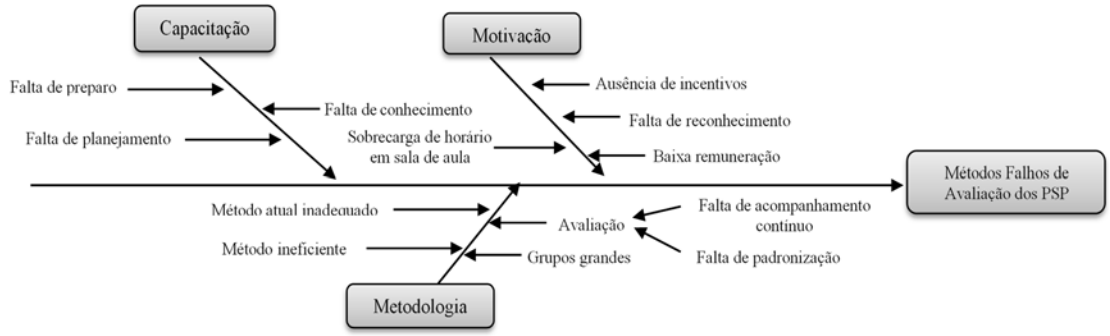

Figura 5 - Diagrama de Ishikawa - Métodos Avaliação dos PSP

A partir da Figura 5, pôde-se avaliar as causas do problema relacionado aos métodos falhos de avaliação dos PSPs. É importante ressaltar e valorizar a experiência e a formação do corpo docente do curso de EPR. Porém, o planejamento e a organização de muitos professores, ainda são ineficientes para a condução eficaz e eficiente da disciplina de PSP, além da falta de padronização da forma como a disciplina é ministrada e avaliada ao longo do semestre. Para mitigar tais falhas faz-se necessário a elaboração de procedimentos que visem à padronização na sistemática de avaliação e também promova uma avaliação contínua de acompanhamento das equipes ao longo dos projetos.

Em razão dos fatos observados pelos pesquisadores, e a partir dos dados extraídos dos questionários, foi possível encontrar um Grau de Desempenho para o curso de EPR segundo cada percepção, com seus respectivos conceitos atribuídos, como mostrado na Tabela 3.

Tabela 3. Grau de desempenho obtido da aplicação dos questionários

Avaliadores	**Corpo Discente**	**Corpo Docente**	**Coordenação**
GD (EP)	Concluintes = 3,653 Não Concluintes = 3,406	3,446	4,051
Conceito atribuído	Regular	Regular	Bom

De acordo com a Tabela 3, os Graus de Desempenho com seus respectivos conceitos atribuídos, explicados pela Equação 2, foram muito próximos um do outro, principalmente entre as percepções dos discentes e docentes, que se classificou como regular. Já a avaliação da coordenação e chefia gerou um Grau de Desempenho bom para o curso. Deve-se ressaltar que estes valores encontrados para os graus de desempenho poderiam ter sido diferentes e mais fidedignos se houvesse maior participação dos discentes e docentes e, consequentemente, mais questionários teriam sido respondidos.

De acordo com a percepção dos discentes, um dos maiores pontos fracos do curso de EPR é a falta de acompanhamento da evolução do aluno no curso. Em contrapartida, na percepção do corpo docente, o ponto mais fraco é a falta de infraestrutura de acordo com a percepção da coordenação e chefia.

6 Propostas de Melhorias

O Modelo de Autoavaliação serviu como subsidio para identificar os *gap´s* existentes no curso de Engenharia de Produção da UnB, segundo as percepções dos discentes, docentes, coordenadores e chefes do EPR, onde foram avaliadas as dimensões da qualidade propostas pelo MEC. Mediante o resultado da aplicação do modelo e a identificação das oportunidades de melhorias, foi elaborado um plano de ação 5W1H que pode ser visto pela Tabela 4.

O 5W1H, mais aplicável para o curso de EP da UnB, consiste em um formulário (*check-list*) para execução e controle de tarefas, indicando o que deve ser feito (what), o motivo (why), são atribuídas responsabilidades (who) assim como o local (where), o prazo para realização da tarefa (when) e o detalhamento de como deve ser realizada (how).

Tabela 4 - Plano de Ação para as lacunas identificadas a partir da aplicação do Modelo de Autoavaliação para o Curso de EPR da UnB - 5W1H

Plano de Ação 5W1H							
	What	**Rever os métodos de avaliação dos PSP**	**Elaborar mais Disciplinas Optativas**	**Rever a carga horária de disciplinas básicas**	**Elaborar um Plano de motivação para o corpo docente**	**Melhorar a infraestrutura de laboratórios, salas de aula e salas de professores**	**Melhorar o engajamento do aluno em sala de aula**
	Why	Para melhorar os métodos e consequentemente obter alunos melhor preparados	Para oferecer mais conhecimentos técnicos e especializados aos alunos	Para nivelar melhor a base das disciplinas iniciais do curso	Para propiciar a motivação e capacitação dos professores em metodologia ativa	Maximizar o aprendizado, desenvolvimento intelectual e cognitivo dos estudantes e possibilitar ao docente desempenhar suas atividades.	Para que durante o processo de aprendizagem e nas atividades, o aluno melhore o seu desempenho
	Who	NDE – Núcleo Docente Estruturante	Colegiado	NDE – Núcleo Docente Estruturante	Coordenador	Coordenador/Chefe de departamento	Corpo docente
	Where	Na ementa das disciplinas	Em toda a estrutura do curso de EPR	Nas disciplinas básicas e obrigatórias	Internamente no corpo docente	Em toda a infraestrutura do curso de EPR	Nas disciplinas ofertadas
	When	Em médio prazo (3 meses)	Em médio prazo (6 meses)	Em médio prazo (6 meses)	Em médio prazo (6 meses)	Em médio prazo (6 meses)	Em médio prazo (3 meses)
	How	Estabelecer procedimentos padronizados para avaliação eficaz	Realizar benchmarking com cursos de EPR conceituados	Propiciar reuniões com o colegiado e colocar a discussão em pauta	Investimento em capacitação/incentivos por premiação por produtividade	Levar a problemática a instância superior ao departamento do curso de EPR	Orientar o corpo docente a optar por interagir com os alunos de maneira diversificada e constante (metodologias ativas)

O Plano de Ação proposto visa sugerir melhorias para o curso de EPR solucionando as principais lacunas encontradas, principalmente através das percepções do corpo discente. Para que este Plano de Ação se torne viável, foram estabelecidas metas, responsáveis, prazos e as maneiras de como deve ser realizada cada tarefa.

Sugere-se que os resultados obtidos sejam discutidos em reunião de Colegiado do curso de EPR para que novas ações sejam implementadas no sentido de propiciar melhorias aos discentes.

7 Conclusão

O curso de Engenharia de Produção da UnB recebeu a avaliação de reconhecimento do curso pelo INEP no segundo semestre de 2014, obtendo conceito 4, que em uma escala de 1 a 5 foi atribuída a nota 4,33, e os itens organização didático-pedagógica e infraestrutura foram os que receberam a menor pontuação, merecendo atenção, devendo ser aprimorados, o que confirma o resultado do Modelo de Autoavaliação aplicado aos docentes. Com relação ao ENADE, o curso obteve a segunda melhor nota entre os cursos de Engenharia de Produção do Brasil, obtendo a pontuação de 4,835 em 2014. Já em 2017, a nota do ENADE ficou em 4,0. Verifica-se que é necessário um estudo mais aprofundado para entender o motivo da redução da nota do ENADE, mas é importante ressaltar que a Universidade de Brasília precisa preparar e estimular seus alunos à participação na prova ENADE, destacando sua importância para os indicadores de qualidade da Instituição.

O objetivo deste artigo foi atingido ao aplicar o Modelo de Autoavaliação para o Curso de EPR da UnB, utilizando como insumos a análise da eficácia dos indicadores de qualidade acadêmica, evidenciando seus pontos relevantes ou não. Para isso, utilizou-se da pesquisa exploratória para compreender e analisar a evolução de cada um dos indicadores estudados.

Vale salientar a limitação do estudo quanto à quantidade de estudantes que responderam os questionários. Com relação aos professores, coordenador e chefia houve uma grande representatividade, mas com relação aos estudantes, a taxa de retorno dos questionários foi muito baixa, não representando a maioria dos estudantes.

Por fim, sugere-se que o Modelo de Autoavaliação, que pode envolver futuras pesquisas sobre os indicadores de desempenho da Educação Superior possa ser novamente aplicado ao curso a fim de averiguar se houve melhoria em seu desempenho, de modo que futuras gestões consigam acompanhar pontualmente os resultados do Departamento de Engenharia de Produção da UnB, ou ainda analisar o atendimento dos indicadores com os eixos do Plano de Desenvolvimento Institucional (PDI).

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Exploring Active Learning Resources for Team Training in a Multidisciplinary Research Project

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Abstract

Recent research on educational methodologies that foster the integration of knowledge and skills in the field of engineering has been reflected in innovative strategies that seek to develop active student participation. However, the effect of such strategies in an academic internship environment is still poorly studied. In view of this, the purpose of this work is to explore active student-centered and group-based active learning resources, applied in the training phase of a public organization-university cooperation research project. This project is formed by a multidisciplinary team that will develop a process improvement research within a large public organization involving three areas of knowledge: Process Management (Production Engineering), Requirements Engineering (Software Engineering and Computer Engineering) and Management by Competencies (Psychology). The goal of the training was to present and qualify the project team for the main tasks developed in the projects routine, in addition to instruct them according to the research systematics and the project management framework. The training phase lasted 2 weeks and counted on the participation of 37 undergraduate students, 4 postgraduate students and 5 professors. The active learning resources implemented in the training phase involved active group dynamics containing simulation of interviews, simulation of real problem solving, group quiz, research development, process modeling in pairs. It was applied computational tools like Aris Express (for process modeling), Astah for the formulation of case use diagrams and Kahoot! (for group quiz application). The analysis of the perception of the students participating in the training suggests that the resources applied effectively developed the motivation and the learning of the students of the different areas of knowledge in less time and with greater effectiveness.

Keywords: Active Learning; Internship environment; Team-based learning; Multidisciplinary research project; Multidisciplinary-team training; Agile teamwork improvement.

Utilização de recursos de aprendizagem ativa na capacitação de equipe de projeto de pesquisa multidisciplinar

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Resumo

Investigações recentes de metodologias educacionais que propiciam a integração entre conhecimento e habilidades no campo da engenharia refletiram em estratégias inovadoras que buscam desenvolver a participação ativa dos estudantes. Entretanto, o efeito de tais estratégias em um ambiente de estágio acadêmico ainda é pouco estudado. Diante disto, este trabalho tem o propósito de explorar recursos de aprendizagem ativa centrado no estudante e baseado em grupos, aplicado na fase de capacitação de um projeto de pesquisa de cooperação organização pública-universidade. Tal projeto é formado por uma equipe multidisciplinar que desenvolverá uma pesquisa de melhoria de processos no âmbito de uma organização pública de grande porte envolvendo três áreas do conhecimento: Gestão por Processos (Engenharia de Produção), Engenharia de Requisitos (Engenharia de Software e Engenharia da computação) e Gestão por Competências (Psicologia). O objetivo da capacitação foi de apresentar e qualificar a equipe para as principais tarefas desenvolvidas no dia-a-dia do projeto além de capacitar a equipe de acordo com a sistemática e o *framework* de gestão do projeto. A fase de capacitação durou 2 semanas e contou com a participação de 37 alunos de graduação, 4 alunos de pós-graduação e 5 professores doutores. Os recursos de aprendizagem ativa implementados na fase de capacitação envolveram dinâmicas ativas de grupo contendo simulação de entrevistas, simulação de solução de problemas reais, *Quiz* em grupo, desenvolvimento de pesquisa, modelagem em pares. Foram aplicadas as ferramentas computacionais *Aris Express* (para modelagem dos processos), *Astah* para a formulação dos diagramas de caso de uso e *Kahoot!* (para a aplicação do *Quiz* em grupo). A análise da percepção dos estudantes participantes da capacitação sugere que os recursos aplicados desenvolveram efetivamente a motivação e o aprendizado dos alunos das diferentes áreas de conhecimento em menor tempo e com maior efetividade.

Keywords: Aprendizagem ativa; Ambiente de estágio; Aprendizagem baseada em equipes; Projeto de pesquisa multidisciplinar; Capacitação de equipe multidisciplinar; Melhoria de trabalho em equipe ágil.

1 Introdução

A expansão de ambientes profissionais multidisciplinares interfere na demanda por recursos de aprendizagem e treinamentos que aprimorem as competências de trabalho em equipe, uma vez que tais competências podem significar vantagens dentro do mercado inovador das organizações atuais (Lerís & Sein-Echaluce, 2014; Aguinis & Kraiger, 2009).

Ainda de maneira mais acirrada, em projetos multidisciplinares, nos quais diferentes disciplinas e conhecimentos se aproximam e interagem, o capital humano é um fator fundamental para o sucesso do projeto, portanto recursos que auxiliem no desenvolvimento das competências de novos integrantes do projeto, reciclar o conhecimento dos membros antigos e acelerar a integração da equipe assume papel central (Belout, & Gauvreau, 2004; Huang, 1997).

Para trabalhar efetivamente em grupo, o membro precisa ampliar suas capacidades de resolver problemas, pensar criativamente, individual e coletivamente, comunicar ideias etc. Quando inserido em um time multidisciplinar também é exigida a capacidade de coordenar terminologias e metodologias distintas de sua área de forma eficiente (Nancarrow, Booth, Ariss, Smith, Enderby, & Roots, 2013). Neste contexto, a multidisciplinariedade assume a conotação dada por Nonaka & Takeuchi (1997), como um grupo de profissionais com diferentes especialidades, que trocam informações e conhecimentos, cooperando na execução de atividades e possuindo objetivos comuns (Nonaka & Takeuchi, 1997).

No contexto educacional é amplamente reconhecida a importância dos alunos construírem o conhecimento de uma maneira ativa (Milhomem, Bezerra, Souza, Fonseca, & Barros, 2013) . Este tipo de abordagem intensifica a autogestão do conhecimento realizada pelos alunos ampliando sua autonomia e segurança para conduzir seu conhecimento técnico em um ambiente multidisciplinar (Martinez, Romero, Marquez, & Perez, 2010). Deste modo as metodologias de aprendizagem ativa sugerem oportunidades para trabalhar em um contexto multidisciplinar.

Nessas circunstâncias, para integrar os novos membros em um ambiente multidisciplinar que faz uso das metodologias ativas, é de fundamental importância que a capacitação destes remetam diretamente as atividades do contexto de trabalho, fugindo das metodologias expositivas vivenciadas por muitos grupos de pesquisa e empresas. Nessa perspectiva, no trabalho de Milhomem, Lima, Fonseca, Barros e Neto (2014) para capacitarem os alunos bolsistas participantes do Programa de Extensão "Laboratório de Engenhocas", inicialmente, foram apresentados todos os projetos do Programa de forma interativa e didática, com a máxima participação de todos, sendo um destes, o desenvolvimento de experimentos físicos e químicos com materiais reutilizáveis e/ou de baixo custo para subsidiar no ensino dessas disciplinas nas escolas de nível médio. O treinamento também teve como intuito avaliar a capacidade de desenvolver atividades em grupo, habilidade em comunicação e, principalmente, a proatividade e interesse em participar do projeto. De modo geral, os autores concluíram que a abordagem de capacitação utilizada alcançou os objetivos esperados.

Diante disto, este trabalho tem o propósito de descrever um programa de capacitação desenvolvido por meio de recursos de aprendizagem ativa no contexto de um projeto multidisciplinar inserido no contexto de um projeto de pesquisa multidisciplinar.

2 Contexto do projeto multidisciplinar

O Projeto MAP é um projeto de extensão da Universidade de Brasília (UnB) em cooperação com uma organização pública de grande porte. Este projeto tem por objetivo de contribuir para a modernização da gestão do Sistema de Pessoal desta organização, por meio de uma gestão do conhecimento que abrange a gestão por competências, gestão por processos e gestão de TI (Mariano, Monteiro, Mota, & Kuhl, 2017). Ressalta-se que por ser classificado como um projeto de extensão, o Projeto MAP também tem o objetivo de desenvolver a aprendizagem e a potencialidade científica dos seus integrantes.

A equipe do projeto é formada por alunos de graduação (estagiários), pós-graduação (tutores) e professores de três diferentes áreas do conhecimento, que formam o tripé da gestão do conhecimento, ilustrado na Figura 1. Gestão por Processos (Engenharia de Produção), Engenharia de Requisitos (Engenharia de Software e Engenharia da computação) e Gestão por Competências (Psicologia).

Figura 1. Estrutura multidisciplinar do projeto de pesquisa

A característica multidisciplinar apresenta relação com o objetivo do projeto e, neste sentido, reflete a necessidade de competências e conhecimentos interdisciplinares para consecução do objetivo proposto.

2.1 Ambiente de trabalho do aluno estagiário

Os alunos estagiários desenvolvem atividades em uma gestão ágil na qual os integrantes trabalham a partir de ciclos curtos (*Sprint)* de 13 dias realizando reuniões *in loco* junto ao cliente para o levantamento de informações que são posteriormente consolidadas de acordo com uma sistemática própria do projeto gerando uma documentação de acordo com as três áreas do projeto.

A equipe do projeto é organizada em times multidisciplinares compostos por um assistente (aluno de pós-graduação) e três estagiários sendo um de processos, um de requisitos e outro de competências. Durante uma *sprint* os estagiários realizam, sob a supervisão dos assistentes, atividades específicas de cada área no ambiente interno e externo ao projeto. Apesar das especificidades de cada área os estagiários são estimulados a realizar a troca dos conhecimentos e informações levantadas *in loco*.

A estrutura de gestão do projeto foi baseada no modelo SCRUM a fim de aperfeiçoar a elaboração das entregas com maior qualidade e efetividade do que seria no caso de uma metodologia tradicional de gestão. É reconhecido que as metodologias ágeis de gestão estão trazendo muitas vantagens acerca da qualidade em contextos com equipes multidisciplinares (Laanti & Abrahamsson, 2011; Moe, 2010).

O trabalho colaborativo é concretizado durante a modelagem de processos que ocorre através de uma técnica colaborativa na qual, não apenas o modelador, e sim toda a equipe, com os estagiários das diferentes áreas, participam ativamente da elaboração dos diagramas trocando informações enquanto um deles conduz a ferramenta *Aris Express* na produção do diagrama. Essa técnica foi inspirada no *pair programming* que, no contexto de desenvolvimento de códigos em ambiente universitário, já provou ser um recurso satisfatório para a retenção e a aprendizagem colaborativa (Bryant & Romero, 2006).

3 Planejamento da Capacitação

O planejamento da capacitação foi baseado na prática do *Team Basead Learning* (TBL) estratégia utilizada para criar oportunidades e obter benefícios do trabalho em pequenos grupos de aprendizagem. O TBL pode substituir ou complementar um curso desenhado a partir de aulas expositivas. É uma estratégia educacional constituída por um conjunto de práticas sequenciadas de ensino-aprendizagem que visa promover o desenvolvimento de equipes de aprendizagem de alto desempenho e fornecer a estas equipes oportunidades para se envolver em tarefas de aprendizagem significativas (Michaelsen & Sweet, 2008).

O TBL tem sua fundamentação teórica baseada no construtivismo, que enfatiza o aprender a aprender e o qual o papel do professor passa de expositor para o de mediador. O ambiente de ensino-aprendizagem é centrado no aluno, no qual a formação de pequenos grupos ressalta a interação e a negociação de significados entre os alunos, estimulando as habilidades de comunicação e trabalho colaborativo em equipes (Hyrnchak & Batty, 2012).

3.1 O programa de capacitação

Como indica o Quadro 1, o programa de capacitação foi separado em duas fases de 5 dias. Primeiramente, a fase teórica na qual os alunos estagiários interagiram com os conhecimentos básicos das três vertentes do projeto por meio de palestras oferecidas pelos professores e dinâmicas ativas desenvolvidas pelo grupo de tutores. Na segunda fase, os recursos de metodologia ativa foram colocados em prática. Chamamos atenção de que todas as atividades desta fase envolviam o trabalho em equipe.

Quadro 1. Cronograma do programa de capacitação e recursos utilizados

Dia	Atividade	Recurso utilizado	Fase
1	Introdução à Gestão por Competências e Sistemática de estudo de competências	Palestra/Dinâmica ativa	Teórica
2	Introdução à *Bussines Process Management* (BPM)	Palestra	
2	Sistemática de modelagem de processos e ferramenta *Aris Express*	Dinâmica ativa	

3	Introdução à Engenharia de Requisitos	Palestra	
3	Sistemática de estudo de requisitos e caso de uso e ferramenta *Astah*	Dinâmica ativa	
4	Validação interna de diagramas de processos e documentação interna	Palestra/Dinâmica ativa	
5	Introdução à Pesquisa Científica	Palestra/Dinâmica ativa	
6	Acolhimento da equipe e simulação de entrevista e coleta de dados junto ao cliente	Simulação de ambiente externo	Prática
7	Tratamento das informações coletadas e elaboração da documentação interna	Simulação de ambiente interno	
8	Elaboração de documentação e pesquisa sobre a organização	Simulação de ambiente interno	
9	Validação da documentação produzida	Simulação de ambiente interno	
10	Apresentação dos resultados de cada equipe, Jogo de integração com *Quiz* de conhecimento gerais e aplicação da autoavaliação	Apresentação/Jogo de integração (*Quiz)*	

A fase prática foi planejada visando simular o ambiente real de trabalho e assim, ampliar a aprendizagem dos alunos estagiários com a crescente troca de experiências entre os estagiários novos e antigos. Durante as simulações os tutores estimulavam a troca de ideias entre os indivíduos para aprimorar a conexão dos conceitos aprendidos na fase teórica com o trabalho a ser desenvolvido durante o projeto. Foram 10 dias trabalhando conceitos de Processos, Requisitos e Competências com quase 38 participantes.

Em uma experiência anterior, constatou-se que palestras expositivas sem qualquer etapa de prática dificultava a fixação dos assuntos tratados. Assim, buscou-se desenvolver uma capacitação que fosse parte teórica e parte prática, com isto foram incorporadas dinâmicas ativas com a resolução de problemas e desafios em equipe, fazendo uso das mesmas ferramentas utilizadas no projeto. O contexto de aprendizagem ativa tem a característica de envolver os alunos num ambiente de aprendizagem dinâmico, com troca de experiências e participação efetiva em busca dos resultados desejados (Reis, Barbalho, & Zanette, 2017; Reis, Zanette, & Barbalho, 2018).

3.2 Atividades e recursos didáticos da capacitação

O programa de capacitação foi estruturado em um ciclo (Figura 2), para facilitar o planejamento e aplicação de novas capacitações. Neste ciclo as três especialidades de estudo, representadas pelos professores, montaram palestras seguidas de dinâmicas ativas elaboradas para enfatizar o trabalho prático no ambiente interno do projeto.

As palestras trabalharam conceitos básicos e a maneira mais adequada de construir os documentos padrões do projeto, que estão definidos na sistemática do projeto, oferecendo exemplos e estudos de caso. Enquanto as dinâmicas envolviam a aplicação individual ou em grupo das ferramentas em casos reais já contemplados pelo projeto anteriormente. Ao concluir a fase teórica os alunos estagiários já haviam entrado em contato com toda a documentação básica do projeto, com as ferramentas e com a realidade de atuação vivenciada durante o trabalho.

Figura 2. Ciclo da capacitação com a sequência dos recursos de metodologia ativa aplicados

O objetivo da segunda fase da capacitação foi simular o ambiente de trabalho colocando os conhecimentos desenvolvidos na primeira fase em prática. Para as simulações os alunos foram separados em equipes que deveriam executar, sem exceção todas as atividades realizadas ao longo de uma *Sprint*, as equipes foram selecionadas para otimizar o contato entre estagiários antigos e novos, independente da sua área do conhecimento. Durante as simulações os instrutores deveriam facilitar a troca de informações da equipe.

Na etapa final da capacitação foi organizada a apresentação dos resultados das equipes, na qual cada equipe deveria deixar suas impressões e relatar a elaboração dos documentos. Seguida de um Jogo de integração elaborado pelos instrutores. O jogo de integração foi aplicado para todo o grupo através da plataforma *online Kahoot,* contendo 25 questões sobre os diversos conteúdos tratados durante as semanas de capacitação. Este recurso foi escolhido para intensificar a motivação e a integração entre os alunos (Junior, 2017).

Em suma, visando capacitar os novos integrantes do Projeto MAP recorreu-se à metodologia ativa, na perspectiva TBL, a partir de recursos didáticos com resultados reconhecidos na literatura, como mostra o Quadro 2. Esta escolha levou em consideração a experiência da última capacitação do Projeto MAP, a qual havia sido expositiva e de pouca interação entre os participantes e não obteve a eficácia esperada.

Quadro 2. Elementos a serem desenvolvidos com a escolha dos recursos e programa de capacitação

Nº	Elementos a serem desenvolvidos	Referências	Recurso relacionado
1	Incentivar a participação ativa, a noção de autogestão e o aprender a aprender dos alunos estagiários	Moe (2013), Romero (2010)	Dinâmica ativa; Simulações
2	Acelerar a troca de experiência entre os membros novos e antigos do projeto	Gerben (2005), Lucch (2011)	Dinâmica ativa; Jogo de integração; Simulações
3	Facilitar a integração entre alunos estagiários com diferentes formações	Gerben (2005), Milhomem (2014)	Simulações; Jogo de integração
4	Estimular a motivação, o engajamento e as competências colaborativas da equipe do projeto	Huang (1997); Aguinis (2009)	Dinâmica ativa; Jogo de integração
5	Acelerar a familiarização dos alunos com as ferramentas e procedimentos internos do projeto	Lucch (2011)	Dinâmica ativa; Simulações

4 Resultados e discussão

Para avaliar a eficácia das atividades de capacitação foi aplicado ao final do ciclo uma autoavaliação dos alunos estagiários acerca de sua percepção sobre a capacitação. A autoavaliação contou com 21 perguntas na parte objetiva além de uma parte subjetiva com pontos positivos, pontos negativos e comentários. Em cada uma das perguntas, objetivas ou subjetivas, foi inserida uma escala de *Lickert* de 5 pontos acerca da compreensão/concordância.

Participaram da autoavaliação 37 alunos estagiários sendo 21 membros novos e 16 antigos. Os resultados e sua discussão são apresentados a seguir.

4.1 Parte objetiva

A parte objetiva do questionário (Quadro 3) foi dividida entre Conhecimentos Trabalhados (CT) e Perguntas sobre a Participação do candidato (PP).

Quadro 3. Elementos estudados pelo questionário de autoavaliação

Nº	Perguntas sobre participação (PP)	Nº	Conhecimentos trabalhados (CT)
PP1	A interação com os assistentes e professores foi satisfatória?	CT1	Contexto organizacional do DGP (cliente)
PP2	A simulação da entrevista favoreceu minha aprendizagem?	CT2	Cadeia de Valor do DGP (cliente)
PP3	A carga horária da capacitação foi adequada?	CT3	Documentação padrão utilizada no projeto
PP4	Conseguiu realizar as tarefas exigidas na capacitação?	CT4	Modelagem de processos
PP5	Participou ativamente das atividades tirando dúvidas com professores e colegas?	CT5	Elicitação de requisitos
PP6	Possui interesse de realizar pesquisa?	CT6	Levantamento de Competências
PP7	Sente-se preparado para realizar uma Sprint?	CT7	Padrão de condução de entrevista
PP8	Cuidei da apresentação dos trabalhos?	CT8	Programação da Sprint
PP9	Tive facilidade com as atividades?	CT9	Produção de revisão bibliométrica
PP10	Contribui com os colegas trocando conhecimento?	CT10	Sistemática da equipe
		CT11	Padrão de vestimenta e postura

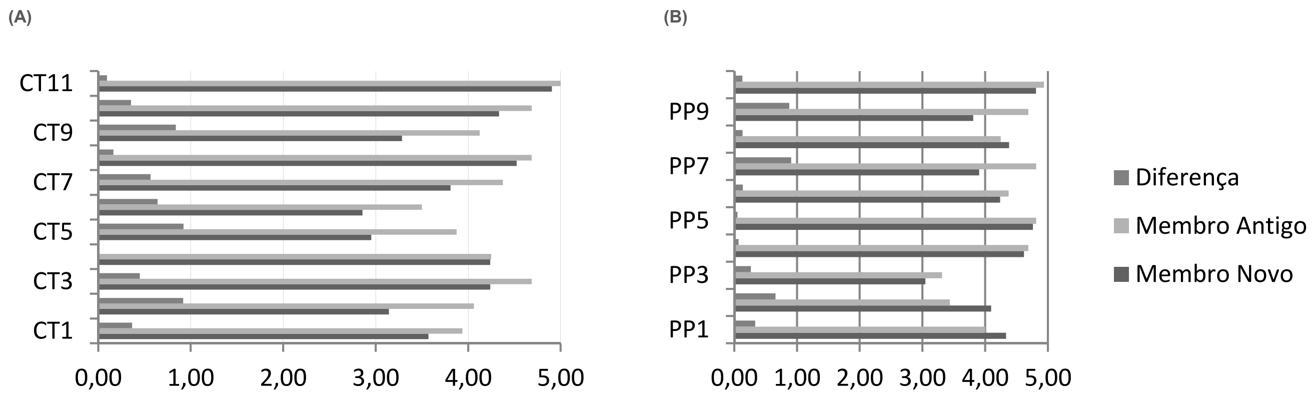

Figura 3. Percepção média dos membros novos e antigos acerca da: **(A)** compreensão sobre os conhecimentos trabalhados (CT) **(B)** concordância com as perguntas sobre participação (PP)

Com relação aos conhecimentos trabalhados (Figura 3) os alunos, de modo geral, consideram ter compreendido positivamente os conteúdos abordados, sendo que os membros antigos tiveram um maior nível de assimilação, o que era esperado por eles já terem entrado em contato com os conteúdos. Entretanto, os novos membros tiveram uma compreensão abaixo de 3 em elicitação de requisitos (CT5 = 2,95) e levantamento de competências (CT6 = 2,86).

Os conhecimentos vinculados diretamente com a organização e trabalho interno no projeto (CT3, CT8, CT10, CT11) tiveram o maior nível de compreensão. Isso indica que o objetivo de preparar os alunos estagiários para o ambiente interno foi satisfatório do ponto de vista do conteúdo. Observou-se também em relação à modelagem de processos (CT4), atividade chave para a integração da equipe e sucesso do projeto, os membros novos e antigos tiveram praticamente a mesma compreensão o que enfatiza que o trabalho em equipe potencializou o entendimento sobre este conteúdo e procedimento.

Os conteúdos com maior discrepância entre os dois tipos de integrantes foram os CT2, CT5, CT6 e CT9, que são específicos de cada área e serão trabalhados de forma mais individualizada ao longo do trabalho, portanto a intenção de introduzir o conteúdo de modo geral para todos os integrantes foi alcançada.

De acordo com a opinião geral dos alunos, a capacitação incentivou a participação ativa (PP5, PP10), além de indicar que a troca de experiência entre os membros novos e antigos do projeto foi favorecida (PP1). Os exercícios da capacitação foram pensados para serem desafiadores para os membros novos (PP9, PP2, PP5). A menor nota foi para a carga horária da capacitação (PP3), entretanto, o grupo respondeu que foi capaz de realizar as atividades da capacitação (PP4), isto indica que o fator cansaço influenciou bastante a (PP3). Além disto, os novos membros se consideraram preparados para realizar uma *Sprint* (PP7).

4.2 Parte subjetiva

O jogo de integração e as dinâmicas de grupo foram citadas positivamente por 13 alunos estagiários enquanto a integração e o ambiente da equipe foram citados positivamente por 16 alunos os quais ressaltaram a integração entre os alunos dos dois turnos, a integração entre os alunos e professores e a integração entre as diferentes frentes de trabalho. Por exemplo (A18), "A diversidade das áreas de capacitação é muito boa. Me permitiu conhecer mais sobre as outras frentes". As simulações e dinâmicas ativas foram diretamente elogiadas por 8 alunos.

De acordo com 11 alunos estagiários o período de capacitação foi curto, o que indica ampliar o tempo para uma melhor absorção e evitar que a capacitação se torne cansativa. Apesar disto, outros alunos explicitaram que o tempo foi bem distribuído. Ainda assim, quando o grupo foi perguntado especificamente sobre a carga horária (PP3) a resposta foi positiva para os dois tipos de membro.

Relatos como o do Aluno 22 (A22) "Integração entre novos e antigos membros (café da manhã e trabalho sem ser extremo) ", (A19) "Colocar os antigos assistentes e estagiários para ajudar e dar as capacitações", (A10) "Praticar o que era ensinado facilitava a compreensão", (A32) "As dinâmicas e interações criaram um laço amigável entre a equipe, o que vai ser muito positivo durante as próximas sprints". Conferem o clima de interação da equipe como ponto positivo. De fato, foi percebido a aproximação e a criação de laços entre os alunos que tendem a facilitar o trabalho colaborativo em equipe.

Além disto, um membro antigo comparou positivamente a capacitação atual e a anterior (A32) "O fato de todo conhecimento necessário para o projeto já estar consolidado favoreceu uma programação de capacitação mais objetiva e planejada se comparada a primeira capacitação do Projeto".

5 Considerações Finais

A aplicação de recursos de aprendizagem ativa baseada em times utilizadas no programa de capacitação, no âmbito do Projeto MAP, foi considerada satisfatória pelos participantes, considerando a opinião dos 37 alunos estagiários sobre sua participação e os conhecimentos trabalhados. Isto, pois suas respostas e opiniões indicaram que os 5 objetivos principais da capacitação foram atingidos:

1) Incentivar a participação ativa e o aprender a aprender dos alunos estagiários;
2) Acelerar a troca de experiência entre os membros novos e antigos do projeto;
3) Facilitar a integração entre alunos estagiários com diferentes formações na equipe multidisciplinar;
4) Estimular a motivação, o engajamento e as competências colaborativas da equipe do projeto;
5) Acelerar a familiarização dos alunos com as ferramentas e procedimentos internos do projeto.

Foi observado que os alunos estagiários tiveram um menor tempo de adaptação às ferramentas e procedimentos internos do projeto, quando em comparação a uma capacitação anterior. Diferenciais como a inclusão de dinâmicas ativas seguidas das palestras teóricas, as simulações de situações reais e a proposição de problemas e desafios para serem trabalhados em equipe, além da utilização de jogo de integração com toda a equipe amplificou a motivação e o engajamento dos alunos.

Os recursos práticos, dentre eles atividades envolvendo a ferramenta *Aris Express* e aplicação de Jogo de integração serviram como um mecanismo para otimizar a transferência de conhecimento entre os membros novos e antigos. Deste modo, a implementação destes recursos em um ambiente multidisciplinar favoreceu a aprendizagem e a gestão de conhecimento do projeto.

Entretanto, a carga horária da capacitação foi criticada pelos alunos que acharam a capacitação cansativa. Sendo assim, ao implementar estes recursos se faz necessário distribuir o curso no maior tempo possível, visando favorecer a assimilação do conteúdo e o conforto dos estudantes.

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Initial Learning of Computer Programming in Engineering: A Pedagogical Practice with Active Learning Using the Code.org's Accelerated Course

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Abstract

Computer programming is an area in which fresh students have many difficulties, mainly because it is a demanding area in terms of cognitive process and most of the fresh students have little or no notion of Computer Science. In the Introductory Programming course in a Brazilian university, the procedural programming paradigm is used with the C ++ programming language. Several learning difficulties were observed, such as problems with language syntax, poor problem-solving abilities and poor logic reasoning. Within this context, Code.org's Accelerated Course was used as a pedagogical practice in Introductory Programming course, in order to facilitate the initial learning of programming of Engineering students. The Code.org is a non-profit organization dedicated to facilitating the access to Computer Science in schools. Although it is recommended for youngest students (e.g. elementary schools), the Code.org's Accelerated Course includes basic programming concepts that can be actively developed by any student in a short period of time. This paper aims to describe the pedagogical practice carried out in an Introductory Programming course in a Brazilian university. The Code.org's Accelerated Course was integrated in the learning outcomes, content, materials and activities carried out in the classroom. The results of a qualitative research point out that the active learning approach used facilitate the learning process in terms of initial programming and motivates students and makes them more confident about what they are learning.

Keywords: Introductory Programming; Active Learning; Multimedia Learning; Pedagogical Practice.

Aprendizagem Inicial de Programação de Computadores em Engenharia: Uma Prática Pedagógica com Aprendizagem Ativa Utilizando o Curso Acelerado da Code.org

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Resumo

A programação de computadores é uma área em que os estudantes novatos têm muitas dificuldades, principalmente por ser uma área cognitivamente exigente e pela maioria dos que ingressam no Ensino Superior terem pouca ou nenhuma noção de Ciência da Computação. Na disciplina de Programação Introdutória em uma universidade brasileira é utilizado o paradigma de programação procedural com a linguagem de programação C++. Várias dificuldades de aprendizagem foram observadas, como problemas com a sintaxe da linguagem, a baixa capacidade de resolução de problemas e o raciocínio lógico deficiente. Nesse contexto, o Curso Acelerado da Code.org foi utilizado em uma prática pedagógica na disciplina de Programação Introdutória, a fim de facilitar a aprendizagem inicial de programação dos estudantes de Engenharia. A Code.org é uma organização sem fins lucrativos dedicada a facilitar o acesso à Ciência da Computação nas escolas. Embora seja recomendado para alunos mais jovens (por exemplo, escolas de ensino fundamental), o Curso Acelerado da Code.org inclui conceitos básicos de programação que podem ser ativamente desenvolvidos por qualquer estudante em um curto período de tempo. Este artigo tem como objetivo descrever a prática pedagógica realizada em um curso de Programação Introdutória em uma universidade brasileira. O Curso Acelerado da Code.org foi integrado nos resultados de aprendizagem, conteúdo, materiais e atividades realizados em sala de aula. Os resultados de uma pesquisa qualitativa apontam que a abordagem de aprendizagem ativa utilizada facilita o processo da aprendizagem em termos de programação inicial e motiva os alunos e os torna mais confiantes sobre o que estão aprendendo.

Palavras-chave: Programação Introdutória; Aprendizagem Ativa; Aprendizagem Multimídia; Prática Pedagógica.

1 Introdução

A programação de computadores é uma área exigente do ponto de vista cognitivo, na qual os estudantes novatos têm que aprender tanto a sintaxe quanto a semântica de uma linguagem de programação, enquanto desenvolvem competências de resolução de problemas (Malik & Coldwell-Neilson, 2017; Raadt, 2008). O baixo rendimento dos estudantes e a consequente falta de competências necessárias ao final da disciplina foram relatados por vários pesquisadores, como deficiências na resolução de problemas (Guzdial, 2011; McCracken et al., 2001; Soloway, Bonar, & Ehrlich, 1983) e nas tarefas de rastreio de código (Lister et al., 2004; Robins, Rountree, & Rountree, 2003). Várias propostas para a melhoria do ensino/aprendizagem em programação vêm sendo publicadas, com abordagens e estratégias instrucionais, além de ferramentas e ambientes de programação (Izeki, Nagai, & Dias, 2016; Malik & Coldwell-Neilson, 2017; Qian & Lehman, 2017; Raadt, 2008; Yadin, 2011). Em 2015, no Brasil, foi criado o Workshop de Ensino em Pensamento Computacional, Algoritmos e Programação em resposta à ausência de um evento brasileiro que concentrasse pesquisas e discussões sobre esses temas (WalgProg, 2015). Desde então, aproximadamente, 40 artigos de um total de 125 foram publicados relacionados a ferramentas, estratégias e metodologias para auxiliar no ensino/aprendizagem de programação introdutória no contexto do Ensino Superior.

Além das particularidades inerentes à programação que a tornam complexa, existe também o fato de que a maioria dos estudantes não teve contato com a programação de computadores antes de ingressar na Universidade. Nesse contexto, para aproveitar os conhecimentos prévios dos estudantes, várias estratégias de ensino têm sido relatadas na literatura (Luxton-Reilly et al., 2018), com o intuito de facilitar a aprendizagem de algoritmos e de vários conceitos de programação, como pedir aos estudantes que resolvam um problema de ordenação e que descrevam uma atividade de contagem de votos no primeiro dia de aula, além do uso de metáforas e analogias para explicar vários conceitos de programação.

Sendo a pedagogia o processo de apresentação de conteúdo no contexto de estratégias de aprendizagens que se conectam a processos cognitivos (Aithal, 2016), ao associá-la com a tecnologia pode-se ocorrer a facilitação e a melhoria do processo de ensino e de aprendizagem. É competência de um professor do Ensino Superior conhecer recursos instrucionais e inseri-los em seus planos de aula, com vista à qualidade do processo de ensino e de aprendizagem (Masetto, 2012; Perrenoud, 2000; Zabalza, 2003).

É nesse contexto que este estudo se insere, em que o objetivo é apresentar uma prática pedagógica, baseada nos princípios da aprendizagem ativa, utilizando um curso online. O propósito inerente a essa prática incide, essencialmente, em facilitar, motivar e aumentar a confiança dos estudantes na aprendizagem inicial de programação. Serão igualmente discutidas e exploradas as implicações dessa prática pedagógica para a aprendizagem inicial de programação no Ensino Superior.

2 Enquadramento Conceitual

Antes de apresentarmos e discutirmos a prática pedagógica descrita neste artigo, é importante a explicitação de três conceitos importantes que formam a base dessa prática que, apesar se serem apresentados separadamente, estão intimamente relacionados: a aprendizagem significativa, a aprendizagem ativa e a teoria cognitiva de aprendizagem multimídia.

A aprendizagem significativa propõe que a tarefa de aprendizagem deve relacionar uma nova informação a outros conceitos relevantes já existentes na estrutura cognitiva, que é o conhecimento existente do indivíduo, sendo que as ideias existentes são refinadas, moldadas e, às vezes, corrigidas (Cañas & Novak, 2009). Contrasta-se a aprendizagem significativa com a aprendizagem mecânica, em que o aprendiz não faz esforço para integrar novo conhecimento com o conhecimento prévio na estrutura cognitiva. Já a aprendizagem ativa, segundo Prince (2004), é definida como qualquer método instrucional que engaje os estudantes no processo de aprendizagem, sendo contrastada com as aulas tradicionais, nas quais os estudantes recebem informações passivamente. Para Bonwell & Eison (1991) a aprendizagem ativa requer que os estudantes executem atividades de aprendizagem significativa e pensem no que estão fazendo. Num esforço de atualizar a visão da aprendizagem ativa no contexto das inovações pedagógicas, Mitchell, Petter, & Harris (2017) a definem como exercícios únicos ou contínuos introduzidos em sala de aula para encorajar o pensamento e a participação dos estudantes num esforço de engajá-los no processo de aprendizagem. Esses autores argumentam que a aprendizagem ativa é tipicamente introduzida em sala de aula, mas pode continuar dentro ou fora dela.

A teoria cognitiva de aprendizagem multimídia foi popularizada pelos trabalhos de Richard Mayer e de outros pesquisadores cognitivistas que argumentam que a multimídia suporta a maneira que o cérebro humano aprende (Sorden, 2013). A aprendizagem multimídia ocorre quando os estudantes constroem representações mentais de palavras (texto falado ou impresso) e de *pictures* (ilustrações, fotos, animação ou vídeo) (Mayer, 2005). A multimídia se refere à apresentação de palavras e *pictures*, enquanto a aprendizagem se refere à construção de conhecimento do estudante. A justificativa para o uso da aprendizagem multimídia é que os estudantes podem aprender mais profundamente com palavras e *pictures* do que apenas com palavras. A teoria da aprendizagem multimídia é fundamentada em três princípios (Khalil & Elkhider, 2016): (i) o princípio de canal duplo com dois canais separados para processamento verbal (texto falado ou escrito) e *pictorial* na memória de trabalho, também chamada de memória de curto prazo; (ii) o princípio da capacidade limitada que lida com a limitação da memória de trabalho para processar simultaneamente vários pedações de informação; e (iii) o princípio do processamento ativo indicando que, para a aprendizagem significativa ocorrer, o processamento de nova informação selecionada e organizada na memória de trabalho requer a ativação e integração de conhecimento prévio armazenado na memória de longo prazo.

3 Contexto do Estudo

O curso online, apresentado a seguir, promove a aprendizagem ativa e constitui a base da prática pedagógica foco deste artigo, sendo fundamental na assimilação dos conceitos básicos de programação abordados na Programação Introdutória, principalmente para estudantes novatos.

3.1 Curso Acelerado da Code.org

A Code.org© é uma organização sem fins lucrativos dedicada a expandir o acesso à Ciência da Computação nas escolas (Code.org, 2019). Foi lançada em 2013 e é apoiada por grandes empresas como Amazon, Facebook e Google, atuando em vários espectros educacionais, como: projetar cursos, treinar professores, ajudar a mudar políticas governamentais, e expandir internacionalmente por meio de parcerias.

A Code.org possui cursos para várias faixas etárias, com atividades com e sem o suporte de computadores. O foco deste artigo é o Curso Acelerado, que é uma introdução acelerada ao curso de Ciência da Computação usando a programação em blocos, com duração de 20 horas e para pessoas com até 18 anos. Foi projetado para o Ensino Fundamental e possui 20 fases: 9 *online* (atividades com uso de computador e acesso à Internet) e 11 *offline* (atividades sem uso do computador). As fases *online*, foco deste estudo, proporcionam o uso de raciocínio lógico e matemático na solução dos problemas apresentados e, desde a primeira fase *online*, o estudante tem contato com as estruturas de controle de repetição e de seleção. Em fases mais avançadas são abordados conteúdos de funções. Na Tabela 1 são apresentados os blocos de comandos abordados por cada uma das 7 fases *online* escolhidas para os estudantes realizarem, classificados por categorias inspiradas no Scratch (https://scratch.mit.edu/), um ambiente de programação em blocos. Essa tabela foi elaborada a partir da análise dos blocos utilizados nas soluções de cada uma das fases, percebendo-se um gradativo aumento na dificuldade de cada fase e o uso de construções algorítmicas mais complexas para um novato em programação, como o aninhamento de 3 laços na terceira fase *online* (fase 7) e definições de funções na sexta fase *online* (fase 13). A seguir são apresentadas cada uma das fases da Tabela 1.

Tabela 1. Blocos das 7 fases do Curso Acelerado separados por categorias. Fonte: elaborada pelos autores.

CATEGORIA	BLOCO	FASES *ONLINE*						
		2	5	7	9	11	13	15
Movimento	Avance	X			X		X	
	Sequência de Avance	X						
	Avance por x pixels		X	X		X		X
	Volte x pixels		X					
	Vire à direita	X			X		X	
	Vire à direita por x graus		X	X		X		X
	Vire à esquerda	X			X		X	
	Vire à esquerda por x graus		X			X		
	Pule para a frente por x pixels					X		
	Remova 1				X		X	
	Preencha 1				X		X	
Controle: Estruturas de Repetição	Repita x vezes	X	X	X	X	X	X	X
	Repita até	X			X			
	Enquanto houver algo				X			
	Para (análogo ao *for*) com contador					X		X
	Sequência de "Repita x vezes"	X	X	X			X	
	Aninhamento de laços			X	X			
Controle: Estruturas Condicionais	Se	X						
	Se/senão	X					X	
	Sequência de Se				X			
	Encadeamento de Se/senão	X						
Funções	Chamada a funções com parâmetro					X		X
	Chamada a funções sem parâmetro						X	X
	Definição de função sem parâmetro						X	X
	Definição de função com parâmetro							X
	Sequência de chamada a funções					X	X	X
	Função que chama outras funções							X
Aparência	Definir cor		X	X		X		
	Definir largura					X		

Na fase 2 (chamada de "O Labirinto") foram utilizadas as temáticas de jogos digitais Angry Birds e Plantas *versus* Zumbis. Há 20 níveis em que o objetivo é orientar um personagem a se deslocar em um labirinto até chegar ao seu destino. Verificando-se a Tabela 1, percebe-se o uso de blocos mais simples, mas já com emprego de condicionais e repetição, o que é muito proveitoso como primeiro contato com programação. Na fase 5 ("O Artista") o objetivo é instruir um personagem artista a realizar desenhos geométricos. São 10 níveis nos quais ocorre o aprimoramento de alguns blocos utilizados na fase anterior: ao invés de "avance", há "avance por `x` pixels"; ao invés de apenas "vire à direita", há "vire à direita por `x` graus". Na fase 7 ("O Artista 2") mantém-se o objetivo da fase anterior, focando-se no aninhamento de laços. São 11 níveis, 8 abordando esse conceito, sendo 4 níveis com 3 laços aninhados. Na fase 9 ("A Fazendeira") o objetivo é aplanar o terreno de uma fazendeira para prepará-lo para o plantio. São 11 níveis nos quais foram introduzidos blocos novos como "preencha 1" e "remova 1". Na fase 11 ("O Artista 3") o objetivo é o de desenhar formas geométricas, mas com a facilidade do uso de funções como desenhar um quadrado com comprimento `x`. São 11 níveis nos quais se introduz o conceito de funções e sua importância, mais especificamente as chamadas a funções, além do laço `para` (análogo ao laço `for`) com contador. Na fase 13 ("A Fazendeira 2") o objetivo é o de aplanar o terreno, sendo que o foco é na chamada e definição de função sem parâmetro, num total de 10 níveis. Finalmente, na fase 15 ("O Artista 4"), retoma-se o objetivo de desenhar formas geométricas. São 10 níveis nos quais apresentam-se chamadas e definições de funções com e sem parâmetro, além da funcionalidade da chamada a várias funções de dentro de uma função.

3.2 Prática Pedagógica: Programação de Computadores em Engenharia

A disciplina de Programação Introdutória é ofertada a estudantes ingressantes nas diversas Engenharias do Campus Itabira da Universidade Federal de Itajubá. O perfil dos estudantes é bem variado, com idades, conhecimentos e competências em vários níveis, tornando o ensino da disciplina mais desafiador, além dos problemas inerentes à área de programação citados na introdução. A linguagem de programação adotada na disciplina é a C++ no paradigma procedural, cuja sintaxe é considerada difícil para estudantes novatos.

O primeiro grande desafio de um estudante em Programação Introdutória, observado pela docente da disciplina, era a dificuldade em relacionar uma nova informação, muitas vezes abstrata, com conceitos já existentes em sua estrutura cognitiva. Isso também gerava insegurança nos estudantes pelo desconhecimento da área de programação. Assim, logo que o Curso Acelerado foi disponibilizado em português pela Code.org, em 2015, a docente realizou e analisou todas as fases *online* (apresentadas anteriormente na Tabela 1) e percebeu que, apesar de ser um curso recomendado a alunos do ensino fundamental, poderia ser utilizado por estudantes ingressantes de Engenharia para que servisse de organizadores prévios, almejando-se a aprendizagem significativa. As vantagens eram muito concretas, como o *feedback* rápido e animado da programação e a motivação alavancada pela ludicidade do ambiente. A própria natureza do Curso Acelerado promove a aprendizagem ativa, engajando os estudantes no processo de aprendizagem. O ambiente é autoexplicativo e leva o estudante a alterar seu raciocínio lógico perante os *feedbacks* da ferramenta.

O Curso Acelerado vem sendo utilizado em disciplinas de Programação Introdutória em algumas turmas dos cursos de Engenharia do campus desde 2015, com o objetivo de facilitar a aprendizagem inicial de programação de computadores. Em uma pesquisa realizada no 1º semestre de 2016 com 48 estudantes (Izeki et al., 2016), estes responderam a um questionário em que 98% deles afirmaram que o Curso Acelerado ajudou a entender os conceitos básicos de programação como condicionais, repetição e funções, 81% se sentiu bem ao realizar as atividades propostas pela ferramenta, e 98% afirmaram que era divertido utilizá-la. A primeira fase *online* (fase 2) era realizada em uma aula de laboratório com duração máxima de 110 minutos, com a maioria dos estudantes completando a fase em menos de 60 minutos. Apesar de ser a primeira fase *online*, ela conta com uma riqueza de aplicação de conceitos: estruturas condicionais simples (`se`), estruturas condicionais compostas (`se/senão`), encadeamento de condicionais compostas, estruturas de repetição (repita `x` vezes, repita até), e sequência de estruturas de repetição. As demais fases *online* deveriam ser realizadas fora do horário de aula pois, tanto em sala de aula quanto em laboratório, já iniciar-se-ia a programação utilizando-se a linguagem C++, que faz parte do currículo formal da disciplina.

Mesmo com as vantagens observadas do Curso Acelerado para a aprendizagem, a docente percebeu que a ferramenta por si só não estava sendo suficiente para facilitar satisfatoriamente a aprendizagem dos estudantes, e que poderia intervir com uma pedagogia que tirasse proveito do Curso Acelerado. Assim, a partir do 2º semestre de 2016, a docente adotou uma prática pedagógica alinhando as atividades do Curso Acelerado com os resultados de aprendizagem, a sequência de conteúdo, os materiais de aula e, principalmente, com as atividades em sala de aula. O tempo dado aos estudantes para concluir o Curso Acelerado foi de 3 semanas do início das aulas, o que coincidia propositalmente com o início do conteúdo de funções (considerado um dos temas mais difíceis para os estudantes), e contribuiria com 10% da avaliação somativa do bimestre. Adotou-se, na maioria das aulas com total de 110 minutos, um tipo de aula com tempo reduzido (de 0 a um máximo de 30 minutos) de explicações pela docente seguidas de atividades em grupos de 2 ou mais estudantes, visando à aprendizagem ativa. Nas apresentações da docente empregou-se a teoria cognitiva de aprendizagem multimídia, em que o conteúdo era apresentado com imagens, explicações orais, e pouco ou nenhum texto. Deve-se gerenciar, nessa teoria, a quantidade de informação apresentada ao estudante para evitar sobrecarga em sua capacidade cognitiva, pois a memória de trabalho é limitada, devendo-se tentar balancear o processamento nos canais verbal e pictórico. Nessa teoria, a aprendizagem significativa é alcançada pela ativação e integração de conhecimento prévio armazenado na memória de longo prazo com o processamento de nova informação selecionada e organizada na memória de trabalho. Por exemplo, em uma das aulas de estruturas condicionais, as imagens utilizadas nas apresentações eram os blocos de programação do Curso Acelerado (informação na memória de longo prazo), fazendo-se analogias com a sintaxe da linguagem C++ (nova informação). Nessa apresentação foi fundamental criar um esquema visual simples de execução caso a expressão condicional resultasse em verdadeira ou falsa. Nesse caso, a utilização do Curso Acelerado ajudou no *misconception* que alguns estudantes têm em relação às estruturas condicionais, que todo comando `se` deve ter um `senão`. A aprendizagem ativa era estimulada em sala de aula com atividades em grupo, em que os estudantes se engajavam nas atividades, discutindo e resolvendo exercícios variados, como: exercícios de rastreio de códigos que resolvem problemas reais com variadas combinações de estruturas condicionais, exercícios de resolução de problema real, exercícios de entendimento de conceitos de funções (passagem de parâmetro por valor e por referência, retorno de função, chamada à função), entre outros.

Havia aula em que a docente não explicava oralmente os conceitos. Por exemplo, na primeira aula de funções em sala de aula a docente já não explicava o conteúdo, pois desenvolvera uma atividade em folhas de papel com imagens dos códigos que os estudantes haviam realizado no Curso Acelerado, com pouquíssimas explicações textuais, induzindo que os estudantes inferissem a importância e o uso de funções e de seus parâmetros. A atividade também facilitava a redução de *misconceptions*. Por exemplo, havia uma questão com duas definições de funções e apenas uma chamada a função. O erro que muitos estudantes cometem é pensar que, por existirem várias definições de funções em um programa, todas serão executadas sem serem chamadas. Após essa atividade que resgata da memória as atividades realizadas no Curso Acelerado, não se observou mais esse tipo de *misconception*.

4 Metodologia

Com o intuito de dar voz aos estudantes em relação à prática pedagógica, foram elaboradas as seguintes questões de investigação: (1) Em que medida a prática pedagógica facilitou a aprendizagem inicial dos conceitos da disciplina? Por quê? (2) Em que medida a prática pedagógica motivou os estudantes na aprendizagem inicial de programação de computadores? Por quê? (3) Em que medida a prática pedagógica tornou os estudantes mais seguros na aprendizagem inicial de programação de computadores? Por quê? (4) De que forma a prática pedagógica influenciou os estudantes na compreensão do conteúdo e na superação das dificuldades?

Considerando o objetivo deste estudo, de natureza exploratória, optou-se por uma pesquisa qualitativa, que busca compreender a perspectiva dos participantes "sobre os fenômenos que os rodeiam, aprofundar em suas experiências, pontos de vista, opiniões e significados" (Sampieri, Collado, & Lucio, 2013, p. 376). A partir das questões de investigação, escolheu-se como instrumento de recolha de dados um inquérito por questionário composto por perguntas abertas e fechadas com a seguinte estrutura: dados biográficos (idade, sexo e período atual na Universidade), conhecimentos prévios em programação e a prática pedagógica.

No início do 2º semestre de 2018, o inquérito por questionário foi passado impresso a 40 estudantes que realizaram o Curso Acelerado no 1º semestre de 2017 e no 1º semestre de 2018, num processo voluntário, sendo que 23 deles (57,5%) devolveram o questionário respondido em uma semana. Essa forma de recolha de dados foi escolhida porque não seria possível em relação ao tempo reunir os alunos para encontros de grupos focais ou entrevistas e, como a maioria das questões possuía resposta dissertativa, eles iam respondendo em seus tempos livres. O perfil dos estudantes foi de 17 a 23 anos, sendo a maioria (69,6%) do sexo masculino, 52,2% cursando o 2º período e 47,8% cursando o 4º período. Ressalta-se que, embora o objetivo do estudo qualitativo seja de extrair significados dos dados e não precisar reduzir a números nem os analisar estatisticamente, foram utilizadas contagens para as questões fechadas. Para as questões abertas foi utilizada a análise de conteúdo, que é um conjunto de técnicas de análise das comunicações, que utiliza procedimentos sistemáticos e objetivos de descrição do conteúdo das mensagens (Bardin, 1977).

5 Resultados

A maioria dos estudantes (60,9%) não tinha noções de programação antes de cursar a disciplina, e todos responderam que o prazo dado pela docente foi suficiente para a realização das fases do curso. Na Tabela 2 são apresentadas as questões relacionadas à facilidade, motivação e confiança com escala de concordância, realizada a partir da assunção de uma notação neutra (opção "Indiferente"), positiva ("Concordo" e "Concordo Totalmente") e negativa ("Discordo" e "Discordo Totalmente").

Tabela 2. Questões relacionadas à facilidade, motivação e confiança.

QUESTÃO	- (%)	neutra (%)	+ (%)
A prática pedagógica **facilitou a aprendizagem inicial** dos conceitos da disciplina? Por quê?	4,5	4,5	90,9
A prática pedagógica **motivou** você na **aprendizagem inicial** de programação? Por quê?	0	17,4	82,6
A prática pedagógica tornou você **mais seguro** na **aprendizagem inicial** de programação? Por quê?	0	30,4	69,5

Relativamente à dimensão **"Facilitação da aprendizagem inicial de programação"**, os 9% que discordaram ou foram neutros justificaram que tinham conhecimento prévio em programação. A maioria concordante disse que o curso facilitou bastante no entendimento de como um programa funciona por ser lúdico, simples, fácil, por ter uma didática visual e de blocos, e que ajudou a relembrar e a reforçar conceitos, além de facilitar nas analogias para melhor compreensão. Alguns excertos: "*Para mim, que não tinha noção de programação, uma didática visual e de blocos ajudou muito*" (E18), "*Apesar de já ter visto programação antes, o curso me ajudou a relembrar e reforçar conceitos*" (E19). Relativamente à dimensão **"Motivação na aprendizagem inicial de programação"**, metade dos 17,4% que foram neutros justificaram que já sabiam programar. A maioria argumentou que era uma forma divertida e prática de aprender, que despertou curiosidade, que ficou empolgado com as coisas acontecendo por seus comandos, que por ser parecido com um jogo com diversas fases a serem completadas o estimulava bastante a aprender, que a programação era apresentada de uma forma simples. Interessante o excerto: "*Não só me motivou, como me fez gostar de programação*" (E11). Relativamente à dimensão **"Segurança na aprendizagem inicial de programação"**, dos 30,4% neutros, alguns disseram que programar em blocos é diferente da linguagem passada em sala de aula e outro respondeu que já sabia programar. A maioria que se sentiu mais confiante justificou que melhorou o raciocínio lógico, que se empolgou, que a programação não era tão complexa quanto imaginava, que o curso proporcionou entendimento do básico da programação, que o aprendizado no curso foi tão significativo que era possível lembrar das atividades e da lógica por serem lúdicas. Interessante as seguintes respostas: "*Mostra que a programação não é um bicho de 7 cabeças*" (E17), "*Já tinha bastante cobrança para programar, então entender que para programar, os erros ensinam mais que os acertos, me davam segurança de tentar e testar tranquilamente*" (E19), "*Quando existia a dúvida sobre a lógica era possível lembrar das atividades que, por serem lúdicas, tornaram mais fácil recordar a lógica*" (E23).

Sobre a questão de investigação "De que forma a prática pedagógica influenciou os estudantes na compreensão do conteúdo e na superação das dificuldades?", foram elaboradas as questões da Tabela 3. Relativamente à dimensão da **"Associação de novo conteúdo em sala de aula com o curso"**, os 17,4% que responderam negativamente justificaram que não se lembraram dele, que tentavam associar com problemas cotidianos. A maioria que respondeu positivamente disse que o conteúdo e a "mecânica" dos níveis do curso eram semelhantes à da programação vistos em sala, que se fazia analogia dos blocos para os códigos. Um aluno respondeu: "*A tentativa de associar a atividade do Code.org com a atividade em sala ajuda muito no entendimento das aulas*" (E17). Relativamente à dimensão **"Entendimento dos conceitos de funções com a retomada dos conceitos de funções do Curso Acelerado nas atividades em sala de aula"**, os 21,7% de estudantes neutros disseram que já sabiam programar ou sentiram dificuldades na abordagem de funções pelo curso. A maioria disse que a prática pedagógica esclareceu o assunto e que a abordagem no curso serviu de base para o aprendizado de funções. Um aluno escreveu: "*Foi uma matéria bem fácil de compreender, o material do curso em conjunto ao material didático da professora era de fácil compreensão*" (E23). Relativamente à dimensão **"Valeu a pena realizar o Curso Acelerado no início da disciplina"**, dos 9% que disseram não, um justificou que não realizou todo o curso e outro disse que já sabia programar. A maioria que afirmou ter valido a pena, justificou: "*Ajuda pessoas como eu, que não tinha muitos conhecimentos na área a se familiarizar com a programação*" (E3), "*Talvez eu faria de novo para testar minha evolução*" (E8), "*Me incentivou muito*" (E10), "*Ajudou bastante. Se não fosse o Curso Acelerado iria achar que a matéria era de outro mundo*" (E11), "*Pois começa a se familiarizar com o que você irá aprender, principalmente para aqueles que nunca viram nada de programação*" (E12), "*O Curso Acelerado é uma excelente ferramenta de introdução à disciplina, sendo muito importante para aqueles que nunca programaram*" (E13), "*Ajudou muito a entender a matéria*" (E17), "*Para noções básicas me ajudou muito*" (E18), "*Com certeza foi uma experiência interessante*" (E19), "*Valeu muito, porque como nunca tive contato facilitou meu entendimento, pois eu conseguia ver o processo de como funcionava cada detalhe da estrutura*" (E21). Relativamente à dimensão **"O que o estudante levou da experiência no Curso Acelerado para a aprendizagem da disciplina na linguagem C++"**, apenas um aluno disse não ter levado nada, pois já sabia programar. Os demais disseram que levaram a lógica de programação, as noções fundamentais de programação usadas no início do semestre, os conceitos de algoritmos, funções e repetição, a empolgação de programar, o interesse pela disciplina, a capacidade de resolver problemas com o mínimo de recursos, a compreender e analisar o problema, a capacidade de visualizar partes do código como blocos, a confiança. Alguns estudantes responderam: "*(...) principalmente do poder que as linhas de código tem sobre um progresso e o que alterações podem afetar no funcionamento*" (E6), "*Que você pode começar a aprender e entender coisas complexas por métodos mais simples de forma que te traga interesse e não pânico*" (E12).

Tabela 3. Questões relacionadas à influência da abordagem pedagógica na compreensão do conteúdo.

QUESTÃO	- (%)	neutra %	+ (%)
A cada **novo conteúdo** passado pela professora você tentava **associá-lo** com a atividade do Curso Acelerado? Por quê?	17,4	8,7	73,9
A **atividade** em **sala de aula retomando** o conteúdo de funções do Curso Acelerado **ajudou** você a **entender** os conceitos de funções (definição, benefícios, parâmetros, chamada a função, definição de função)? Por quê?	0	21,7	78,2
Valeu a pena realizar o Curso Acelerado da Code.org no início da disciplina? Por quê?	9	0	91
O que você **levou da experiência** em realizar as atividades do Curso Acelerado **para a aprendizagem da disciplina** na linguagem C++?		Não se aplica.	

6 Conclusões

Segundo os resultados da pesquisa qualitativa, apesar de não poder generalizá-los, a prática pedagógica com o uso do Curso Acelerado da Code.org alinhada aos resultados de aprendizagem, conteúdo, materiais e, principalmente, com as atividades em sala de aula dá indícios que facilita, motiva e torna os estudantes mais seguros na aprendizagem inicial de programação, corroborando com as observações da docente da disciplina pelo *feedback* dado pelos estudantes nos últimos anos. Esse curso, apesar de ser recomendado para alunos do ensino fundamental, oferece oportunidades de aprendizagem ativa, engajando os estudantes na solução de problemas algorítmicos e no entendimento de conceitos básicos de programação em um curto período de tempo, sendo bastante vantajoso para alunos novatos. As atividades com materiais instrucionais em sala de aula, utilizando a teoria cognitiva de aprendizagem multimídia, juntamente com as atividades em grupo, proporcionaram a aprendizagem ativa dos conceitos básicos de programação na linguagem C++. Aulas menos expositivas e com maior engajamento dos estudantes em grupos em sala de aula foram bastante enriquecedores, proporcionando uma aprendizagem mais significativa. Dando voz aos estudantes, conseguimos compreender melhor o processo de aprendizagem e, consequentemente, melhorar a prática docente nos próximos semestres. Apesar da minoria dos estudantes que já tinha noções de programação responder negativamente às questões, houve estudantes que já programavam e que acharam desnecessário realizar o curso. Assim, uma sugestão é que se deixe para escolha do estudante que já saiba programar, se deseja ou não realizar o Curso Acelerado. Como sugestão de trabalhos futuros, para um aprofundamento desta problemática, sugere-se que o inquérito por questionário seja aplicado ao final de cada disciplina de programação introdutória, ao longo de várias turmas, configurando-se em um estudo longitudinal, podendo ser complementado com outros métodos de recolha de dados que vise compreender de forma aprofundada a problemática em questão.

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Unified Platform of Active Methodology (PUMA): Development Steps of the Module Divulgation and Request Projects

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Abstract

This work is the continuation of the article "Evaluating direct and indirect results of the active methodology in learning: proposal of an integrative design in 360º via unified platform", presented by PAEE / ALE, 2018, whose objective was to present the design of a Unified Platform of Active Methodology by means of the survey of requirements. At that time, the project was contemplated in the 3rd Millennium Learning Program (A3M) of CEAD / UnB, with the sponsorship of 25 thousand for its accomplishment and as future work was suggested to follow the development of the PUMA system - Unified Platform of Active Methodology. Thus, this article aims to present the first module of the platform called Project Disclosure and Request, focusing on the requirements survey process, the management method used, the risks associated with the development of the system and the functionalities implemented. This research has a qualitative approach and is classified as a case study, since it is centered in an automated system module that has as input the problems coming from the external agents who submit their project proposals in the platform within the scope of the Production Engineering course. The module developed will be put into production, in its Beta version in the first half of 2019, in the discipline of Production System Project 5 (PSP5), which has as an anchor technical thematic Quality Management. User feedback will be collected to improve the platform. It is hoped that this PUMA module will bring greater cooperation between the University and the companies, since the best projects developed in partnerships with public and / or private institutions will be disseminated through the platform, which will give greater visibility to the results of the application of the PBL in the course.

Keywords: project risks; requirements gathering; active methodologies; Problem Based Learning; project management methodologies.

Plataforma Unificada de Metodologia Ativa (PUMA): Etapas de Desenvolvimento do módulo de Divulgação e Solicitação de Projetos

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Resumo

Este trabalho é a continuação do artigo "Avaliando resultados diretos e indiretos da metodologia ativa na aprendizagem: proposta de um desenho integrador em 360º via plataforma unificada", apresentado do PAEE/ALE, 2018, que tinha como objetivo apresentar o desenho de uma Plataforma Unificada de Metodologia Ativa por meio do levantamento de requisitos. Naquela ocasião o projeto foi contemplado no Programa Aprendizagem para o 3º Milênio (A3M) do CEAD/UnB, com o Patrocínio de 25mil para sua realização e como trabalhos futuros sugeriu-se o acompanhamento do desenvolvimento do sistema PUMA - Plataforma Unificada de Metodologia Ativa. Assim, este artigo tem como objetivo apresentar o primeiro módulo da plataforma denominado Divulgação e Solicitação de Projetos, com foco no processo de levantamento de requisitos, no método de gestão utilizado, nos riscos associados ao desenvolvimento do sistema e nas funcionalidades implementadas. Essa pesquisa tem uma abordagem qualitativa e é classificada como estudo de caso, pois está centrada em um módulo de sistema automatizado que tem como insumo os problemas oriundos dos agentes externos que submetem suas propostas de projetos na plataforma no âmbito do curso de Engenharia de Produção. O módulo desenvolvido será colocado em produção, na sua versão Beta no primeiro semestre de 2019, na disciplina de Projeto de Sistema de Produção 5 (PSP5), que tem como âncora técnica temáticas de Gestão da Qualidade. Serão coletados os feedbacks dos usuários para a melhoria da plataforma. Espera-se que este módulo do PUMA traga uma maior cooperação entre a Universidade e as empresas, uma vez que os melhores projetos desenvolvidos em parcerias com instituições públicas e/ou privadas serão divulgados por meio da plataforma, o que dará maior visibilidade dos resultados da aplicação do PBL no curso.

Palavras-chave: riscos de projetos; levantamento de requisitos; metodologias ativas; Problem Based Learning; metodologias de gerenciamento de projetos.

1 Introdução

O mercado profissional requer que os engenheiros tenham boas habilidades de comunicação interpessoais e que apresentem competências profissionais que extrapolem os conhecimentos teóricos (Deshpande & Huang, 2011). O alinhamento do aluno, corpo docente e empresas sobre o que constitui os objetivos desejados na aprendizagem pode ser uma tarefa difícil. Nesse sentido, as universidades e as organizações empresariais têm buscado cooperar no desenvolvimento de profissionais, criando um perfil alinhado com a demanda da prática profissional, adotando um modelo de educação focado na disseminação do conhecimento com foco no desenvolvimento de competências, sendo ambas responsáveis pela formação dos profissionais de engenharia (Lima et al., 2017).

Os alunos são motivados a aprender quando entendem as conexões entre os assuntos e seus interesses, valores, objetivos e aspirações de carreira, pois o sucesso a longo prazo pode depender de sua capacidade de acessar e aplicar o que aprenderam (Fuentes, Crown e Freeman, 2008). Estudantes que estão chegando ao fim de seu aprendizado parecem ter uma preocupação crescente sobre a transição das habilidades e capacidades que têm aprendido durante a educação e as necessidades e exigências das empresas (Schoenau-Fog, Reng & Kofoed, 2015).

O curso de Engenharia de Produção (EPR) da Universidade de Brasília (UnB) tem observado esse cenário, e por isso apresenta em sua grade curricular sete disciplinas de Projeto de Sistemas de Produção (PSP), e adota a metodologia Project Based Learning (PBL) como a base estrutural dessas disciplinas. O PBL tem como objetivo fazer com que os alunos apliquem os conhecimentos teóricos da Engenharia de Produção na resolução de problemas reais, garantindo uma visão articulada entre as características da atuação profissional e as diferentes áreas de conhecimento, permitindo compreender a diversidade de aspectos determinantes envolvidos na solução de problemas (Monteiro et al., 2018).

As sete disciplinas de PSPs são focadas nas áreas de Probabilidade e Estatística, Sistema de Informação aplicado à Engenharia de Produção, Planejamento e Controle da Produção, Gestão da Qualidade, Engenharia do Produto e Gestão Estratégica. Os estudantes trabalham em equipes e participam de todas as etapas dos projetos, desde a fase de planejamento do projeto até a fase de encerramento. Além de promover a geração de soluções para os problemas reais, e às vezes ideias inovadoras, os PSPs proporcionam uma experiência completa de gerenciamento de projetos. Essas disciplinas são a espinha dorsal do curso, do quarto ao décimo semestre, e tem o intuito de desenvolver no aluno as competências transversais, tais como liderança, gerenciamento, proatividade, profissionalismo, capacidade de comunicação oral, além das competências técnicas (Monteiro et al., 2017).

Os problemas reais das empresas, sejam elas privadas ou públicas, grandes ou pequenas, de manufatura ou de serviços, fornecem o insumo para as temáticas a serem trabalhadas nas disciplinas de PSPs. O grande desafio é a captação desses agentes externos. A fim de facilitar o processo de captação foi desenvolvido o primeiro módulo, denominado Divulgação e Solicitação de Projetos, da Plataforma Unificada de Metodologia Ativa (PUMA), cuja modelagem foi apresentada no artigo "Avaliando resultados diretos e indiretos da metodologia ativa na aprendizagem: proposta de um desenho integrador em 360º via plataforma unificada" no PAEE/ALE (Monteiro et al., 2018)". Esse módulo está centrado na automatização do processo de captação das propostas de projetos para as disciplinas de PSPs, oriundos de problemas reais dos agentes externos.

Este artigo tem como objetivo apresentar os resultados do primeiro módulo da plataforma PUMA e está estruturado em 6 seções, a saber: na seção 2 é mostrada a visão geral da plataforma PUMA; a seção 3 apresenta a metodologia utilizada na pesquisa; na seção 4 são exibidos os métodos utilizados para o levantamento de requisitos e para a gestão do desenvolvimento do primeiro módulo da plataforma; e os resultados do primeiro modulo do PUMA, suas funcionalidades implementadas e os riscos associados ao seu desenvolvimento; e, por fim, a seção 5 traz as conclusões.

2 Plataforma Unificada de Metodologia Ativa (PUMA)

A Plataforma em desenvolvimento faz parte do projeto contemplado no Programa Aprendizagem para o 3º Milênio (A3M) do Centro de Educação a Distância (CEAD) da UnB, com o Patrocínio de 25mil reais para sua implementação. Espera-se que a Plataforma tenha funcionalidades que serão utilizadas ao longo das disciplinas de PSPs do curso de Engenharia de Produção da Universidade de Brasília, com o intuito de apoiar a melhoria e a automatização dos processos.

Essas funcionalidades comporão módulos que posteriormente se integrarão para automatizar desde a captação dos agentes externos (*stakeholders*) na busca de problemas reais a serem resolvidos pelos alunos das disciplinas de PSPs, até a avaliação e evolução das competências transversais e técnicas dos alunos em todas as 7 disciplinas de projetos. Os módulos que compõem o PUMA são: Divulgação e Solicitação de Projetos, Pesquisas, Avaliação Transversal, Avaliações e Relatórios. Será uma ferramenta de integração de resultados, avaliação contínua da metodologia empregada, resultados dos projetos e avaliação das competências transversais dos estudantes. (Monteiro et al., 2018)

Dessa forma, o PUMA está fortemente voltado ao incentivo e a cultura acadêmica para o uso da Tecnologia da Informação e Comunicação (TIC) como instrumento útil para o desenvolvimento do ensino e da aprendizagem, visando permitir a medição da eficácia do PBL, *feedbacks* e informações substanciais e seguras para o redirecionamento dos PSPs ao longo dos anos, além de acompanhar as exigências do mercado, e estar sempre alinhado às expectativas de todos os *stakeholders* do curso.

O edital do A3M retrata uma iniciativa da Universidade de Brasilia para apoiar o uso de Tecnologias da Informação e Comunicação (TIC) no Ensino Superior, e o projeto PUMA, que é oriundo dessa iniciativa, representa a cooperação entre universidade e empresas como forma de prover uma maior visibilidade da adoção do PBL no curso de Engenharia de Produção da UnB, que tem como objetivo propiciar a aprendizagem do aluno na prática.

3 Metodogia da Pesquisa

A estratégia da pesquisa é classificada como um estudo de caso, pois está centrada no estudo de um fenômeno dentro de seu contexto real (Yin, 2013), com abordagem qualitativa. Mediante uma pesquisa exploratória, foi desenvolvido um módulo de um sistema automatizado, a partir do insumo dos problemas oriundos pelos agentes externos que submetem suas propostas de projetos na plataforma PUMA, para que possam ser solucionados pelos estudantes do curso de Engenharia de Produção da Universidade de Brasília, com a utilização da metodologia PBL, nas áreas técnicas condizentes com cada disciplina de PSP.

O módulo 1 do PUMA foi desenvolvido entre abril de 2018 a fevereiro de 2019. Seguiu-se as etapas básicas para desenvolvimento de software, que envolveu o levantamento de requisitos, análise e modelagem, desenvolvimento de código, teste de software e implantação, além da gestão do projeto. O levantamento de requisitos se deu por meio das técnicas *Brainstorming* e *Storyboards* aplicadas em uma reunião com os professores dos PSPs. Para a gestão do desenvolvimento do projeto aplicou-se uma metodologia híbrida, com base nas abordagens ágil e tradicional.

4 Apresentação do Módulo 1 do PUMA

A seção 4 apresenta os elementos essenciais para a construção do Módulo 1 do PUMA, que envolve a etapa de desenvolvimento, as funcionalidades requeridas e os riscos associados ao desenvolvimento.

4.1 Desenvolvimento do módulo Divulgação e Solicitação de Projetos

O artigo de Monteiro et al. (2018) teve como resultado a modelagem a nível macro da Plataforma, servindo de insumo inicial para o desenvolvimento do módulo Divulgação e Solicitação de Projetos. Para o levantamento de requisitos a nível de funcionalidades desse primeiro módulo, foi realizada uma reunião de *Brainstorming* com 5 professores das disciplinas PSPs.

A reunião teve como agenda a apresentação da Plataforma PUMA aos professores, o compartilhamento de ideias para captar clientes externos para os projetos das disciplinas de PSPs, as vantagens da utilização da plataforma nessa captação de problemas oriundos de empresas públicas e/ou privadas e os mecanismos de *feedbacks* aos alunos e clientes, por meio da plataforma. Essa fase teve como ponto de partida alguns *storyboards* que são apresentados na Figura 1.

Figura 1. *Storyboards* utilizados no levantamento de requisitos do Módulo 1 do PUMA

Os *Storyboards* são histórias em quadrinhos e, no presente contexto ilustrado pela Figura 1, representam as sequências de ações ou eventos que ilustram o processo da dinâmica ocorrida nas disciplinas de PSPs, a partir da captação dos clientes externos pelo professor, solicitação de um agente externo para a resolução de um problema real e o *feedback* necessário para a execução do projeto. A aplicação desse método visou ajudar a equipe de desenvolvimento descobrir os requisitos, além de auxiliar no desenho das interações dos usuários com o sistema a ser desenvolvido, e isso só foi possível com os *feedbacks* obtidos dos usuários durante a reunião (Rogers, Sharp & Preece, 2013).

A utilização dos *Storyboards* serviu também para introduzir os professores na problemática que o sistema procura resolver. Essa fase foi uma das mais importantes para o projeto, uma vez que a qualidade do produto final dependeu fortemente da qualidade desses requisitos (Ferguson & Lami, 2006). Os requisitos levantados nessa reunião foram traduzidos em histórias de usuários descritas no Quadro 1.

Quadro 1. Requisitos em forma de histórias de usuários

Interface	Histórias de usuários	Funcionalidades
Agente externo	Como agente externo quero solicitar projetos para os alunos desenvolverem nas disciplinas de PSPs	● Ter um espaço para solicitar projetos, onde os agentes externos poderão propor projetos para resolução de problemas reais; ● Desenvolver um formulário para cadastro com as informações do agente externo (Exemplo: nome da organização, área de atuação, endereço e CNPJ), e do projeto proposto; ● Conceber login e senha para os agentes externos.
	Como agente externo quero acompanhar o desenvolvimento dos projetos.	● Elaborar uma página aberta de divulgação dos melhores projetos (como um blog); ● Criar um espaço para cada empresa cadastrada para o acesso e acompanhamento dos projetos submetidos.
Departamento	Como coordenador quero fazer a triagem dos projetos, a fim de selecionar os projetos de pesquisas de maior interesse para o curso de EPR	● Ter acesso às informações dos agentes externos e dos projetos propostos; ● Poder arquivar os projetos de maior interesse para o departamento; ● Dividir os projetos em áreas de interesse e tema.
Administrador	Como administrador quero manter a divulgação das informações dos PSPs na página inicial da Plataforma	● Poder editar, excluir e acrescentar projetos em destaque; ● Poder divulgar edital; ● Poder divulgar notícias.

De posse dos requisitos a nível micro e da modelagem realizada no estudo de Monteiro et al. (2018), foram implementadas as funcionalidades da Plataforma que são descritas na seção 4.2.

4.2 Funcionalidades implementadas no Módulo 1 do PUMA

Os principais clientes do módulo Divulgação e Solicitação de Projetos são os agentes externos, sendo representados por qualquer empresa ou pessoa que queira(m) solicitar à UnB a resolução de problemas reais a serem resolvidos pelos alunos através das disciplinas de PSPs. Diante deste contexto, a interface inicial da Plataforma permite a divulgação da abertura do edital de oferta de projetos, conforme é apresentado na Figura 2.

Figura 2 – Interface do PUMA para captação de projetos nas disciplinas de PSPs

A página inicial da plataforma visa o aumento da captação dos agentes externos para uma elevação e diversificação dos temas abordados nas disciplinas de PSPs, além de funcionar como meio de divulgação e promoção da abordagem PBL utilizada nas disciplinas. O objetivo da página é promover notícias, possibilitando a divulgação dos melhores projetos desenvolvidos pelos alunos, sobre as disciplinas de PSPs, reportagens sobre a adoção do PBL no curso de EPR da UnB, depoimentos dos clientes e, sobre o edital de abertura do processo de submissão de projetos. Após o cadastro, os usuários têm acesso ao painel do PUMA, em que pode visualizar seu (s) projetos, vide Figura 3.

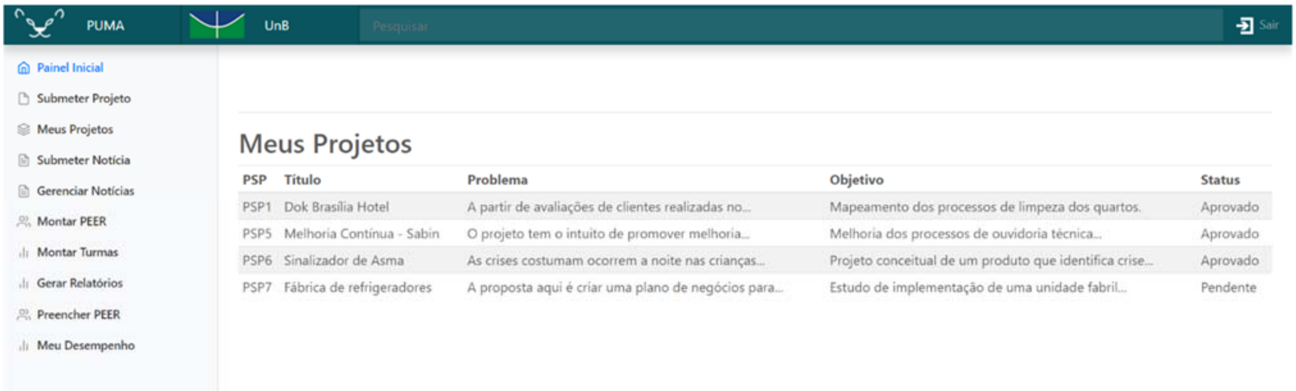
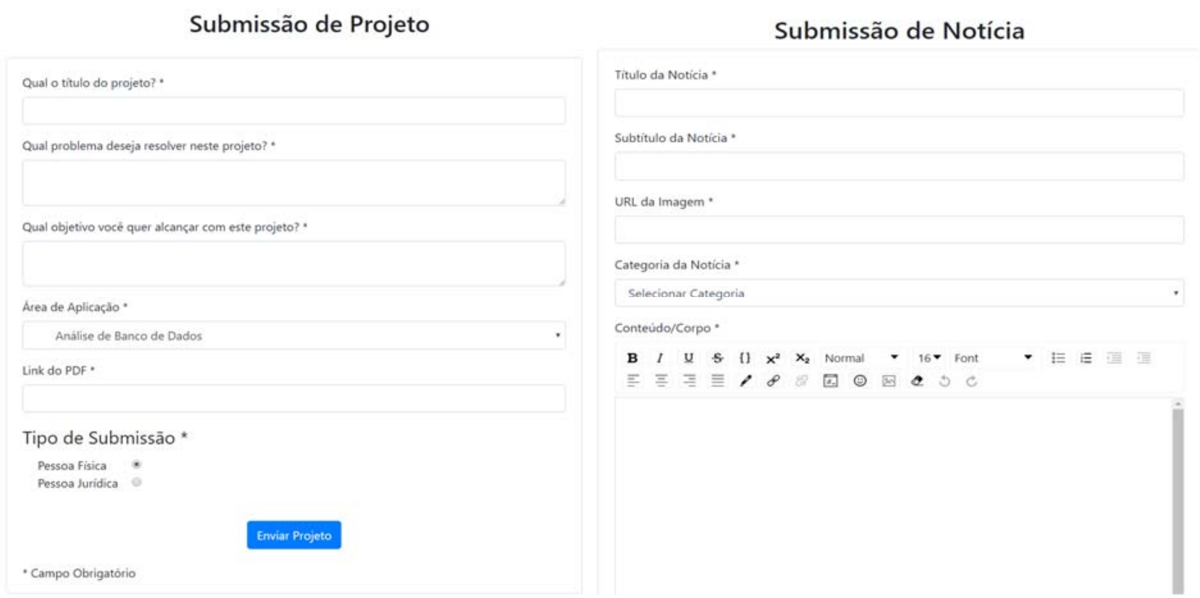


Figura 3 – Tela de acompanhamento das solicitações dos projetos pelos agentes externos

Ao entrar na Plataforma PUMA, os usuários podem ter acesso às funcionalidades do primeiro módulo, a saber: Submeter Projeto, que permite a solicitação de envio de projeto; Meus Projetos, que possibilita o acompanhamento do *status* dos projetos submetidos; Submeter Notícias, que permite a inclusão de alguma notícia na página inicial; e o Gerenciar Notícias, que mantém as divulgações. As Figuras 4 e 5 mostram como é feita a Submissão de Projeto e de Notícia na Plataforma.



Figuras 4 e 5 – Telas para submissão de projeto e submissão de notícia

A solicitação de envio de projetos é feita de forma automatizada, no momento em que é preenchido o formulário de Submissão de Projeto, que por sua vez é enviado à análise posterior do coordenador dos PSPs para a triagem dos projetos, com intuito de selecionar aqueles mais pertinentes às pesquisas que são desenvolvidas no EPR. Essa funcionalidade permite ainda que se mantenha uma base de agentes externos para posterior divulgação dos resultados e possíveis parcerias.

A funcionalidade Gerenciar Notícias é utilizada para pesquisar, editar e excluir alguma notícia publicada na página inicial da Plataforma, mantendo a divulgação das informações dos PSPs. Com a aba Meus Projetos, os agentes externos podem saber se seu projeto foi aprovado, rejeitado ou se está em fase de avaliação por parte do departamento do Curso.

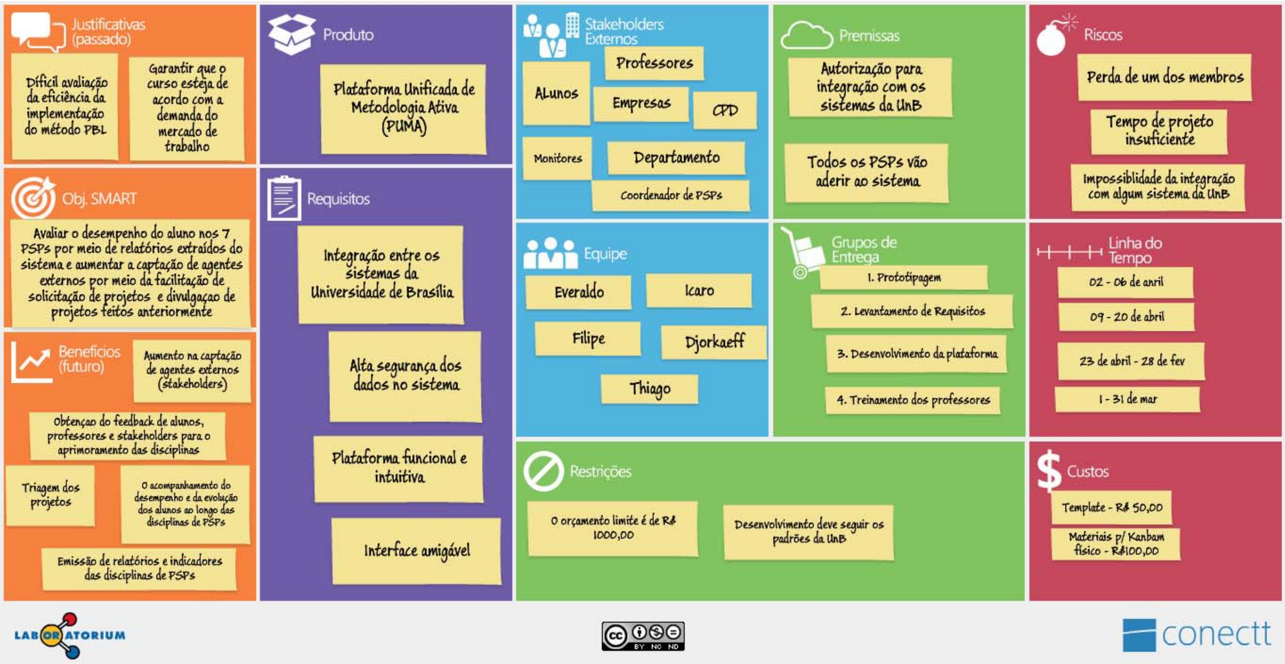
Gerenciar riscos em um projeto não é uma tarefa fácil, pois o desenvolvimento de um software pode ser impactado pelo tempo, não atendimento ao escopo, restrição de orçamento, dificuldades de infra-estrutura, etc. Para o gerenciamento dos riscos do projeto, foi utilizado o método ágil de gerenciamento de riscos, que é relatado na seção 4.3.

4.3 Tratamento dos riscos associados ao desenvolvimento do Módulo 1 do PUMA

Ao montar a equipe para o desenvolvimento do projeto, buscou-se uma equipe multidisciplinar, formada por alunos, mestrandos e professores das áreas de Engenharia de Produção, Computação e Engenharia de Software. Utilizou-se o Canvas como ferramenta de planejamento inicial para apresentar o projeto e seus riscos associados, veja Figura 6.

A montagem do Canvas foi feita de forma interativa, contando com todos os alunos que tiveram o papel de desenvolver e levantar os requisitos. Apenas as informações essenciais foram colocadas no quadro. Os riscos identificados nessa fase foram a perda de um dos membros da equipe, tempo de projeto insuficiente e impossibilidade de integração com algum sistema da UnB. Esses três riscos e outros que aconteceram durante o desenvolvimento foram tratados e monitorados durante as reuniões diárias ou de entrega por toda a equipe.

Buscou-se produzir um sistema de alta qualidade, atendendo às expectativas dos futuros usuários dentro do prazo estabelecido, mas foram identificados alguns atrasos nas entregas, aumentando a probabilidade do tempo do projeto ser insuficiente. Uma das causas do aumento dessa probabilidade é a equipe não ter conseguido se autogerenciar, sendo este um dos pilares das metodologias ágeis. Não houve uma boa adaptação da equipe com a metodologia de gerenciamento ágil no início do projeto. Nos 4 primeiros meses, utilizou-se para a gestão do desenvolvimento o framework ágil Scrum, mas optou-se para os meses seguintes a aplicação de uma metodologia híbrida, permitindo uma abordagem ágil e tradicional. A principal contribuição da tradicional foi a divisão das tarefas não ficarem a cargo dos desenvolvedores e sim pelos professores.



Figuras 6 – Canvas do Projeto PUMA

A impossibilidade de integração com algum sistema da UnB foi identificada quando se realizou o levantamento das arquiteturas e infraestruturas do Centro de Processamento de Dados (CPD) da Universidade. Nesse momento, foi constatado os impedimentos e limitações de tecnologia para a hospedagem da Plataforma pela UnB. Para a mitigação deste risco, foram previstas na plataforma, em seu segundo módulo, funcionalidades que permitam importações e exportações de informações dos prováveis sistemas na integração, com vistas a minimizar esforços da não integração com os mesmos.

A perda de um membro do time causou impacto negativo no rendimento da equipe. Para a mitigação deste risco, haviam alguns alunos já pré-selecionados para ser reposto no time de desenvolvimento. Ao primeiro momento houve desconfortos na equipe, mas após a visibilidade de um melhor apoio do novo membro, o impacto foi amortizado.

O risco do tempo insuficiente para a conclusão do projeto, ainda continua sendo monitorado e controlado visto ser ainda um risco ao projeto. Neste sentido, estão sendo aplicados técnicas de paralelismo e compressão nas atividades do projeto para mitigar os impactos do tempo insuficiente.

5 Conclusão

Espera-se que o módulo de Divulgação e Solicitação de Projetos desenvolvidos pelo projeto PUMA traga como resultado uma maior cooperação entre a Universidade e as empresas, uma vez que os melhores projetos desenvolvidos em parcerias com instituições públicas e/ou privadas serão divulgados. A página inicial também dará maior visibilidade aos resultados da aplicação do PBL no curso, além de servirem de base para toda a comunidade acadêmica que estuda a utilização dessa metodologia em diversas áreas de conhecimento.

Vale ressaltar como uma limitação do projeto PUMA a questão relativa à tecnologia para a hospedagem da Plataforma. Isso é um risco que está sendo gerenciado, e que foi elaborado como plano de contingência a solicitação de hospedagem para o programa A3M, que é o financiador do projeto por parte da UnB.

Como trabalhos futuros, pretende-se apresentar os módulos restantes da Plataforma com todos os benefícios e dificuldades que serão advindos. O módulo desenvolvido será colocado em produção, na sua versão Beta no primeiro semestre de 2019, na disciplina de Projeto de Sistema de Produção 5 (PSP5), que tem como âncora técnica a disciplina de Gestão da Qualidade. Serão coletados os *feedbacks* dos usuários para a melhoria da Plataforma.

A plataforma PUMA continua em desenvolvimento, seguindo o cronograma estabelecido pelo programa A3M da UnB. A funcionalidade Manter Avaliação Peer está em processo de finalização. Assim que for finalizada, poderá ser feito uma pesquisa sobre sua funcionalidade, inclusão, alteração e exclusão de itens a serem utilizados nas avaliações transversais dos PSPs, servindo de insumo para o acompanhamento do desempenho e da evolução das competências dos alunos ao longo das disciplinas.

A funcionalidade Realizar Avaliação Peer também está em desenvolvimento com o intuito de apoiar a avaliação dos projetos. Para a criação dessa funcionalidade, estudou-se cada disciplina separadamente, visto que os métodos de avaliação e as entregas esperadas se diferem entre os PSPs, pois cada disciplina busca desenvolver competências técnicas e transversais distintas a depender do que o professor julgar importante à temática apresentada. Está funcionalidade busca deixar claro para o aluno o que é considerado na avaliação pelos professores ao comporem suas notas finais, deixando evidente o que se esperar dele durante os projetos. Espera-se que uma vez concluída a plataforma, os resultados sejam disponibilizados a todos os usuários, aumentando a interação entre os alunos, professores e agentes externos, sejam eles empresas ou pessoas físicas.

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The mapping of the use of active learning strategies in an engineering school

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Abstract

The objective of this work is to analyse the perception of the teachers of an engineering school about the use of active strategies, which strategies they use in their classes and, in addition, the satisfaction with the use of traditional teaching strategies. The teachers' perception of new teaching strategies is important to ensure adherence to their implementation, because when acting directly in the teaching-learning process, their belief may support or hinder the implementation of new strategies. The questions are: Are teachers satisfied with the teaching strategies used? How do they perceive and eventually adhere to the active strategies in engineering teaching? The answers are important because as more teachers are aligned with his premises of new strategies, more efficient is an institutional change of strategies. In order to analyze teachers' satisfaction with teaching strategies, the option was to use the conceptual change model, which considers that if there is dissatisfaction with the strategies in use, there is an "open door" to the approach with new learning strategies. The survey data were collected by a multiple-choice questionnaire on a Likert scale, answered by 80 teachers of an engineering course, many of whom went through a training process in active learning strategies. The results indicate that, although there is a belief that active learning strategies can contribute to students' learning; teachers are satisfied with the use of traditional teaching strategies, which is a barrier to change.

Keywords: Curricular change; Active Learning; Project Based Learning; Conceptual change.

Mapeamento do uso de estratégias de aprendizagem ativa numa escola de Engenharia

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Resumo

O objetivo deste trabalho é analisar a percepção dos professores de uma escola de engenharia sobre o uso de estratégias ativas, quais dessas estratégias utilizam em suas aulas e, além disso, a satisfação com o uso de estratégias tradicionais de ensino. A percepção dos professores sobre novas estratégias de ensino é importante para garantir a aderência à sua implementação, porque ao atuar diretamente no processo de ensino-aprendizagem, sua crença pode favorecer ou dificultar a implementação de novas estratégias. A questão é: Os professores estão satisfeitos com as estratégias de ensino que utilizam? Como percebem e, eventualmente, aderem às estratégias ativas no ensino de engenharia? As respostas são importantes porque tanto mais eficiente é uma mudança institucional de estratégias, se o professor estiver alinhado com suas premissas. Para analisar a satisfação dos professores com as estratégias de ensino, a opção foi o uso do modelo de mudança conceitual que, considera que se há insatisfação com as estratégias em uso, há uma "porta aberta" para a aproximação com novas estratégias de aprendizagem. Os dados da pesquisa foram coletados por um questionário de múltipla escolha, numa escala de Likert, respondido por 80 professores de um curso de engenharia, muitos dos quais passaram por um processo de formação em estratégias ativas de aprendizagem. Os resultados indicam que, ainda que haja a crença de que as estratégias ativas de aprendizagem podem colaborar para a aprendizagem dos estudantes, os professores sentem-se satisfeitos no uso de estratégias tradicionais de ensino, o que representa uma barreira à mudança.

Keywords: Mudança curricular; Estratégias Ativas; Project Based Learning; Mudança conceitual.

1 Introdução

A percepção dos professores sobre as estratégias de ensino utilizadas no processo de ensino aprendizagem, é importante para que novas estratégias possam ser implementadas nas diversas formações de engenharia. Essa importância se justifica pelo fato de que o professor está na linha de frente do trabalho no processo de ensino-aprendizagem, junto aos estudantes, e essa percepção do professor pode favorecer a implementação de estratégias ou, pelo contrário, dificultar esse processo. Por isso é importante conhecer a percepção dos professores sobre as estratégias de ensino utilizadas (TERRÓN-LÓPEZ, 2016).

Atualmente tem-se recorrido cada vez mais ao uso de estratégias ativas para promover a aprendizagem como o *peer-instruction*, o *think pair share*, a sala de aula invertida, o ensino híbrido, o *Project Based Learning* (PBL) dentre outras estratégias (VILLAS-BOAS et al., 2012; SESOKO e MATTASOGLIO Neto, 2014; LIMA et al. 2012). Essa implementação vem sendo estudada, pelo fato de ajudarem a motivar os professores no seu trabalho e, ainda, promoverem o desenvolvimento de habilidades transversais e maior engajamento nos estudos.

O método de ensino tradicional consiste no fato do professor ser o responsável pela transmissão do seu conhecimento e experiência aos alunos. Já os métodos de aprendizagem ativa consistem no fato do aluno ser o principal responsável por sua aprendizagem, uma vez que o professor auxilia na construção do aprendizado, tendo um papel de "tutor", e avaliador do aprendizado do aluno.

Em particular no *Project Based Learning* - PBL - os professores propõem um projeto, com duração de aproximadamente um semestre, no qual a responsabilidade de desenvolvimento é do estudante (KOLMOS, 1996; ALVES et al, 2012). Essa estratégia é muito identificada com os cursos de engenharia, porque o engenheiro é naturalmente o profissional que projeta, visando a solução de problemas na sua ação no mundo.

A questão que se coloca é como os professores percebem e, eventualmente, aderem às estratégias ativas no ensino de engenharia? Essa pergunta é importante porque num processo de mudança para estratégias ativas, tanto mais eficiente será o processo de implementação de novas estratégias, quanto o professor estiver alinhado com suas premissas.

Para interpretar como o professor se alinha a esse processo de mudança, a opção neste trabalho foi utilizar o modelo de mudança conceitual (POSSNER et al, 1982). Como descreve Mattasoglio Neto e Pavão (2006) o processo de mudança conceitual de professores envolve uma primeira etapa que é da insatisfação com o processo de ensino-aprendizagem praticado. Se há insatisfação há uma "porta aberta" para a aproximação com outras estratégias de aprendizagem. Essa insatisfação deve ser entendida com algo que incomoda os professores e os tornam permeáveis à mudança para novas estratégias de ensino-aprendizagem. Identificar se há insatisfação é fundamental para saber da disposição do professor em mudar de estratégia de ensino.

Uma vez que exista uma insatisfação, o modelo de mudança conceitual prevê algumas etapas seguintes, até que a mudança para uma nova estratégia se consolide. A primeira é a inteligibilidade, que corresponde ao entendimento dos símbolos e códigos da nova estratégia. A segunda é a plausibilidade, que corresponde a se ter valores compatíveis na nova estratégia com os do professor. O terceiro é a fertilidade do trabalho com a nova estratégia, que é fundamental para o convencimento dos participantes de que o esforço para essa mudança tem valor. Este trabalho, no entanto, tem somente foco na etapa preliminar do modelo de mudança conceitual que é a etapa de insatisfação com o modelo praticado.

A pesquisa foi realizada numa instituição de ensino na qual a opção pela implementação mais intensiva das estratégias ativas de aprendizagem foi iniciada em 2015. Os professores foram assistidos nessa mudança por cursos de treinamento em estratégias ativas promovidos pela Academia de Professores, que é o órgão assessor da reitoria, com o papel de promover a formação dos professores na dimensão pedagógica.

A Academia de Professores oferece diversos cursos, oficinas, palestras e treinamentos aos professores. Dentre as oficinas oferecidas, houve uma série voltada para aprendizagem ativa e nessa categoria foram oferecidas as seguintes oficinas:

- *Peer Instruction*
- Ensino Híbrido
- *Design Thinking*
- Sala de aula invertida
- *Project Based Learning*
- Oficina para discussão sobre avaliação no *PBL*.

O foco do trabalho serão os professores do curso de engenharia, que responderam um questionário sobre a satisfação com o atual modelo de ensino praticado, como percebem e qual a satisfação com as estratégias de ensino utilizadas nas disciplinas e atividades complementares, na nova proposta curricular da escola.

O objetivo deste trabalho é expor as percepções dos professores com relação ao uso de estratégias ativas para a aprendizagem nos cursos de engenharia, se utilizam tais estratégias em suas aulas e se estão satisfeitos com os resultados alcançados. É fundamental esclarecer que para se atingir bons resultados nesse processo de mudança os professores devem sentir-se motivados e engajados para que a mudança obtenha os objetivos esperados.

2 Metodologia

2.1 Contexto de estudo

A escola em foco oferece nove diferentes cursos de engenharia. Uma mudança curricular está sendo implantada gradativamente no curso e engenharia desde 2015, chegando em 2017 à terceira série, implicando numa mudança na matriz curricular e a introdução de projetos no curso. Esses projetos são atividades oferecidas em paralelo às disciplinas e são de livre escolha dos estudantes. Cada projeto tem duração de um semestre e o estudante tem que cumprir pelo menos dois projetos por semestre, com o objetivo de trabalhar, principalmente, as habilidades desejadas na formação dos estudantes. O objetivo dos projetos é oferecer aos estudantes conhecimentos e habilidades, contribuindo para a formação de atitudes.

2.2 Coleta e análise dos dados

O trabalho constitui-se num estudo de caso exploratório, de análise qualitativa de dados. Para o levantamento das informações da pesquisa, foi elaborado um questionário enviado aos docentes da Instituição, com o objetivo de se obter informações de caráter geral, além de dados sobre a formação desses professores, a formação em educação que tiverem ao longo de sua formação profissional, a satisfação com os métodos utilizados de ensino e quais cursos realizaram no processo de capacitação interno da escola.

Os questionários foram organizados no *google.doc* e enviados ao professor por e-mail. Por um link, neste e-mail, os professores puderam acessar os questionários e responde-lo. De um total de aproximadamente 200 professores da Instituição retornaram 80 questionários respondidos. Além de questões de múltipla escolha, os questionários também tinham questões tipo escala *Likert*.

3 Resultados e Discussão

3.1 Caracterização do professor

Com menos de 5 anos de experiência tem-se 7,5% da amostra e, a maioria o tem tempo de docência está entre 11 a 20 anos, sendo que 76,25% tem mais de 10 anos de experiência na docência (Figura 1). Relativamente ao tempo de docência na instituição (Figura 2), 69 respondentes (86,25%), tem mais de 5 anos de instituição, o que mostra pouca rotatividade dos docentes.

Figura 1 - Tempo de docência dos professores

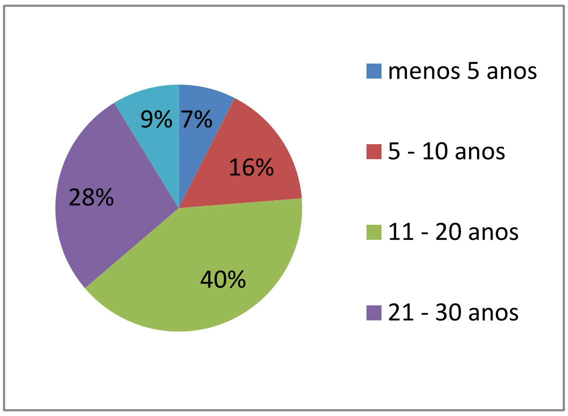
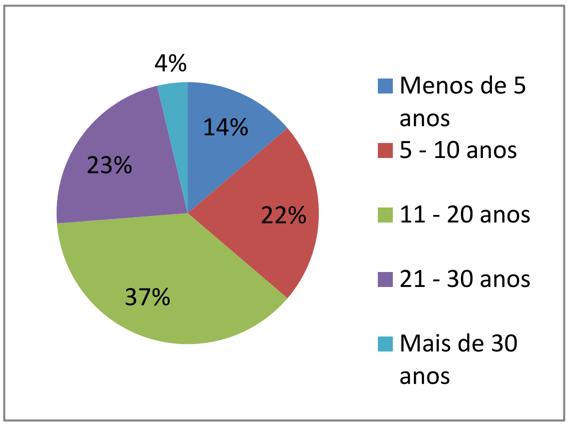
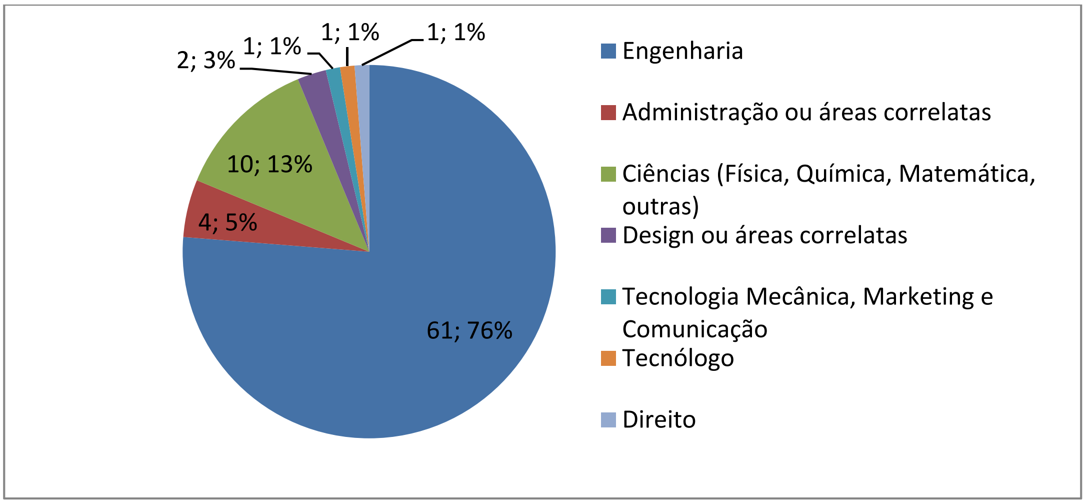


Figura 2 - Tempo de docência na instituição



A grande maioria que corresponde a 61 professores (76,25%) tem formação em engenharia (Figura 3).

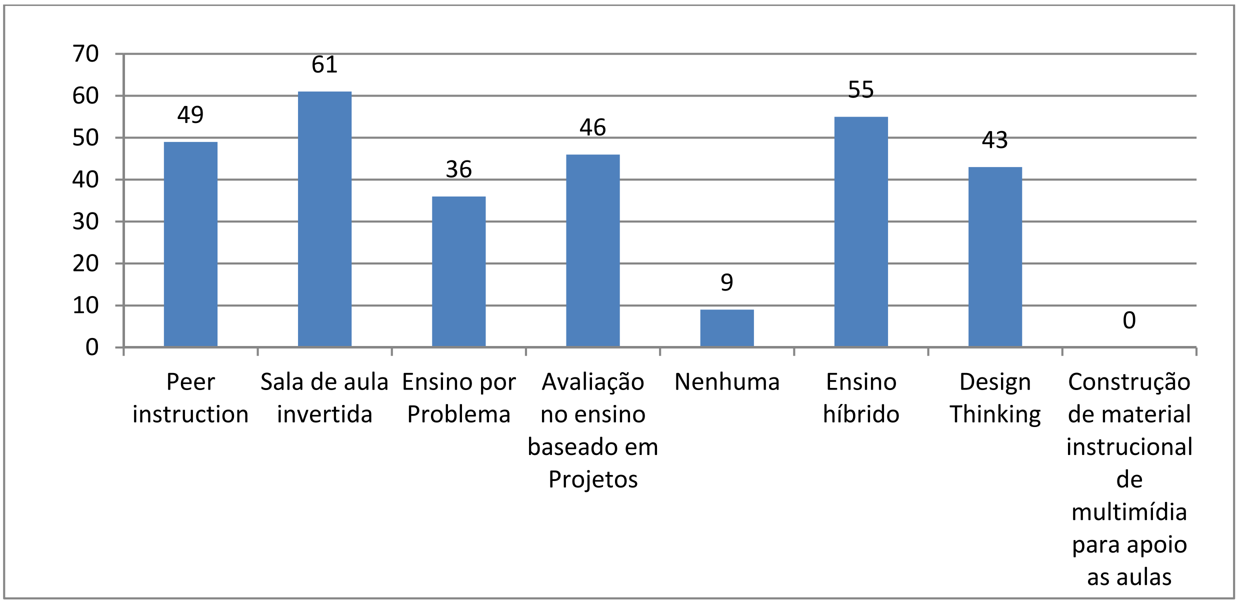
Figura 3 - Formação básica dos professores do curso de engenharia



3.2 Formação em Aprendizagem Ativa

Aos professores foram oferecidas diversas oficinas pela Academia de Professores para que conhecessem e aprendessem a aplicar estratégias ativas de aprendizagem. A partir do questionário enviado aos docentes chegou-se à conclusão que os cursos que mais tiveram sua presença foram: Sala de aula invertida, *Peer instruction*, Ensino híbrido e Avaliação baseado em projetos (Figura 4).

Figura 4 - Participação dos professores nas oficinas oferecidas pela instituição



3.3 Atuação como professor

Os professores do curso de engenharia atuam em até 5 disciplinas (Figura 5). Em sua maioria, eles usam estratégias ativas de aprendizagem em duas disciplinas (Figura 6). É interessante observar pelos dados da Figura 8 que apenas 9 professores indicaram que não utilizam estratégias ativas em suas disciplinas.

Figura 5 - Quantas disciplinas os professores atuam

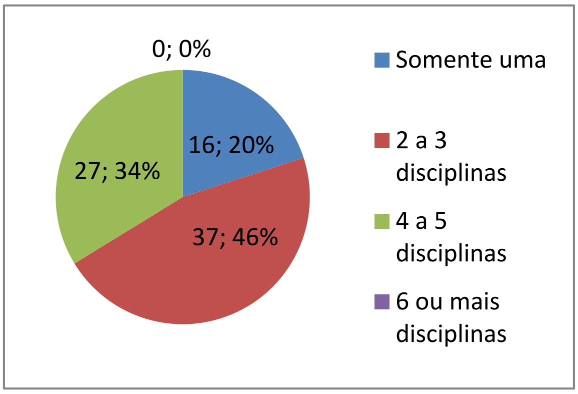
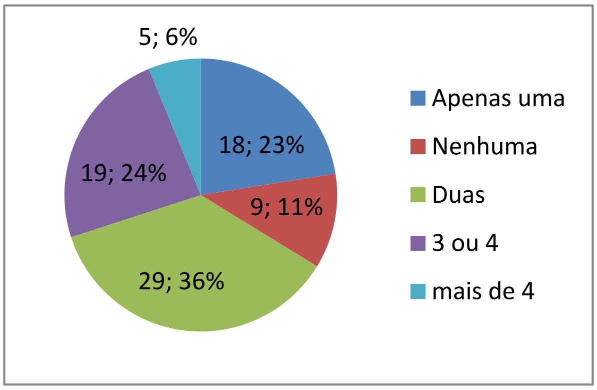
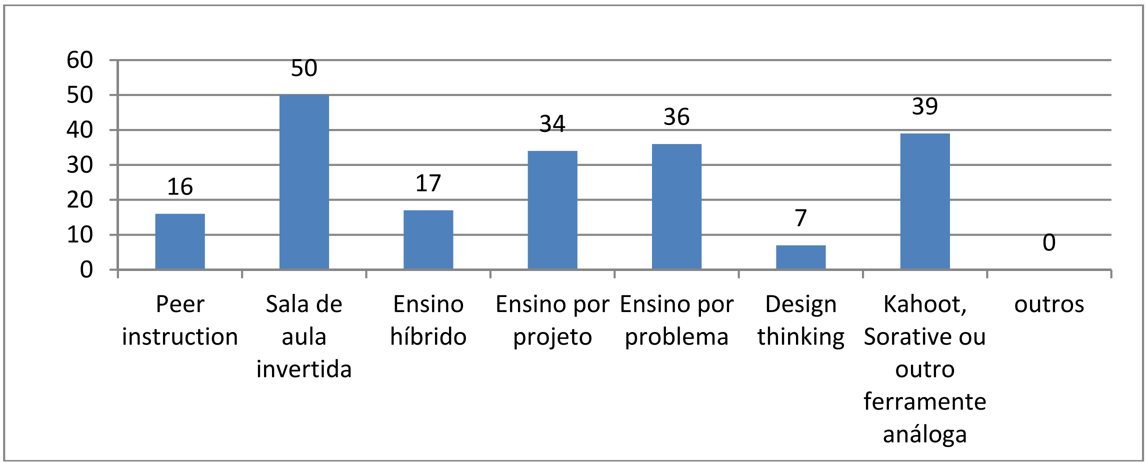


Figura 6 - Quantas disciplinas usam estratégias ativas



Dentre as estratégias citadas anteriormente, a mais utilizada por eles é a sala de aula invertida (Figura 7).

Figura 7 – Estratégias ativas usadas durante as aulas.



3.4 Análise da (in)satisfação com as estratégia de ensino

Considerando uma escala de 1 a 5 na qual 1 é discordo plenamente e 5 Concordo plenamente, obtivemos os resultados indicados a seguir.

Crença nas estratégias ativas de aprendizagem

Sobre a crença nas estratégias ativas de aprendizagem, os resultados apresentados na Tabela 1 indicam que os professores acreditam no uso de estratégias ativas para a aprendizagem, visto que apenas 6 indicaram discordar dessa afirmação. Sobre ser dispensável o uso de estratégias ativas, apenas 2 professores concordam que essas estratégias são dispensáveis.

É interessante notar que sobre a possibilidade de utilizar estratégias ativas, as respostas dos professores não indicam a intenção de utiliza-las em breve, já que 60 dos respondentes discordaram que pretendem utilizar as metodologias em breve, o que pode indicar uma indisposição para a mudança.

Tabela 1 – Resultados sobre a crença no uso de estratégias ativas de aprendizagem

Item	5	4	3	2	1
Acredito que o uso de estratégias ativas é mais eficaz para a aprendizagem, do que o modelo tradicional/expositivo.	24	35	15	6	0
O ensino superior dispensa o uso de Metodologias Ativas.	1	1	8	30	40
Tenho dúvidas sobre a eficácia do uso de estratégias ativas para aprendizagem.	1	10	22	32	15
Não utilizo estratégias ativas de aprendizagem mas quero utilizar em breve.	4	4	12	33	27

Dificuldade no uso de estratégias ativas para aprendizagem

Sobre a dificuldade em utilizar as estratégias ativas, ou seja, a colocar em prática em sala de aula o uso dessas estratégias, os resultados apresentados na Tabela 2 indicam que os professores se sentem seguros no uso das estratégias ativas de aprendizagem 53 concordam com a afirmação, no entanto, também indicam que o uso dessas estratégias é trabalhoso e requer tempo para sua preparação, 43 concordam com isso.

Tabela 2 – Resultados sobre a dificuldade no uso de estratégias ativas de aprendizagem

Item	5	4	3	2	1
Acredito que o uso de estratégias ativas é muito trabalhoso pois requer tempo para prepara-las.	6	37	22	10	5
Me sinto seguro para utilizar estratégias ativas.	18	35	20	7	0

Insatisfação com as estratégias tradicionais de ensino

Sobre a insatisfação com as estratégias tradicionais de ensino os resultados apresentados na Tabela 3 indicam que os professores se sentem satisfeitos em suas aulas sem o uso de estratégias ativas de aprendizagem 42 concordam com isso. Mesmo para a afirmação "Sinto dificuldade em manter um bom nível de aprendizado com aulas tradicionais/expositivas" o resultado foi uma variação que 29 concordam e discordam da afirmação, o que indica que isso não é um problema significativo.

Tabela 3 – Resultados sobre a dificuldade no uso de estratégias ativas de aprendizagem

Item	5	4	3	2	1
Tenho obtido bons resultados (boa aprendizagem) na minha disciplina SEM O USO de estratégias ativas.	5	37	18	12	8
Sinto dificuldade em manter um bom nível de aprendizado com aulas tradicionais/expositivas.	2	27	22	26	3

4 Conclusion

O principal objetivo desse trabalho é conhecer e entender a percepção dos professores sobre a mudança curricular, com relação a implementação de estratégias ativas durante as aulas do curso de engenharia e se estão satisfeitos com os resultados alcançados.

Os 80 respondentes realizaram 299 oficinas voltadas para o treinamento do uso de estratégias ativas de aprendizagem, o que corresponde a uma média de 3,7 oficinas por professor, o que indica um número alto de participação, cobrindo quase todo o rol de oficinas propostas para o tema. Ou seja, o grupo de professores está atendendo à solicitação para formação em estratégias ativas. Dos respondentes apenas 9 não utilizam estratégias ativas em suas disciplinas.

Quase 88% dos professores que responderam o questionário, pouco mais de 35% do total de professores da instituição, dedicam uma fração de seu trabalho para o uso de estratégias ativas, sendo que este uso se dá em cerca de duas disciplinas.

Os resultados indicam que 71 professores participaram do treinamento oferecido pela escola. Por sua vez há uma incoerência nas opiniões sobre o uso de estratégias ativas, uma vez que há professores que dizem conseguir atingir bons resultados sem o uso de estratégias ativas, enquanto outra parte diz ter dificuldades em alcançar um bom nível de aprendizado somente com as aulas tradicionais.

Portanto, há uma crença de que o uso de estratégias ativas pode colaborar para a aprendizagem, no entanto, há ainda uma resistência ao uso dessas estratégias, o que é indicado pelo alto índice do uso de aulas tradicionais.

Agradecimentos: Ao CNPq pelo auxílio de bolsa iniciação científica.

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Degree of inclusion of the active methodologies: A study through the learning styles of Felder-Silverman

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Abstract

The increase of studies on the use of active methodologies and their implementation as a practice of learning in institutions has gradually increased. The need to engage students in a context that facilitates the discussion and formation of knowledge has transformed classrooms, facilitating learning. However, it is known that students learn differently and use a 100% active methodology in the classroom, it may not include part of the students, making the initiative not inclusive. Thus, from the perspective of learning styles of Felder-Silverman this study aims to consider the use of active methodology to the detriment of different learning styles. In order to reach the objective, an exploratory research was conducted through the meta-analytic approach in the databases Scopus, Web of Science and Google Scholar, establishing the main reflections of the degree of inclusion of the use of active methodologies according to the learning styles.

Keywords: Learning styles; Felder-Silverman; Non-traditional methodologies; Active Learning; Inclusion.

Grau de inclusão das metodologias ativas: Um estudo por meio dos estilos de aprendizagem de Felder-Silverman

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Abstract

O incremento de estudos sobre o uso de metodologias ativas e sua implementação como prática de aprendizagem nas instituições vem aumentando gradativamente. A necessidade de engajar os alunos em um contexto que facilite a discussão e formação do conhecimento tem transformado as salas de aula, facilitando o aprender. Porém, sabe-se que os estudantes aprendem de maneira diferente e usar uma metodologia 100% ativa em sala de aula, pode não contemplar parte dos discentes, tornando a iniciativa não inclusiva. Assim, desde a perspectiva de estilos de aprendizagem de Felder-Silverman este estudo tem como objetivo ponderar sobre o uso da metodologia ativa em detrimento dos diferentes estilos de aprendizagem. Para alcançar o objetivo, foi realizada uma pesquisa exploratória via teoria do enfoque meta analítico nas bases de dados Scopus, Web of Science e Google Scholar, estabelecendo as principais reflexões do grau de inclusão do uso das metodologias ativas, segundo os estilos de aprendizagem.

Keywords: Estilos de aprendizagem; Felder-Silverman; Metodologias não tradicionais; Aprendizagem ativa; Inclusão.

1 Introdução

Muitos estudos (Felix, Rocha, Mariano, Mello, & Neumann, 2018; Mariano, Teixeira, Monteiro, Martín, & Rocha, 2018; Monteiro, Campos, Lima, Mariano, & Junior, 2018; Rocha, Mariano, Gomes, Monteiro, & Castilho, 2018) têm se preocupado em explicar os benefícios da adoção das metodologias ativas no contexto brasileiro. Estes efeitos podem ser observados além da aprendizagem do discentes, como no impacto no Conceito Preliminar de Curso-CPC(Felix et al., 2018), no momento do estudante escolher o curso de graduação (Mariano et al., 2018), ou na inclusão das minorias (Mello et al., 2018).

Segundo Larraz, Vázquez & Liesa (2017), a metodologia ativa tem como objetivo desenvolver habilidades, competências e atitudes nos estudantes, relacionando conhecimento teórico e empírico, colocando o estudante como um parte do processo de construção do aprendizado, contrastando com o método tradicional, centrado na transmissão da informação pelo professor (Morán, 2015).

Porém, as abordagens dos estudos estiveram centradas em comprovar e conhecer os benefícios da metodologia ativa, sem questionar as possíveis perdas em sua adoção. Debdi, Paredes-Velasco, & Velazquez-Iturbide (2014), explicam que os discentes normalmente respondem de diferentes maneiras aos ambientes de aprendizagem segundo seu estilo, assim quando o método de ensino está alinhado com o estilo de aprendizagem o estudante aprende de forma mais efetiva, melhorando seu desempenho. Desse modo, o grande alerta se encontra naquele grupo de alunos que não possuem o estilo de aprendizagem alinhado com o ambiente de metodologia ativa.

Segundo Ramírez-Correa & Mariano (2017), existem na literatura diferentes classificações de estilos de aprendizagem, porém o modelo de Felder & Silverman (1988) é considerado um modelo bastante consolidado, principalmente porque seu uso foi desenhado para estilos de aprendizagem nas Engenharias, categorizando 4 grupos, cada qual com dois estilos antagônicos.

Felder, R. M., & Spurlin (2005), realizaram uma revisão de 12 estudos que aplicaram a categorização de estilos de aprendizagem segundo Felder & Silverman (1988), com o objetivo de demonstrar a confiabilidade e validade do instrumento para identificar estes estilos. Adicionalmente pode-se observar que todos resultados, em todas as universidades onde foram realizados os estudos (algumas de maneira longitudinal), sempre existiam alunos com diferentes estilos de aprendizagem, o que era algo esperado, uma vez que cada aluno possui suas particularidades.

A metodologia ativa sempre esteve associada a determinadas habilidades e resultados positivos para a aprendizagem dos alunos (Mello, Mariano, Monteiro, & Martin, 2017), porém existe uma indagação: as metodologias ativas conseguem atender aos diferentes estilos de aprendizagem?

Essa é uma preocupação real, uma vez que a metodologia ativa nasceu como uma tentativa de melhorar a aprendizagem e engajar o aluno em sua própria formação, por outro lado se existem estilos de aprendizagem diferentes, isso significa que ao adotar a metodologia parte do grupo pode sentir-se desmotivado, uma vez que seu estilo de aprendizagem é diferente dos demais. Alguns estudos (Debdi et al., 2014; Sousa, Stadnicka, Dinis-Carvalho, Ratnayake, & Isoherranen, 2016) buscaram responder a esta questão e trouxeram contribuições importantes.

Debdi et al. (2014), realizaram uma pesquisa sobre a eficiência educacional em alunos de Engenharia de Ciências da Computação comparando metodologia ativa e tradicional e seu sucesso associado ao estilo de aprendizagem de Felder e Silverman. Os autores conseguiram associar os estilos ativo, visual, sensorial e sequencial com metodologias ativas e estilos intuitivos e verbais com metodologia tradicional. Já Sousa, et. al. (2016), realizaram uma pesquisa sobre a efetividade da abordagem de games/hans -on na melhoria da aprendizagem em Engenharia de Produção observando desde a perspectiva da Taxonomia de Bloom e o modelo de Felder-Silverman. Os resultados revelaram que 92% dos estudantes se sentiram envolvidos e motivados e que o processo de aprendizagem considerou os diferentes estilos de aprendizagem segundo Felder-Silverman e os diferentes níveis de objetivos da Taxonomia de Bloom. Assim, pode-se perceber que em ambos os casos o uso exclusivo de metodologia ativa não garante inclusão de todo o grupo e seus diferentes estilos de aprendizagem.

Deste modo o objetivo deste estudo é ponderar sobre o uso da metodologia ativa em detrimento dos diferentes estilos de aprendizagem.

Este trabalho continua com um referencial teórico, seguido da metodologia, resultados e discussões e finalmente as considerações finais.

2 Estilo de Aprendizagem de Felder & Silverman

A Universidade é um ambiente onde a aprendizagem deve ser inclusiva para garantir participação dos discentes. Segundo Ramírez-Correa & Mariano (2017), estas diferenças entre os estudantes impactam em suas preferências na forma que recebem e processam a informação, determinando assim, sua maneira de aprender.

Algumas pesquisas de estilos surgiram nos últimos anos, entre as mais destacadas estão o estilo de Myers-Briggs, que mensura a maneira que os discentes assimilam a informação e toma sua decisão via quatro dimensões (a) introversão a extroversão (b) intuitivo a sensorial, (c) emocional a pensativo, e (d) perceptivo e qualificado e o estilo Kolb, que classifica os estudantes segundo suas preferências por (a) a experiência concreta ou conceitualização abstrata, e (b), a experimentação ativa ou a observação reflexiva (Lee e Sidhu, 2015)

Porém, em 71 trabalhos analisados por Coffield, Moseley, Hall, & Ecclestone (2004), foram encontrados graves problemas de confiabilidade e validade nos modelos de medida, sendo considerado o modelo mais confiável o de Felder & Silverman. Adicionalmente, Felder, R. M., & Spurlin (2005), acompanharam 12 estudos publicados onde observaram a confiabilidade e validade do modelo de Felder & Silverman e o fato de ter sido desenhado para a Engenharia, enriquecendo a escolha do modelo.

O modelo de Felder & Silverman (1988), classifica os discentes a partir de quatro perguntas: (i) que tipo de informação percebe preferencialmente o aluno: sensorial ou intuitiva? (ii) que tipo de informação sensorial se percebe mais efetiva: visual ou verbal? (iii) como o estudante prefere processar a informação: ativamente ou reflexivamente? (iv) como avança o estudante para uma compreensão progressiva: sequencial ou global ?(Felder & Brent, 2005; Felder & Silverman, 1988; Ramírez-Correa & Mariano, 2017).

As respostas a estas perguntas categorizam os estudantes em quatro grupos(Debdi et al., 2014; Felder, R. M., & Spurlin, 2005; Felder & Silverman, 1988; Ramírez-Correa & Mariano, 2017):

(i) Percepção da informação: sensorial, pensador concreto, prático, orientado para resultados e procedimentos, são bons em memorizar fatos e tendem a serem cuidadosos e demoram na realização de seu trabalho, ou intuitivo, tipo de estudante pensador abstrato, inovador, orientado para as teorias e significados subjacentes, normalmente entediados com os detalhes, porém, são bons para entender novos conceitos e tendem a concluir tarefas rapidamente. Os estudantes sensoriais preferem tratar com fatos e dados e geralmente, preferem aprender por meio da experimentação, já os estudantes intuitivos, por serem mais rápidos e menos atentos aos detalhes, preferem lidar com princípios e teorias.

(ii) Percepção da informação sensorial: Os alunos de percepção visual, preferem as representações visuais do material apresentado, como imagens, diagramas e diagrama de fluxo, pois lembram melhor o que eles veem e podem esquecer a informação que é comunicada verbalmente. Por outro lado, os alunos de estilo verbal preferem as explicações escritas e faladas lembram muito do que ouvem e ainda mais do que eles veem e ouvem. Assim, a aprendizagem visual pede figuras, diagramas, filmes e demonstrações para melhor aprendizagem do aluno e o estilo verbal, optam sua aprendizagem por informações orais ou escritas.

(iii) Quanto ao processamento da informação, existem os alunos do tipo ativo, aqueles que aprendem provando coisas e disfrutam trabalhando em grupo, pois são atraídos pela possibilidade de experimentar ideias e participar em atividades sociais, como discussões ou explicações em grupo. Do outro lado estão os estudantes reflexivos, aqueles que aprendem pensando nas coisas e preferem trabalhar sozinhos ou apenas com o companheiro mais próximo. Alunos cujo estilo de aprendizagem está ativo não aprende muito com palestras ou aulas tradicionais, mas aprende melhor experimentando e trabalhando em grupos. Alunos cujo estilo é reflexivo exigem situações que ofereçam a oportunidade de pensar sobre a informação apresentada.

(iv) Progresso para a compreensão: alunos sequenciais possuem um processo de pensamento linear, aprendendo em pequenos passos incrementais. Se sentem confortáveis em níveis sequenciais, com lógica e uma ordem, seguindo o raciocínio linear para resolução de problemas. Eles podem ser fortes em pensamento convergente e análise e aprender melhor quando os professores apresentam material em uma progressão constante de dificuldade. Já os estudantes globais possuem um processo de pensamento holístico, aprendendo em grandes saltos. Estes estudantes podem se sentir perdidos por dias ou semanas sem serem capazes de resolverem problemas simples ou mostrando a compreensão mais elementar, até de repente "fazerem coisas". Eles evoluem apenas no final da sequência na qual todas as partes do conteúdo parecem ter sentido, pois conseguem enxergar o global.

Assim, a depender do perfil que os alunos possuam em relação aos estilos de aprendizagem, eles podem se ver mais identificados com um tipo ou outro de método de aprendizagem. Debdi et al. (2014); Ramírez-Correa & Mariano (2017); Felder, R. M., & Spurlin (2005) explicam que em seus estudos, 19 de 23 pesquisas, os perfis encontrados foram ativo, visual, sensorial e sequencial, podendo aprender melhor por uma metodologia não tradicional de aprendizagem, sendo que nenhum deles apresentou resultados totalmente ao contrário, apenas um ou outro estilo.

Pode-se observar por meio deste estudo, que embora os estilos diretamente associados as metodologias de aprendizagem não tradicionais possuam valores altos, os pequenos valores alcançados dos estilos antagônicos em realidade representam alunos, que não se sentem bem com metodologias não tradicionais, sendo tão entediante para eles a metodologia não tradicional, como costuma ser a metodologia tradicional para os estilos que não respondem bem ao estilo tradicional.

3 Método

Este estudo é do tipo exploratório com abordagem qualitativa e quantitativa via pesquisa bibliográfica. Foram realizadas buscas nas bases de dados *Web of Science, Scopus* e *Googles Scholar*. Foram escolhidas as três bases de dados devido sua relevância quanto a qualidade científica, representatividade e alcance. Quanto ao instrumento de coleta, as bases de dados *Web of Science* e *Scopus* possuem em suas plataformas, motores de busca e integração dos dados, que podem ser exportados e, para a coleta de dados do *Googles Scholar,* foi utilizado o software *Publish or Perish* 6.0. A busca foi realizada seguindo os princípios de Mariano & Rocha (2017) de (i) Preparação da pesquisa, (ii) apresentação e interrelação dos dados, (iii) detalhamento, modelo integrador e validação por evidências.

As palavras chaves escolhidas foram "Felder-Silverman" and "Active Learning" or "Learning Styles" and "Active Learning". Foram encontrados 355 registros em *Scopus*, sendo 18 de revisão, em *Web of Science*, foram encontrados 144 trabalhos, sendo 2 de revisão. Por último o *Google Scholar,* que foi pesquisado via o software *Publish or Perish*, que limita os resultados aos 1000 trabalhos mais citados (restrição do programa).

Foram realizados dois filtros, o primeiro para trabalhos dos últimos 20 anos e outro para trabalhos de revisão, que era um ponto do interesse desta pesquisa. Foram feitas duas análises, uma antes do filtro de artigos de revisão e uma leitura depois. Foram escolhidos 14 trabalhos, sendo um deles fora do universo temporal escolhido, porém identificado via co-citação no mapa de calor como um trabalho importante, que data de 1988 (Felder & Silverman, 1988). Este trabalho é o estudo que explicita a ideia dos estilos de aprendizagem e por isso sempre é citado pelos artigos mais atuais.

Os trabalhos foram analisados detalhadamente com a finalidade de integrar em um quadro os resultados dos estudos quanto a quantidade de estudantes por estilo de aprendizagem.

4 Resultados e análises

Foram analisados os resultados apresentados por Felder, R. M., & Spurlin (2005), em uma revisão de 20 estudos, em um total de amostra de 3237 alunos, o estudo de Debdi et al. (2014), com 93 alunos e Ramírez-Correa & Mariano (2017), com uma amostra de 122 estudantes. Os resultados confirmam que a maioria dos estudantes participes possuem um perfil ativo, visual, sensorial e sequencial, porém existem outros grupos de estudantes que não possuem este perfil.

Debdi *et al.* (2014), explicam que os estilos de aprendizagem ativo, visual, sensorial e sequencial aprendem melhor com abordagens não tradicionais. Observando a tabela 1, pode-se perceber que a escolha por apenas um estilo de aprendizagem pode ser prejudicial para o aluno. Se o professor opta pelo uso da Metodologia Ativa 1/3 dos alunos de três estilos de aprendizagem estariam desatendidos, e se optasse por opta pelo uso da Metodologia Tradicional 1/4 do quarto estaria sem conexão com o ensino.

Tabela 1. Média aritmética de estilos de aprendizagem

Estudos	**Média dos estilos de aprendizagens encontrado em alunos**							
(Debdi et al., 2014; Felder, R. M., & Spurlin, 2005; Ramírez-Correa & Mariano, 2017	Ativo	Reflexivo	Sensorial	Intuitivo	Visual	Verbal	Sequencial	Global
	61%	39%	67%	33%	75%	25%	61%	39%

Fonte: Adpatado de (Debdi et al., 2014; Felder, R. M., & Spurlin, 2005; Ramírez-Correa & Mariano, 2017)

Assim, uma das premissas da metodologia ativa é criar possibilidade de inclusão (Mello et al., 2018), porém observando estes resultados é importante compreender que uma parte dos alunos continuaria desatendida, repetindo-se o problema do uso da metodologia tradicional de ensino. Esta discussão é importante visto que existe um movimento progressivo de cursos de graduação, ensino médio e pós-graduação a se tornarem 100% orientados as metodologias não tradicionais, especialmente metodologias ativas. Deste modo este estudo abre indagações sobre em que medida devemos fazer uso das metodologias não tradicionais, como a metodologia ativa de ensino, ou se as metodologias tradicionais devem ser abandonadas como uma prática do passado. Estas perguntas não são alvo de respostas neste estudo, porém se espera que a apresentação deste estudo seja um momento de refletir sobre o uso de apenas uma prática de ensino.

5 Considerações finais

O objetivo deste estudo foi ponderar sobre o uso da metodologia ativa em detrimento dos diferentes estilos de aprendizagem. Foram resgatados na literatura alguns estudos apresentando os resultados de estilos de aprendizagem e foi observado que, apesar de terem uma tendência nas amostras estudadas, nenhum estudo encontrou apenas um perfil, significando que o uso da metodologia ativa ou qualquer outra não tradicional não alcança a todos os estudantes. Estes resultados contribuem com a discussão sobre o ensino, que começam neste trabalho e devem continuar da sessão de apresentação no evento. Para uma agenda futura espera-se que se possa realizar uma prova com grupo controle para tentar encontrar o grau adequado de composição disciplinar entre as abordagens tradicionais e não tradicionais (como as metodologias ativas).

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The challenges of adopting a constructivist learning: the abandonment of PowerPoint and the role of the student

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Abstract

The adoption of constructivist learning is a challenge. The new roles assumed by the teacher, the student and the university are paramount for the proper functioning of this approach. However, the scientific literature shows that in many cases students prefer to continue in a traditional classroom model via PowerPoint, because according to their perception, the use of slides facilitates the achievement of the objectives of the discipline. Withdrawal of the use of PowerPoint will require the student an increase in their role of responsibility in the classroom, compromising more time dedicated to the study. Thus, the purpose of this research is to discuss the role of the student in the process of changing the class via PowerPoint to the constructivist classes from the perspective of the contribution of literature. This research is of the exploratory type with a qualitative approach through literature review. The results pointed out that the role of the student becomes fundamental and that class time, program content and university timetable can be obstacles in the moment of implementing constructivist learning.

Keywords: Constructivist learning; Traditional learning; Power point; Role of the student.

Os desafios da adoção de uma aprendizagem construtivista: o abandono do PowerPoint e o papel do discente

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Abstract

A adoção de uma aprendizagem construtivista é um desafio. Os novos papeis assumidos pelo professor, pelo discente e pela universidade são primordiais para o bom funcionamento desta abordagem. Porém a literatura científica comprova que em muitos casos os discentes preferem continuar em um modelo tradicional de aula via PowerPoint, pois segundo sua percepção, o uso de slides facilita o cumprimento dos objetivos da disciplina. O abandono do uso do PowerPoint vai requerer do discente um aumento em seu papel de responsabilidade em sala de aula, comprometendo mais tempo dedicado ao estudo. Assim, o objetivo desta pesquisa discutir o papel do discente no processo de mudança da aula via PowerPoint para as aulas construtivistas desde a perspectiva da contribuição da literatura. Esta pesquisa é do tipo exploratória com abordagem qualitativa via revisão da literatura. Os resultados apontaram que o papel do discente passa a ser fundamental e que o tempo de classe, o conteúdo programático e cronograma universitário podem ser empecilhos no momento de implementar a aprendizagem construtivista.

Keywords: Aprendizagem construtivista; Aprendizagem tradicional; PowerPoint; Papel do estudante

1 Introdução

A educação e o processo de aprendizagem estão em constante mudança. Muitos estudos (Mariano, 2018; Mariano, Teixeira, Monteiro, Martín, & Rocha, 2018; Mello, Mariano, Monteiro, & Martin, 2017; Monteiro, Campos, Lima, Mariano, & Junior, 2018) têm relatado suas experiência positivas na adoção de metodologias ativas.

Embora as metodologia ativas sejam vistas como práticas inovadoras para a aprendizagem, há quase duas décadas o uso da tecnologia em sala de aula (compreendido como o uso de PowerPoint) foi contrastado em relação ao método tradicional em seu período (compreendido como o uso de giz e fala) e os resultados revelaram que em 48 estudos realizados em 22 anos de pesquisa, não houveram efeitos sobre a aprendizagem cognitiva (Baker, Goodboy, Bowman, & Wright, 2018). Porém, apesar de não serem encontrados benefícios relacionados a aprendizagem cognitiva, os alunos preferem o uso de PowerPoint pois ajuda na organização do conteúdo e na atenção(Butler & Mautz, 1996; Hill, Arford, Lubitow, & Smollin, 2012), além de aumentar a confiança no professor (Ledbetter & Finn, 2018). Adicionalmente, Craig & Amernic (2006), descrevem que o uso do PowerPoint para muitos locais foi visto como fundamental, sendo até pretencioso chegar a uma reunião sem uma apresentação formulada e no caso do ensino superior a falta do seu uso foi considerado durante muito tempo como sinônimo de professor antiquado.

Apesar do uso PowerPoint durante anos e sua associação a uma comunicação de qualidade, nos últimos anos têm prosperado os estudos que defendem o fim do uso da ferramenta em empresas e principalmente nas Universidades, alegando que continuar usufruindo da ferramenta deixariam os estudantes estúpidos, os professores chatos e que o uso dos slides são tóxicos para a Educação, pois desencorajam o pensamento complexo, e dão a falsa impressão que os conteúdos da disciplina estão contidos nos slides (Sørensen, 2015).

Neste contexto, as metodologias ativas aparecem como uma solução plausível para uma mudança do hábito do uso do PowerPoint na Educação, uma vez que está comprovado que as metodologia ativas incrementam a aprendizagem dos alunos(Amoras, Mariano, & Milhomem, 2018; Mariano et al., 2018).

Porém, esta mudança acarreta em um custo, onde o estudante exerce um papel fundamental e muitos não estão dispostos a pagá-lo. Sørensen (2015), explica que para o aluno é muito mais cômodo ler um resumo do conteúdo em slides do que se empenhar em ler o livro para construir o conhecimento conjuntamente e que o fato de atualmente se medir satisfação do aluno, ao invés do aprendizado, faz com que o PowerPoint permaneça independente de sua eficácia operacional.

Deste modo, o discente assume um papel decisivo na adoção de metodologias não tradicionais de aprendizagem, sendo estes a pedra fundamental do processo de mudança. Assim, este estudo tem como problema de pesquisa responder: quais os desafios no processo de mudança da aprendizagem tradicional via uso de PowerPoint para a aprendizagem construtivista?

Compreender o papel do discente no processo de mudança é importante para favorecer discussões sobre as iniciativas que devem ser adotadas a fim de melhorar o engajamento do aluno. Embora existam outros atores, nesta pesquisa foi restringido o papel do acadêmico e como a literatura tem observado este processo de mudança. Espera-se que por meio destas análises, se revelem possíveis desafios das metodologias não tradicionais em seu processo de adoção.

Assim, o objetivo desta pesquisa é discutir o papel do discente no processo de mudança da aula via PowerPoint para as aulas construtivistas desde a perspectiva da contribuição da literatura. Este estudo apresenta a revisão da literatura no capítulo 2, métodos no 3, resultados e análises no 4 e considerações finais no 5.

2 Referencial Teórico

Segundo Craig & Amernic (2006), no ano de 2002 estimava-se que aproximadamente 400 milhões de cópias estivessem circulando em todo mundo, com cerca de 20 a 30 milhões de apresentações por dia. Já em 2012, Hill et al., (2012), realizaram uma pesquisa e em 387 estudantes que informaram que 67% dos professores utilizavam a ferramenta e destes 67%, 95% a usavam amplamente ou a maior parte do tempo.

Embora a metodologia tradicional não seja exclusivamente o uso do PowerPoint, sua adoção é sem dúvida símbolo das salas de aula, cursos ou qualquer outra reunião com intuito de comunicar, exemplificar e aprender. Isso porque a maneira que o interlocutor oferece o conteúdo é uma questão fundamental não apenas na comunicação, mas na educação(Hill et al., 2012).

Assim, as mudanças previstas no intuito de melhorar a aprendizagem estão recriando uma nova maneira de relação entre professor, aluno e tecnologia. Atualmente uma apresentação é uma tarefa do professor que organiza o conteúdo de suas aulas, seus exemplos e recursos de aprendizagem, porém é uma tarefa do professor, de sua visão, interpretação e perceptiva do tema. Deste modo o aluno chega em sala de aula para participar e opinar em um contexto delimitado do conteúdo desde a visão do professor(Baker et al., 2018; Craig & Amernic, 2006; Kim, 2018; Roberts, 2018; Sørensen, 2015). Por outro lado, ao adotar alguma metodologia ativa, este processo se modifica, pois, o aluno passa a ter seu papel em sua própria aprendizagem.

Segundo Sørensen (2015), é neste ponto que reside o grande desafio onde todos possuem sua parcela de responsabilidade, o universitário que prefere o uso do PowerPoint porque é cômodo e requer menos "energia" do que estudar todo conteúdo no livro, a universidade que priorizou medir satisfação em detrimento da aprendizagem e o professor que simplifica seu trabalho cotidiano. Porém neste trio de atores o estudante passa a ter um papel fundamental, pois sem sua participação ativa, em um contexto onde não se adere o uso do PowerPoint, a aula não existiria.

Kim (2018), explica que tomar notas é uma das estratégias de aprendizagem mais importantes, porém no processo construtivista as notas seriam tomadas anteriormente ao dia de construção do conteúdo. Assim, em uma aula construtivista, onde o conteúdo é construído em sala de aula com os presentes, o aluno necessitaria de haver cumprindo uma série de leituras prévias, indagações, estudo de material complementar para chegar na aula e ativamente participar da construção por igual com os colegas e professores.

3 Método

Este estudo é do tipo exploratório, com abordagem qualitativa. Foi utilizada a pesquisa bibliográfica para conhecer os principais desafios na adoção progressiva de métodos não tradicionais de aprendizagem (aqui neste estudo entendemos o método tradicional de aprendizagem aquele onde o professor usa o PowerPoint e explica o conteúdo da disciplina em tópicos).

Foi realizada uma busca na literatura com as palavras-chave: "Active Learning" e "PowerPoint" nas bases de dados *Web of Science* e *Google Scholar*, onde foram encontrados 69 e 321 trabalhos respectivamente. Foi utilizado o termo PowerPoint pois se trata de um símbolo das salas de aulas dos últimos 20 anos e recentemente tem se discutido muito a continuidade de seu uso.

Os textos encontrados foram filtrados qualitativamente pela aderência ao tema e depois foram identificados os desafios desta mudança do tipo de aprendizagem voltando ao papel do estudante.

4 Resultados e Análises

Conforme explicado anteriormente, Butler & Mautz, (1996); Craig & Amernic (2006); Hill et al. (2012); Ledbetter & Finn (2018) e Sørensen (2015), ratificam que apesar das restrições dos estudantes quanto ao uso excessivo do PowerPoint, o formato das aulas tradicionais e a falta de incremento da aprendizagem pelo seu uso, os estudantes adotam o PowerPoint e atribuem pontos positivos ao professor que se apresenta usando a ferramenta.

Isso ocorre porque o abandono do uso do PowerPoint geraria uma redistribuição das tarefas e responsabilidades entre professores e alunos. Na figura 1 pode-se observar que na abordagem tradicional o professor prepara as aulas, realiza sua apresentação e os alunos assistem, já na abordagem construtivista, os alunos devem anteriormente se preparar para as aulas e no dia de construir o conteúdo em sala ele deve ter ferramental (adquirido com leitura e reflexão) para poder colaborar.

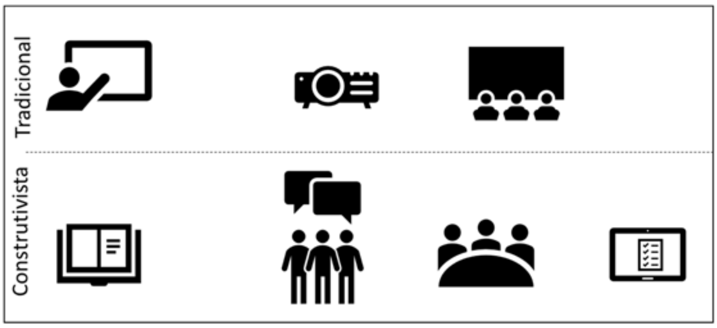

Figura 1. Abordagem vis PowerPoint e Abordagem Construtivista

O grande alerta reside em que sem estudante o processo de construção não existe e muitas vezes estes possuem um discurso contraditório, onde veem as aulas maçantes, mas não querem assumir um papel ativo em seu próprio benefício(Diesel, Baldez, & Martins, 2017).

Ramirez & Mariano (2017), explicam que os diferentes estilos de aprendizagem possuem uma relação direta sobre a postura dos discentes no momento de assumir uma postura ativa no processo de aprendizagem, sendo necessário conhecer os estilos de aprendizagem presentes no grupo.

Assim, pode-se perceber que o discente é a pedra fundamental da transformação junto ao professor e, que sem sua participação diária, o processo de construção do conhecimento não existe de fato. Deste modo, por meio das análises dos autores contidos neste trabalho pode-se considerar o discente corresponsável pelo seu aprendizado, ou seja, na falta de sua participação o processo de construção não existe. Porém o próprio processo de construção tem seus desafios, pois ao abandonar o conteúdo em tópicos disposto pelo PowerPoint, representando uma interpretação de mão única do professor, um conteúdo novo, construído em sala de aula deve ser implementado, mas o tempo necessário para consolidar a ideia de um grupo muitas vezes é maior que o tempo de aula da disciplina.

Apesar dos desafios serem grandes, a abordagem de metodologia ativa avança (Amoras et al., 2018), espera-se que este estudo reflexivo seja um dos pontos de partida para outros pesquisadores auxiliarem em responder como superar estes desafios.

5 Considerações finais

O objetivo deste estudo foi discutir o papel do discente no processo de mudança da aula via PowerPoint para as aulas construtivistas desde a perspectiva da contribuição da literatura. Pode-se observar que o estudante é pedra fundamental no processo de aprendizagem construtivista, porém os desafios são grandes, pois ao adotar uma nova abordagem o estudante passa a ser corresponsável de seu aprendizado. Adicionalmente outros pontos importantes devem ser levados em consideração como o tempo de aula, conteúdo programático e cronograma acadêmico. Para agenda futura espera-se que se possa realizar entrevista com discentes e docentes para saber suas percepções sobre as descobertas na literatura científica.

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Key Evasion Factors: A bibliometric study of the last 6 years

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Abstract

Many studies have advanced in order to find alternative practices to traditional learning methods, directly impacting the quality and satisfaction of the student, since this influences their cognitions and a direct influence on the behaviour of abandonment of the course. But there are many other factors that are decisive in understanding the reasons for student avoidance. This study aimed to present the contributions of the scientific literature in Web of Science and Scopus regarding student evasion. Exploratory research was conducted through bibliometrics between the years of 2104 and 2019. The results indicate that school drop-out accompanies the individual throughout adult life, including in other countries and even has consequences in the development of children. Among the factors that most lead to evasion are the lack of basic knowledge, lack of encouragement through extracurricular activities, drug use (licit and illicit), juvenile pregnancy, poorly designed subjects, poor student status, and diseases resulting from sexual practices such as HIV.

Keywords: Evasion, Evasion Factors, Literature Review.

Fatores-chave de Evasão: Um estudo bibliométrico dos últimos 6 anos

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Abstract

Muitos estudos avançaram no intuito de encontrar práticas alternativas aos métodos tradicionais de aprendizagem, impactando diretamente na qualidade e satisfação do aluno, uma vez que este tem efeito em suas cognições e influência direta nos comportamentos de abandono do curso. Porém existem muitos outros fatores que são decisivos para compreender os motivos de evasão por estudantes. Este estudo teve como objetivo apresentar as contribuições da literatura científica em *Web of Science e Scopus* a respeito da evasão estudantil. Foi realizada uma pesquisa do tipo exploratória por meio da bibliometria entre os anos de 2104 e 2019. Os resultados apontam que a evasão escolar acompanha o indivíduo durante toda a vida adulta, inclusive em outros países e até mesmo chega a ter consequências no desenvolvimento dos filhos. Entre os fatores que mais levam a evasão são a falta de conhecimentos básicos, falta de incentivo por meios de atividades extracurriculares, uso de drogas (lícitas e ilícitas), gravidez juvenil, disciplinas mal elaboradas, situação precária do aluno e doenças decorrentes de prática sexual de risco, como o HIV.

Keywords: Evasão, Fatores de Evasão, Revisão da Literatura.

1 Introdução

Muito tem se discutido a respeito de uma aprendizagem mais participativa onde o aluno se sinta engajado (Mello, Borges, Mariano & Neumann., 2018; Mello, Mariano, Monteiro, & Martin, 2017; Mello, Monteiro, & Mariano, 2018).

Segundo a Confederação Nacional da Industria (CNI, 2015), no Brasil, 50% dos ingressantes dos Cursos de Engenharia não concluem a Graduação. Porém os motivos são múltiplos, não apenas se restringindo ao processo de aprendizagem(Ramírez & Grandón, 2018). Porém o problema da evasão não é pontual na vida universitária e devido seus efeitos contínuos é necessário compreender esta evasão em um contexto amplo na educação(Cauchie, Bruyninckx, & Meuris, 2014; Dore, Amorim, & Sales, 2014; Finn, 1989; Maynard, Salas-Wright, & Vaughn, 2015; Ramírez & Grandón, 2018)

Assim, este estudo busca responder quais os fatores que levam a evasão em sala de aula?

Compreender estes fatores é ampliar as ações em prol do ensino, contribuindo para reflexão das instituições como um todo. A Evasão escolar está relacionada a fatores como violência, uso de drogas e saúde mental, sendo importante compreender as pesquisas nesta área (Rumberger, 2011; Kelly et al, 2015; Esch et al., 2014).

Deste modo o objetivo desta pesquisa é apresentar as contribuições da literatura científica em *Web of Science* e *Scopus* a respeito da evasão estudantil.

Este estudo apresenta o método e a revisão da literatura em conjunto com os resultados, uma vez que a revisão é o resultado em si. Em seguida, as considerações finais e referências.

2 Método

Este estudo é do tipo exploratório com abordagem quantitativa por meio da Teoria do Enfoque Metaanalítico Consolidado – TEMAC, de Mariano & Rocha (2017). O TEMAC é composto de três passos (a. Preparação da pesquisa, b. Apresentação e inter-relação dos dados, c. Detalhamento, modelo integrador e validação por evidências) e estão descritos em videoaulas em www.pesquisatemac.com. As bases de dados escolhidas foram a *Web of Science (WoS)* e *Scopus* e a coleta de dados foi entre 10/02/2019 e 24/04/2019. O objeto de estudo foi a evasão estudantil. Inicialmente seria realizada apenas para os cursos de Engenharias, porém ao realizar o filtro, a quantidade de artigos diminuía expressivamente, chegando de uma das bases de dados apresentar apenas 6 artigos no total (Wos) e a outra 27 (Scopus), antes mesmo de ponderar o espaço temporal delimitado. Assim se resolveu trabalhar em um escopo maior, sem a delimitação das Engenharias neste momento, para garantir uma maior consolidação do tema como um todo.

As buscas realizadas utilizaram as palavras-chave: "*School Dropouts" or "School Evasion*" or "*School Desertion*", em ambas bases de dados. Utilizou-se como instrumento de coleta de dados as próprias plataformas das bases de dados, que possuem métodos de exportação dos arquivos. Foi realizada a unificação das bases de dados *Web of Science* e *Scopus* para gerar os mapas de co-citation e coupling. Para as análises foi usado o programa VosViewer.

3 Revisão e Resultados

Segundo (Mariano, García-Cruz, & Arenas-Gaitán, 2011), o pesquisador deve buscar, tratar, entender e trabalhar com dados, gerando novas informações e agregando conhecimento.

O TEMAC é um modelo de revisão sistemática que identifica literaturas relevantes e de impacto seguindo as leis da bibliometria, o modelo é dividido em três passos: (a) preparação da pesquisa, (b) apresentação e (c) inter-relação dos dados e detalhamento, modelo integrador e validação por evidências.

3.1 Preparação da Pesquisa

Nesta primeira etapa definiram-se os termos "*School Dropouts*" ou "*School Evasion*" ou "*School Desertion*" nas bases de dados a *Web of Science* e *Scopus* com raio de busca de 2014-2019. O resultado foram 149 trabalhos e 834 em *Wos* e *Scopus*, respectivamente.

3.2 Apresentação e inter-relação dos dados

Segundo Mariano & Rocha (2017), na segunda etapa da TEMAC, são realizadas as inter-relações entre os dados dos registros encontrados, utilizando das leis da bibliometria.

Neste espaço temporal o estudo mais antigo em WoS foi "The Vocational Education Dropouts in the Brazilian Federal Institutes", de Dore et al., (2014), que fala a respeito da expansão dos Institutos Federais Ahmad, I., Said, H., Awang, Z., Yasin, M. A. M. Z., Hassan, Z., & Mansur, S. S. S. (2014). Effect of self-efficacy on the relationship between corporal punishment and school dropout. Review of European Studies, 6(1), 196-200.no Brasil, porém o grande grau de desistência dos alunos devido à dificuldade de aprendizagem por falta de conhecimentos básicos (71,7%), falta de incentivo de atividades extracurriculares (47,8%).

Na base de dados Scopus, o registro mais antigo foi *"Effect of self-efficacy on the relationship between corporal punishment and school dropout"*, de Ahmad, Said, Awang, Yasin, Hassan, Z., & Mansur, S. S. S. (2014), que explicam o castigo físico como fator influente na evasão, constatado pelo resultado de 300 questionário respondido pelos professores. Adicionalmente o estudo concluem que uma maneira de reduzir a evasão é criando um ambiente de apoio e cuidado ao estudante.

O artigo mais citado em *Web of Science* foi "*Evidence for the Social Role Theory of Stereotype Content: Observations of Groups' Roles Shape Stereotypes*" (82 citações) de Koenig et al., (2014). O artigo explora a "*Social Role Theory*", teoria do papel social em tradução literal, onde é feito um estudo com um grupo de pessoas sobre o papel delas na sociedade de acordo com o seu grupo social e estereótipos atribuídos a tal grupo. Os autores citam à alta taxa de desemprego no o grupo de pessoas que abandonaram a escola, sendo que restaurantes *fast food* o principal local de trabalho deste grupo. Pode-se perceber que este trabalho está relacionado aos efeitos da evasão estudantil.

Em Scopus o artigo mais citado foi "The Reciprocal Links Between School Engagement, Youth Problem Behaviors, and School Dropout During Adolescence" (119 citações), de Wang & Fredricks (2014). No estudo, os pesquisadores pesquisam o engajamento escolar associado a comportamentos problemáticos. Os resultados indicarem que o jovem que diminuiu o engajamento escolar, aumentou a probabilidade de estar envolvido em delinquência e uso de substâncias (drogas).

Os autores que mais publicaram em WoS foram Wendee M. Wechsberg e Felicia A. Browne, com três artigos. Seus estudos se centram em fatores externos como uso de drogas, gravidez juvenil e doenças sexualmente transmissíveis, como o HIV como fatores da evasão escolar(Carney et al., 2019; Wechsberg et al., 2015, 2018).

Os autores que mais publicaram em Scopus foram Janosz, M. (8), Archambault, I. (7), De Witte, K. (7) e Dupéré, V. (7). Janosz, M. , Archambault, I. e Dupéré, V., são co-autores na maioria dos trabalhos. Seus estudos identificam fatores externos como estressores (memória na infância, uso de drogas, depressão, entre outros) como variáveis que influem o abandono escolar. De Witte segue a mesma linha de fatores externos que influenciam o abandono, porém seus estudos chamam a atenção para a mobilidade residencial do aluno, a demissão acadêmica e características das famílias (segundo o autor, famílias em situação de vulnerabilidade incidem sobre a evasão dos estudantes pertencentes as mesmas.

Em Web of Science, o encontro que se destacou teve 3 trabalhos, o "6º International Conference on Education and New Learning Technologies" que ocorreu em 2014 na Espanha. O artigo mais antigo aparece neste encontro, seguido de outros dois que relatam a disciplinas mal elaboradas e situação precária dos alunos(Cauchie et al., 2014; Dore et al., 2014; Zaldivar-Colado, Lizarraga-Reyes, Rodelo-Moreno, Moncada-Estrada, & Zurita-Cruz, 2014). Em Scopues o *ACM International Conference Proceeding Series*, foi o encontro que mais registros gerou na base (3). Todos os trabalhos publicados falam a respeito do uso da tecnologia como elemento para diminuir a evasão, se destacando o trabalho "*Building security bubbles: Design of a wearable device for child tracking in vulnerable zones*" de Ylizaliturri-Salcedo, Ramos-Salvio, García-Macías, Aguilar-Noriega & Cárdenas-Osuna, que abordam o uso de um artefato por alunos em locais de vulnerabilidade, garantindo a segurança das mesmas.

A base do *Web of Science* tem por padrão o uso da língua inglesa, assim, de 143 trabalho, 128 estão em inglês. O Espanhol aparece em segundo, com 6 trabalhos, seguido pelo português com 4 trabalhos, sendo que os Estados Unidos o país que mais publica, com 54 registros, seguido de Índia com 10. O Brasil apresentou 8 registros estando como o terceiro país que mais pública. Já em Scopus, dos 834 registros, 729 estão em inglês, 42 em Espanhol, 19 em Francês, 14 em Português e 30 em outros idiomas variados. Em Scopus, os Estados Unidos é o país com maior número de publicação (307), seguido do Reino Unido (61). O Brasil aparece 10º lugar com 29 publicações.

Finalmente foi realizada uma busca das palavras-chave contidas nos 149 trabalhos de Wos e 834 de Scopus, unificando as duas buscas. Segundo Mariano et al., (2011), as palavras chaves indicam as linhas de pesquisa onde os temas se concentraram no período da busca. A figura 1 apresenta as palavras mais utilizadas, o tamanho das palavras é proporcional ao número de aparições nas publicações, o mapa foi gerado na plataforma online *TagCrowd*.

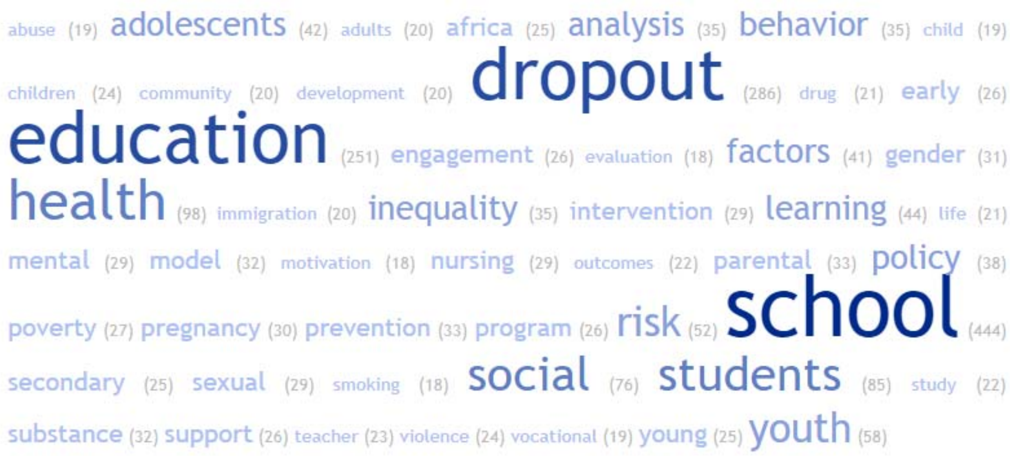

Figura 7. Nuvem de Palavras

As palavras "*School*", "*Dropouts*" e "*Education*" são as palavras mais frequentes, o que era esperado devido a busca por estes termos. Porém verifica-se as palavras como comportamento, droga, álcool, risco, engajamento aparecem como palavras secundárias, porém que evidenciam possíveis causas desta evasão escolar.

3.3 Detalhamento, modelo integrador e validação por evidências

A terceira e última etapa do TEMAC analisa as principais contribuições e abordagens da base selecionada por meio de *coupling*, e *co-citation* que demonstram respectivamente as frentes de pesquisa e as principais abordagens. Foi utilizado o software VOSviewer para criar o mapa de calor apresentado na Figura 2 e 3, respectivamente.

O Co-citation separa os autores em grupos, de acordo com as abordagens estudadas, por meio de algoritmos de clusterização. Foram unificadas ambas bases de dados utilizando o algoritmo scop2wos. O Co-citation promove um agrupamento que auxilia na identificação de autores com teorias, assuntos e abordagens similares e que são citados juntos com certa frequência (Ramos-Rodrígue & Ruíz-Navarro, 2004). No resultado obteve-se três clusters.

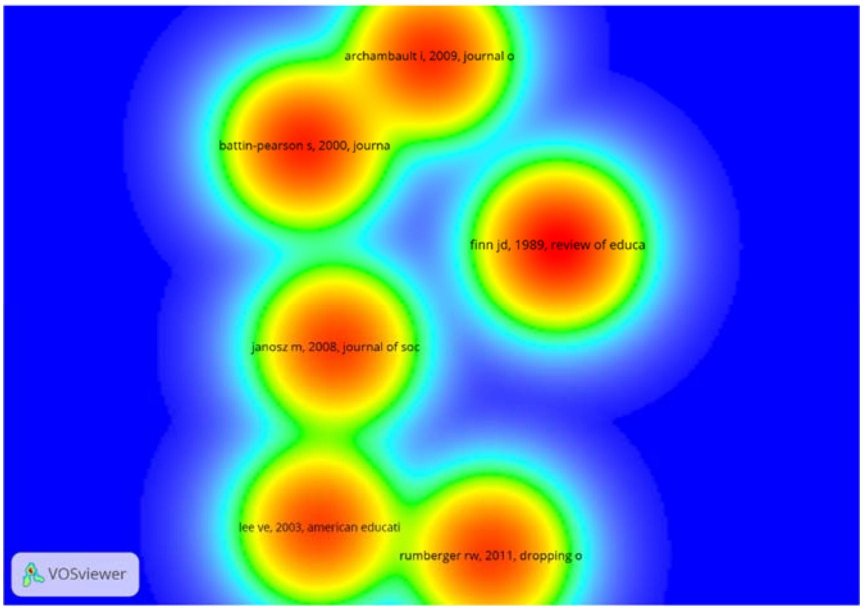

Figura 2. Mapa de calor Co-citation

Pode-se observar Jeremy D. Finn isolado em uma mancha de calor, em seu estudo de 1989 buscou correlacionar características do indivíduo ou das instituições de ensino com a decisão de abandono e cita que a participação do indivíduo em atividades relevantes das escolas auxilia na conexão e identificação do estudante com a instituição, consequentemente, aumentando as chances de que se complete todo o ciclo escolar(Finn, 1989).

O segundo núcleo é representado por Battin-Pearson et al. (2000) e Archambault, (2009), Janosz (2008), Lee (2003) e Rumberger (2011). A abordagem que une estes autores está associada a predição do abandono e do engajamento do estudante, em muitas ocasiões com uso das equações estruturais. Entre as principais contribuições deste Cluster estão os trabalhos de Battin-Pearson et al. (2000), que não conseguiu validar completamente nenhuma das cinco hipóteses levantadas pelo autor a respeito da evasão, porém, todas foram parcialmente validadas para explicar o fenômeno(Battin-Pearson et al., 2000), Archambault (2009), que concluiu que a falta de engajamento que leva ao abandono ocorre inicialmente pelo desengajamento afetivo devido as sanções, devido seu mal desempenho estudantil e Rumberger (2011), que apresenta um livro com causas externas e comportamentais que levam a evasão.

O segundo mapa de calor, representa aponta os principais fronts de pesquisa, revelando quais abordagens tendem a permanecer importantes (Figura 3).

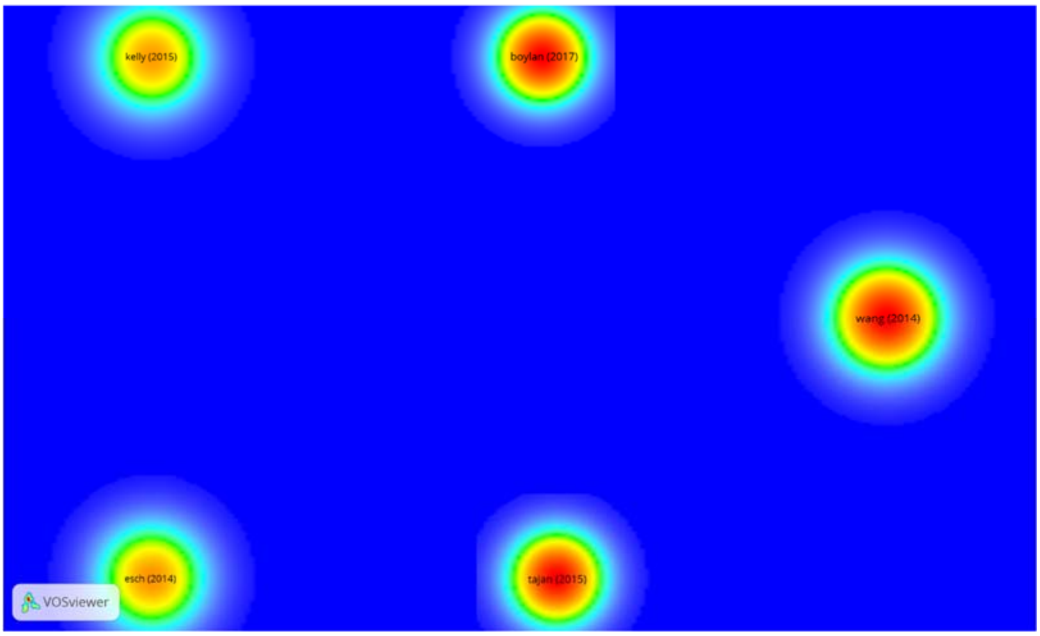

Figura 3. Mapa de calor Coupling

Foram encontradas na unificação das duas bases de dados 5 núcleos de calor. Boylan & Renzulli (2017), realizam uma republicação de um estudo de 2014, onde as pesquisadoras explanam a respeito dos fatores que "empurram" ou "puxam" os discentes da vida estudantil ou para vida estudantil. Estes fatores estão relacionados ao clima inóspito para o estudante, causado pela relação com professores e outros colegas. O estudo sugere que nos Estados Unidos (local onde foi realizado), se aumente a diversidade dos professores na escola secundária (objeto do estudo), pois 67% dos professores são mulheres e 77% são brancos.

Já o trabalho de Tajan (2014), apresenta o abandono do ensino médio no Japão, considerando um tema muito pouco abordado por artigos científicos. O estudo sugere formação especializada para se tratar com alunos que podem apresentar psicopatologias e que o excesso de trabalho dos professores pode prejudicar a saúde mental dos mesmos, além de incidir sobre a qualidade das aulas.

Wang & Fredicks (2014) também aparecem como autor mais citado de Scopus e seu estudo, conforme explicado anteriormente, explica os efeitos da evasão estudantil. O estudo de Kelly et al (2015), estudaram o uso de drogas relacionado ao abandono do ensino médio pelos adolescentes e encontraram que o uso de drogas legais ou ilegais aumentam potencialmente a chance de evasão. Finalmente Esch et al. (2014), realiza uma revisão sistemática sobre os efeitos de transtornos psiquiátricos e encontrou uma forte associação entre saúde mental e educação nos dois sentidos.

Pode-se perceber que os fronts de pesquisa na área de evasão estão relacionados ao impacto em toda a vida do indivíduo, desde sua recolocação na sociedade, ao tipo de relação que vai se estabelecer com seus filhos, entre outros.

Assim, observando as principais contribuições, pode-se perceber que dos fatores que mais impactam na evasão escolar estão centrados na falta de conhecimentos básicos, falta de incentivo por meios de atividades extracurriculares, uso de drogas (lícitas e ilícitas) , gravidez juvenil, disciplinas mal elaboradas, situação precária do aluno e doenças decorrentes de prática sexual de risco, como o HIV.

4 Considerações Finais

Este estudo teve como objetivo apresentar as contribuições da literatura científica em *Web of Science* e *Scopus* a respeito da evasão estudantil. Foi realizada uma pesquisa bibliométrica entre os anos de 2104 e 2019 e os resultados apontam que a evasão escolar acompanha o indivíduo durante toda a vida adulta, inclusive em outros países e até mesmo chega a ter consequências no desenvolvimento dos filhos. Entre os fatores que mais levam a evasão são a falta de conhecimentos básicos, falta de incentivo por meios de atividades extracurriculares, uso de drogas (lícitas e ilícitas), gravidez juvenil, disciplinas mal elaboradas, situação precária do aluno e doenças decorrentes de prática sexual de risco, como o HIV. Adicionalmente foram encontradas forte correlação entre saúde mental e educação, evasão e inclusão social, laços emocionais e engajamento estudantil.

Deste modo o problema da pesquisa foi respondido. Para estudos futuros aconselha-se delimitar os estudos apenas em Universidades, pois como limitação pode-se perceber que a maioria dos estudos dizem respeito à antes da universidade, sugerindo que o processo de evasão é uma linha contínua que pode ter seu gatilho a qualquer momento da vida estudantil. Porém essa limitação de poucos estudos presente nas bases de dados para universidades e menos ainda paras Engenharias revela um campo a ser explorado pelo pesquisador.

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Active Methodologies: a proposal of practical steps for building an integrated assessment tool for National Curricular Guidelines.

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Abstract

The active teaching and learning methodologies have been adopted in several undergraduate courses. Although its use prevails in health courses, there is a significant growth in other areas of knowledge, as in Engineering. Although there are different possibilities of adaptation of this methodology to the realities of the courses, all of them must be structured in the light of the National Curricular Guidelines (DCN). Regarding the assessment for learning, the DCN establish that these should be carried out through formative evaluation, considering the competency skills provided for the training of the professional. Regarding the follow-up of the course, according to the DCN, the institution must develop instruments that verify the structure, processes and results, in line with the National System of Evaluation of Higher Education (SINAES) and with the curricular dynamics implemented by the institution of higher education (HEI). In this sense, the follow-up of the course should take into account the profile of the professional that one wishes to train, described in the pedagogical project. Thus, the purpose of this work was to present practical steps to elaborate an institutional assessment instrument to guide course management, taking into account the theoretical contributions of the active methodology of teaching and learning and the DCN's of the area of Production Engineering. As a result, a systematic proposal was offered to assemble with the ability to measure the adhesion of DCNs to the active methodology used in the Production Engineering Course at the University of Brasília-UnB.

Keywords: Active methodologies, National Curricular Guidelines, Evaluation of active methodologies.

Metodologias Ativas: uma proposta de etapas práticas para construção de instrumento de avaliação integrada às Diretrizes Curriculares Nacionais

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Resumo

As metodologias ativas de ensino e aprendizagem vêm sendo adotadas em diversos cursos de graduação. Ainda que seu uso prevaleça nos cursos da saúde, existe um crescimento significativo em outras áreas do conhecimento, como nas Engenharias. Embora existam diferentes possibilidades de adaptação dessa metodologia às realidades dos cursos, todas elas devem ser estruturadas à luz das Diretrizes Curriculares Nacionais (DCN). Quanto à avaliação para a aprendizagem, as DCN estabelecem que essas devem ser realizadas por meio da avaliação formativa, considerando-se as competências e as habilidades previstas para a formação do profissional. Quanto ao acompanhamento do curso, segundo as DCN de cada área do conhecimento, a instituição deve desenvolver instrumentos que verifiquem a estrutura, os processos e os resultados, em consonância com o Sistema Nacional de Avaliação da Educação Superior (SINAES) e com a dinâmica curricular implementada pela instituição de educação superior (IES). Nesse sentido, o acompanhamento do curso deve levar em consideração o perfil do profissional que se deseja formar, descrito no projeto pedagógico. Assim, o objetivo deste trabalho é apresentar etapas práticas de elaboração de um instrumento de avaliação institucional para nortear a gestão do curso, levando-se em consideração os aportes teóricos da metodologia ativa de ensino e aprendizagem e as DCN da área de formação da Engenharia de Produção. Como resultado, foi oferecida uma proposta sistemática para montar e mensurar a aderência dos DCN à metodologia ativa utilizada no Curso de Engenharia de Produção na Universidade de Brasília-UnB.

Palavras-Chave: Metodologias ativas**,** Diretrizes Curriculares Nacionais**,** Método Delphi.

1. Introdução

Conforme previsto no Sistema Nacional de Avaliação da Educação Superior (Sinaes), a avaliação institucional deve contemplar a autoavaliação realizada pela Comissão Própria de Avaliação (CPA) e, assim, subsidiar o processo de planejamento das atividades e, consequentemente, da tomada de decisões das instituições de ensino superior (IES). Esse processo avaliativo é usualmente realizado pelas IES com o objetivo de diagnosticar pontos positivos e aqueles passíveis de melhoria, a fim de se atingir as metas e as ações previstas no planejamento institucional. Esses diagnósticos são provenientes de diferentes etapas e dimensões avaliativas, conforme demandas institucionais e em consonância com os instrumentos de avaliação propostos pelo Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira (INEP). De acordo com o Sinaes, o acompanhamento do perfil do profissional dos cursos de graduação desejado pelas IES é realizada por meio da avaliação em larga escala intitulada Exame Nacional de Desempenho dos Estudantes (ENADE). Para tanto, com base nas Diretrizes Curriculares Nacionais dos cursos de graduação, o INEP organizou matrizes de referências (quadro descritivo das competências profissionais esperadas para a formação e qualificação dos graduandos que subsidia a elaboração de itens avaliativos dos exames de larga escala) para os cursos avaliados por esse exame, a fim de verificar o desempenho dos estudantes e diagnosticar a qualidade das IES brasileiras. O resultado desse exame pode subsidiar a análise, pelos gestores dos cursos de graduação, das competências desenvolvidas pela matriz curricular dos cursos. As matrizes de referência, neste caso, servem, também para orientar possíveis alterações das matrizes curriculares, elaboradas com base nas DCN para cada área de formação. As DCN propõem que os projetos pedagógicos dos cursos (PPC) sejam organizados seguindo a metodologia baseada em problemas (PBL) e utilizem as metodologias ativas de ensino e aprendizagem no processo de formação. Alguns cursos que utilizam essa metodologia, como, por exemplo, Engenharia, também são avaliados a partir de matrizes de referência organizadas pelo INEP. Dessa forma, algumas IES têm buscado organizar etapas avaliativas de autoavaliação, construindo matrizes de referência para os cursos para, assim, avaliar suas matrizes curriculares.

Embora possamos encontrar literatura sobre construção de instrumentos (Vieira, 2009), a operacionalização das etapas, muitas vezes, parece ser algo distante para o profissional da educação. Assim, o objetivo desta pesquisa é apresentar etapas práticas de elaboração de um instrumento de avalição institucional para nortear a gestão do curso, levando-se em consideração os aportes teóricos da metodologia ativa de ensino e aprendizagem e as DCN da área de formação da Engenharia de Produção.

Desse modo, a estrutura deste trabalho se difere do convencional, sendo o método proposto resultado da pesquisa em si. Em um primeiro momento, é apresentada a fundamentação teórica do trabalho, o segundo tópico explica brevemente os dois temas principais a serem agregados e cumpridos no instrumento (DCN e metodologias ativas), posteriormente, no tópico 3, apresentam-se, juntas, a metodologia e os resultados, com uma descrição mais detalhada das etapas que devem ser utilizadas na construção do instrumento e, finalmente, as considerações finais.

2. Fundamentação teórica

2.1 Diretrizes Curriculares Nacionais (DCN).

Os cursos de Graduação de Engenharia encontram-se regulamentados pela Resolução CNE/CES 11/2002, que sugere para as matrizes curriculares dos cursos dessa grande área tenham uma sólida formação técnico-científica e profissional geral, além de prever o incentivo ao estudante em adquirir competências específicas imprescindíveis para o desenvolvimento do perfil profissional, conforme demandas de qualificação e formação para cada subáreas. A proposta dessa Resolução é também ampliar o escopo da atuação do estudante e fazer com que o sujeito da aprendizagem faça parte desse processo e, assim, passe do ensino tradicional para o ativo. Pinto *et al.* (2003) explica que um dos pontos mais relevantes que diferencia a Resolução de 2002 em relação à Resolução anterior (CFE/76) é a mudança do foco do processo de ensino e aprendizagem centrado no professor para o foco centrado no aluno, além de estabelecer a realização de trabalhos integradores do conhecimento e o uso de metodologias capazes de garantir o desenvolvimento de habilidades e competências nos estudantes.

As DCN (Brasil, 2002), além de estabelecer conteúdos básicos e específicos para a formação dos engenheiros, estabelecem, também, catorze competências e habilidades para o desenvolvimento do perfil profissional dessa área do conhecimento. Neste estudo, as habilidades e as competências descritas no artigo 4º das DCN de engenharia foram agrupadas em seis dimensões, conforme Figura 1.

Figura 1. Dimensões das competências e habilidades gerais requeridas pelo CNE/CES 11/2002 para os cursos de engenharia
Fonte: Resolução CNE/CES 11/2002/ Própria

Pode-se observar que as competências e as habilidades da Figura 1 podem ser desenvolvidas por meio de instrumentos de metodologias ativas, conforme descrito na experiência de aplicação do PBL no Curso de Engenharia de Produção da Universidade de Brasília – EPR-UnB (Mariano *et al.* , 2017).
As dimensões apresentadas acima serão utilizadas na proposta de organização da seleção das competências para compor uma possível matriz de referência capaz de auxiliar a revisão da matriz curricular. Essa matriz de referência pode ser organizada por módulos temáticos e auxiliar a organização dos indicadores da avaliação do curso. No caso da EPR-UnB, apesar de experiências comprovadas da presença dos objetivos da DCN e do PBL aplicados no curso, faz-se necessário mapear a construção destas habilidades e competências, estabelecendo conexões com as dimensões propostas na Figura 1.

2.2 Metodologia Baseada em Problemas e Metodologias Ativas

Conforme Veiga (2015), a aprendizagem baseada em problemas (PBL) é originária do pensamento de John Dewey, direcionado pela tendência pedagógica liberal progressiva, inserida, no Brasil, na década de 1960. O movimento iniciado por esse filósofo norte-americano tem sua concepção fundamentada na psicologia evolutiva e da psicologia da aprendizagem. Pode-se dizer, então, que a metodologia PBL não é considerada tão nova, pois seus fundamentos encontram base nos pensamentos de John Dewey sobre a importância de aprender por meio da interação e da necessidade de dar respostas com base em eventos da vida real. Atualmente, segundo Veiga (2015), essa metodologia é uma tendência internacional e propõe a substituição do paradigma clássico de ensino para resolver um dos problemas do processo de ensino e aprendizagem: a insatisfação dos estudantes diante da quantidade de conteúdos percebidos como irrelevantes à sua formação da área da saúde. Para Veiga (2015, p. 21): "A PBL é um método de ensino-aprendizagem em que os estudantes deparam inicialmente com um problema, que é sucedido por uma investigação, em um processo de aprendizagem centrada no estudante". Nesse sentido, é uma metodologia participativa que transfere a centralização do processo de ensino do professor para o aluno, tornando-o o principal ator na construção de seu aprendizado.
Para se obter sucesso nesse processo, todavia, há necessidade de os currículos serem reestruturados a fim de articularem a integração entre a teoria e a prática. Para tanto, as matrizes curriculares são organizadas em módulos temáticos a fim de nortear o conjunto de docentes no desenvolvimento de atividades com base em metodologias ativas, isto é, por meio de estratégias que possibilitem ao estudante a reflexão crítica sobre a realidade vivenciada e a transformação pela práxis social (Araújo, 2017).

Nesse sentido, contemplar esses dois elementos complexos (diretrizes curriculares nacionais e as metodologias ativas) em um instrumento confiável e válido para aferir seu resultado, útil para o processo de avaliação dos cursos ,é um desafio para as Comissões Próprias de Avaliação (CPA), principalmente quando cada curso necessita de instrumentos diferentes para aferir competências específicas. Desse modo, este trabalho apresenta um modelo prático para essa finalidade, baseado na bibliometria e no método Delphi para organizar as competencias a partir da percepção dos professores e especialistas da área e, assim, construir uma matriz de referência para os cursos. Depois de construída a matriz modelo por meio do método Delphi, as equações estruturais são utilizadas para validar a matriz e o instrumento de avaliação elaborada a partir desta.

3. Método e Resultados

Esta pesquisa, do tipo exploratória, foi realizada a partir da revisão sistemática, por meio do TEMAC, sobre os três eixos de interesse (Diretrizes Curriculares Nacionais (DCN) do Curso de Engenharia de Produção no Brasil + Metodologias Ativas + Instrumento de mensuração), não tendo sido encontrados registros sobre esses eixos na literatura especializada. Com a ausência desses eixos na literatura, procuraram-se registros sobre o desenvolvimento de habilidades e competências e validação de instrumentos para avaliar cursos organizados com a perspectiva de metodologias ativas. A pesquisa bibliométrica resultou em ausência de registros sobre esse tema. A abordagem sistematizada para formulação do instrumento foi de base qualitativa-quantitativa.

Como não foram encontradas informações para tal, propôs-se esta metodologia para organizar uma matriz de referência para o EPR-UnB, com as competências do perfil de profissional a ser formado. Essa metodologia pode ser aplicada na avaliação de qualquer curso de graduação.

3.1 Modelo de construção do instrumento (Teoria do Enfoque Meta Analítico Consolidado - TEMAC, Método Delphi e Equações estruturais)

O método de construção do instrumento proposto segue as sete etapas de Vieira (2009): i) busca de informações, ii) redação das questões, iii) correção semântica e gramatical, iv) análise de consistência dos conceitos, v) análise de delineamento, vi) análise de coleta de dados e vii) análise estatístico, que se divi em a. teste de confiabilidade e; b. teste de validade, conforme Figura 2.

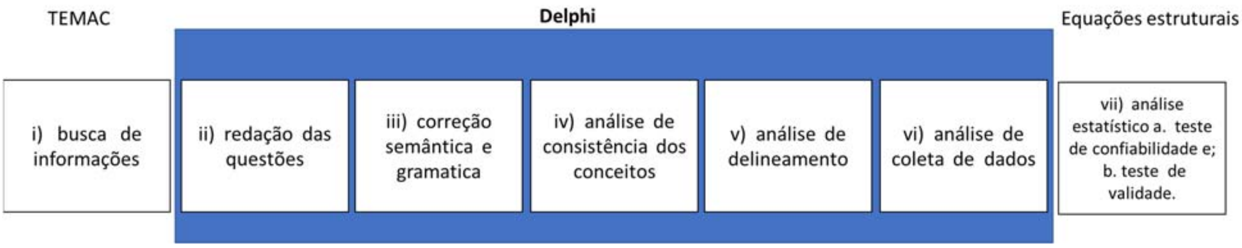

Figura 2. Etapas de criação e validação de instrumento
Fonte: Adaptado de Vieira (2009)

A etapa i) - busca de informações, realizada por meio da Teoria do Enfoque Meta-Analítico Consolidado – TEMAC, de Mariano e Rocha (2017), uma técnica para mapear a literatura científica que unifica diferentes propostas de enfoque meta-analítico. O enfoque meta-analítico é uma técnica proveniente dos estudos de Arenas et. al (2001), sendo esta uma adaptação das meta-análises de Smith e Glass (1977).

A TEMAC é dividida em três etapas: preparação da pesquisa (escolha das palavras chaves, espaço temporal e bases de dados para realização da pesquisa); apresentação e inter-relação dos dados (frequência de autores que mais publicaram, artigos mais citados, países que mais publicaram, entre outros) e; detalhamento, modelo integrador e validação por evidências (mapas de calor de co-citação, acoplamento e palavras-chave), todos fundamentados nas leis e princípios da bibliometria como Fator de Impacto (FI), citação, citação/ano, média/moda/mediana e a adoção de índices bibliométricos como a Lei de Lokta, Lei de 80/20, Lei do Elitismo, colégios invisíveis e Obsolescência da literatura.

Esta é a primeira etapa da presente proposta de construção de instrumento. Ao se a realizar pesquisa bibliográfica nas bases de dados *Web of Science*, *Scopus* e *Google Schoolar*, não foram encontrados trabalhos que unissem os três eixos necessários para essa verificação: Diretrizes Curriculares Nacionais (DCN) do Curso de Engenharia de Produção no Brasil + Metodologias Ativas + Instrumento de mensuração. Assim, a partir da aplicação dessa etapa, propôs-se a realização das demais etapas.

As etapas ii) redação das questões, iii) correção semântica e gramatical, iv) análise de consistência dos conceitos, e v) análise de delineamento (Figura 2) devem ser realizadas por meio da técnica Delphi. Essa técnica nasceu em 1966, por meio de Olaf Helmer com o objetivo de integrar as opiniões de especialistas possibilitando consenso e sinergia (Oliveira, 2008). O processo de Delphi desenhado neste estudo foi uma adaptação do artigo de Santos (2001). Para identificar as competências necessárias para compor a matriz de referência do curso, tomam-se como base as dimensões contempladas na Figura1: Planejamento, inovação, interação, impactos sociais, aplicação, organização e avaliação. A seleção das competências de cada uma dessas dimensões dá-se por meio de três questionamentos sobre as atividades desenvolvidas na formação do Engenheiro de Produção: o que é feito, como é feito e por que é feito.

A partir daí, aplica-se o método Delphi, por meio de rodadas de respostas para cada dimensão e suas respectivas competências e habilidades. Para tanto, reúne-se o grupo de professores comprometidos com o curso e, de preferência, os participantes do Núcleo Docente Estruturante (NDE), uma vez que esse grupo é responsável por acompanhar as avaliações do curso. Em um primeiro momento, explica-se para o grupo de docentes a importância da atividade de elaboração da matriz de referência e como é o procedimento de identificação das competências da matriz e sua relação com os componentes curriculares da matriz do curso.

Uma vez realizada esta etapa prévia, analisa-se o resultado do levantamento de informações por meio do método Delphi, seguindo-se as etapas de Santos (2001), conforme segue:

1ª Etapa: Cada professor recebe uma folha de papel para responder, individualmente, sobre cada dimensão: "Quais competências são necessárias para a formação do profissional ou para a dimensão x?" Depois de sistematizadas as competências sugeridas pelos docentes, eliminam-se as repetidas. As competências indicadas pelos professores devem ser organizadas e comparadas, pontuando-se a frequência com que cada uma é escolhida e quantas competências cada professor escolheu. O resultado dessa indicação é sistematizado e organizado conforme proposta de Tabela 1.

Tabela 1 – Competências em nível individual

Competência	Análise dos professores			
	Professor 1	Professor 2	Professor 3	...Professor 16
1	X		X	X
(...)		X		
20	X		X	X

Marca-se um X nas competências pontuadas pelos professores, sem identificá-los, a fim de sistematizar as de maior incidência.

2ª Etapa: Cada professor recebe uma lista com as competências levantadas na etapa 1ª com suas respectivas frequências, isto é, as de maior frequência primeiro, seguidas das de menor frequência. A pergunta para esta rodada é: "Concorda que esta competência é necessária para formação do profissional ou tarefa X"? Os professores devem colocar "S" para aquelas com as quais concorda e "N" para as que não concorda. O resultado dessa seleção deve ser sistematizado e organizado conforme proposta de Tabela 2.

Tabela 2 – Competências em nível coletivo

Competência	Análise dos professores			
	Professor 1	Professor 2	Professor 3	Professor 4
1	S	S	N	S
(...)	S	S	S	N
20	S	N	N	N

Uma vez sistematizadas as respostas dos professores, procede-se o cálculo do nível de concordância por meio da equação (1):

(1) $Cc = (1 - Vn / Vt) * 100$

onde:

Cc = Coeficiente de concordância expresso em porcentagem.
Vn = Quantidade de professores em desacordo com o critério predominante.
Vt = Quantidade total de professores.
Para ser validada uma competência, o resultado deve ter um Coeficiente de Concordância (CC) ≥ 60%, conforme propõe Santos(2001) e todas as competências abaixo desse valor devem ser eliminadas. O resultado desse cálculo deve ser sistematizado e organizado conforme proposta de Tabela 3.

Tabela 3 – Competências segundo nível de concordância

Competência	Análise dos professores				
	Professor 1	Professor 2	Professor 3	...Professor 16	CC%
1	S	S	N	S	100
(...)	S	S	S	N	89
20	S	N	N	N	70

Fonte: Própria

Uma vez definidas essas competências, aplica-se a 3 ª etapa.

3ª Etapa: Esta rodada é dividida em duas fases: a primeira identifica possíveis aproximações e categorização de variáveis similares; a segunda estabelece a ordem de importância das competências mapeadas na 2ª. etapa. Cada professor deve eleger a ordem de importância das competências resultantes da etapa anterior. Cada docente deve indicar a competência eleita como mais importante com o número 1 e a de menor importância com o maior némro da sequência. Por exemplo, em um grupo de 20 competências, deve levar o número 20. Uma vez estabelecida esta ordem, realiza-se o somatório das ordens das competências indicadas pelos professores, gerando-se um valor SC (Somatório de competências), que deve ser organizado conforme proposta da Tabela 4.

Tabela 4 – Somatório de competências

Competência	Análise dos professores				
	Professor 1	Professor 2	Professor 3	...Professor 16	SC
1	5	5	1	1	12
(...)	1	1	2	2	6
20	20	12	3	3	38

Com essa sistematização, é possível identificar as competências de maior concordância definidas pelos docentes. A partir dessa sistematização de nível de importância de cada competência, gera-se uma tabela final (tabela 5) que apresenta as competências indicadas como principais na formação do Engenheiro de Produção do curso da instituição.

Tabela 5 – Resultados de indicadores

Competência	Média SC	SC	CC	Ordem SC
1	3	12	100%	2
(...)	1,5	6	89%	1
20	9,5	38	70%	3

4ª Etapa: Com base nesses resultados, explica-se aos docentes o procedimento para se chegar a esses dados e se realiza a última pergunta: "Estão de acordo com as ponderações e ordem obtidas"? Nesta rodada, é necessário ter cautela para não gerar repetição de etapas de validação já realizadas anteriormente.

Espera-se que, com o resultado desta etapa, as competências sejam mapeadas por meio de uma aproximação objetiva e, então, organizada a matriz de referência do curso. A partir daí, podem ser realizadas atividades para desenvolver habilidades por meio de instrumentos voltados para metodologias ativas, isto é, por meio de problemas a serem resolvidos em situações reais. Depois de selecionadas as competências, procede-se, seguindo a mesma metodologia, a indicação das competências dentro das dimensões, seguindo-se a Figura 1. Nessa fase, uma competência pode aparecer em mais de uma dimensão da matriz.

Após a seleção das competências essenciais para cada dimensão da matriz da formação do Engenheiro de Produção, organizada a partir do entendimento dos professores do curso, sugere-se que a matriz de referência norteie as atividades desenvolvidas para a formação do profissional engenheiro. Essas competências mapeadas podem nortear a reorganização da matriz curricular e a elaboração dos indicadores de avaliação do curso a fim de se verificar se os objetivos traçados estão sendo cumpridos. Dessa forma, será possível mapear as habilidades relacionadas às competências da matriz do EPR-UnB e os indicadores avaliativos. A validação dos indicadores avaliativos podem ser realizadas por meio da aplicação das equações estruturais via PLS-SEM (Hair, *et al.,* 2016). Nesse sentido, uma vez concluído o processo de seleção das competências, descritas na seção anterior, podem ser selecionados os indicadores para avaliação do curso, contemplando-se, assim, o proposto nas DCN e, então, verificar a formação do profissional que se deseja formar.

Por fim, a etapa vii) análise estatístico (Figura 2) , é dividida em: teste de confiabilidade e teste de validade, ambos realizados via o software *SmartPLS 3.0* para equações estruturais.

Segundo Ramirez, Mariano & Salazar (2014), as equações estruturais utilizam modelos estatísticos de múltiplas variáveis, permitindo avaliar o grau de correlação e regressão entre elas. As equações estruturais permitem verificar se o resultado do modelo teórico proposto condiz com os dados obtidos pelo pesquisador e indica as relações entre as variáveis. Parte-se do princípio de que o mundo é formado de variáveis complexas, de difícil grau de medição, variáveis latentes. As variáveis latentes não se explicam sozinhas, elas necessitam de aproximações através de um conjunto de indicadores (Maccallum, 1995) e as equações estruturais podem auxiliar essa análise.

Os dados obtidos são processados e organizados em uma planilha do Excel e submetidos a uma análise feita pelo programa estatístico SPLS (*Smart Partial Least Square*), com a finalidade de sustentar o modelo de equações estruturais utilizando-se o teste de confiabilidade dos itens, analisando-se a relação das perguntas do questionário aplicadas com a variável correspondente a cada uma delas.

A mensuração da confiabilidade dos dados é realizada por meio do coeficiente de confiabilidade de item. Este estudo correlaciona cada indicador individualmente e a variável latente à qual está conectado, pois ela não pode ser explicada diretamente, somente através de indicadores. Com base no estudo de Ramirez, Mariano e Salazar (2014), as correlações são satisfatórias quando o índice for superior a 0,707, sendo, em alguns casos, aceitável o índice a partir de 0,6. Itens ou perguntas que estejam abaixo desses índices devem ser desconsiderados em razão da baixa correlação estabelecida entre estes e a variável que representa. Isso significa que os indicadores com índice abaixo de 0,6 não são confiáveis para validação e devem ser descartados.

Após o teste do coeficiente de confiabilidade de item, faz-se o estudo do coeficiente de confiabilidade interna, que é medido através da Confiabilidade Composta ou *Alpha de Cronbach* (Chin, 1998). O coeficiente de confiabilidade do constructo analisa a força dos indicadores juntos, agregados às suas respectivas variáveis. A literatura explica que para tais valores serem considerados satisfatório,s necessitam de um valor superior a 0,7 (Ramirez, Mariano & Salazar, 2014).

Uma vez realizados os testes de confiabilidade que garantem que o instrumento seja confiável, é necessário realizar o teste de validade que explica se os instrumentos medem o que se propõem medir. Em seguida, a validade do instrumento é expressa de duas formas: a variância média extraída (AVE), que determina se os indicadores de uma variável não interferem nas outras variáveis latentes, isto é, se eles são diferenciados o suficiente para explicar apenas sua própria variável, sendo que o valor de AVE não deve ser inferior a 0,5 (Fornell & Larckel, 1981). Este deve se diferenciar pelo menos em 50% dos demais; e a variância discriminante, que explica que os constructos são diferentes uns dos outros, é expressa pela raiz quadrada de AVE em comparação aos pesos das cargas *outerloading* das variáveis. Essa variância é aferida por meio da raiz quadrada de AVE, comparada com os valores latentes das variáveis que realiza essas relações. Esses valores devem ser superiores às demais variáveis relacionadas e servem para confirmar que os construtos (conjunto de indicadores) são diferentes uns dos outros.

Os cálculos de equações estruturais não apenas testam a confiabilidade e a validade do modelo proposto, como também conseguem expressar o grau de predição e influência das variáveis independentes e dependentes, isto é, pode-se valorar os fatores que mais implicam para um determinado resultado e a porcentagem relativa desta influência para ser considerada pertinente. Espera-se que com esse método de validação, já realizado em validação de outros instrumentos (Mariano, *et al*. 2015; Paldês, *et al*., 2016), seja possível elaborar um instrumento de avaliação institucional compatível com as DCN para a avaliação do curso de Engenharia de Produção da UnB e também de outros cursos.

4. Considerações finais, limitações e futuras linhas de pesquisa

Este estudo teve como objetivo apresentar etapas práticas de elaboração de um instrumento de avaliação institucional para nortear a gestão do curso, levando-se em consideração os aportes teóricos da metodologia ativa de ensino e aprendizagem e as DCN da área de formação da Engenharia de Produção. Foram apresentadas etapas de elaboração de instrumento de avaliação com soluções metodológicas para cumprimento de todas as etapas para tal, envolvendo os docentes que atuam no curso e sua percepção sobre as competências e habilidades a serem desenvolvidas. Com a construção de um instrumento de avaliação validado, pretende-se contribuir para a avaliação do perfil profissional proposto por projeto pedagógico estruturado por PBL e se este está em consonância com as DCN.

Este estudo é importante para cobrir uma lacuna na literatura sobre instrumentos para mensurar resultados de projetos organizados com base no PBL e, assim, verificar se as DCN das diversas áreas do conhecimento estão sendo concretizadas. Espera-se, em 2019, realizar a primeira prova deste instrumento já validado.

Como limitante da pesquisa está a dificuldade de detalhar a metodologia e ao mesmo tempo oferecer um exemplo aplicado de todo o processo.

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Experience of Project-Based Learning - PBL applied to the context of a Project Management discipline at the University of Brasília

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Abstract

The adoption of active methodology in education has grown considerably, bringing more effective results for student learning. This paper reports the results of the application of the Project-Based Learning (PBL) methodology in the teaching of the Advanced Project Management course offered in the Production Engineering course of the University of Brasília, during 4 semesters, in the years 2017 and 2018. The focus of the course is focused on the development of projects carried out by the students, using the traditional methodology and the agile management methodology, so that students can visualize the difference between them. The structure of the discipline, the formation of the teams, the schedule of deliveries and the results obtained were discussed, where the project deliveries were the construction of a website, a game, two academic events and newsletters for the Production Engineering Department. A case study was adopted as a research strategy in order to investigate students' feedback regarding the teaching methodology used, with a qualitative character, and questionnaires were used as a technique for data collection. The students' experience in the projects provided the development of the technical skills of the discipline from the point of view of two methodologies (Agile and Traditional), as well as the possibility of developing transversal skills, such as leadership, management, proactivity, communication, according to feedback from themselves.

Keywords: Active Learning; Project Based Learning; Project Management; Engineering Education.

Experiência de Project-Based Learning – PBL aplicado ao contexto de uma disciplina de Gestão de Projetos na Universidade de Brasília

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Abstract

A adoção da metodologia ativa na educação tem crescido consideravelmente, trazendo resultados mais efetivos para a aprendizagem do aluno. Este artigo relata os resultados da aplicação da metodologia de Aprendizagem Baseada em Projetos (Project-Based Learning - PBL) no ensino da disciplina de Gestão de Projetos Avançados ofertada no curso de Engenharia de Produção da Universidade de Brasília, durante 4 (quatro) semestres, nos anos de 2017 e 2018. O foco da disciplina está voltado para o desenvolvimento de projetos realizados pelos alunos, utilizando a metodologia tradicional e a metodologia ágil de gerenciamento, para que os alunos consigam visualizar a diferença entre elas. É abordado a estrutura da disciplina, a formação das equipes, o cronograma de entregas e os resultados obtidos, onde as entregas dos projetos foram a construção de um site, um jogo, dois eventos acadêmicos e boletins informativos para o Departamento de Engenharia de Produção. Foi adotado como estratégia de pesquisa um estudo de caso, a fim de investigar o feedback dos alunos com relação à metodologia de ensino empregada, com cunho qualitativo, e foram utilizados questionários como técnica para a coleta dos dados. A vivência dos alunos nos projetos proporcionou o desenvolvimento das competências técnicas da disciplina do ponto de vista de duas metodologias (Ágil e Tradicional), além da possibilidade de desenvolver as competências transversais, tais como liderança, gerenciamento, proatividade, comunicação, segundo o feedback dos próprios estudantes.

Keywords: Aprendizagem Ativa, Aprendizagem baseada em Projetos, Gerenciamento de Projetos, Educação em Engenharia

1 Introdução

Os recursos tecnológicos possibilitam um processo de ensino-aprendizagem mais efetivo quando aliados a metodologias ativas. Alguns exemplos de metodologias ativas adotadas são *Inquiry Learning, Problem Based Learning, Project Based Learning, Case-Based Teaching, Discovery Learning, and Just-in-Time Teaching*. Estudos relatam que essas metodologias melhoram a qualidade dos processos de obtenção de conhecimento nas instituições de ensino (Prince & Felder, 2006).

O *Project Based Learning* - Aprendizagem Baseada em Projetos (PBL) está inserida como uma metodologia de aprendizagem ativa no contexto da Educação em Engenharia, e permite aos estudantes um processo de ensino-aprendizagem que busca desenvolver a autonomia na resolução de problemas e na habilidade de trabalho em equipe. Os cursos de Engenharia têm procurado metodologias adequadas para formar estudantes capacitados para lidar com as exigências do mercado. Nesse sentido, a metodologia PBL vêm sendo adotada nos currículos das universidades, trazendo melhorias ao processo de aprendizagem (Vieira, 2017).

Com um currículo inovador, o curso de Engenharia de Produção da Universidade de Brasília tem como espinha dorsal a utilização da metodologia PBL em disciplinas de projetos. A adoção do PBL visa desenvolver nos alunos além das competências técnicas voltadas ao contexto da gestão de projetos, competências transversais tais como liderança, gerenciamento, proatividade, planejamento, comunicação oral, profissionalismo, dentre outras habilidades, que requer o perfil do engenheiro.

Considerando este contexto, a disciplina de Gestão de Projetos Avançados (GPA) utiliza a metodologia PBL, a fim de ressaltar as diferenças entre as metodologias de gestão de projetos (tradicional - PMBOK e ágil –

SCRUM), por meio do desenvolvimento de projetos reais pelos alunos, para que eles possam entender quando deve ser utilizada uma ou outra metodologia.

Esse artigo apresenta um estudo de caso, de cunho qualitativo, que demonstra o resultado da aplicação do PBL na disciplina de GPA para o curso de Engenharia de Produção, em que os estudantes desenvolveram projetos reais, sendo eles: Criação de um site para o curso, Desenvolvimento de um jogo, Preparação de dois eventos para divulgação dos produtos desenvolvidos na disciplina e Desenvolvimento de boletins informativos para o Departamento de Engenharia de Produção (EPR). Os projetos foram desenvolvidos durante 4 semestres (2017 e 2018).

A seção 2 apresenta conceitos teóricos concernentes a metodologia de aprendizagem com foco na realização de projetos. Na seção 3 é relatada a metodologia utilizada na pesquisa, a seção 4 traz uma visão da disciplina de GPA, na seção 5 é contextualizada a implementação e avaliação da disciplina e por fim, a seção 6 exibe as conclusões da pesquisa.

2 Aprendizagem Ativa por meio de Projetos

A aprendizagem Ativa requer uma instrução centrada no aluno ao invés do professor. A instrução centrada no aluno responsabiliza os alunos por seus próprios aprendizados, estimulando a aprendizagem ao seu ritmo, e também por meio dos colegas. (Taylor et al., 2012).

Gómez-de-Gabriel et. al (2011) aplicaram a metodologia ativa de aprendizagem, em que propuseram o desenvolvimento de um LEGO NXT Mobile Robots como prática de laboratório para os estudantes do curso de graduação de Engenharia Mecatrônica na Universidade de Málaga, na Espanha. Os professores observaram que houve um alto nível de motivação dos estudantes com as competições, o que estimulou o interesse em aprender. O resultado dos estudos mostrou uma melhoria significativa no desenvolvimento das competências técnicas adquiridas pelos estudantes.

A aprendizagem baseada em projetos (PBL) trata de uma abordagem pedagógica inspirada por John Dewey, um filósofo, psicólogo e reformador educacional americano, que instaurou o imperativo da experiência prática ou do aprender fazendo (Lam, 2009), por meio da resolução de problemas complexos pelos estudantes, com foco na melhoria significativa da integração do conhecimento. Segundo Cocco (2016), a aprendizagem baseada em projetos é um método de ensino centrado no aluno e baseia-se em três princípios do construtivismo: a aprendizagem é específica do contexto; os alunos estão envolvidos ativamente no processo de aprendizagem e atingem os seus objetivos através de interações sociais; e partilha de conhecimento e compreensão.

O PBL foca em atividades como o trabalho em equipe, confrontando a aprendizagem e solução de projetos de grande escala e diversas outras possibilidades. Uma equipe de estudantes analisa o projeto, fornece solução e entrega um produto em um prazo determinado, tais como protótipo e relatório. Os estudantes mostram o que aprenderam, discutindo com os tutores e refletindo como alcançaram o resultado final. Com a utilização desse método, uma série de projetos exploram diferentes temas e desenvolvem níveis crescentes de competências profissionais e assim os estudantes aprendem a dominar as competências especificadas no currículo (conhecimentos, habilidades e atitudes) dentro do contexto da prática profissional (Powell e Weenk 2003).

O desenvolvimento de um projeto é uma forma colaborativa de aprendizagem, visto que todos participam e contribuem para o resultado final. Essa estrutura permite que os alunos trabalhem em equipe e utilizem a gestão de projetos, que contempla o ciclo de vida, envolvendo as fases de planejamento, execução, monitoramento e controle e encerramento do projeto.

As metodologias tradicionais de gerenciamento de projetos defendem um planejamento extensivo e focam na entrega do produto dentro do orçamento, prazo estimado, e itens do planejamento, e utilizam abordagens lineares que busca entregar o produto completo ao final do projeto, com o apoio do guia de boas práticas de gerenciamento de projetos PMBOK como referência (Wysocki, 2014). Ao longo do tempo, as metodologias tradicionais, apesar de apresentar conceitos básicos, que são utilizados em qualquer gestão de projetos, apresentou falhas e insucesso nos resultados de projetos, o que motivou a busca por soluções e abordagens alternativas, isso é, teorias com princípios, técnicas e ferramentas, mais tarde rotuladas por Gerenciamento Ágil de Projetos. A demanda crescente por produtos inovadores desafiou as práticas e métodos consagrados de gerenciamento de projetos, e o gerenciamento ágil de projetos surgiu com o propósito de preencher essa lacuna. Seu foco está no aprendizado contínuo por meio de iterações constantes e entregas em tempo reduzido, possibilitando assim, agregar valor em ambientes dinâmicos de negócio. O *Scrum* é um *framework* para gerenciar e desenvolver entregas e manter produtos complexos, dentro do contexto do método ágil. (SCHWABER, 2013). Ambas as metodologias enfocam a gestão do projeto e a entrega do produto, serviço ou resultado, entretanto, a metodologia tradicional é orientada ao planejamento, e a entrega do produto é realizada ao final do projeto e deve ser utilizada em situações em que os requisitos são estáveis e requisitos futuros são previsíveis. Já a metodologia ágil é orientada ao atendimento de mudanças constantes, e as entregas são curtas e os desenvolvimentos são rápidos. Neste sentido, o estudo de caso apresentado neste artigo mescla a utilização das duas metodologias, conforme apresentado na seção 3.

3 Metodologia da Pesquisa

A pesquisa foi desenvolvida a partir de um estudo de caso, que de acordo com Yin (2010) é definido como uma investigação de um fenômeno dentro de um contexto real, mediante o estudo de um ou mais objetos de análise. O objeto de estudo foi a disciplina de Gestão de Projetos Avançados - GPA, ministrada no curso de Engenharia de Produção da Universidade de Brasília. É um estudo exploratório com abordagem qualitativa, que apresenta o resultado da aplicação do PBL na disciplina de projetos, segundo o ponto de vista dos estudantes, e utiliza como técnicas para a coleta de dados um questionário e uma avaliação PEER, ambos aplicados ao final da disciplina. A avaliação PEER destaca as competências transversais a serem desenvolvidas considerando o ambiente de aplicação da metodologia PBL, ao qual os alunos se auto avaliam e avaliam os membros de sua equipe, de forma individual. Já o questionário, foi aplicado com o intuito de buscar a percepção dos estudantes com relação à retenção do conhecimento sobre a aprendizagem das duas metodologias de gestão de projetos (tradicional e ágil) e quanto à metodologia de ensino utilizada (PBL), abrangendo 40 respondentes, dentre os alunos que participaram da disciplina.

A escolha por esta disciplina justifica-se pelo fato de possibilitar a aplicação da metodologia PBL (Aprendizagem baseada em Projetos) em uma disciplina de gestão de projetos, contemplando duas vertentes metodológicas tradicionais e ágil. Os dados analisados são provenientes de 4 semestres em que a disciplina de GPA foi oferecida, sendo o 1º e o 2º semestre de 2017, e o 1º e o 2º semestre de 2018 ao qual foram desenvolvidos projetos reais de Criação de um site para o curso, Desenvolvimento de um jogo, Preparação de dois eventos para divulgação dos produtos desenvolvidos na disciplina e Desenvolvimento de boletins informativos para o Departamento de Engenharia de Produção (EPR) utilizando as metodologias de gestão de projeto e PBL. A seção 4 apresenta um detalhamento sobre a disciplina de GPA.

4 Desenvolvimento da disciplina Gestão de Projetos Avançados – GPA

Essa seção apresenta a estruturação da disciplina, o método de avaliação e o resultado obtido pelo projeto final.

4.1 Estruturação da Disciplina

A disciplina de GPA foi estruturada com base na metodologia PBL. Seu objetivo foi fornecer aos alunos conhecimentos teóricos e práticos sob o ponto de vista de duas metodologias de gerenciamento de projetos: tradicional e ágil, e entender como os aspectos de qualidade, prazo, risco, escopo e custo impactam o sucesso desses projetos.

A abordagem de utilização dos dois modelos de gestão de projetos foi proposta na disciplina com o intuito de permitir aos alunos uma vivência prática nas metodologias, com vistas a obter a percepção de diferença entre ambas, escolha de utilização de uma ou de outra, dependendo do contexto do projeto e, vantagens e desvantagens de utilização.

Em cada semestre, os alunos foram distribuídos em equipes de no máximo 4 alunos cada equipe, para o desenvolvimento dos projetos, sendo metade do semestre no modelo tradicional e a outra metade no modelo ágil, sendo de livre escolha dos alunos a montagem das equipes. Adotou-se no modelo tradicional o guia PMBOK como referência, e nos projetos ágeis o guia *SCRUM*, como pode ser observado na Figura 1. A disciplina ofertada aos alunos, tem como pré-requisito a disciplina de Metodologia de Projetos em Sistemas de Produção – MPSP (Monteiro, 2017) que aborda conceitos básicos de gestão de projetos (foco na metodologia Tradicional).

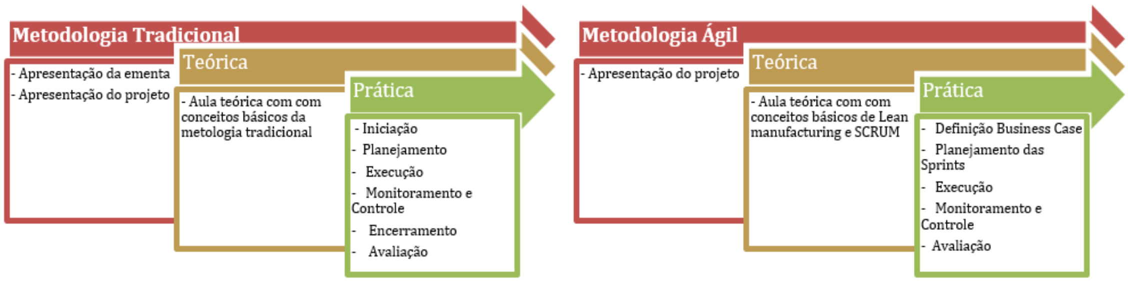

Figura 1 – Abordagem de atuação da disciplina

A estrutura de ensino-aprendizagem considerou os conceitos da metodologia PBL, em que os professores e alunos desempenham papéis, vinculados a uma responsabilidade específica no projeto, conforme apresentado na Figura 2.

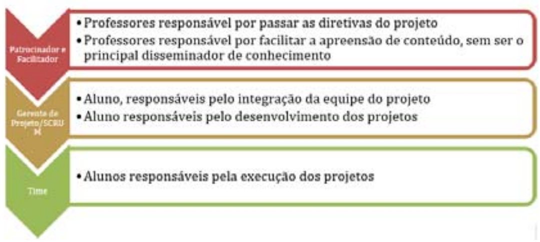

Figura 2 – Papéis dos integrantes no projeto

Ao longo do desenvolvimento do projeto, os Patrocinadores/Facilitadores apoiam os gerentes de projetos e time na definição dos requisitos, critérios de aceitação, motivação, orientação e avaliam toda documentação apesentada no projeto com *feedback* de todo material entregue para correção e reavaliação. As aulas práticas são utilizadas para monitoramento e controle das atividades dos projetos das equipes, com *status report* e planejamento das próximas atividades, além de sanar dúvidas que possam surgir no contexto conceitual, sobre o projeto e sobre as entregas do produto. As atividades não se limitam apenas ao tempo de sala de aula, exigindo aos integrantes do projeto dedicação fora dos horários de aula.

4.2 Entregas e Avaliação

As entregas e a avaliação da disciplina foram estruturadas em 3 pilares, alicerçados nas metodologias de gestão de projetos e na metodologia PBL. Foram apreciados os principais artefatos utilizados no mercado de trabalho, conforme apresentado no Quadro 1.

Quadro 1 – Estrutura de entregas da disciplina de Gestão de Projetos Avançado

Pilares	Projeto Tradicional	Ágil
01 – Avaliação do Ciclo de Vida do Projeto	Termo de Abertura do Projeto, Plano de Gerenciamento do Projeto, *Status Report* Semanal, Encerramento e Lições Aprendidas.	PM Canvas, História dos usuários, Apresentação das *Sprints* Semanais, *Sprints Plannig, Daily Meeting, Sprint Review, Sprint Retropective.*

02 – Avaliação e Apresentação do Produto Final	Avaliação dos produtos do projeto, considerando critérios de aceitação estabelecido na declaração do projeto, fornecidos no início de cada fase do projeto, além da apresentação de todos os membros da equipe visando ampliar as habilidades interpessoais de cada membro.	
Pilares	**Projeto Tradicional**	**Ágil**
03 - Avaliação dos Pares	Avaliação PEER, ao qual cada aluno se auto avalia e ainda avalia todos os integrantes do projeto atribuindo nota de 1 a 10, considerando todas as competências transversais, sendo elas: Comunicação, Liderança, Efetividade, Profissionalismo, Capacidade de Gerenciamento e Habilidade Cognitiva.	

A avaliação final é composta considerando os três pilares, conforme demonstrado pela Fórmula 1, onde **ACVP:** Avaliação do Ciclo de Vida do Projeto; **AAFP:** Avaliação e Apresentação do Produto Final; e **FC:** Fator de Correção para avaliação individual (Avaliação dos Pares).

$$Composição\ Final = (0{,}5\ ACVP + 0{,}5\ AAFP) * FC \quad Fórmula\ (1)$$

A partir desse critério, os estudantes são avaliados, abrangendo todos os aspectos técnicos e de participação ativa através da realização do projeto.

4.3 Projeto Final

A escolha do projeto foi motivada considerando seus conceitos básicos da aplicação do PBL, com o intuito de motivar e conduzir o aluno para novas descobertas, cobrindo, no mínimo, o conteúdo programático definido para o curso e ainda conceitos básicos de projeto, que expressa que um projeto é um empreendimento temporário com início e fim determinados para criar um produto, serviço ou resultado final (PMBOK, 2018).

A Figura 3 apresenta a estrutura utilizada na disciplina, em que foram propostos projetos distintos a cada semestre, e os times de projetos ficaram responsáveis por todas as ações, compreendendo todas as fases do projeto, desde o planejamento, execução, monitoramento e controle, encerramento, busca do patrocínio financeiro para efetiva execução do projeto e a busca de insumos materiais para sua efetiva realização.

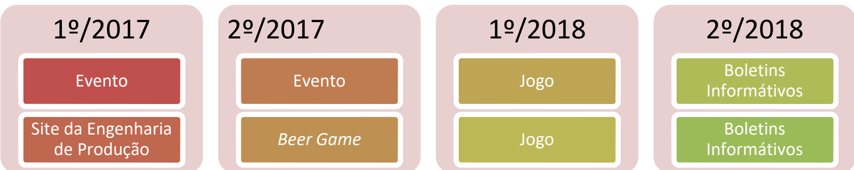

Figura 3 – Estrutura dos projetos para cada semestre

As equipes foram divididas em no máximo 5 membros, baseado em Collofello e Hart (1999), conforme experiências em cursos de Engenharia e relatos sobre a aplicação do PBL. Para as disciplinas ministradas no ano de 2017, a turma foi designada para 2 projetos distintos, sendo um entregue com a utilização da metodologia tradicional e um com a metodologia ágil, e cada equipe foi responsável por um tema dentro do projeto, sendo uma equipe responsável pela integração do todo. Nesses modelos todos eram responsáveis pela entrega final do projeto. Para as disciplinas ministradas no ano de 2018, cada projeto tinha como entrega final o mesmo produto, entretanto, com temas diferentes para cada grupo.

5 Implementação e Avaliação da Disciplina GPA

A aplicação das Metodologias de Gestão de Projetos adotadas na disciplina de GPA permitiu aos estudantes do curso de Engenharia de Produção confeccionar os produtos apresentados na seção 5.1. Os resultados da adoção do PBL são apresentados na seção 5.2.

5.1 Produtos (Entregas do projeto)

Na metodologia do projeto tradicional, foram realizados no 1° e 2° semestre de 2017 dois eventos (Agilizando projetos e Agilizando projetos 2ª edição) conforme apresentado na Figura 4, abordando conteúdos de Gestão de Projetos Tradicionais e Ágil, *Startups* e *Lean Manufacturing* e os *Cases* aplicados à metodologia PBL na disciplina, tendo como público em sua totalização mais de 300 participantes, em que a maioria foram estudantes do curso de Engenharia de Produção.

- Agilizando projetos – 1º/2017 (https://www.facebook.com/events/428204010892663)
- Agilizando projetos 2ª edição – 2º/2017 (https://www.facebook.com/events/180882229143220)

Na metodologia ágil de gerenciamento de projetos, foi construído no 1° semestre de 2017 um site para a Engenharia de Produção, com vistas a conceder fácil acesso a informações gerais do Departamento da Engenharia de Produção e no 2° semestre de 2017 um jogo de simulação de negócios de aprendizagem que simula todos os princípios fundamentais da Gestão da Cadeia de Suprimentos na produção. O jogo *Beer Game* foi ofertado na segunda edição do Agilizando projetos e teve mais de 100 participantes.

- Site da Engenharia de Produção: http://producaounb.com.br/ e Beer Game: https://www.youtube.com/watch?v=unV6dbD_nvg&fbclid=IwAR160bAshJGpfyD7t9vs XXmDdqH77pfVA22sZ7JjQ_RVi4klodGji-t2ooM

Figura 4 – Folders dos eventos realizados no 1° e 2° semestre de 2017

Para o 1° semestre de 2018, com o apoio da metodologia tradicional e ágil, foram desenvolvidos jogos educativos pela plataforma RPGMaker, em que foram abordados os temas: Desenvolvimento Sustentável da ONU 2030, Empreendorismo, Produção Sustentável e Práticas Inovadoras na Educação Superior (ISO 9001:2018). Os projetos foram divididos em 2 fases, sendo primeiro abordado a metodologia tradicional e posteriormente a metodologia ágil para o desenvolvimento do jogo, conforme apresentado na Figura 5.

Figura 5 – Jogo desenvolvido no 1º semestre de 2018

Para o 2° semestre de 2018, com o apoio da metodologia tradicional e ágil, foram desenvolvidos boletins informativos com intuito de serem publicados no PUMA – Plataforma Unificada de Metodologia Ativa que tem como objetivo a captação de projetos reais e avaliação da eficiência e eficácia da aplicação da metodologia PBL no curso. Os boletins abarcaram os seguintes temas: Projetos destaques das disciplinas de PSPs (Projetos de Sistemas de Produção), Edital de submissão de projetos para disciplinas de PSPs, Iniciativas de PBL na Universidade de Brasília, Mercado de Trabalho para os Engenheiros de Produção, Egressos da Universidade de Brasília e Adoção do PBL no curso de Engenharia de Produção. Os boletins desenvolvidos, tem expectativa de serem publicados em agosto/2019 através do endereço http://producaounb.com.br/pumav01/.

5.2 Resultados da adoção da Metodologia PBL

Dentre os principais resultados obtidos, a adoção do PBL proporcionou o desenvolvimento das competências transversais, conforme abordado no Quadro 2, que abrange um consolidado geral de todas as avaliações PEERs aplicadas nos 4 semestres da disciplina, ao qual cada aluno se auto avaliou dentro das características das competências transversais e ainda avaliou os integrantes de sua equipe dentro do projeto. Neste sentido o Quadro 2 é um consolidado da pontuação média de todos os alunos agrupados por semestre e características das competências transversais e a média geral compreende média geral de todos os semestres por competência transversal, sendo elas: Comunicação, Liderança, Efetividade, Profissionalismo, Capacidade de gerenciamento e habilidade cognitiva.

Quadro 2 – Consolidado da Avaliação PEER

Competências Transversais		01/2017	02/2017	01/2018	02/2018	Média por comp.	Média geral
Comunicação	Tempestividade das informações	8,91	8,79	9,26	8,79	8,94	
	Meios de comunicação utilizados	9,17	8,83	8,82	8,83	8,92	
	Comunicação interpessoal	9,09	9,17	9,10	9,17	9,14	
	Linguagem abordada	9,35	9,28	9,21	9,28	9,28	9,07
Liderança	Motivação	8,96	8,33	8,66	8,33	8,57	
	Bom relacionamento interpessoal	9,46	9,21	9,40	9,21	9,32	
	Proatividade	8,89	8,36	8,78	8,36	8,60	8,83
Efetividade	Disponibilidade para solucionar problemas	8,96	8,67	8,83	8,67	8,78	
	Assertividade para executar as tarefas	8,99	8,95	8,85	8,95	8,94	
	Resiliência	9,09	8,75	9,14	8,75	8,93	8,88
Profissio nalismo	Assiduidade e pontualidade nas reuniões	8,94	8,89	9,22	8,89	8,99	
	Pontualidade na entrega das atividades/tarefas	8,93	8,98	8,17	8,98	8,77	
	Capacidade de trabalhar em equipe	9,40	9,37	9,32	9,37	9,36	9,04
Capacidade de Gerenciam ento	Planejamento	8,80	8,48	8,58	8,48	8,58	
	Organização	8,93	8,54	8,61	8,54	8,66	
	Alocação de Recursos	9,11	8,82	8,89	8,82	8,91	8,77
Habilidade Cognitiva	Identificação de problemas e proposição de melhorias	9,02	8,97	8,81	8,97	8,94	
	Utilização de ferramentas e técnicas adequadas	9,12	9,12	9,04	9,12	9,10	9,02

Destaca-se o desenvolvimento das competências de comunicação, essencial para uma gestão de projetos eficiente dentre as duas metodologias apresentadas neste artigo. E ainda o profissionalismo e habilidade cognitiva, considerando a aplicação dos métodos na prática permitindo o desenvolvimento de tais habilidades.

A disciplina de GPA permitiu aos alunos uma análise crítica na diferenciação da utilização das duas metodologias e um ganho de conhecimento em ambas as metodologias, conforme resultados apresentados abaixo que foram coletados através de questionário aplicados aos alunos no final da disciplina, compreendo os 4 semestres no período de 2017 e 2018.

- Ao perguntar aos alunos com qual das duas metodologias de gerenciamento de projetos escolheriam trabalhar, 75% escolheram ambos e 25% escolheram a metodologia Ágil, demostrando o ganho de conhecimento considerável, visto que não existe uma orientação de se utilizar uma ou outra. Tudo dependerá do contexto apresentado ao projeto.
- Ao perguntar aos alunos qual era o conhecimento nas metodologias de gestão de projetos, antes e depois da disciplina, identificou-se a seguinte evolução realizando uma união e calculo médio das duas metodologias:
  - 25% dos alunos relataram ter o conhecimento (Muito baixo e Baixo) antes do início da disciplina, caindo para 5% após a conclusão da disciplina.
  - Cerca de 35% relataram ter o conhecimento (Alto e Muito) antes do início da disciplina, elevando para 50% após a conclusão da disciplina.
  - Considerando o conhecimento médio foi apresentado em 40% e ao final da disciplina elevou para 45%.
- Ao perguntar aos alunos se os usos das metodologias apresentaram resultados satisfatórios ao projeto, cerca de 87% concordam que foram satisfatórios e 12% discordam.

Seguem alguns relatos de alunos que cursaram a disciplina:

  - A disciplina foi a melhor disciplina com metodologia PBL que participei!!
  - A experiência foi cansativa, porém proveitosa!!

- Primeira turma ao qual os objetivos foram superados!!
- Ampla comunicação e flexibilidade que integrou a turma no desenvolver dela!!
- Excelente porque foi feito de fato para entregar algo de concreto!
- Muito boa. Informações relevantes
- Amei a disciplina pelo fato de aprender e perceber maior as diferenças das metodologias de gerenciamento ágil e tradicional.

A pesquisa completa, pode ser acessada através do seguinte link: https://docs.google.com/forms/d/1ECkwtTtoFOKdS9RPT3nXtElGn_87qUqfRJCcFH6VUUk/edit#responses

6 Conclusão

A metodologia PBL aplicada na disciplina de Gestão de Projetos Avançados – GPA relatada neste artigo, representa um caso de sucesso, que envolveu a participação dos estudantes na confecção de um produto real. Esse estudo de caso proporcionou resultados de produtos de alta qualidade, sendo eles um site para o curso de Engenharia de Produção, dois eventos com mais de 300 participantes, jogos que por sua vez tiveram sua publicação no *Play Store* para *downloads* e boletins informativos para divulgação, que foram fundamentais para a evolução da plataforma PUMA, que está sendo desenvolvida para o Departamento de Engenharia de Produção, além do desenvolvimento das competências técnicas e transversais dos estudantes.

Além dos produtos desenvolvidos, pôde-se destacar a viabilidade da utilização da metodologia proposta, retratando a realidade profissional dentro de sala de aula, constatando-se a realização das principais atividades práticas por Engenheiros de Produção em ambientes reais do mercado de trabalho, mediante equipes distribuídas, com atuação simultânea.

Destaca-se a oportunidade de ter proporcionado aos alunos relacionar os conteúdos teóricos e práticos das duas metodologias de gestão de projeto aliados ao PBL, ao qual eles se depararam com problemas reais do cotidiano profissional e se envolveram nas decisões relacionadas com a aprendizagem, transformando-se em agentes ativos e principais responsáveis pelo processo de aprendizagem.

A realização de estudos de caso dessa natureza representa para as comunidades acadêmica, científica e tecnológica a aplicação prática do estado da técnica e do estado da arte, podendo ser seguido por outros estabelecimentos de Ensino Superior do país e replicado em outros domínios de conhecimento, onde o processo de Aprendizagem Baseada em Projeto também possa ser aplicado.

A vivência dos estudantes no desenvolvimento dos projetos da disciplina de GPA, proporcionou o desenvolvimento de competências técnicas, do ponto de vista da utilização de duas metodologias (Tradicional e Ágil), além de desenvolver competências transversais, segundo o feedback dos próprios estudantes.

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Pedagogical Training of Teachers in Higher Education: findings from the Centre for Excellence in Teaching (CET@UPT)

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Abstract

Promoting quality teaching and learning is at the heart of the mission and goals of any Higher Education Institution. At Portucalense University (UPT), a private higher education institution, located in the north of Portugal, this goal has been strengthened by the creation of a Centre for Excellence in Teaching (CET), launched by the hands of the Vice Rectory. This structure aims to promote academic staff development, provide pedagogic training for teachers, create pedagogical resources and enhance the dissemination of best practices and teaching quality at UPT. One of the main activities organized by CET is pedagogic training sessions for academic staff. These sessions are designed, organized and developed according to teachers' individual motivations, interests and needs. This paper describes part of the change process carried out at UPT, in terms of the development of student-centred pedagogical approaches and active learning methods. Results from the implementation of the first activities developed by the CET reveal a positive participation and involvement of academic staff in training sessions, according to data collected from teachers, at the end of the training sessions. Teachers showed interest in developing active learning strategies and openness to change their teaching practices, but they were also aware of the difficulties and challenges which these approaches require. The impact of the pedagogical training sessions, carried out in the year 2017/2018, for all teachers at UPT, will also be analysed and discussed in the paper.

Keywords: Higher Education; Pedagogical Training; Continuous Professional Development.

Formação Pedagógica Docente no Ensino Superior: o caso do *Centre for Excellence in Teaching* (CET@UPT)

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Resumo

Este artigo visa apresentar os resultados da avaliação de um conjunto de sessões de formação pedagógica realizadas no âmbito do *Center for Excellence in Teaching* (CET@UPT) da Universidade Portucalense, durante o ano letivo de 2017/2018. Os módulos de formação, com duração de 12h cada, incluíram as seguintes temáticas: Aprendizagem baseada em Projetos (PBL – *Project-based Learning*), Aprendizagem baseada em Equipas (Team-based Learning), Sala de Aula Invertida (*Flipped Classroom*), *Scholarship of Teaching and Learning* (SoTL) e Desenvolvimento Curricular para Coordenadores. No final da formação, foi aplicado um inquérito por questionário relativo à avaliação de cada um dos módulos de formação pelos docentes. O questionário foi criado através da ferramenta *Google Forms*. Foi assegurado anonimato e a confidencialidade dos dados obtidos. No total, foram obtidas 57 respostas ao inquérito por questionário, de um total de 149 inscritos nos 5 módulos de formação. As perceções da formadora (externa), sobre o modo como decorreram as sessões, foram igualmente recolhidas através de uma narrativa escrita no final dos 5 módulos de formação. De uma forma geral, os docentes que participaram nas sessões de formação revelaram uma apreciação positiva da experiência, destacando-se a oportunidade para a partilha e discussão sobre as suas práticas pedagógicas, a interdisciplinaridade, o trabalho colaborativo docente, a implementação de projetos PBL em casos concretos e, ainda, o desempenho da formadora durante as sessões. A necessidade de sessões de follow-up para a implementação dos projetos PBL e estratégias de aprendizagem ativa, foram algumas das recomendações e sugestões de trabalho futuro enumeradas pelos docentes e pela formadora.

Palavras-chave: ensino superior; formação pedagógica; desenvolvimento profissional docente.

1 Introdução

O relatório recentemente publicado pela *European University Association* (EUA) apresenta as tendências de 2018 relativas aos processos de Ensino e de Aprendizagem no Espaço Europeu do Ensino Superior, sendo possível verificar que a preocupação com o ensino e aprendizagem se tornaram uma prioridade institucional (Gaebel & Zhang, 2018). A definição desta política ou estratégia institucional visa, sobretudo, contribuir para a melhoria do ensino, dos ambientes de aprendizagem e para o desenvolvimento profissional dos professores. Em virtude desta realidade, surgem nas instituições de ES diversas estratégias e estruturas de apoio, dos quais se destaca o papel dos centros de apoio ao ensino e aprendizagem. Por outro lado, os *European Standards and Guidelines for Quality Assurance in Higher Education* reforçam a necessidade do processo de ensino, aprendizagem e avaliação serem centrados no estudante, o que pressupõe a adoção de metodologias de ensino e de aprendizagem onde o estudante desempenha um papel ativo no seu processo de aprendizagem (ENQA, ESU, EUA & EURASHE, 2015).

É neste contexto que a formação pedagógica de docentes adquire uma importância fulcral. Esta formação pretende não só colmatar as necessidades formativas dos professores do ES, muitos dos quais sem qualquer preparação prévia no domínio pedagógico, mas antes afirmar-se como uma forma privilegiada de desenvolvimento profissional docente no Ensino Superior (Rosado-Pinto, 2016). Segundo esta autora, «é essencial que se desenvolva, a nível do ES, uma investigação pedagógica que requer que os docentes estudem as suas práticas para as poderem compreender e inovar, que estimule o diálogo entre docentes e a disseminação de boas práticas, e que contrarie o divórcio entre pedagogia e investigação» (Rosado-Pinto, 2016, p. 103).

Este artigo visa apresentar o exemplo da implementação de uma estratégia institucional de melhoria da qualidade do ensino e da aprendizagem, através da criação de um centro de excelência no ensino – o *Centre* *for Excellence in Teaching* (CET), na Universidade Portucalense (UPT), Porto, Portugal. Uma das principais atividades do CET é a formação pedagógica dos docentes.

2 O Centre for Excellence in Teaching (CET) na UPT

O *Centre for Excellence in Teaching* (CET) é um projeto da Reitoria da Universidade Portucalense, criado em maio de 2017, que visa contribuir para a promoção da excelência do ensino e da aprendizagem na UPT. O CET, reconhecendo a importância da formação pedagógica para a qualidade do ensino, tem como principais objetivos responder às necessidades individuais de formação dos docentes da UPT, desenvolver estratégias que promovam a reflexão sobre as práticas pedagógicas, criar redes de discussão e de partilha de práticas pedagógicas e, ainda, distinguir, promover e divulgar exemplos de práticas de excelência na UPT. Neste sentido, as atividades desenvolvidas pelo CET centram-se em três áreas fundamentais: a) Formação para Docentes; b) Publicações Pedagógicas c) Website e Recursos online.

No que diz respeito à atividade de formação para os docentes, numa primeira fase, a equipa do CET efetuou uma avaliação das necessidades de formação dos docentes e a caracterização das suas práticas pedagógicas em contexto de sala de aula, através do *Questionário de Estratégias de Ensino na Sala de Aula* (Bonwell & Eison, 1991). Com base nos resultados obtidos, que constatavam que a maioria dos docentes da UPT utiliza o ensino expositivo com grande regularidade nas suas aulas, foi preparado um conjunto de sessões de formação pedagógica para docentes, sobre a temática de *Estratégias de Aprendizagem Ativa*. A formação foi de caráter voluntário e teve a duração total de 12h, dividida em 4 sessões de 3h. As estratégias abordadas na formação incluíam: *Think Pair Share*; Sala de Aula Invertida; *Peer Instruction*; *Kahoot*; *Brain Break*; *Gallery Walk*. Foram, ainda, abordados conteúdos relacionados com o processo de Planificação, Técnicas de Avaliação e a definição de um Plano de Ação por parte dos docentes participantes na formação. De uma forma geral, os docentes mostraram-se satisfeitos com a formação e revelaram interesse em participar em iniciativas futuras no âmbito desta área.

Em 2017/2018, a formação promovida pelo CET foi integrada no plano de formação docente da UPT, que passou a incluir um conjunto de sessões de natureza pedagógica, com caráter obrigatório, para todos os docentes em regime de tempo integral e para os coordenadores dos ciclos de estudos dos vários departamentos da UPT. Os módulos de formação, com duração de 12h cada, incluíram as seguintes temáticas:

1. Aprendizagem baseada em Projetos / *Project-based Learning* (PBL)
2. Aprendizagem baseada em Equipas / *Team-based Learning* (TBL)
3. Sala de Aula Invertida / *Flipped Classroom*
4. *Scholarship of Teaching and Learning (SoTL)*
5. Desenvolvimento Curricular para Coordenadores

Foi escolhida uma formadora externa para a dinamização das sessões de formação, considerando a sua vasta experiência na área da formação de professores do Ensino Superior, sendo também formadora e *Coach* certificada. A sua formação inicial e Doutoramento na área das Ciências da Educação, sendo igualmente investigadora e docente do Ensino Superior, foram fatores que contribuíram positivamente para o êxito da formação, dada a proximidade com a realidade e contexto do ES. Em conjunto com a equipa do CET, a formadora definiu os objetivos de cada módulo de formação e um conjunto de competências pedagógicas que se esperava desenvolver, nomeadamente: trabalho colaborativo, reflexão sobre a prática, comunicação, criatividade, entre outras. Algumas destas competências foram transversais a todos os módulos (e.g. trabalho colaborativo entre os professores) mas outras competências foram mais enfatizadas em determinados módulos, como por exemplo, reflexão sobre a prática no módulo de *Scholarship of Teaching and Learning* (SoTL). De referir que, foi preocupação da formadora que a lógica das sessões e o ambiente criado em todos os módulos se centrasse numa abordagem de simulação, de natureza prática, participativa e reflexiva, com vista à realização de uma proposta de implementação em contexto real. Por outras palavras, considerando a estratégia de aprendizagem ativa abordada, a própria formação centrava-se nessa estratégia, de modo a que os participantes pudessem ter a experiência de um ambiente equivalente.

3 Metodologia

Este artigo tem como principal objetivo apresentar os resultados da avaliação da formação pedagógica, realizada no âmbito do CET@, durante o ano letivo de 2017/2018. Para tal, a metodologia do estudo centrou-se numa abordagem que combina dados de natureza quantitativa e também qualitativa, permitindo assim uma complementaridade de informação no que se refere à satisfação dos docentes com os módulos de formação realizados. No que se refere aos métodos de recolha de dados, foram utilizados o inquérito por questionário, narrativas escritas e a observação participante.

Relativamente ao inquérito por questionário, este foi aplicado no final da formação, com o objetivo avaliar a satisfação dos participantes relativamente a cada um dos 5 módulos de formação. O questionário foi criado através da ferramenta *Google Forms*. A estrutura do questionário encontra-se apresentada na tabela 1.

Tabela 1. Estrutura do Inquérito por Questionário aplicado online

Questões	Tipo de Questões
1. Os temas/conteúdos abordados na formação foram relevantes. 2. As atividades desenvolvidas serão úteis para a minha prática docente. 3. Participei, de forma ativa, na realização das atividades. 4. As atividades realizadas foram adequadas. 5. Os objetivos foram cumpridos. 6. Os materiais disponíveis foram adequados. 7. O desempenho da formadora correspondeu às minhas expectativas. 8. De uma forma geral, estou satisfeito/a com o resultado final. 9. Estou motivado/a para participar nas próximas atividades do CET@UPT.	Resposta Fechada (escala de Likert, 1 a 5)
10. Na minha opinião, os aspetos mais positivos desta experiência foram… 11. Na minha opinião, os aspetos menos positivos desta experiência foram… 12. Para melhorar as próximas sessões, sugiro…	Resposta Aberta

No total, foram obtidas 57 respostas ao inquérito por questionário, de um total de 149 inscritos nos 5 módulos de formação. O módulo sobre PBL, o primeiro a ser realizado, obteve a maior taxa de resposta (79%). A tabela que se segue apresenta o nº. de inscritos em cada módulo de formação e o nº. de respostas obtidas em cada um dos respetivos inquéritos por questionário.

Tabela 2. Número de inscritos por módulo e respostas obtidas no questionário.

Módulo de Formação	Nº. inscritos no módulo	Nº. respostas obtidas
Project-based Learning (PBL)	19	15
Scholarship of Teaching and Learning (SoTL)	20	06
Aprendizagem baseada em Equipas	41	15
Flipped Classroom	43	15
Desenvolvimento Curricular para Coordenadores	26	06

Considerando o número reduzido de respostas obtidas por parte dos professores, nos inquéritos online, consideramos que esta amostra não poderá ser considerada representativa do grupo de professores que participaram nas sessões de formação. Contudo, este resultado permite um contributo importante para a redefinição dos procedimentos de recolha de dados no âmbito da avaliação da formação, nomeadamente, os momentos de recolha de dados (imediatamente após o término da formação) e as modalidades de preenchimento (presencial vs online).

No que se refere às narrativas escritas e à observação participante, estas permitiram recolher informação por parte da formadora que organizou e dinamizou as sessões de formação, bem como a equipa de coordenação do CET, que esteve presente durante todas as sessões de formação.

4 Apresentação dos Resultados

De uma forma geral, a avaliação realizada pelos docentes, aos vários módulos de formação, foi considerada positiva, tendo uma média de avaliação global de 4,2 numa escala de 1 a 5. O módulo sobre PBL foi o mais positivamente avaliado pelos docentes. A tabela que se segue apresenta a média (escala de 1 a 5) da avaliação global dos docentes relativamente a cada um dos módulos de formação.

Tabela 3. Avaliação Global da Formação pelos docentes

Módulo de Formação	*Média*
Project-based Learning (PBL)	4,7
Scholarship of Teaching and Learning (SoTL)	4,2
Aprendizagem baseada em Equipas	4,2
Flipped Classroom	3,9
Desenvolvimento Curricular para Coordenadores	4,1
Média Global	4,2

4.1 Avaliação da formação pelos docentes

De seguida, apresentamos uma síntese dos principais resultados da avaliação de cada um dos módulos pelos docentes.

4.1.1 *Project-based Learning* (PBL)

Esta formação decorreu de 14 de março a 4 de abril de 2018, tendo sido a primeira do conjunto de 5 módulos a serem realizados. Esta formação visava dois grandes objetivos: i) simular um ambiente de projeto: como uma equipa de professores se organiza, trabalha e pesquisa em PBL; e ii) criar uma proposta de projeto interdisciplinar com vista a ser implementado num semestre, considerando num determinado contexto (um curso ou vários cursos). Para além disso, pretendia-se, em todas as sessões de formação, desenvolver competências que se consideram fundamentais à inovação pedagógica e curricular.

Os docentes avaliaram, de forma bastante positiva, a formação sobre PBL. Destacam-se os temas/conteúdos abordados, as atividades realizadas, o cumprimento dos objetivos e o desempenho da formadora como os itens do questionário com a média mais elevada. A estes tópicos acresce a oportunidade de partilha e interação com os colegas, numa lógica de colaboração docente.

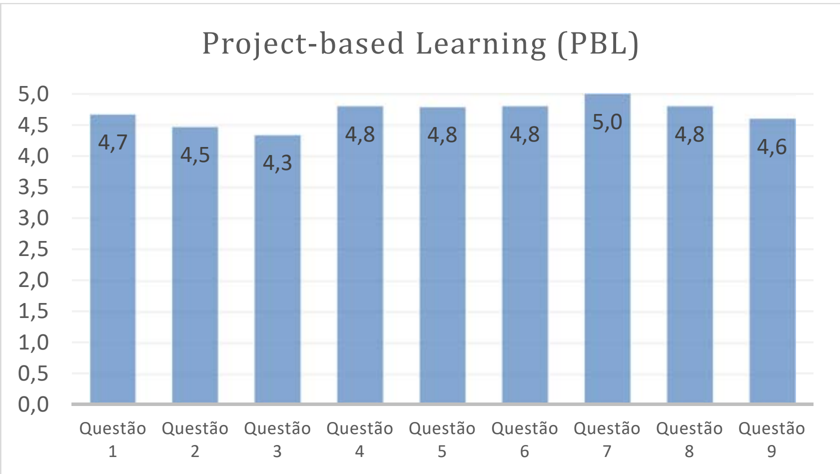

Figura 1. Avaliação do módulo sobre PBL pelos Docentes

Como aspetos menos positivos, os docentes salientam as dificuldades de aplicação do PBL em contexto real, os desafios da interdisciplinaridade e a impossibilidade de frequentar todas as sessões de formação. De seguida, apresentamos a transcrição de uma das respostas abertas do questionário, obtida neste módulo:

“O medo que os docentes têm em inovar e compreender qual a utilidade prática que futuramente os conhecimentos (vulgo competências) adquiridos pelos alunos têm profissionalmente, assim como da necessidade de agregação de múltiplas áreas do conhecimento para que vários profissionais trabalhem em conjunto com uma única finalidade - resolução de um caso que necessita da multidisciplinaridade de profissionais. Sente-se um medo enorme de saírem do seu "canto" de pretenso ou real domínio.”

4.1.2 ***Scholarship of Teaching and Learning*** **(SoTL)**

O segundo modulo de formação realizado foi sobre o tema do *Scholarship of Teaching and Learning* (SoTL). Decorreu de 11 de abril a 4 de julho de 2018, sendo o intervalo entre as sessões de cerca de um mês. Esta formação tinha como principais objetivos: i) apresentar, discutir e analisar os princípios do *Scholarship of Teaching and Learning* (SoTL); ii) desenvolver tempos e espaços de reflexão crítica sobre a prática de ensino e das aprendizagens desenvolvidas pelos alunos; iii) desenvolver e apresentar uma proposta de investigação sobre a prática pedagógica.

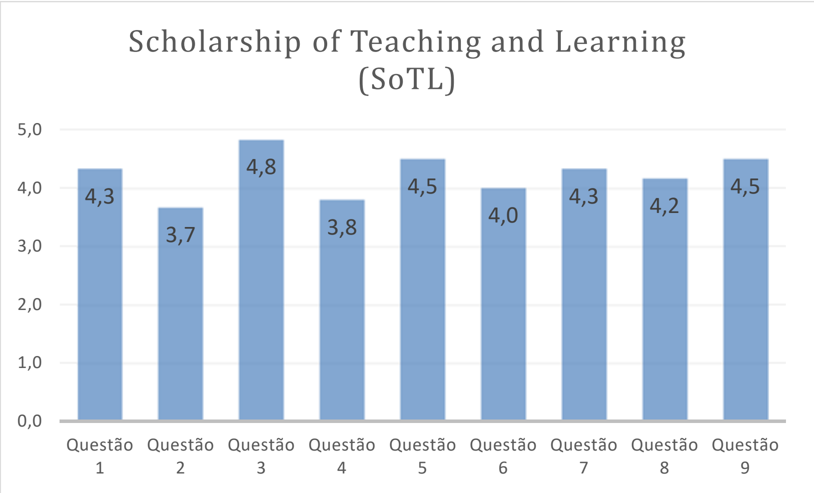

Figura 2. Avaliação do módulo sobre SoTL pelos Docentes

No que diz respeito aos resultados da avaliação, apenas 6 docentes responderam ao questionário, de um total de 20 inscritos no módulo de formação. Com base na análise da figura 2, é possível destacar a participação ativa dos docentes na realização das atividades de formação (questão 2) como o aspeto mais positivamente avaliado. Com a menor classificação, encontramos os itens relativos à adequação das atividades realizadas e a sua utilidade para a prática docente que, apesar de apresentarem classificações mais baixas, continuam a ser consideradas uma avaliação positiva. Nas respostas abertas do questionário, os docentes referiram novamente a interação entre os pares como um dos aspetos mais positivos da formação, ao qual se aliam as oportunidades para a realização de projetos de investigação conjuntos. Algumas afirmações evidenciam esta realidade:

“O aprofundar de conhecimentos sobre métodos de ensino, contando com informação organizada e atualizada. Também a possibilidade de estreitar relações profissionais com colegas de diferentes departamentos.”

“Os trabalhos práticos desenvolvidos entre os diferentes colegas e as sinergias que daí decorreram em termos de projetos futuros no âmbito da investigação.”

Sobre as dificuldades sentidas, os docentes referem a gestão do tempo e a conciliação com outras atividades profissionais como aspetos menos positivos. A falta de suporte documental de forma a permitir o aprofundamento das temáticas abordadas foi outro aspeto mencionado por um dos docentes. A este respeito, é importante referir que todo o material de apoio utilizado nas sessões (powerpoints, artigos científicos, relatórios nacionais e internacionais, material pedagógico e grelhas, links, etc.) foi disponibilizado aos docentes na plataforma Moodle.

4.1.3 ***Team-based Learning*** **(TBL)**

Este módulo, sobre o tema da Aprendizagem baseada em Equipas (TBL), juntamente com o módulo sobre a Sala de Aula Invertida (*Flipped Classroom)*, foram os módulos com maior número de docentes inscritos (41 e

43 respetivamente). A formação sobre TBL teve início a 7 de maio e terminou a 11 de junho 2018, sendo realizada uma sessão (3h) em cada semana. Os objetivos específicos deste modulo incluíam: i) explorar aspetos relacionados com a gestão e desenvolvimento de equipas de trabalho em ambiente de ensino e aprendizagem (e.g. trabalho em equipa, papel do professor, etc.); ii) explorar os princípios do TBL, através de uma simulação prática; iii) planear uma aula utilizando TBL como estratégia de aprendizagem ativa.

De uma forma geral, os docentes avaliaram o modo de funcionamento da sessão de uma forma muito equilibrada, isto é, a média das classificações variou entre 4,1 e 4,4 como classificações mínimas e máximas.

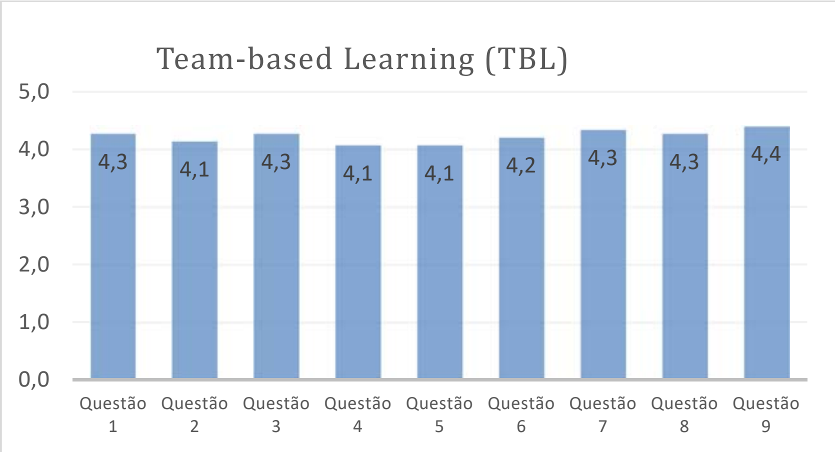

Figura 3. Avaliação do módulo sobre TBL pelos Docentes

Sobre os aspetos mais positivos referidos, destaca-se a relação formadora-formandos, a oportunidade de desenvolver atividades em grupo e partilhar experiências, a troca de experiências entre docentes de diversos departamentos e a informação recebida relativamente às práticas pedagógicas analisadas. No que se refere aos aspetos menos positivos, o número excessivo de participantes foi apontado como um dos principais entraves ao sucesso da formação, ao qual se aliou a sobreposição de vários módulos de formação durante o mês de maio. Como sugestões de melhoria, os docentes referem a necessidade de definir um limite máximo de participantes (exemplo max. 20) e novamente a necessidade de "fornecimento de mais documentação relativamente aos temas em análise" e ainda "temas mais cirúrgicos, com 'take-away' mais concreto".

4.1.4 Sala de Aula Invertida / *Flipped Classroom*

O módulo relativo ao tema do *Flipped Classroom* foi o módulo com uma duração mais concentrada, tendo decorrido de 11 a 18 de junho 2018. Os objetivos deste módulo incluem: i) explorar aspetos relacionados com a inovação pedagógica, especificamente o papel do professor no desenvolvimento das competências dos alunos. ii) explorar os princípios da Sala de Aula Invertida, através de uma simulação prática; iii) planear uma aula utilizando a Sala de Aula Invertida como estratégia de aprendizagem ativa.

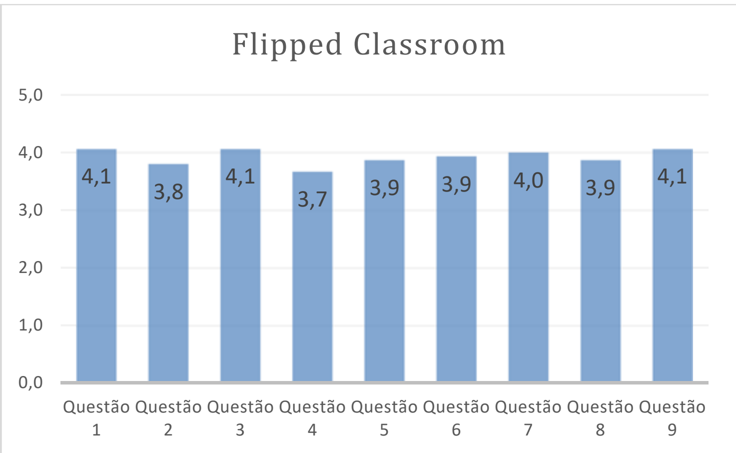

Figura 4. Avaliação do módulo sobre *Flipped Classroom* pelos Docentes

Como aspetos mais positivos, os docentes destacam, nas questões abertas, os vídeos tutoriais, a partilha e reflexão acerca das experiências docentes, o conhecimento de metodologias ativas e dinâmicas que podem ser implementadas no contexto de sala de aula, bem como a qualidade do desempenho da formadora. Como aspetos menos positivos, referem o número excessivo de formandos por sessão, a excessiva carga horária, o caráter obrigatório da formação e algum ritmo inconstante nas sessões, devido aos atrasos dos professores e entradas/saídas constantes.

4.1.5 Desenvolvimento Curricular para Coordenadores

Relativamente ao módulo sobre Desenvolvimento Curricular, destinado exclusivamente aos coordenadores de ciclos de estudos da UPT, este decorreu de 7 de maio a 4 de julho 2018. Os objetivos do módulo incluem: i) explorar aspetos relacionados com o desenvolvimento do currículo, através de uma estratégia de aprendizagem ativa (gamificação); ii) desenvolver tempos e espaços de reflexão crítica sobre os diversos aspetos relacionados com o currículo dos cursos da UPT; iii) desenvolver e apresentar uma matriz de desenvolvimento curricular.

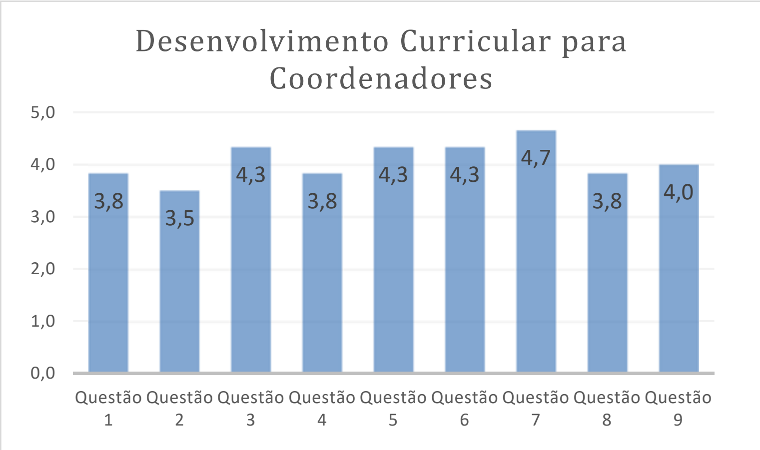

Figura 5. Avaliação do módulo sobre Desenvolvimento Curricular pelos docentes

De uma forma geral, os coordenadores avaliaram a utilidade das atividades realizadas na formação para a coordenação dos cursos com classificação média de 3,5 (escala de 1 a 5). Esta foi a média mais baixa obtida, o que poderá significar um desfasamento entre as expectativas dos docentes e os objetivos da formadora. O desempenho da formadora foi, no entanto, muito bem avaliado pelos docentes. Na avaliação efetuada pela formadora, a referência concreta a este módulo é mencionada, apontando as dificuldades sentidas e formas de ultrapassar as mesmas:

"Tendo sido um módulo especificamente solicitado, procurou-se, em primeiro lugar, compreender as expectativas dos coordenadores relativamente à formação e, efetivamente, verificou-se que tais expectativas não se encontravam completamente alinhadas com o objetivo da formação. Por exemplo, uma das principais expectativas dos participantes era na gestão de tempo considerando o que a função de coordenação implica. Assim, a temática do desenvolvimento do currículo não se enquadrou completamente no esperado, pelo que se procurou ajustar o melhor possível em termos de benefício para a função e, cumulativamente, para a prática docente (daí se ter utilizado alguns elementos de gamificação."

Como aspetos mais positivos, os docentes destacam a oportunidade para a reflexão sobre as fichas das unidades curriculares do curso e a articulação entre os vários elementos do currículo (objetivos, conteúdos e avaliação).

4.2 Avaliação da formação pela formadora

Na perspetiva da formadora, foi possível evidenciar, ao longo das sessões de formação, o nível de interação entre os participantes e um forte empenho e envolvimento nos desafios propostos. A dinamização dos diferentes módulos, pela mesma formadora, permitiu um contacto privilegiado, entre os professores e a formadora, ao longo do tempo, o que também permitiu à formadora compreender melhor os contextos da prática docente dos professores, as suas dificuldades e preocupações. De uma forma geral, a formadora identificou um conjunto de potencialidades que podem ser resumidas na tabela que se segue.

Tabela 4. Potencialidades da formação na perspetiva da formadora

Potencialidades	**Perceções da Formadora**
Desenvolvimento profissional dos professores	"ter assistido à evolução de alguns participantes, quer no que diz respeito à forma como pensam e entendem a prática docente e a forma como é possível inovar, quer no que diz respeito ao nível de discussão entre pares, que evidencia a mobilização de conhecimento teórico, a experiência e até algumas inseguranças, com vista a um apoio nesse sentido."
Partilha de experiências e trabalho colaborativo	"as diferentes sessões permitiram aos professores conhecerem-se melhor uns aos outros (sobretudo quando são de diferentes áreas), interagirem na partilha de experiências e no trabalho colaborativo e, principalmente, aprenderem uns com os outros que é uma das formas mais significativas de aprendizagem."
Resultados / propostas apresentadas	"Gostaria de enfatizar, as propostas PBL pelo seu enorme potencial de implementação; as propostas SoTL que resultaram em, pelo menos, trabalhos publicados num congresso nacional sobre Ensino Superior (CNAPPES 2018) e propostas de projeto de investigação-ação a desenvolver em diferentes áreas de conhecimento, como o Turismo, Direito, Educação e Psicologia, Gestão e Informática.
Envolvimento e implicação dos participantes	"Nesse evento [Seminário Final CET], foi possível também verificar o empenho e a dedicação dos professores presentes na discussão e na própria identidade do CET da UPT, propondo novas ideias, partilhando mudanças na sua prática, etc."

No que se refere às dificuldades sentidas, a formadora identifica um conjunto de constrangimentos e obstáculos que condicionaram o modo de funcionamento das sessões, nomeadamente:

- O número de participantes por módulo ultrapassou o inicialmente previsto e recomendado (máximo 25 participantes), afetando o funcionamento das sessões, quer em termos de acompanhamento individual, quer em termos de logística das atividades. Esta situação verificou-se, particularmente, nos módulos de Sala de Aula Invertida e Aprendizagem Baseada em Equipas (TBL).
- Os constrangimentos dos participantes para estarem presentes em todas as sessões ou até no tempo integral das sessões.
- Apesar do reforço e incentivo para que os participantes acedessem ao Moodle para explorarem a informação disponibilizada, tal não se verificou na maioria dos casos.
- Para a concretização do resultado final de cada um dos módulos foi dado tempo na sessão para o efeito. Na maioria dos casos o resultado final foi entregue e, consequentemente, foi dado feedback detalhado por escrito. Contudo, noutros casos, tal não se verificou.

5 Considerações Finais

De uma forma geral, os docentes que participaram nas sessões de formação revelaram uma apreciação positiva da experiência, destacando-se a oportunidade para a partilha e discussão sobre as suas práticas pedagógicas, a interdisciplinaridade, o trabalho colaborativo docente, a implementação de projetos PBL em casos concretos e, ainda, o desempenho da formadora durante as sessões. Após a conclusão da formação, foi possível identificar um conjunto de projetos e/ou atividades reais, implementadas por docentes de diversas áreas, nomeadamente: i) Implementação da avaliação pelos pares em UCs de Informática; ii) implementação de projetos interdisciplinares, articulando diferentes áreas disciplinares (Educação e Psicologia); iii) implementação de um modelo de avaliação capaz de incluir formas diferenciadas que vão além dos testes (e.g. feedback) (Informática); iv) realização de dinâmica de trabalho em equipa na primeira aula (Gestão); v) implementação de um modelo de apresentação de trabalhos diferente na área do Direito, baseado em Gallery

Walk (Direito). Para um maior impacto da formação, existe a necessidade de sessões de *follow-up* para a implementação dos projetos PBL e estratégias de aprendizagem ativa, tenda esta sido uma das principais recomendações enumerada pelos docentes, no questionário de avaliação final da formação CET. Por último, é de referir que a participação dos docentes nas diversas ações de formação promovidas pelo CET permitiu, ainda, criar um espaço de reflexão, de partilha e de colaboração docente, traduzindo-se numa oportunidade para a realização de projetos conjuntos, quer ao nível do ensino, quer ao nível da investigação (Abelha, Fernandes, Conde & Mesquita, 2018; Fernandes, Abelha, Fernandes & Albuquerque, 2018; Oliveira, Fernandes, Abelha, Fernandes, Carvalho, Jesus, Leite & Mesquita, 2018).

No que se refere às implicações deste estudo, foi possível identificar um conjunto de aspetos que carecem de uma maior reflexão no sentido de contribuir para a melhoria de futuras atividades de formação desenvolvidas com os docentes. Como recomendações que emergem deste estudo e que vão ao encontro de algumas das propostas identificadas também pela formadora que dinamizou as sessões, destaca-se as seguintes sugestões de trabalho futuro:

- a necessidade de diversificar os formatos de formação (por exemplo, formação orientada para algumas áreas de conhecimento em particular, atendendo às suas necessidades mais específicas; formação mais teórico-concetual e formação mais prática e interativa; formação curta e formação de longa duração; formação para diferentes níveis - inicial, médio e avançado).
- a redução do número de horas totais, de cada módulo, existindo a possibilidade de módulos ou temas de formação mais curtos (3h) e a definição de um número máximo de participantes por sessão.
- o acompanhamento e consultoria a projetos específicos ou atividades pedagógicas em curso, na lógica de *coaching & mentoring*, através de um apoio mais individualizado e personalizado aos docentes.
- a avaliação da formação deverá decorrer imediatamente após a conclusão da mesma, privilegiando a modalidade de recolha de dados presencial.
- a realização de sessões de follow-up para uma análise mais aprofundada do impacto da formação, (recolha de dados, no final do semestre, procurando compreender as mudanças efetivas na prática docente e, nesse sentido, identificar novas necessidades de formação.

Para concluir, é importante referir que o CET se tem revelado uma estrutura de apoio adequada à promoção da melhoria dos processos de ensino e de aprendizagem na UPT, contribuindo para a excelência pedagógica e o desenvolvimento profissional dos seus docentes (Fernandes, Morais, Mesquita, Abelha, Fernandes & Albuquerque, 2018; Mesquita, Fernandes & Morais, 2018).

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Educating in values in chemistry courses for engineers.

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Abstract

There are currently some problems in the world, several of which could be diminished or eliminated if people took into account some social values, such as ethics or professional dignity. To educate in values implies to relate a specific knowledge with the social values, seeking to reach, in a conscious and meaningful way, a new knowledge. For an educational institution at the higher level, the foregoing must imply that any plan, program or subject should be directed towards the profession itself, with an integrative vision; So much so that the development of a discipline will aim to seek the training and development of professional values, contextually and effectively, considering: knowledge, technique, ethics and personal and professional commitment, in order to form a professional of quality, that possesses knowledge and ethical values according to the new social requirements. For its part, the formal education of a university student of engineering is mainly based on the physical sciences: Mathematics, physics and chemistry; However, we must now make a greater emphasis, also on other issues, such as professional ethics, which includes social and environmental responsibility, coherence, honesty, adherence to law and respect, which are values that have become essential An engineer. Therefore, the teaching of science must combine knowledge with these values, which leads to propose here that in chemistry classes, future engineers are explained through examples, the importance of applying social values in the processes of Research or problem solving. In this case, examples are presented whose main objective is to make students understand the evaluative situations applied to subjects of the subject.

Keywords: Values education, chemistry, University.

Educando en valores en cursos de química para ingenieros

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Resumen:

Actualmente existen algunos problemas en el mundo, varios de los cuales podrían disminuirse o eliminarse si las personas tomaran en cuenta algunos valores sociales, como son la ética o la dignidad profesional. Educar en valores implica relacionar un conocimiento especifico con los valores sociales, buscando alcanzar, de manera consciente y significativa, un nuevo conocimiento. Para una institución educativa en el nivel superior, lo anterior debe implicar que todo plan, programa o asignatura deberá estar dirigido hacia la profesión misma, con una visión integradora; tanto así, que el desarrollo de una disciplina tendrá como finalidad el buscar la formación y desarrollo de valores profesionales, de forma contextual y eficaz, considerando: el conocimiento, la técnica, la ética y el compromiso personal y profesional, para poder conformar un profesional de calidad, que posea conocimientos y valores éticos acordes a los nuevos requerimientos sociales. Por su parte, la educación formal de un estudiante universitario de ingeniería está, principalmente, basada en las ciencias físicas: la matemática, la física y la química; sin embargo, ahora se debe de hacer un mayor énfasis, también en otros temas, como son la ética profesional, que incluye la responsabilidad social y ambiental, la coherencia, la honestidad, la adhesión a la ley y el respeto, que son valores que se han vuelto imprescindibles en un ingeniero. Por lo tanto, la enseñanza de la ciencia debe conjugar el conocimiento con esos valores, lo que lleva a proponer aquí que en clases de química, a los futuros ingenieros se les explique a través de ejemplos, la importancia de aplicar valores sociales en los procesos de investigación o de resolución de problemas. En este caso, se presentan ejemplos cuyo objetivo principal es hacer comprender a los alumnos las situaciones valorativas, aplicados a temas propios de la asignatura.

Palabras clave: Educación en valores, Química, Universidad.

1 Introducción

Actualmente existen algunos problemas en el mundo, varios de los cuales podrían disminuirse o eliminarse si se consideraran los valores sociales correctamente. Educar en valores implica relacionar un conocimiento específico con los valores sociales, buscando alcanzar, de manera consciente y significativa, un nuevo conocimiento. Para una institución educativa en el nivel superior, lo anterior debe implicar que todo plan, programa o asignatura deberá estar dirigido hacia la profesión misma, con una visión integradora; tanto así, que el desarrollo de una disciplina tendrá como finalidad el buscar la formación y desarrollo de valores profesionales, de forma contextual y eficaz, considerando: el conocimiento, la técnica, la ética y el compromiso personal y profesional, para poder conformar un profesional de calidad, que posea conocimientos y valores éticos acordes a los nuevos requerimientos sociales.

En México, en los últimos años, y debido a los cambios en los planes y programas de la Secretaría de Educación Pública no se enseñan con profundidad temas de carácter cívico o valorativo en las escuelas de educación básica, lo que ha llevado a que muchos jóvenes no perciban de la misma forma la importancia de los valores sociales, como son la honestidad, la responsabilidad, la igualdad, etc.; sobre todo, porque las expectativas económicas han permitido visualizar que es más fácil llegar a tener una estabilidad económica haciendo a un lado los valores que trabajando con ellos, sin importar las consecuencias personales y para la sociedad.

Es bien sabido que en México se tienen muchos problemas sociales y económicos que se encuentran interrelacionados, como son la corrupción, el narcotráfico, la violencia, la pobreza, la contaminación ambiental y la desigualdad social, entre los más importantes; muchos de estos problemas tienen que ver con la educación, haciendo referencia a los valores, que con el transcurso del tiempo se ha devaluado y se ha permitido que desde la primera educación, que es la familiar, se debilite.

Sin embargo, si se quiere evitar un problema mayor, o disminuir la magnitud de los problemas actuales, se debe de incidir en la educación de los jóvenes para que ellos, cuando concluyan su educación, al aplicar los conocimientos propios de su carrera sean capaces de discernir entre lo que es mejor para sí mismos y para la sociedad y lo que no lo es. Se debe de hacer énfasis en temas como ética, moral y reflexión crítica haciendo énfasis en la situación ambiental. En la UAM, en la Unidad Azcapotzalco se imparten algunas asignaturas como: Ética, Introducción al Desarrollo Sustentable y algunas otras, sin embargo estos temas deben incluirse en asignaturas técnicas para que tengan más peso en la formación de los alumnos.

Las instituciones educativas siempre han formado a los alumnos en valores, a través de diferentes fuentes: la política educativa, la historia, las tradiciones y el ejemplo de los docentes, desde el punto de vista de las tendencias pedagógicas de la época, las coyunturas políticas del momento, las culturas particulares del lugar y los sectores sociales en los que se está inmerso, por lo que la Educación en Valores puede asumirse como un proceso educativo humanizador, integral que va de lo individual hasta lo social a lo largo de la vida de las personas, determinando su personalidad desde su nacimiento hasta la ancianidad; en dicho proceso, al intervenir múltiples instituciones educativas, marcos sociales y personas, el sistema de influencia en un individuo se vuelve muy complejo y lleno de contradicciones que aunque no llegan a ser antagónicos si se pueden desvirtuar en su momento, en dependencia del contexto específico.

Hablar de valores es complejo y multilateral pues se trata de la relación entre la realidad objetiva y los componentes de la personalidad, lo que se expresa a través de conductas y hábitos, por lo tanto, sólo se puede educar en valores a través de conocimientos, habilidades de valoración, reflexión en la actividad práctica con un significado asumido y considerando la objetividad y subjetividad del docente. Se trata de alcanzar costumbres como resultado de aprendizajes conscientes y significativos en lo racional y lo emocional.

Es necesario comprender las particularidades de la formación y el desarrollo de los valores y sus relaciones en el proceso docente-educativo. Integrar los valores al aprendizaje de manera intencionada y consciente significa no sólo pensar en el contenido como conocimientos y habilidades, sino que es necesario vincularlo a la parte afectiva-emocional que pueda tener el tema en un contexto específico.

En este sentido, los valores científicos son igual de importantes que los valores sociales o más específicamente, con los valores éticos debido a que tiene que ver con la forma de explicar los fenómenos científicos, así como con la objetividad de la persona, y su pensamiento lógico y crítico. Por lo tanto, aquellas instituciones educativas y sobre todo las de educación superior deben de considerar este tipo de valores también en la impartición de sus asignaturas (Rojas, 2003).

Ana Hirsch (2003) indica "Las instituciones de educación superior deben proporcionar a la sociedad personas, no sólo profesionalmente bien preparadas, sino además, cultivadas, con criterio, de mente abierta, capaces de hacer un buen uso de su profesión y de participar libre y responsablemente en las actividades de convivencia social".

En la Universidad Autónoma Metropolitana Unidad Azcapotzalco, se ofrece la asignatura de Estructura y Propiedades de los Materiales en Ingeniería, que pertenece al área de conocimientos de química, a los jóvenes que estudian alguna de las diez licenciaturas de ingeniería que se ofrecen en esa institución. En esta asignatura los temas a revisar tienen que ver con los materiales, sus propiedades y su uso. En este último punto es donde puede y debe de hacerse referencia a los valores y a la ética profesional de un ingeniero en las labores propias de su profesión. Sin embargo no es tan fácil, ya que de por sí la enseñanza de la química es difícil (González y Portilla, 2010a y 2010b) debido a que los jóvenes estudiantes piensan que es innecesario estudiarla, aunado a esto incorporar valores y hacer hincapié en la ética profesional, lo vuelve más complicado, no obstante es necesario hacerlo, para mejorar la situación del país.

Así, la educación superior prepara al ingeniero en su disciplina, con lo cual un ingeniero además debe ser capaz de comunicarse efectivamente y afectivamente en y con la sociedad, para lo cual debe de ser capaz de conocerla, aportar ideas y entender sus problemas, pero sobre todo debe de aplicar sus conocimientos para beneficio de la sociedad en la que convive y trabaja, entendiéndose esto último en que el ingeniero debe de asumir una verdadera actitud profesional hacia su trabajo, aplicando todos sus conocimientos , pero sobre todo aplique valores que le permitan tener objetividad al realizar su trabajo y por ende, tomar buenas decisiones.

2 Referentes teóricos

El ser humano como individuo debe de tomar decisiones, algunas con mayor influencia en su vida que otras; la elección dependerá de los valores y la formación que cada persona tenga en ese momento.

Según el Instituto Interamericano de Derechos humanos (IIDH, 2003), "Los valores constituyen componentes inevitables en el mundo humano por lo que educar en valores es una necesidad ineludible en la sociedad actual. Es imposible imaginar una vida humana sin valores, especialmente sin valores éticos, pues no existe ningún ser humano que pueda sentirse más allá del bien y del mal, sino que todas las personas somos inevitablemente morales."

Hay que reconocer que los valores son convicciones profundas que cada ser humano presenta. Estos valores se aprenden por el ejemplo principalmente, y se afirman cuando se involucran sentimientos y emociones. Pueden ser modificados, pero para ello es necesario hacerle ver a la persona que lo que piensa o siente no está totalmente de acuerdo con el beneficio esperado para la humanidad.

Según María Cristina Tarrés y colaboradores (2005) "Los valores constituyen experiencias humanas del diario vivir relacionadas con la capacidad de evaluar el mundo que nos rodea y de preferir jerárquicamente en él lo que consideramos más estimado dentro de una gama de posibilidades, guiándonos por un cierto "sentimiento" hacia lo más apreciable". Entonces, para evaluar es necesario conocer, pero también reconocer la escala valorativa usada por la sociedad para determinar lo bueno y lo malo, lo mejor o lo peor, lo aceptable o lo inaceptable, etc., y reconocer que además la escala propia puede ser semejante o igual o no a la de la sociedad y tanto una como otra son indicadas para obtener lo mejor de la vida.

En el desarrollo de una persona, a través de la educación institucional, la enseñanza de las ciencias y en específico de la química, se basa en una instrucción donde se dan conocimientos referentes a hechos, fechas, situaciones, etc., siempre dando relevancia a lo que el docente considera importante o lo que se ha visto que las personas aceptan aunque no sea lo importante, sin embargo, hay que recordar que la instituciones y sobre todo las de educación superior son las encargadas de la formación integral de una persona, esto quiere decir que no solo se deben de formar intelectual, profesional, social o físicamente a una persona, sino que se deben de integrar todos estos elementos junto con una dimensión moral y un comportamiento ético que se encuentre basado en creencias y valores, para que realmente beneficie a la vida humana en todas sus dimensiones.

En particular, la educación de la química en valores debe de ser capaz de explicar los procesos químicos de una manera objetiva, sin que intervengan juicios de los individuos involucrados, pero la enseñanza también debe de estar enfocada a que una persona pueda discernir qué es lo mejor basándose en el conocimiento de la ciencia; sobre todo aquellos sujetos que estudian una carrera de ingeniería, debido a que estas personas son las que utilizan la ciencia para satisfacer las necesidades humanas.

Es importante reconocer los valores en cada individuo, debido a que como cada uno es un ser social y es necesario convivir en sociedad, los valores van a permitir el acoplamiento con otras personas mediante un análisis comparativo que permite evaluar las cualidades presentes. Los valores influyen en la manera de pensar o de actuar, buscando siempre las mejores condiciones en la vida.

Ahora, como ingeniero, algunos de estos valores son la responsabilidad profesional hacia la sociedad y el ambiente, la honestidad y la ética profesional, ésta última se relaciona con el comportamiento profesional apropiado para el bienestar de la humanidad, de forma tal que debe de guiar a la ciencia para volver a encauzar al hombre en el bien mismo. Para Yoania De Paz (2014) esta educación debe encaminarse a la formación de valores dirigidos hacia la profesión de forma contextualizada, contribuyendo a definir una concepción integral del ejercicio profesional, mediante el análisis de intereses, actuaciones, conocimientos, motivaciones de los estudiantes y contexto, que es lo que se busca con el trabajo aquí expuesto.

Así, en las clases de ciencias, como son la química y la física para ingenieros se debe de asegurar la adquisición de conocimientos, pero también que los valores de los alumnos estén en concordancia con lo que busca la ingeniería: el beneficio de la humanidad.

3 Metodología

En la enseñanza de los conocimientos es necesario hacer énfasis en lo que es bueno y lo que podría ser malo, refiriéndose a la persona en particular y a la sociedad en general.

En el curso denominado Estructura y Propiedades de los Materiales en Ingeniería de la Universidad Autónoma Metropolitana Unidad Azcapotzalco, ofrecido por la División de Ciencias Básicas e Ingeniería de manera obligatoria para alumnos de las diez licenciaturas de ingeniería que ofrece esta División Académica, se tiene como objetivo “explicar y relacionar la estructura con las propiedades físicas y químicas de los materiales de uso en la ingeniería” (UAM, 2013).

En este curso, como su nombre lo indica, se deben de revisar conceptos como el de estructura cristalina, estructura amorfa, defectos en las estructuras y se deben de relacionar con el tipo de enlace y las propiedades físicas y químicas de los materiales que presentan estas estructuras. Posteriormente se revisan los diferentes tipos de materiales como son los metálicos, cerámicos, poliméricos y compuestos, relacionándolos con las estructuras y las propiedades. En el programa no se contempla la parte de ética, valores o algo que tenga que ver con estos temas.

Como primer paso, se efectuó el análisis del programa de la asignatura, en donde se ubicaron lo temas a los que se les puede integrar un contexto valorativo, incorporando puntos como el de la calidad del material o la selección de los mismos.

En el tema de la calidad de los materiales se pueden relacionar valores tales como honestidad, ética, responsabilidad social y ambiental, coherencia, adhesión a la ley y el respeto, conjuntamente con temas propios de química, como es la estructura del material, sus defectos y el uso que se le va a dar.

En cuestión de la selección del material se les puede indicar como se tienen que triangular los conocimientos, la calidad y el costo para obtener la mejor solución de los intereses económicos, los materiales y el uso que se le va a dar a los mismos, siendo un factor primordial para esta triangulación los valores de la persona y de la empresa o industria que tenga bajo su responsabilidad esta función.

El docente debe de ser el que, en virtud de su experiencia introduzca el tema de los valores dentro de la planeación de la asignatura, utilizando ejemplos que los alumnos sean capaces de relacionar con la vida cotidiana y en donde se vea la importancia de aplicar correctamente estos valores, sabiendo que son a juicio personal.

¿Cómo abordar el tema de los valores? La forma más fácil de explicar un concepto es con un ejemplo, de esta manera se puede atraer la atención de los jóvenes al tema. Es necesario que los jóvenes reconozcan desde que están estudiando, por ejemplo, los riesgos y consecuencias que puede implicar el utilizar un material de mala calidad y que los puedan minimizar o hasta evitar cuando ejerzan su profesión.

Aunque actualmente ha habido mucha publicidad acerca de la calidad de los materiales o equipos que se venden, a veces no logran relacionar que ellos, como ingenieros, van a tener en sus manos algún día, esa responsabilidad y que siempre es necesario aplicar valores o hacer una valoración de las situaciones, procesos o hasta individuos, para poder aportar un trabajo excelente como ingeniero ante la sociedad; pero estas valoraciones deben de hacerse con criterio, responsabilidad y honestidad, y a veces es hasta necesario incluir otros valores como son: fe, compasión, coraje y lealtad.

Como se había mencionado, otro punto con el cual introducir el tema de los valores en el curso de química, es considerando la selección del material: haciéndoles ver que es más importante tomar en cuenta el uso y las propiedades del material a utilizar, que el precio del mismo. Este último punto debe de influir solamente para determinar a quién se lo compran, considerando que el precio puede depender de las propiedades y características del mismo, de la calidad del material y además del proceso de producción y/o la zona en la que se produce.

Los ejemplos que se utilizaron en el curso fueron:

Acero: Se incluye el tema de la calidad del material. El acero, material metálico, que debe de ser utilizado ha de estar certificado. Sí el material no cuenta con la certificación adecuada, indica que el material no cumple con las normas, o sea, que su composición química no corresponde a lo esperado, que pudiera tener defectos internos como rechupes o que el material no cumplió con las pruebas de ensayo; pero esto implica más: que el productor no se hace responsable de las propiedades del material y por ende de los riesgos al usarlo.

Los plásticos: Un segundo ejemplo está en los materiales poliméricos denominados plásticos. Los plásticos, recién formados son materiales amorfos -aunque sus propiedades están influenciadas por su formulación- y presentan ciertas propiedades, con el uso y el reciclaje se vuelven cristalinos y cambian las propiedades. Algo elaborado con material plástico nuevo tiene cierto precio y puede considerarse elevado, sin embargo, si ese objeto se elabora con material reciclado pudiera ser más barato. Los valores entran en juego cuando se trabaja con este material, debido a que su uso puede implicar hasta un riesgo de salud para la persona que lo use: al utilizar material virgen para generar un polímero, éste muestra una estructura amorfa, la cual no permite el paso de la corriente eléctrica; al utilizar material reciclado para hacer un objeto, este va a presenter estructura semicristalina o cristalina, la cual permite el paso de la corriente eléctrica a través del material o que se genere la corriente estática, lo cual puede provocar descargas eléctricas de la persona que utilice este objeto, sobre todo si son prendas de ropa.

La madera: Considerando el tema de calidad que relaciona la ciencia y los valores, en la unidad de materiales compuestos se puede hablar de la madera: que al reconocer que es un material fibroso, se puede hablar de la estructura –en este caso la madera muestra una estructura fibrosa- y que al igual que todo material obtenido directamente de la naturaleza, va a presentar defectos o deformaciones en su estructura que afectan su uso como material de ingeniería. Como bien es sabido, la madera se obtiene de los árboles; éstos se cortan, se eliminan las ramas y la corteza del tronco para poder ser utilizado como un material para obtener un beneficio. Generalmente se corta en forma de placas o tablas, sin embargo, las tablas de madera obtenidas de la superficie del árbol, presentan mayor número de imperfecciones debido al crecimiento de las ramas, que formaron un "nudo" en el tronco para sostenerse en el árbol; al obtener la madera, estos "nudos" provocan una disminución de la calidad de la misma y se reconoce, como madera de primera, segunda, tercera o cuarta, dependiendo del tamaño de la placa, tamaño, forma, cantidad y localización del defecto en la madera. El uso y el precio de la madera van a depender de la calidad de la misma. Los valores se pueden incluir al indicarles que una tabla de madera de primera presenta alta resistencia mecánica, alta dureza y baja flexibilidad, propiedades que se ven modificadas conforme disminuye la calidad de la madera, a lo mismo que el precio. Adquirir material de segunda para la elaboración de algún equipo o mueble por ser más barato, puede acarrear problemas, percances, situaciones riesgosas o peligrosas a las personas que los adquieran o trabajen con ellos. Aquí hay que tener cuidado, porque no por utilizar mejor madera, vayan a talarse los árboles sin considerar la explotación sostenible.

Estos ejemplos, se han presentado ante los alumnos en dos grupos en los trimestres 15I, 16I y 17I –trimestres que empezaron en enero de los años 2015, 2016 y 2017, respectivamente-. Los alumnos han aceptado la inclusión de los temas y han respondido haciendo preguntas al docente y comentarios que amplían el tema o dan otros ejemplos.

Sin embargo no se ha evaluado puntualmente el impacto que han tenido esta inclusión, debido a que los exámenes están basados en el contenido programático, que no incluye los temas de calidad del material y selección del mismo; además de que los exámenes son de tipo departamental, esto es, los envía la Coordinación de estudios correspondiente y el docente solo lo aplica y lo califica.

Sin embargo se han obtenido comentarios al finalizar cada trimestre de los alumnos, en donde indican se sienten más capacitados para entender:

- El por qué algún objeto nuevo, puede ser extremadamente más barato que otro con las mismas características

- El por qué ocurren ciertas situaciones como el hecho de que al comprar un librero de madera, éste al poco tiempo se rompe, debido a que no resistió el peso del material puesto en él.
- Y por último, como se relacionan la estructura, las propiedades con el uso o desempeño de los materiales y que deben hacer las personas y sobre todo los ingenieros para poder obtener lo mejor y no dejarse impresionar por ofertas, descuentos u otras situaciones, porque esto puede llevar a malas situaciones de estabilidad económica, de salud o de estabilidad emocional.

4 Conclusiones

Este tipo de enseñanza no se debe de dar en un solo curso, sino en todos y cada uno de los cursos que se tiene en el plan de estudios de las licenciaturas, para que tenga impacto, y aunque en la UAM Azcapotzalco en la División de Ciencias Básicas e Ingeniería se está haciendo un esfuerzo para introducirlo en los planes y programas de estudio, no se ha logrado, sin embargo se están haciendo esfuerzos para hacerlo en cada asignatura.

Enseñar los conceptos básicos de una ciencia como lo es la química, no es fácil, sin embargo todavía es más difícil si hay que considerar los valores sociales, considerando los juicios valorativos solo del docente y no de la institución educativa, debido a que se deben de buscar ejemplos que hagan comprender a los alumnos las situaciones valorativas y cuáles podrían ser las consecuencias de no tomar buenas decisiones.

Es necesario que ellos sepan que implica tener una cédula profesional y que es la responsabilidad profesional desde que inician sus estudios universitarios, que el trabajar o ejercer una profesión no es solamente para ganar "más" dinero, sino que conlleva un gran compromiso personal, familiar y social y que pueden ayudar en la solución de muchos de los problemas de la sociedad.

Es una labor ardua para el docente, debido a que no nada más va a enseñar al estudiante, sino que debe de ser capaz de enseñar sin asustar, de hacerlos comprender sin que carguen el mundo sobre sus hombros, de que sean asertivos, que tengan el conocimiento suficiente tanto de la asignatura como de lo que es su responsabilidad profesional.

Un acercamiento a este proceso ha sido trabajar con competencias, en donde se incluyen algunos valores, como la comunicación asertiva, la responsabilidad del trabajo en equipo y/o colaborativo, sin embargo educar en valores va todavía más allá de las competencias.

Hay que reconocer que la enseñanza de valores no solo se debe dar con los ejemplos que el docente presenta en la clase, sino con el actuar diario dentro del salón o espacio de clase; y lo que aprende de esta forma el joven tiene mayor influencia que todo lo demás. Asi mismo, es necesario involucrar más a los estudiantes; pudiera ser que a través de un trabajo, analicen un tipo de material o un material específico, relacionando el conocimiento adquirido durante el curso, con valores y sustentabilidad.

También es necesario admitir que la ética profesional y los valores, en general, no son puntos fáciles a desarrollar en un ciclo escolar, sino que es una respuesta al grado de compromiso que surge de la persona conforme ha ido aprendiendo de su entorno social –incluida la educación escolar- y que ha sido consistente a sus creencias, lo que le ha ofrecido un mayor equilibrio y bienestar emocional, sin embargo, siempre hay que reafirmarlo y más, considerando el compromiso profesional del futuro profesionista.

Finalmente, se debe el considerar que enseñar o aprender con valores debería de ser nuestro objetivo de ahora en adelante para lograr un mejor ambiente dentro de la sociedad.

5 Recomendaciones

Es necesario que el docente se prepare continuamente, para poder enseñar con valores. Esta preparación puede consistir en tomar cursos específicos o puede ser observar y analizar situaciones específicas en las que pueda aplicarse una escala valorativa, para que los alumnos puedan comprender el valor de la situación misma.

También es necesario que el docente se abstenga de darle un valor nominal a la situación ejemplificada, por ejemplo, no es benéfico para el aprendizaje de los alumnos que el docente diga que es malo utilizar un material, sin ponerlo en contexto, porque ya está influyendo en las expectativas del alumno, y no les está permitiendo que ellos efectúen la valoración, que aprendan a identificar el alcance de la situación o a ponerlo en perspectiva.

Hay que reconocer que algunos valores han sufrido variaciones, y no se puede esperar que los actuales jóvenes, que tienen diferentes intereses culturales, a los de hace tiempo atrás, tengan las mismas creencias o las mismas conductas y por lo tanto consideren la misma escala de valores y esta situación también debe de ser considerada por el docente y cualquier persona. En ese sentido, tanto docentes como alumnos deben de ser abiertos para explorar conjunta y objetivamente situaciones dándoles una escala valorativa acorde a los implicados.

Es importante que el estudiante se apropie de estas ideas, una forma es que él realice un trabajo donde aplique el conocimiento adquirido y lo relacione con los valores, teniendo así oportunidad de obtener una calificación que permitiría, a su vez, al docente verificar los valores de los alumnos.

Así, el docente debe buscar que el futuro ingeniero se forme en una actitud ética que se manifieste en el beneficio personal y colectivo de la sociedad y del ambiente. Esta afirmación demanda la exploración de diversas rutas para lograr tener una cultura integral que permita que los estudiantes de las nuevas generaciones obtengan a su vez una formación profesional en armonía con las exigencias de la sociedad.

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Analysis of projects as a tool to identify Sustainable Development in engineering careers. Case study

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Abstract

Sustainable Development is now a cross-disciplinary subject in engineering careers as necessary as well inevitable; the role of a future professional in this area is to recognize their ethical and professional responsibility in relevant situations for engineering that allows them to make informed judgments considered the impact of the proposed solutions in the social, environmental and economic contexts, including both local and the global fields. It is crucial that a student initially identify the situations of the environment in which they will develop their professional activities, in addition to recognizing the fundamental characteristics of sustainable development. Once this objective is achieved, he will be able to establish a relationship between these factors and any project that involves engineering. This target may be accomplished with the use of a qualitative tool, the SWOT analysis (strengths, weaknesses, opportunities, threats); in Spanish, they allude to strengths, opportunities, weaknesses and threats. Even if it is a tool that can be considered simple, it allows to get a general perspective of the strategic situation of any organization. The SWOT analysis estimates the effect that a strategy has on the balance or adjustment of and organization, considering both, its internal capacity and the external situation (Thompson and Strikland, 1998). In this case, the possibility of applying this tool to projects in which sustainable development was involved was considered, that means, its characteristics can be identified and related to the dimensions: social, economic and environmental. As a result, working in teams made up of students from different engineering careers and with different projects selected by themselves, they elaborated diagrams, revealed their viability and issued reasoned evaluations, once they made the analysis of each delimited project.

Keywords: Analysis of Projects, SWOT Tool, Active Learning.

Análisis de proyectos como una herramienta para identificar el Desarrollo Sostenible en las carreras de ingeniería. Estudio de caso

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Resumen

Actualmente el Desarrollo Sostenible es una asignatura transversal en las carreras de ingeniería tan necesaria como inevitable; el papel de un futuro profesionista en esta área es reconocer su responsabilidad ética y profesional en situaciones relevantes para la ingeniería que le permita elaborar juicios informados donde se considere el impacto de las soluciones propuestas en los contextos social, ambiental y económico, tanto en el ámbito local como en el global. Es esencial que un estudiante identifique inicialmente los contextos del entorno en que desarrollará sus actividades profesionales, además de reconocer las características fundamentales del desarrollo sostenible. Una vez cumplido este objetivo él podrá establecer una relación entre estos factores con cualquier proyecto que involucre a la ingeniería. Con el uso de una herramienta cualitativa, el análisis FODA, siglas que provienen del acrónimo en inglés SWOT (strenghts, weaknesses, opportunities, threats); en español, aluden a fortalezas, oportunidades, debilidades y amenazas. Aunque es una herramienta que puede considerarse sencilla, permite obtener una perspectiva general de la situación estratégica de una organización determinada. Thompson y Strikland (1998) establecen que el análisis FODA estima el efecto que una estrategia tiene para lograr un equilibrio o ajuste entre la capacidad interna de la organización y su situación externa, esto es, las oportunidades y amenazas. En este caso se consideró la posibilidad de aplicar esta herramienta a proyectos en los que estaba involucrado el desarrollo sostenible, es decir que, se pueden identificar sus características y relacionarlas con las dimensiones: social, económica y ambiental. Como resultado, trabajando en equipos conformados por estudiantes de distintas carreras de ingeniería y con diferentes proyectos seleccionados por ellos mismos, elaboraron esquemas, reflexionaron sobre su viabilidad y adicionalmente emitieron evaluaciones razonadas, una vez que hicieron el análisis de cada proyecto delimitado.

Palabras clave: Análisis de proyectos, Herramienta FODA, Aprendizaje activo.

1 Introducción

Este trabajo está relacionado con la identificación algunos factores y su vínculo con los tres aspectos que son la base del Desarrollo Sostenible, esta asignatura es parte del troco transdisciplinar en las carreras de ingeniería en la Universidad Autónoma Metropolitana del Campus Azcapotzalco, es una introducción a los conceptos y conocimientos fundamentales del futuro profesionista y establecer la importancia de su responsabilidad ética y profesional en situaciones relevantes para la ingeniería, con el objetivo de emitir opiniones informadas en las que se tomen en cuenta el impacto de algunas propuestas.

Para cumplir con este objetivo se utilizó un instrumento cualitativo, el análisis FODA, siglas que provienen del acrónimo en inglés SWOT (strenghts, weaknesses, opportunities, threats); en español, aluden a fortalezas, oportunidades, debilidades y amenazas. Apoyados en autores como Thompson y Strikland (1998) quienes reconocen al análisis FODA como una herramienta cualitativa valiosa que permite obtener una perspectiva general de la situación estratégica de un proyecto determinado.

En este caso se utilizó esta herramienta para analizar algunos proyectos seleccionados por los mismos estudiantes y su tarea fue determinar en qué medida estaban involucrados los aspectos del desarrollo sustentable, es decir que, se pueden identificar sus características y relacionarlas con las dimensiones: social, económica y ambiental.

Tomando en cuenta que los hallazgos apuntaron sobre todo a las dificultades encontrada en el aspecto económico, se planeó la participación voluntaria de los equipos en un taller de entrenamiento en otra institución para poner en práctica el diseño, la planeación y el arranque de un proyecto de innovación, siempre relacionado con el desarrollo sostenible.

El evento que ayudara a cumplir con estos objetivos tuvo una duración de tres días y fue de inmersión total, con un proyecto para desarrollar un producto, un servicio, un modelo de negocio innovador y de preferencia con un impacto social visible; con la intención de identificar claramente su entorno, los problemas sociales y ambientales que existen en él y la posibilidad de colaborar con otros actores para proponer soluciones innovadoras con potencial para resolver problemas reales.

El resultado fue que quienes participaron en el taller de entrenamiento no solo aprendieron sobre los estilos de innovación si no que comprendieron que, para tener un impacto social, ambiental y en general con un aspecto sostenible, sus proyectos deberán ser también sustentables económicamente para así poder ser realmente unos agentes ciudadanos de cambio.

2 Alcance del Proyecto

La inclusión del desarrollo sostenible como base del conocimiento que todo ingeniero debe tener es hoy una necesidad ineludible, por este motivo en el currículo de todas las carreras de ingeniería se incluye el curso obligatorio llamado "Introducción al Desarrollo Sustentable", como parte de la formación interdisciplinaria que se les imparte a todos los estudiantes de las diez diferentes carreras de ingeniería de la Universidad Autónoma Metropolitana, Unidad Azcapotzalco.

El programa es bastante extenso y solo se tienen once semanas, frecuentemente los temas suelen desarrollarse de la forma tradicional; con una clase del profesor ante un grupo de alumnos desinteresados que toman algunas notas, en el mejor de los casos, sin contar con que habitualmente los conceptos no tienen algún significado o una aplicación inmediata. Por este motivo, entender que es el Desarrollo Sostenible y establecer desde el inicio su diferencia con el concepto de sustentabilidad, así como las relaciones existentes con el entorno presentan cierta complejidad.

La realidad frecuente que se observa en las ciencias básicas de muchos programas de ingeniería, sobre todo en los primeros cursos, son generalmente los temas áridos, que carecen de interés y en la mayoría tienen solo contenidos teóricos, sin tomar en cuenta la desconexión que hay entre estos y la práctica. Para los alumnos, hay una gran diferencia entre entender o aprender los conceptos teóricos y aplicarlos a una situación en la vida real; este problema crea una barrera para que los jóvenes universitarios, es decir, los profesionistas del mañana, no se apropien de un determinado concepto ni tampoco sea relevante para ellos su comprensión.

2.1 Modelo organizacional

Desde 1987, en el Informe Brundtland definió el Desarrollo Sostenible como: "el desarrollo que satisface las necesidades del presente sin comprometer la capacidad de las generaciones futuras para satisfacer sus propias necesidades", publicado por la Comisión Mundial sobre el Medio Ambiente y el Desarrollo (WCED, 1987). Tomando como base este documento se profundizó en este concepto, describiéndolo como: "un proceso de cambio en el cual la explotación de los recursos, la dirección de las inversiones, la orientación del desarrollo tecnológico y el cambio institucional deben estar todos en armonía para mejorar el potencial actual y futuro, para satisfacer las necesidades y aspiraciones humanas" (Goméz, 2013).

A nivel mundial el concepto aparece por primera vez en la Declaración de Estocolmo (ONU, 1972), no obstante el Desarrollo Sustentable está presente de forma implícita desde el inicio de la segunda mitad del siglo XX, con casos documentados y publicados (Carson, 1962), aunque inicialmente solo estuvo asociado al daño causado a la agricultura, sin embargo con el transcurso de los años y apoyados en diferentes investigaciones no sólo ha evolucionado sino también se ha enriqueciendo tomando en cuenta muchos componentes más, que incluyen el contexto social y los factores económicos que se involucran en la producción y el consumo de un producto o de un proyecto que se pretende evaluar.

Entonces es muy importante mencionar que los espacios económicos, sociales y ambientales, se han convertido en los tres pilares del Desarrollo Sostenible y se hacen presentes de una u otra forma en varios ámbitos (Blanchard, 2014). Debido a que inicialmente se relacionaba con mayor interés a la parte ambiental, predominó el concepto de sustentabilidad y en algunos casos se utiliza como sinónimo del primero.

Ante la polémica generada entre distintos autores, se les sugiere a los alumnos la lectura de algunas referencias donde se revisa la evolución del concepto; con fines didácticos en este curso se adopta la siguiente definición para el desarrollo sostenible como el término que se obtiene cuando hay un equilibrio en el manejo del planeta en tres aspectos: el económico, el ambiental y el social; subrayando que ningún recurso deberá utilizarse a un ritmo superior al de su generación, (Cortés Mura & Peña Reyes, 2015).

Sin embargo, lograr la conceptualización, el avance y la implantación en un proyecto que pueda satisfacer de igual manera las tres dimensiones del Desarrollo Sostenible no es tarea fácil, es decir, alcanzar la sustentabilidad medioambiental, el equilibrio económico y la justicia social requiere de mucha información, conocimientos específicos y de un intenso trabajo en equipos colaborativos.

Una herramienta utilizada para hacer una planeación estratégica lo constituye el análisis situacional, también conocido como análisis FODA (fortalezas, oportunidades, debilidades y amenazas), el cual posibilita la recopilación y uso de datos que permiten conocer el perfil de operación de una empresa en un momento dado (Ramírez Rojas, 2012). Es en este caso el instrumento que permitirá definir la factibilidad de un proyecto.

Este estudio se representa a través de una matriz de doble entrada, llamada matriz FODA, en la que el nivel horizontal se analizan los factores positivos y los negativos. En la lectura vertical se analizan los factores internos y por tanto controlables del programa o proyecto y los factores externos, considerados no controlables.

Las Fortalezas son todos aquellos elementos internos y positivos que diferencian al programa o proyecto de otros de igual clase. Las Oportunidades son aquellas situaciones externas, positivas, que se generan en el entorno y que una vez identificadas pueden ser aprovechadas. Las Debilidades son problemas internos, que una vez identificados y desarrollando una adecuada estrategia, pueden y deben eliminarse. Las Amenazas son situaciones negativas, externas al programa o proyecto, que pueden atentar contra éste, por lo que, llegado al caso, puede ser necesario diseñar una estrategia adecuada para poder sortearla (Castillo, 2016).

Una fortaleza de la organización es alguna función que ésta realiza de manera correcta, como son ciertas habilidades y capacidades del personal con ciertos atributos psicológicos y la evidencia de su competencia (McConkey, 1988; Stevenson, 1976). Otro aspecto identificado como una fortaleza son los recursos considerados valiosos y la misma capacidad competitiva de la organización como un logro que brinda ésta o una situación favorable en el medio social.

Una debilidad se define como un factor que hace vulnerable a la organización o simplemente una actividad que la empresa realiza en forma deficiente, lo que la coloca en una situación débil (Henry, 1980). Para Porter (1998), las fortalezas y oportunidades son, en conjunto, las capacidades, esto es, los aspectos fuertes como débiles de las organizaciones o empresas competidoras (productos, distribución, comercialización y ventas, operaciones, investigación e ingeniería, costos generales, estructura financiera, organización, habilidad directiva, etc). Estos talones de Aquiles pueden generar en la organización una posición competitiva vulnerable (Vandenberg y Lance, 1992).

Para el análisis FODA, una vez identificados los aspectos fuertes y débiles de una organización se debe proceder a la evaluación de ambos. Es importante destacar que algunos factores tienen mayor preponderancia que otros: mientras que los aspectos considerados fuertes de una organización son los activos competitivos, los débiles son los pasivos también competitivos.

Generalmente si se trata de equilibrar la balanza se comete un error. Lo importante radica en que los activos competitivos superen a los pasivos o situaciones débiles; es decir, lo trascendente es dar mayor preponderancia a los activos (Wilhelm, 1992).

Las oportunidades constituyen aquellas fuerzas ambientales de carácter externo no controlables por la organización, pero que representan elementos potenciales de crecimiento o mejoría. La oportunidad en el medio es un factor de gran importancia que permite de alguna manera moldear las estrategias de las organizaciones.

Las amenazas son lo contrario de lo anterior, y representan la suma de las fuerzas ambientales no controlables por la organización, pero que representan fuerzas o aspectos negativos y problemas potenciales.

Las oportunidades y amenazas no sólo pueden influir en el atractivo del estado de una organización, sino que establecen la necesidad de emprender acciones de carácter estratégico; pero lo importante de este análisis es evaluar sus fortalezas y debilidades, las oportunidades y las amenazas y llegar a conclusiones.

La evaluación de un proyecto o una propuesta para producir un producto o generar un servicio para una comunidad y que además involucre el Desarrollo Sostenible requiere de indicadores con el propósito de monitorear el progreso en las distintas dimensiones involucradas y de esta forma ayudar a quienes toman las decisiones.

Con fines didácticos se usa este instrumento y en consecuencia son los factores que deben estar presentes en el análisis del proyecto y deben identificarse en un esquema tal y como se solicita al evaluar una organización.

2.2 Hitos del proyecto

Este trabajo está dirigido a la observación del aprendizaje adquirido cuando los estudiantes participan activamente al hacer el análisis de proyectos o propuestas que ya existen en el acervo de la universidad y acorde con los atributos y criterios que se espera que tengan al finalizar el curso "Introducción el Desarrollo Sustentable", esto es: el alumno relaciona la importancia y características del desarrollo sostenible con los proyectos en ingeniería.

Considerando la importancia de esta asignatura y aunque en algunos casos no se le da el valor real, si permite al estudiante conocer los conceptos y el vocabulario relacionado con proyectos de ingeniería, es decir se apropia de los fundamentos sobre el tema y del lenguaje académico que utilizara a lo largo de su vida profesional.

En los cursos anteriores esta asignatura estaba impartida con los métodos tradicionales: enseñanza de conceptos áridos, sin ninguna conexión con sus intereses o la realidad que les rodea, gradualmente durante los últimos periodos lectivos se intenta modificar su estructura mental e invitarles a analizar proyectos que no solamente sean tecnológicamente atractivos, sino que también se tome en cuenta la parte de sostenibilidad.

Para ejemplificar el cambio se incluyen algunos nombres de proyectos desarrollados a finales del periodo lectivo del año 2016, por los estudiantes, así como una breve descripción de los mismos:

Nombre del proyecto	Descripción de los temas desarrollados
AIRBUS A 320	Se eligió al Airbus porque es un avión en el cual podemos encontrar los 7 tipos de materiales utilizados en la ingeniería con mucha facilidad.
Casa Serna	Vivienda ubicada en suelo no urbanizado cerca de la ciudad de Valencia, España. Es una casa autosuficiente y generadora de energía, agua y alimentos que puedan necesitar sus ocupantes.
Auto de carreras	Descripción de los materiales que se utilizan en la fabricación de este tipo de autos
Impacto social y ambiental de la reforma energética	Un análisis crítico sobre la reforma energética, la economía del país, la injerencia del sector privado en la extracción de hidrocarburos; y en consecuencia el daño causando al medio ambiente
El ultimo apaga la luz	Sin mucha información se analiza un proyecto visual y artístico para llamar la atención del público sobre temas relativos al impacto del desarrollo económico, la desigualdad, el consumismo, la falta de interés ecológico y sus efectos colaterales
Traje de astronautas	Descripción, funciones partes que lo componen y materiales poliméricos utilizados para su fabricación.

Estos trabajos se limitaban a investigar y describir, solo en algunas ocasiones se incluía un breve análisis u opiniones no muy informadas.

Gradualmente se observó una evolución, a continuación, se incluye un registro como el anterior, de los proyectos desarrollados durante el periodo lectivo al inicio del año 2018.

Nombre del Proyecto	Descripción de los temas desarrollados
Pavimento luminiscente	Mediante el aprovechamiento de la energía que proviene del sol, se ha creado la idea de usar pavimento luminiscente
Archi-Carbon Positive House	Diseño de la primera casa prefabricada de carbono positivo del mundo. Con reducciones energéticas iniciales, estos inmuebles introducen un estilo de vida sustentable después de su construcción
Drywash SYS	Es un proyecto de productos para lavado de autos en seco, que tiene como objetivo generar un gran impacto, reduciendo el consumo de agua en esta actividad. Diagrama FODA sin una asociación con las dimensiones del desarrollo sostenible.
Tesla Productos	Descripción de los productos que satisfacen diferentes necesidades de uso de energía y transporte con un mínimo impacto ambiental
Auto a gas natural	Auto que puede utilizar como combustible tanto gasolina común, como gas natural (Híbrido)
Popotes (Straws)	Descripción del producto, su uso, proceso de fabricación, descripción de algunas propuestas alternativas para sustituirlos y el análisis FODA de las propuestas. Adicionalmente se hace una contrapropuesta con su respectivo diagrama FODA y en los dos casos se hace una asociación con las tres dimensiones del Desarrollo Sostenible

En estos ejemplos ya se identificaban las tres dimensiones del desarrollo sostenible, la social, la económica y la ambiental, eventualmente solo dos equipos hicieron un análisis con el diagrama FODA.

Es un hecho que como descriptores solo se toman en cuenta los contenidos desarrollados en los temas que cada equipo selecciona libremente, otros indicadores que un equipo menciona son: las huellas ecológicas, de carbono y la hídrica, aunque lo hace de manera muy superficial.

3 Grupos de interés

La búsqueda la hacen al inicio los estudiantes de forma individual, sin ninguna restricción sobre el tema, todos los proyectos encontrados se exponen ante todos los integrantes del equipo y más adelante la selección será consensuada para que cada equipo trabaje en el análisis de un solo proyecto que ellos decidan.

Previamente los alumnos hacen una revisión relacionada con el Desarrollo Sostenible desde su origen, las organizaciones internacionales que lo impulsan, los modelos de desarrollo existentes y la influencia que estos modelos ejercen en la sociedad, con la finalidad de establecer los indicadores que permitan medir la sustentabilidad; finalizando con el conocimiento de algunos elementos necesarios para el diseño de un proyecto.

Los estudiantes analizaron los cuatro factores (FODA) para siete diferentes proyectos y la instrucción fue relacionarlos con los tres aspectos involucrados en el desarrollo sostenible, es decir, el económico, el social y el ambiental. Los proyectos fueron los siguientes:

Nombre del Proyecto	Descripción de los temas desarrollados
Azoteas verdes	Una cubierta verde es una superficie de cubierta que está preparada para acomodar vegetación para el uso humano, ya sea como terraza, patio, zona de recreo, zona de juegos infantiles, etc.
Solubag	Elaboración de bolsas no plásticas (ecológicas) que se disuelven en agua.
Aircarbon	Recolección de gases de efecto invernadero para producir biopolímeros
Asfalto de neumáticos	Fabricación de asfalto para pavimentos con llantas, mediante la adición del grano de caucho reciclado o GCR en asfaltos modificados

Nombre del Proyecto	Descripción de los temas desarrollados
Earthships	Es un tipo de vivienda ecológica que cuida de sus propias necesidades en materia de energía, agua, eliminación de residuos e incluso a veces hasta de producción de alimentos
Cultivos hidropónicos	Una modalidad en el manejo de plantas, que permite su cultivo sin suelo. Mediante esta técnica se producen plantas principalmente de tipo herbáceo
Paneles de grafeno	Utilización y adaptación del grafeno a los paneles solares. Las celdas de grafeno captan la luz solar, transformándola en energía eléctrica, teniendo como resultado una mayor eficiencia.

Los diagramas FODA elaborados para cada proyecto son particulares por su diferente naturaleza, sin embargo, los estudiantes refieren que la identificación de las fortalezas y las oportunidades fue relativamente rápido y fácil, básicamente lo atribuyen a que generalmente estos son factores positivos que predominan en todas las propuestas. Su recopilación y comparación es motivo de otro trabajo para el análisis de contenidos, similitudes y diferencias, que puede desarrollarse más adelante con algún programa específico para esta actividad.

En contraste los resultados obtenidos para las debilidades y las amenazas, generalmente están relacionados con el aspecto económico, como los altos costos, tanto en la obtención de los insumos como en la inversión inicial del proceso para la manufactura del producto, encontraron también que el costo del mantenimiento es una limitante, se le atribuye a que sus propuestas son diversas.

Adicionalmente también determinaron, que en algunos casos hay una resistencia al cambio, se identifican competencias desleales ocultas, algunas políticas públicas que involucran intereses económicos, sin dejar de lados el desconocimiento y la desconfianza hacia las innovaciones, además de factores externos sobre los que no hay control como la influencia del entorno y el clima, por mencionar algunos.

Acorde con la literatura el análisis FODA sugiere que debe existir un equilibrio entre las condiciones internas de un proyecto, un proceso o una organización y su situación externa (Thompson, 1998), sin embargo este aprendizaje está incompleto si no se lleva a la práctica y para ello los estudiantes participan en otra actividad de forma voluntaria y que se lleva a cabo en otra institución.

El evento, un taller de entrenamiento, se lleva a cabo en una institución privada, la Universidad Iberoamericana, principalmente enfocado a la Innovación, organizado entre varios departamentos de la universidad y otros socios clave internos y externos. Esta iniciativa tiene como objetivo el fomentar el espíritu emprendedor y una mentalidad innovadora en sus participantes, siendo los estudiantes de las licenciaturas del Departamento de Estudios Empresariales (como administración, mercadotecnia, contabilidad, finanzas, negocios internacionales, entre otras carreras) los que en general se inscriben en él, por ello la importancia de la participación de los estudiantes de ingeniería de una universidad pública.

Además de este objetivo general, el evento también tiene como metas específicas la contribución por medio de la enseñanza de metodologías, el uso de herramientas, la creación de redes y el intercambio de experiencias a uno de los objetivos primordiales de la universidad Iberoamericana y sus socios clave, que es el fomentar la formación de mejores personas, profesionistas y ciudadanos comprometidos con la sociedad.

Este es un evento de inmersión total durante 3 días, dentro las instalaciones de la universidad en dónde los participantes tienen que idear y desarrollar un proyecto por medio de metodologías específicas de innovación y diseño (p.ej. (Brown, 2008)). Durante estos 3 días los participantes asisten durante el primer día a una serie de pláticas con expertos, mesas redondas con emprendedores y sesiones con actores clave del ecosistema emprendedor en la Ciudad de México. Después los participantes toman parte activa del evento a través de talleres intensivos (de 8 a.m. a 8 p.m. durante los otros dos días) en dónde se les explican una serie de herramientas y metodologías novedosas para innovar enfocándose en el usuario, para inmediatamente después poner en práctica los conceptos aprendidos en un proyecto por equipos de 4 a 6 personas.

Esta es una oportunidad ideal para conectarse con participantes con otros tipos de perfiles y antecedentes, así como con actores con los que no siempre se tiene relación. Y a su vez esta conexión y formación de redes se hace con el fin de poder crear una idea de negocio innovadora y con potencial para ser implementada en la realidad.

En versiones anteriores los proyectos creados por los equipos se enfocaban principalmente en la innovación tecnológica y dejaban del lado otros tipos de innovaciones (Kotsemir, 2013; Mortensen, 2005; Tidd, 2014) que pudiesen resolver problemas sociales y ambientales más relevantes para la sociedad.

En la edición 2018 la temática del evento se invitó a dirigir los esfuerzos de los participantes hacia un proyecto que ideara y desarrollara un producto, un servicio, e idealmente un modelo de negocio innovador y de preferencia con un impacto social visible. Para lograr esto todas las actividades estuvieron enfocadas al cambio de modelos mentales en el que los participantes practicarán como entender desde otra perspectiva cómo funciona su entorno, los problemas sociales y ambientales que existen en él y la posibilidad de colaborar con otros actores para proponer soluciones innovadoras con el potencial para resolver problemas reales (Hill, 1995) y relevantes para la sociedad mexicana.

4 Conclusiones

Los estudiantes identificaron de forma muy clara la dificultad de tener un proyecto equilibrado en los tres pilares en los que descansa el desarrollo sostenible, en la primera etapa con el análisis FODA de los proyectos seleccionados libremente, aunque esta actividad se ha llevado a cabo por dos periodos lectivos, menos de un año, observamos que tiene varias áreas de oportunidad y de mejora. Algunas de estas áreas para mejorar son la formalización y estandarización del proceso pensando en que al hacerlo se podría replicar e implementar como parte del curso de manera obligatoria.

Otra oportunidad de mejora es la evaluación de esta actividad de manera sistemática para conocer el impacto que tiene en sus participantes y en el tipo de proyectos que se analizan durante el curso, con un instrumento creado para ello, por ejemplo, una rúbrica.

En el caso de la actividad extracurricular, el taller de inmersión total, existen indicadores actuales de registro y asistencia de los participantes, así como la encuesta de retroalimentación al finalizar el evento, sin embargo, no reflejan de la manera más adecuada si los participantes experimentan realmente un cambio o beneficio después de haber participado en este evento de innovación. Esta situación deja abierta la interrogante sobre si este tipo de eventos intensivos logran realmente algún impacto positivo y relevante en sus participantes, independientemente de sus antecedentes, como por ejemplo mejorar su perfil de innovación o cambiar su mentalidad para proponer ideas que den soluciones a problemáticas sociales y ambientales actuales.

Se observó que los participantes inicialmente pensaron que era relativamente fácil ser empáticos y tener inteligencia emocional para así tener la iniciativa de proponer un nuevo proyecto. Sin embargo, con las herramientas y metodologías vistas durante el taller de entrenamiento se dieron cuenta que, en cuestiones de tener iniciativa, tener realmente empatía y demostrar una verdadera inteligencia emocional es más fácil decirlo que hacerlo, y por lo tanto los participantes tuvieron una visión más realista después del evento.

En general los resultados parciales aquí descritos junto con las metodologías utilizadas tanto en el curso como en el taller dejan claro que una estrategia de diseño bien desarrollada puede ofrecer un rendimiento y una ventaja competitiva en el triple objetivo de los objetivos económicos, sociales y ambientales (Holland, 2014). De igual manera se podría decir que al entrenar intensivamente a los participantes en estrategias de diseño y pensamiento de diseño sirve para evaluar y establecer direcciones claras para la innovación futura e identificar oportunidades de diseño para mejorar el entorno de cada persona. En general podría decirse que si los conceptos de diseño para la innovación nueva e incremental pueden desarrollarse simultáneamente con los objetivos que conducen a soluciones de valor agregado viables (Holston, 2011) entonces también son válidos para la ideación, creación y desarrollo de proyectos que puedan incidir en problemas sociales y ambientales relevantes de una manera diferente e innovadora.

Otra parte importante de los hallazgos reconocidos al término de esta actividad fue el cambio que experimentaron los participantes sobre sus proyectos propuestos inicialmente con un gran impacto social o ambiental carecen de rentabilidad, viraron hacia los proyectos que, si son rentables, aunque con un impacto social o ambiental no tan grande. Esta situación podría parecer negativa, sin embargo, al evaluar las propuestas finales presentadas por los participantes, en 4 de los 5 proyectos tenían un impacto social y/o ambiental claro. Estos resultados nos indican que quienes asistieron al taller de entrenamiento no solo cambiaron su estilo de innovación si no que comprendieron que, para tener un impacto social, ambiental y en general con un aspecto sostenible, sus proyectos deberían ser también sustentables económicamente para así poder ser realmente unos agentes ciudadanos de cambio.

5 Recomendaciones

Las referencias citadas aunque no muy actuales, son fundamentales, aun cuando hay trabajos más recientes sobre la utilidad de los diagramas FODA, estos se enfocan generalmente a la industria o las grandes empresas y no al trabajo con estudiantes de los primeros cursos universitarios, es en este rubro donde se puede mencionar la contribución y una invitación para involucrar a nuestros estudiantes en cualquier momento y con diferentes asignaturas en la utilización de herramientas que en el futuro desarrollaran en el desempeño de su profesión, especialmente en las carreras de ingeniería.

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PBL as an alternative to transform the Engineering Curricula in Colombia

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Abstract

This work summarizes three different strategies used to motivate the curricular transformation of engineering curricula in Colombia, for promoting the design and application of student-centered approaches and particularly, Project Based Learning. The proposed strategies include i) a teacher training program in PBL, ii) the definition of strategies for PBL spreading and iii) strengthening of Engineering Education Community. The first strategy considers a training course for engineering teachers, which deals the PBL philosophy and how to apply it in engineering subjects. The second one focuses on creating learning spaces such as workshops, meetings or seminars to promote the use of PBL in Engineering and the third one, focuses on the creation common graduate programs and the Colombian Network of PBL in Engineering. The results presented herein correspond to the second strategy, for which the researchers designed and developed a PBL Workshop that used as the trigger of the learning process the 'marshmallow challenge.' The workshop is carried out as a part of the International Meeting of Engineering Education (EIEI ACOFI 2018), in which teachers from different universities participate. The workshop emphasizes the 'exemplarity' principle, offering a complete scenario to live a PBL experience.

Keywords: Project-Based Learning; Engineering Education; Curricular transformation.

El Aprendizaje Basado en Proyectos como una alternativa de transformación de los currículos de ingeniería en Colombia

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Resumen

Este trabajo resume tres diferentes estrategias utilizadas para incentivar la transformación curricular de los programas de Ingeniería en Colombia, con el fin de promover el diseño y la aplicación de enfoques centrados en el estudiante y particularmente, el Aprendizaje Basado en Proyectos (más conocido como PBL por sus siglas en inglés, *Project-Based Learning*). Como estrategias se tienen, i) la capacitación docente en PBL, ii) la difusión de PBL como enfoque educativo, y iii) el fortalecimiento de la Comunidad de Educación de Ingeniería del país. La primera estrategia considera una cualificación docente en la filosofía y la aplicación del PBL; la segunda se centra en generar espacios de aprendizaje tales como talleres, reuniones o seminarios con el fin de promover el uso del PBL en Ingeniería y la tercera, se enfoca en la creación de programa de posgrados conjuntos y de la Red Colombiana de PBL en Ingeniería. Los resultados presentados en este artículo corresponden a la segunda estrategia, para la cual los investigadores diseñan y desarrollan un Taller sobre PBL utilizando como detonante del proceso de aprendizaje el reto del Masmelo (*marshmallow challenge*), el taller es llevado a cabo en el Encuentro Internacional de Educación en Ingeniería (EIEI ACOFI 2018), con la participación de docentes de diferentes universidades. El taller hace énfasis en los principios de 'ejemplaridad y trabajo colaborativo' ofreciendo un escenario completo para vivir una experiencia PBL.

Palabras clave: Aprendizaje Basado en Proyectos; Educación en Ingeniería; Transformación Curricular;

1 Introducción

Teniendo en cuenta la importancia de la Ingeniería en la transformación de la sociedad y el entorno, y los desafíos que supone un desarrollo económico y social pertinente al contexto regional, en un mercado global cada vez más competitivo y exigente, la comunidad de educación en ingeniería en Colombia se reúne para analizar y repensar el quehacer de la formación de los futuros Ingenieros, a través de la construcción de currículos que promuevan el desarrollo de capacidades para liderar la transformación que el país necesita.

Como estrategia para enfrentar el desafío que supone una transformación de la Ingeniería desde la transformación de la educación en éste campo de conocimiento, la comunidad académica junto con la Asociación Colombiana de Facultades de Ingeniería - ACOFI, apoyada por la Universidad Nacional de Colombia, definieron un plan para incentivar la transformación curricular de los programas de Ingeniería del país, a partir de la capacitación de los profesores de Ingeniería en nuevos enfoques y modelos educativos. Es así como año a año ACOFI reúne a los académicos e investigadores de la educación en ingeniería para compartir experiencias con pares internacionales y la empresa sobre el trabajo y las tendencias de la formación en este campo.

Este artículo se enfoca en la socialización de una de las estrategias de formación realizadas en el marco de ésta cooperación académica, y la cual ha tomado como núcleo la formación y transformación de los currículos a través del Aprendizaje-Basado en Problemas y Proyectos (más conocido como PBL, por sus siglas en inglés *Project-Based Learning*), dado el éxito que este enfoque educativo ha tendido en los programas de ingeniería alrededor del mundo. Es así como el trabajo considera tres etapas –que a su vez se configuran como estrategias de cambio–, i) la capacitación docente en PBL, ii) la difusión de PBL como enfoque educativo, y iii) el fortalecimiento de la Comunidad de Educación de Ingeniería del país.

De esta manera, este trabajo busca contribuir a contestar la pregunta ¿Cómo se puede implementar el aprendizaje basado en problemas y proyectos en los currículos de ingeniería como una alternativa para la transformación curricular de la educación en ingeniería en Colombia?

2 Contexto

La Facultad de Ingeniería de la Universidad Nacional de Colombia se encuentra discutiendo los modelos actuales de enseñanza aprendizaje y la incorporación de nuevas metodologías como mecanismo de innovación pedagógica para sus programas curriculares. Es por ello que ha entablado relaciones académicas con instituciones nacionales e internacionales que le permitan conocer, diseñar e implementar dichas metodologías en sus planes de estudio. En particular, ha reconocido el Aprendizaje Basado en Problemas y el Aprendizaje Basado en Proyectos (PBL) como efectivos para la enseñanza de la ingeniería en Colombia. De manera conjunta con las Universidades de Aalborg y de Purdue, ha organizado espacios de formación docente, talleres de incorporación del PBL en los planes curriculares y ha iniciado la incorporación de la metodología al interior de algunas de sus asignaturas. Por ejemplo, Cortés-Mora (2016, 2017), Ordóñez (2017) y Rodríguez Mesa (2016) presentan algunos de los resultados de dicha incorporación. Este trabajo ha permitido articular la discusión alrededor del PBL con otras universidades y facultades de ingeniería del país que también se encuentran incorporando el PBL a su interior, generando una oportunidad de construcción de redes de conocimiento e intercambio de experiencias que han permitido el fortalecimiento de la función docente para la ingeniería colombiana.

La Asociación Colombiana de Facultades de Ingeniería ACOFI ha desarrollado dentro de sus líneas de actuación, la disposición de abrir espacios para la formación docente y para la discusión del papel de la educación en ingeniería. Muestra de ello, han sido los ejes centrales de los Encuentros Nacionales de Educación en Ingeniería – EIEI que ha organizado en los últimos años. Así, por ejemplo, para el año 2016 el evento giró en torno a la "Innovación en las facultades de ingeniería: el cambio para la competitividad y la sostenibilidad", en 2017 el tema central fue "Las facultades de ingeniería y su compromiso con la sociedad" y para el 2018 bajo el marco de "Gestión, calidad y desarrollo en las facultades de ingeniería". En este último evento decidió programar un espacio de formación para docentes universitarios, en donde se transfiriera el conocimiento adquirido durante el proceso de formación.

2.1 Aprendizaje Basado en Proyectos

Un proyecto es definido como un esfuerzo complejo que requiere un análisis del objetivo (análisis del problema), debe ser planificado y administrado debido a los cambios deseados que se llevarán a cabo en: las personas del entorno, la organización, el conocimiento y la actitud ante la vida; esto involucra una nueva tarea o problema previamente no resuelto, que necesita conocimientos y recursos a través de las organizaciones tradicionales, y que debe ser completado en un momento determinado de tiempo, Alggreen-Ussing (1990) citado por (de Graaff and Kolmos, 2007).

Entre las discusiones que se presentan cuando se habla de PBL, está la diferencia que existe entre 'basado en Problemas' y 'basado en Proyectos'. Al respecto, entre los conceptos citados por (de Graaff and Kolmos, 2007) está el de proyecto definido por Alggreen-Ussing (1990), como una única y compleja tarea que requiere más recursos que los que una sola persona es capaz de entregar. Otra de las citas usada por de Graaff and Kolmos, corresponde a Van Woerden (1991), la cual hace referencia a los problemas usados por los enfoques, enfatizando en que los problemas que activan el proceso de aprendizaje en proyectos son más auténticos que la mayoría de los casos artificiales utilizados en problemas. De igual forma, los autores enfatizan en que no es solo el problema el que decide el proceso de aprendizaje, sino también el contexto. Además, consideran que ambos enfoques están basados en los mismos principios de aprendizaje y que se pueden obtener enfoques fusionados en donde se mezclen las dos formas de aprendizaje.

La diferencia entre aprendizaje basado en problemas y aprendizaje basado también se puede observar desde la comparación que presentan los autores de Graaff and Kolmos (2007), a partir de comparar el tiempo que le puede tomar médico de familia en llegar a un diagnóstico y un tratamiento versus el desarrollo de los grandes proyectos de ingeniería que pueden requerir muchos años y miles de hombres. Los autores también señalan que otra diferencia importante entre los dos enfoques se encuentra en la naturaleza del producto que los estudiantes deben entregar al final.

Por otra parte, el aprendizaje basado en proyectos también es considerado como una estrategia pedagógica que desarrolla en el estudiante competencias de diferentes clases. En (Miralles and Sala, 2004), con respecto al proyecto se dice: "tendrá unos datos de partida, unos resultados a obtener, unas restricciones y unos condicionantes, todo ello exigirá el aprendizaje de conceptos, procedimientos y actitudes mediante los cuales será posible conseguir los objetivos del mismo". De esta definición se puede resaltar el desarrollo de dimensiones de competencias (cognitivas, instrumentales y actitudinales); en un ejercicio propio del desempeño profesional de los ingenieros "Concebir, planear y ejecutar proyectos", haciendo del escenario de aprendizaje una réplica del contexto real donde se va a trabajar.

Aunque muchos de los más importantes desarrollos del PBL en Ingeniería datan de los años 70, el PBL sigue siendo considerado un enfoque novedoso, es así, como algunos autores se han referido al PBL como un enfoque innovador centrado en el estudiante que es "capaz de mejorar el conocimiento interdisciplinario, la colaboración, las habilidades de resolución de problemas, la comunicación, el pensamiento crítico y el aprendizaje autodirigido de los estudiantes" (Graaff y Kolmos, 2003; Savin-Baden y Major, 2004; Dolmans et al., 2005)

Como se observa de las anteriores definiciones, las características del PBL resultan apropiadas para la formación en Ingeniería, cuyo ejercicio profesional se caracteriza por el desarrollo de proyectos que requieren de la intervención e interacción de diferentes disciplinas, el trabajo en equipo, el manejo de recursos, la gestión de la información y del tiempo. El PBL ofrece la posibilidad de desarrollar estas y otras capacidades como escenario para la construcción del conocimiento, y donde el contexto aparece como un escenario de 'vida' que involucra al estudiante en un aprendizaje profundo.

En este sentido debe buscarse desde la formación en ingeniería la integración de estos elementos, y el currículo debe estar acorde con las necesidades del contexto –fuente de problemas– . De esta manera, el PBL se convierte en una herramienta que permite a los docentes motivar a los estudiantes a construir el conocimiento, desarrollar destrezas y habilidades propias de la profesión y desarrollar capacidades transversales en pro de la solución de problemas interesantes y retadores. Donde el problema es, por tanto, cualquier situación, necesidad o reto que sirva como detonante del proceso de aprendizaje.

2.2 Formación en ingeniería en Colombia

El primer intento de formar ingenieros en Colombia se remonta a la creación del Colegio de Ingenieros del ejército, el 12 de abril de 1814. El Estado inicia la formación de doce cadetes bajo la dirección del Francisco José de Caldas. Por causa de las luchas por la independencia, la escuela solo duró abierta dos años (Bateman, 1998; Díaz Piedrahíta, 2012; Valencia Giraldo, 2010). Varios intentos de reabrir una escuela de ingenieros se vieron interrumpidos años después a causa de las luchas internas políticas. Desde sus inicios, la Escuela de Ingeniería se conformó a la imagen de *l'École Polytechnique* de Paris. Los dos primeros años se dedicaban a la enseñanza de las ciencias y los cuatro siguientes a las asignaturas de la ingeniería. Centrada en la formación en matemáticas, astronomía e ingeniería civil. En 1887 se crea la Escuela Nacional de Minas cuyo modelo fue la Escuela de Minas de California, en Berkeley. Cuyos ingenieros estaban más orientados a la gestión. Sus egresados estuvieron en el origen de la industrialización colombiana. Aun cuando las principales obras de ingeniería, hacia fines del siglo XIX, fueron realizadas por ingenieros inmigrantes, la escuelas de ingeniería de la Universidad Nacional y la de Minas permitieron la consolidación de la profesión de la ingeniería en el país (Ocampo, 1996).

El aumento de la producción de café propició la construcción de líneas férreas y carreteras que las unían entre sí. La crisis de los años 30 del siglo XX hizo que las utilidades del café no se pudieran gastar en lujos importados y por el contrario, se invirtieran en industrias nacionales de cigarrillos, dulces, gaseosas, cervezas, tejidos y cementos. Esto a su vez permitió que los ingenieros tuvieran nuevas opciones de desarrollo (Bejarano, 1980).

Entre 1944 y 1948, el rector de la Universidad Nacional, Gerardo Molina impulsa la participación de estudiantes de últimos semestres o de los recién graduados en el desarrollo de obras públicas. Es la primera vez que se plantea que los ingenieros en formación participen en una actividad pre-gradual en proyectos en comunidades.

Hoy día, Colombia tiene más de 1000 programas activos de ingeniería que bajo la herencia de sus dos escuelas fundadoras ha creado un sistema particular de formación. A semejanza de *l'École Polytechnique* de Paris dedica un 40% a la formación en ciencias básicas. Por otra parte, busca una vinculación con la práctica a través de pasantías y prácticas empresariales a imagen de la Escuela de Minas de California. La Asociación Colombiana de Facultades de Ingeniería, ACOFI, en convenio con el Instituto Colombiano Para el Fomento de la Educación Superior, ICFES, "desarrolló durante los años de 1996 y 2000, la actualización y modernización curricular para 14 denominaciones de ingeniería, la cual se constituyó en el insumo fundamental para la organización y establecimiento de los programas de ingeniería del país"[1]. Lineamientos que, salvo algunos ajustes, continúa rigiendo los procesos de acreditación de programas de ingeniería. Los autores de este trabajo hacen parte de un grupo de profesores que propugnan por una actualización de dichos lineamientos que involucre más aprendizaje activo, integral, que forme ingenieros conscientes y responsables con los Objetivos de Desarrollo Sostenible y constructores de paz en un país que trata de superar décadas de conflicto armado.

[1] https://www.acofi.edu.co/capitulo/consideraciones-generales/ [Consulta hecha el 08/03/2019]

2.3 Metodología

El trabajo se configuró en tres etapas, i) la formación de docente, ii) las estrategias para la difusión del PBL, iii) y el fortalecimiento de la Comunidad de Educación de Ingeniería. La primera etapa considera una cualificación docente en la filosofía y la aplicación del PBL, donde diferentes universidades puedan conocer sobre PBL se desarrolló con la colaboración del Centro de Aalborg para el Aprendizaje Basado en Problemas en Ciencias de la Ingeniería y Sostenibilidad bajo el auspicio de la UNESCO de la Universidad de Aalborg, Dinamarca. La segunda se centra en generar espacios de aprendizaje tales como talleres, reuniones o seminarios en los cuales los docentes (quienes no participaron en el programa de capacitación) de diferentes universidades pudieran conocer el PBL. Finalmente, la tercera etapa considera la creación de un programa de Doctorado en Educación en Ingeniería y la Red Colombiana de PBL en Ingeniería.

2.4 Formación de docentes

La primera fase se desarrolla con la colaboración del Centro para el Aprendizaje Basado en Problemas en Ciencias de la Ingeniería y la Sostenibilidad de la Universidad de Aalborg, Dinamarca (https://www.ucpbl.net/, *Aalborg Centre for Problem Based Learning in Engineering Science and Sustainability under the auspices of* UNESCO). Esta fase considera la formación de docentes de Ingeniería de diferentes Universidades a través de un curso que tiene una duración de 196 horas, 3 créditos académicos – en Colombia un crédito académico corresponde a 48 horas de trabajo en el semestre– .

En este curso de formación docente denominado '*Basics of PBL and Curriculum Change*', que atendiendo a su objetivo y filosofía utiliza el PBL como enfoque, se consideran 40 horas de trabajo presencial, en las que se desarrollan diferentes actividades con el fin de promover la interacción entre participantes y profesores. Igualmente, toma la experiencia de los participantes como base para el diseño y desarrollo de intervenciones PBL en las diferentes áreas de trabajo.

Figure 1. Profesores participantes en el curso junto con los instructores del *AAU Centre*

2.5 Estrategias de intervención y difusión en PBL

Con el fin de incentivar el uso de PBL en otras universidades, se toma como escenario el Encuentro Internacional de Educación en Ingeniería (EIEI ACOFI 2018), que se realizó en la ciudad de Cartagena de Indias (Colombia) en el mes de septiembre de 2018. Alrededor de 25 profesores de ingeniería de varias universidades colombianas participaron en el Taller de PBL, que tenía como resultados de aprendizaje: a) fomentar la colaboración, el trabajo en equipo y el liderazgo compartido; b) mejorar la creatividad; c) conceptualizar una idea y aplicar el proceso de prototipado; y d) aprender la importancia de la iteración en cualquier proceso creativo. La organización del taller integra a profesores de diferentes universidades, quienes, trabajando en equipo, guiaron el desarrollo de la actividad. Asimismo, los participantes son motivados para trabajar en grupos y explorar diferentes habilidades como la comunicación, la toma de decisiones, la resolución de problemas y la creatividad.

2.5.1 Descripción del Taller

Utilizando el 'Reto del malvavisco' como un desencadenante del proceso de aprendizaje y haciendo énfasis en los principios del PBL, 'la ejemplaridad y trabajo colaborativo'. Es así como la organización del taller integra a docentes de diferentes universidades, quienes, trabajando en equipo, planean y guían el desarrollo de la actividad. El taller considera tres fases, 1) el diseño y la planeación, 2) el desarrollo y 3) la evaluación (ver Figura 2).

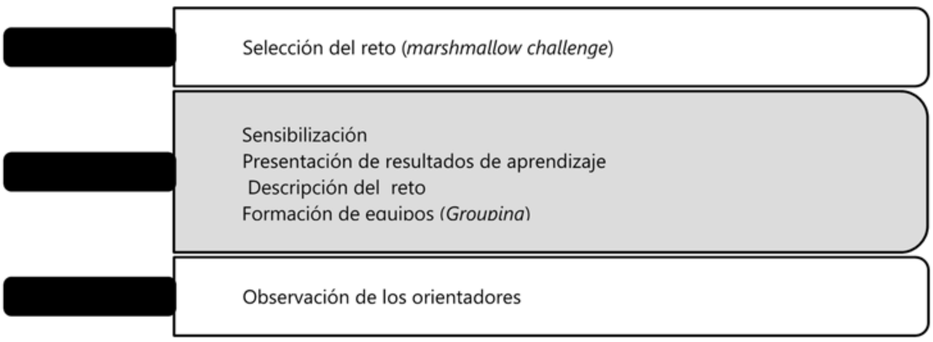

Figure 2. Fases de ejecución del Taller PBL en el marco del EIEI ACOFI 2018

Durante el diseño del taller, denominado *Aprendizaje basado en problemas de ingeniería* se definió como objetivo para la convocatoria 'Facilitar a los participantes la comprensión de los principios básicos del PBL, ejemplaridad y trabajo en equipo, a través de un ejercicio práctico'.

2.5.2 Desarrollo del Taller

Alrededor de 25 profesores de ingeniería de varias universidades colombianas participaron en el taller EIEI ACOFI-PBL, que abordó cuatro resultados de aprendizaje:

- Fomentar la colaboración, el trabajo en equipo y el liderazgo compartido.
- Potenciar la creatividad como competencia básica para aportar soluciones a un problema.
- Conceptualizar una idea y aplicar en un proceso de prototipado.

- Aprender la importancia de la iteración en cualquier proceso creativo.

Figure 3. Profesores participantes taller de Aprendizaje basado en problemas de ingeniería

El taller se desarrolló en su totalidad, permitiendo a los participantes interactuar entre sí para lograr el objetivo. Los grupos discutieron sobre el objetivo de la actividad porque uno de los grupos construyó la torre más alta, pero ésta se derrumbó. Este hecho sirvió como disparador de la reflexión, ya que los organizadores mostraron la importancia de la definición de los objetivos de aprendizaje. Se hizo hincapié en los objetivos de aprendizaje propuestos y se evidenció que ningún objetivo hacía referencia a la altura de la torre ni a la que la estructura estuviera terminada. Lo anterior concuerda con la teoría del PBL, cuando establece que los objetivos de aprendizaje son diferentes a los objetivos del proyecto o problema en cuestión y que lo que se debe medir y evaluar, son los resultados de aprendizaje y no únicamente los resultados del proyecto o la solución del problema.

2.5.3 Evaluación del Taller

De acuerdo con los comentarios registrados al final del taller, los participantes manifestaron sentirse motivados para trabajar en grupos y explorar diferentes habilidades como la comunicación, la toma de decisiones, la resolución de problemas; igualmente, hicieron énfasis en habilidades propias de la formación para la innovación como la creatividad.

Algunos de los participantes expresaron haber desarrollado experiencias similares a la del taller, lo que significa que existe el interés por utilizar enfoques diferentes a la educación tradicional y el compromiso en el diseño de experiencias centradas en el estudiante. De acuerdo con sus narraciones se observó que estas experiencias son cercanas al PBL, sin haber sido necesariamente declaradas como tal; igualmente, se evidenció la aplicación de sus principios y métodos. La mayoría de los participantes expresaron opiniones favorables acerca de trabajar en PBL. Dada la identificación de los participantes con el enfoque y la actividad desarrollada, el taller de PBL fue el escenario perfecto para lanzar la Red Colombiana de PBL en ingeniería.

Los autores destacan como los resultados más destacables: i) la consolidación un espacio de discusión y trabajo conjunto dentro del Encuentro Internacional de Educación en Ingeniería convocado por ACOFI, ii) la consolidación de esfuerzos alrededor de prácticas centradas en el estudiantes y en especial en el Aprendizaje Basado en Proyectos, iii) la articulación de actores que han trabajado de forma independiente en el desarrollo de estrategias PBL, en pro de la construcción de una cultura de transformación curricular de la educación en ingeniería en Colombia.

2.6 Fortalecimiento de la comunidad de educación en ingeniería

Estos espacios de discusión y trabajo conjunto sobre el diseño y aplicación de nuevos enfoques, promovidos por ACOFI, han permitido fortalecer la comunidad de educación en ingeniería, la cual actualmente tiene como proyecto bandera la creación de un Doctorado en Ingeniería. En este proyecto participan 15 universidades colombianas, siete públicas y ocho privadas y que busca la formación de investigadores líderes que promuevan el mejoramiento de la calidad de la formación en ingeniería, (DIEE, 2018). El programa propone un diseño novedoso que sirve igualmente como espacio ejemplificación para motivar el cambio en la educación en ingeniería, el cual es concebido no solo para la formación en pregrado, sino para cualquier nivel de formación que vea la 'Ingeniería' como un área de formación (*e.g. STEM Education*). Cabe resaltar, que esta iniciativa no es una estrategia definida por los autores de este artículo, sino una dinámica que se produce como resultado de la interacción de la comunidad, y la cual se incluye dada la importancia que ha tenido en el desarrollo de este trabajo.

3 Conclusiones

Una forma efectiva de motivar a los docentes de ingeniería a trabajar hacia una transformación curricular es utilizar estrategias en las que observen las ventajas de implementar un nuevo enfoque educativo. En este caso, el diseño del taller tomó en cuenta los principios del PBL, como la ejemplaridad y el trabajo colaborativo, al utilizar un pequeño desafío como desencadenante del proceso de aprendizaje, donde la gestión de los recursos y el tiempo son igualmente importantes. La ejemplaridad de la actividad fomenta la participación de los docentes y permite evaluar rápidamente las ventajas de este enfoque educativo, por su parte el trabajo en equipo simula un escenario en el que la concertación y la definición de roles son clave para el desarrollo del reto.

Con el fin de lograr una transformación efectiva de los currículos de ingeniería se hace necesario la creación de un mayor número de espacios y estrategias que pongan derroteros comunes a los participantes, buscando la generación de una cultura de cambio que permee las instituciones a nivel organizacional y curricular, y salvaguardando la identidad propia de cada institución y las particularidades que impone el contexto en el que se encuentra. Este ejercicio de trabajo conjunto entre pares de diferentes instituciones ha sido igualmente un escenario PBL, por plantear como reto para los autores, la creación de una vivencia PBL dentro de un escenario en el que participan diferentes disciplinas y actores de la Educación en Ingeniería.

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Development and impact of the teachers' educational concepts in the new model ETHAZI of Vocational Training in the Basque Country

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Abstract

In response to rapid changes in the economic, productive and technological contexts that redefine the teaching model, as from the 2013-2014 academic year, as from the ETHAZI educational innovation model has been implemented throughout the network of Vocational Training centers in the Basque Country. This educational model has the objective of developing technical and transversal competences through collaborative learning based on challenges or projects. However, given that it was detected that not all centers meet the characteristics of the model (intermodularity, self-managed teaching teams, evaluation of competences and adaptation of learning spaces). Based on the hypothesis that the level of implementation of the model in each center corresponds largely to the need perceived by teachers for change, this research aims to understand how teachers' conceptions and practices change when they move from didactic-methodological forms based on individuality to interdisciplinary and collaborative modes that lead to a collective teaching culture. To this end, the design and results of the previous phase of a collective case study is presented. There, by means of in-depth interviews the discourse analysis of two professors of the HVET Cycle of Design and Mechanical Manufacturing was carried out. The results obtained from the preliminary analysis show a clear cognitive dissonance in their discourses. Besides, the importance of responding to the needs of the self-managed teaching teams by the management teams was identified. Finally, the training and exchange of experiences between the centers was emphasized.

Keywords: Educational Innovation; Soft Skills; Vocational Education and Training; ETHAZI.

Desarrollo e impacto de las concepciones educativas del profesorado en el nuevo modelo ETHAZI de Formación Profesional del País Vasco

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Abstract

En el curso 2013-2014 se comenzó la implementación del modelo de innovación educativa ETHAZI en toda la red de centros de Formación Profesional del País Vasco para responder a los rápidos cambios de los contextos económicos, productivos y tecnológicos. El modelo educativo ETHAZI tiene como objetivo el desarrollo de competencias técnicas y transversales mediante el aprendizaje colaborativo basado en retos. Se detecta que no todos los centros de la Comunidad Autónoma Vasca cumplen las características propias del modelo (intermodularidad, equipos docentes autogestionados, evaluación de las competencias y adecuación de los espacios de aprendizaje) y partiendo de la hipótesis, en la que el nivel de implementación del modelo en cada centro corresponde en gran parte a la necesidad que percibe el profesorado de dicho cambio de modelo, esta investigación tiene como objetivo entender cómo cambian las concepciones y la praxis de los docentes cuando transitan desde formas didáctico-metodológicas basadas en la individualidad hacia modos interdisciplinares y colaborativos que desembocan en una cultura docente colectiva. Para ello, se presenta el diseño y resultados de la fase previa de un estudio de caso colectivo en el que se ha realizado el análisis del discurso de dos sujetos del Ciclo Superior de Diseño y Fabricación Mecánica obtenido mediante entrevistas en profundidad. Los resultados del análisis preliminar muestran una clara disonancia cognitiva en los discursos, a la vez que se identifica la importancia de responder a las necesidades de los equipos docentes autogestionados por parte de los equipos directivos y la formación e intercambio de experiencias entre los centros.

Keywords: Innovación Educativa; Competencias transversales; Formación Profesional; ETHAZI.

1 Introducción

Los contextos económicos, productivos y tecnológicos están cambiando a gran velocidad y con ello la reformulación de los objetivos y formas de los procesos de enseñanza y aprendizaje en la Formación Profesional. En este escenario, se inició en el curso 2009-2010 una reflexión sobre la naturaleza de los Ciclos de Formación Profesional dentro del área de investigación de métodos y procesos de aprendizaje de Tknika, centro de investigación e innovación aplicada de la FP del País Vasco.

En este proceso se identificó la necesidad de trabajar, además de las competencias técnicas específicas de cada Ciclo de Formación Profesional, ciertas competencias transversales tales como el trabajo en equipo, la responsabilidad y la resolución de problemas (Astigarraga & Agirre, 2018). Este cambio de enfoque en la conceptualización y desarrollo de los procesos de aprendizaje ha impulsado un nuevo modelo formativo llamado ETHAZI.

Este modelo educativo pone en el centro del proceso de aprendizaje al alumnado y precisa del trabajo en equipo de los docentes. El modelo ETHAZI tiene como objetivo el desarrollo de competencias técnicas y transversales mediante el aprendizaje colaborativo basado en retos. Astigarraga, Agirre y Carrera (2017) describen la base y las características del modelo en profundidad en su artículo *El aprendizaje basado en retos de la Formación Profesional del País Vasco*. En su narrativa definen los cuatro ejes vertebrales sobre los que se impulsa el nuevo modelo de la FP del País Vasco: programación basada en retos, programaciones desarrolladas por los equipos docentes de Ciclo, flexibilidad organizacional y evaluación por competencias orientada hacia la evolución de las personas y el desarrollo de sus aprendizajes. Sobre estos ejes se fundamentan las principales características del modelo: a) aprendizaje colaborativo (Astigarraga, Agirre & Carrera, 2017; Astigarraga & Agirre, 2018) basado en el trabajo en equipo positivamente interdependiente, que interactúe simultáneamente poniendo en práctica habilidades sociales tanto interna como externamente y que necesite responsabilidad y reflexión a nivel individual y grupal durante desarrollo de la propuesta de trabajo; b) aprendizaje basado en situaciones problemáticas reales que presenten la posibilidad de vivir al alumnado la situación como un reto para generar el conocimiento necesario que le permita aportar continuamente mejores soluciones; c) orientado al desarrollo de las competencias técnicas y transversales necesarias en el mundo laboral.

Los cuatro ejes sobre los que se construye el modelo necesitan un nuevo planteamiento estructural donde repensar la malla curricular cobra vital importancia. Al comenzar la incursión en el nuevo modelo, el equipo docente de Ciclo debe hacer una profunda reflexión sobre las competencias y resultados de aprendizaje claves en él, la dedicación relativa de cada una y las estrategias de implementación. Para definir la malla curricular del Ciclo, el equipo docente debe analizar, priorizar y adecuar los resultados de aprendizaje, según la tipología del alumnado y el contexto laboral donde se encuentra el centro. Una vez obtenida la malla curricular en la que se determina cuáles son los resultados de aprendizaje que se van a trabajar en cada reto, se crea el cronograma de retos del curso escolar de cara a obtener la programación del Ciclo. Por último, teniendo en cuenta la malla curricular y el cronograma, se diseña cada reto en dos planos: el alumnado y el profesorado.

La ayuda aportada por los procesos de aprendizaje mediante metodologías basadas en proyectos (PBL) al desarrollo de las competencias transversales no es una cuestión novedosa. Son varias las investigaciones empíricas que demuestran el aporte de estas metodologías al desarrollo de las competencias para el trabajo en equipo, análisis, resolución y comunicación de problemas, así como la competencia para gestionar proyectos y experiencias cercanas al mundo laboral (Archana, Gupta & Chitkara, 2008; Du & Kolmos, 2006). No sólo porque cuanto más se trabaja mediante esta metodología (PBL) el alumnado muestra ser más competente para el trabajo en grupo o para la gestión de proyectos (Graaf & Kolmos, 2003), sino también porque desarrollan mejor las competencias transversales denominadas competencias para la vida: la autonomía, la planificación del trabajo o el pensamiento y razonamiento crítico (Pagander & Read, 2014). Por todo ello, se puede concluir que los procesos de aprendizaje basados en proyectos son procesos activos que facilitan el desarrollo de las competencias transversales necesarias para la vida y el mundo laboral (Du & Kolmos, 2006).

Poner en el centro de aprendizaje el desarrollo de las competencias transversales, además de resultar un reto novedoso para los colectivos implicados en la etapa de la Formación Profesional, genera un gran interés en los grupos de investigación didáctica y metodológica de los procesos de aprendizaje. Así, el grupo de investigación Gaitasunez (Eizagirre & Altuna, 2014) llevó a cabo un trabajo de investigación del que se concluye que los factores de éxito para el desarrollo de las competencias transversales en el modelo formativo ETHAZI son: a) la concepción que tiene el profesorado respecto al perfil de salida del alumnado y la cultura colectiva que construye el grupo docente en torno a ello; b) el diseño de los procesos de enseñanza y aprendizaje basados en retos o proyectos aplicables a contextos reales que finalizan en objetos tangibles y c) disponer de espacios físicos y temporales flexibles para llevar a cabo el proceso de aprendizaje.

Otros estudios y experiencias ratifican que además de poner el foco en el cambio de rol del alumnado, el profesorado también tiene que cambiar su rol y praxis si se quiere conseguir una transformación educativa para la mejora en la calidad de la educación (Astigarraga y Agirre, 2018). El nuevo modelo formativo ETHAZI implica un cambio de cultura docente promovido por los cuatro ejes del modelo en el que para conseguir retos reales los módulos que forman el Ciclo se difuminan y entremezclan teniendo en cuenta la interdisciplinaridad de los contenidos. Para diseñar nuevos procesos de enseñanza y aprendizaje, el profesorado transita obligatoriamente desde el individualismo del modelo anterior a la cultura colectiva (Alonso, 2015; Rué & Lodeiro, 2010; Terrón et al., 2007). En este aspecto, son varios los autores que señalan que la forma en la que transitan las identidades profesionales del profesorado en los procesos de innovación o cambios de la sociedad tienen que ver con el grado de éxito del proceso (Alonso, 2015; Beijaard, Meijer & Verloop, 2004; Bolívar, Fernández & Molina, 2005).

Desde el inicio de la implementación del modelo ETHAZI en toda la etapa de Formación Profesional, cada año se ha incrementado el número de centros que ofrecen sus ciclos formativos basados en el nuevo modelo. A día de hoy en todos los centros de Formación Profesional de la Comunidad Autónoma del País Vasco parte del profesorado ha recibido desde Tknika cursos de formación sobre el modelo. Así, la implementación del mismo en toda la red de centros a corto plazo es un objetivo real.

No obstante, se intuye que el nivel de implementación y desarrollo del modelo depende, en gran medida, de la cultura de los centros. Esta realidad se evidencia tanto en los cursos de formación como en los demás foros de participación que se organizan desde Tknika y ha creado la necesidad de identificar los factores que favorecen o dificultan no sólo el entendimiento y el desarrollo del modelo educativo ETHAZI, sino también, qué factores pueden ayudar en su implementación. Para ello, se está ejecutando un proyecto de investigación cuantitativa basada en la percepción del profesorado que abarca toda la red de centros de FP de la CAPV.

Junto con este trabajo y para ahondar en el cambio en la identidad profesional del profesorado, uno de los ejes del modelo formativo ETHAZI, se ha diseñado otro proyecto de investigación cualitativa que busca profundizar en la concepción docente del profesorado en el transcurso del modelo de innovación educativa ETHAZI. El objetivo principal es analizar el cambio en la identidad profesional, poniendo el foco en las concepciones y la praxis de los docentes (Bolívar, 2006). Así, se tendrán en cuenta las dimensiones personales, sociales y culturales de las personas y colectivos (Clegg, 2008; Sheridan, 2013), asumiendo que la interacción entre las concepciones y la praxis está construida sobre el trayecto biográfico y la interacción social del sujeto (Dubar, 2000).

Ambos proyectos de investigación se están desarrollando en HUHEZI (Facultad de Humanidades y Ciencias de la Educación de la Universidad de Mondragón).

2 Objetivos

El objetivo general de la investigación es analizar el desarrollo e impacto de las concepciones educativas del profesorado en el nuevo modelo ETHAZI de Formación Profesional del País Vasco y se basa en las líneas de actuación futuras sugeridas por Astigarraga y Agirre (2018).

Para responder al objetivo es necesario identificar los elementos facilitadores y obstructores que influyen en la implementación del modelo ETHAZI analizando la relación en tres dimensiones: el marco teórico del modelo, las concepciones educativas del profesorado y la praxis.

Así, se plantean como las principales cuestiones de investigación las siguientes preguntas: ¿Cómo influye el modelo ETHAZI en las concepciones y praxis de los docentes de la FP de la Comunidad Autónoma Vasca y cuál es la interacción entre éstas? ¿Cuáles son las causas por las que los centros de FP se sitúen en diferentes niveles de implementación del modelo?

De la pregunta general, en la primera fase de la investigación emerge la siguiente pregunta: ¿Cuál es el discurso acerca del nuevo modelo ETHAZI del profesorado y cómo ha sido construido? ¿Cuáles son ahora sus concepciones educativas?

La hipótesis de partida plantea que el discurso sobre el modelo ETHAZI del profesorado está condicionado en gran parte por el grado de participación que han tenido esos docentes en el diseño y en el desarrollo del modelo tanto a nivel general, como particular desde el centro. Entender en qué grado afecta esto en su concepción respecto de la necesidad de cambiar el modelo educativo es una de las claves que nos ayudarán a identificar los factores de éxito que pueden ayudar a implementar este modelo de innovación educativa.

3 Diseño

3.1 Metodología y técnicas

Para entender la identidad profesional no estática de los sujetos que se encuentran en un determinado contexto, la investigación se fundamenta en el marco de la investigación cualitativa y en el paradigma interpretativo (Beijaard, Meijer & Verloop, 2004).

Se quiere entender la identidad profesional de los profesores desde su marco de referencia, arraigado a la realidad y asumiendo las particularidades de cada caso. Siguiendo esta teoría, se propone un análisis de caso colectivo (Stake, 1998) para analizar el cambio de las concepciones y praxis del profesorado en un contexto concreto. Para ello, se han determinado los criterios de elección de los casos (Stake, 1998) y la muestra:

- Se analiza el Ciclo Superior de Diseño de Fabricación Mecánica en tres centros de la misma zona geográfica.
- En cada centro participan un profesor y el coordinador del Ciclo como sujetos principales.

El estudio de caso tiene como objetivo analizar la particularidad y la complejidad de un caso para comprender su actividad en condiciones importantes (Stake, 1998). También se plantea el método narrativo-biográfico para el estudio del caso, entendiendo el significado que atribuyen los sujetos a sus experiencias y analizando la construcción de la identidad profesional, comprendiendo el proceso de evaluación grupal mediante cruces entre las narrativas individuales. De esta forma, daremos importancia tanto al desarrollo de la trayectoria personal de cada docente, como a la colectiva, a partir de las identidades individuales construidas sobre biografías e interacciones individuales e identidades colectivas construidas a partir de procesos históricamente sociales (Bolívar, 2006).

Siendo la identidad profesional un constructo de la experiencia sobre los significados, sentidos e intenciones, se proponen técnicas individuales (entrevistas en profundidad) contextualizadas en grupo (focus group) y observadas en la praxis (observación no participante) como técnicas de investigación, teniendo siempre en cuenta los criterios de calidad (Denzin, 1970; Denzin & Lincoln, 2005, Sandín, 2000).

Con ánimo de contextualizar la fase previa, en la Tabla 1 se presenta el diseño total de la investigación:

Tabla 1. Técnicas de investigación cualitativa previstas en el diseño de la investigación.

Técnica	Sujetos
Entrevistas en profundidad	Profesor y coordinador de Ciclo
Focus group	Equipo docente de Ciclo / Equipo directivo
Observación no participante	Aula de Ciclo (profesorado y alumnado)
Análisis documental	Documentos aportados por los participantes

La primera fase de la investigación en curso se ha centrado en el diseño y mejora de las técnicas y herramientas para el trabajo de campo. Este artículo incide en esta primera fase de análisis previo por su carácter de validación, necesario para matizar cuestiones en el diseño inicial debido a los resultados obtenidos.

Se han realizado dos entrevistas en profundidad con dos sujetos relevantes en la implementación del modelo ETHAZI: la coordinadora y un profesor del Ciclo Superior de Diseño y Fabricación Mecánica de un centro perteneciente a la muestra general. En las entrevistas se ha analizado la validez del guion para responder tanto a las preguntas de investigación previas como a la hipótesis de partida. El guion se ha creado a partir del estudio previo Gaitasunez, realizado en el sistema de Formación Profesional de la CAPV (Eizagirre & Altuna, 2014). Aunque dos entrevistas no son una muestra representativa, en esta fase han sido suficientes para identificar la necesidad del rediseño del guion y futuras técnicas de investigación debido a los aspectos y matices emergentes durante el transcurso de las entrevistas.

Las entrevistas en la investigación cualitativa tienen como objetivo compartir entre el sujeto o sujetos e investigador información detallada sobre un tema o acción concreta mediante el diálogo (Fontana & Frey in Vargas-Jiménez, 2011:123). Según Fernández (en Vargas-Jiménez, 2011:124), debido al estímulo y presencia del investigador en la conversación, surgen comentarios inmediatos sobre experiencias de vida o recuerdos que obligan al investigador a interpretar el significado atribuido. Sanmartín (en Tójar, 2006:249) explica que el objetivo de la entrevista es construir puentes entre los universos culturales para entender el sentido de las palabras y las vivencias.

Por lo tanto, se justifica la elección de esta técnica como medio para entender un caso concreto desde la voz del sujeto situado en una realidad concreta en la que mediante preguntas que invitan a la reflexión se construye el significado de las vivencias y acontecimientos, dando sentido a la experiencia profesional actual (Bolívar, Fernández & Molina, 2005) y entendiendo cada sujeto como una unidad simple de análisis (Yin, 2009). Esta técnica permite entender cómo está viviendo el proceso de cambio el profesorado en tránsito hacia el modelo de innovación ETHAZI.

Se presentan a continuación los datos obtenidos a partir del análisis de dos entrevistas en profundidad realizadas a una profesora (A) y a un profesor (B) del mismo Centro y Ciclo Superior de Formación Profesional. Ambos tienen la misma edad, son ingenieros, se sumergieron a la vez en la implementación del nuevo modelo en el curso 2013-2014 y hoy en día desempeñan las funciones de docente y tutor en el Ciclo Superior de Diseño y Fabricación Mecánica. Además, la docente A ocupa el cargo de coordinadora de Ciclo.

4 Resultados y discusión

Debido a que la investigación se encuentra en la fase inicial, se presentan los resultados previos a un análisis más exhaustivo y riguroso que se llevará a cabo mediante un software de análisis para la investigación cualitativa. Aun así, un análisis inicial de las entrevistas ha dado como resultado la identificación de ciertas incongruencias o disonancias cognoscitivas (Festinger in Arnau & Capdevila, 2017:1287) en el discurso de las personas entrevistadas.

En el análisis del discurso del sujeto A destacan sobre las demás categorías las disonancias en la forma de concebir las competencias transversales. El sujeto, al describir las características del modelo de aprendizaje ETHAZI, destaca la importancia que tiene el desarrollo y la evaluación de las competencias transversales. Sin embargo, cuando se le pregunta por las debilidades que a su entender tiene este modelo, aprecia un alto riesgo de pérdida en el espacio temporal y laboral de las competencias técnicas de Ciclo al incluir en el curso escolar diversos proyectos para trabajar temas relacionados con el desarrollo sostenible (Agenda Escolar 21) u otros valores (Valores 4.0) estrechamente ligados a las competencias transversales. A su vez, al preguntar por las características del perfil de salida del alumnado del Ciclo ETHAZI en el que trabaja, el sujeto destaca que debido a las características del puesto para el que se prepara el alumnado deben de estar más cualificados para ejecutar lo que se les asigne, que preparados para pensar. Por último, subraya que el profesorado no ha recibido en su formación pedagógica inicial preparación alguna para trabajar en el aula las competencias transversales, pero a la vez, manifiesta que todo el profesorado sabe qué es lo que hay que hacer para trabajar dichas competencias.

Otro ejemplo de disonancia se aprecia al resaltar la necesidad de implantar el modelo ETHAZI con el ánimo de responder a los requerimientos que se precisan en el ámbito laboral en cuanto a las competencias técnicas y transversales se refiere, así como al perfil del alumnado en el inicio de los estudios de Formación Profesional. A su vez, afirma que no veía ninguna necesidad de cambiar el modelo educativo y su rol como docente hasta que fue invitada a formar parte del grupo de profesorado que diseñó el modelo ETHAZI.

En el caso del sujeto B, destacan las incongruencias relacionadas con el proceso de enseñanza y aprendizaje al comparar el nuevo modelo con las formas de hacer anteriores, determinando que, aunque la forma ha cambiado, el objetivo del proceso de enseñanza y aprendizaje no lo ha hecho porque el Diseño Curricular Base tampoco ha cambiado. El sujeto destaca que la metodología del modelo ETHAZI es mucho más atractiva y amena para los estudiantes y ayuda en el proceso de cambio, suponiendo un salto cualitativo positivo del que no retrocedería. Menciona que el porcentaje de enseñanza teórica ha disminuido y con este modelo el alumnado se enfrenta a un estado de incertidumbre mayor, aunque ciertos contenidos se siguen dando de forma teórica y la programación ayuda a establecer el contenido y orden de las sesiones, que, por otro lado, se rediseñan continuamente para responder a las necesidades del alumnado.

Se presentan en su discurso diferentes visiones sobre las competencias transversales. Reconoce la dificultad relativa a su perfil profesional técnico para desarrollar las competencias transversales, pero subraya la importancia que le otorgan las empresas a estas competencias. Aun así, al verbalizar la necesidad identificada en las empresas de adherir las competencias transversales al perfil de salida del estudiante, cabe destacar la forma implícita que emerge de esta afirmación sobre la adquisición también de las competencias técnicas de cada Ciclo Formativo, nunca contrapuestas sino complementarias. El sujeto identifica como las principales competencias transversales el trabajo en equipo, la autonomía, la actitud (ganas y voluntad) y el sentido crítico para hacer frente a los tiempos difíciles que se acercan, pero no cree que la función de educador se encuentre entre las características que debería de tener el profesorado de Formación Profesional. Reconoce que como profesor influye en la identidad del alumnado y cree que su labor consiste no sólo en el logro de los objetivos de aprendizaje técnicos, sino también y cada vez con más fuerza de los relacionados a las competencias transversales.

Respecto a la formación continua, el sujeto B subraya la necesidad de aprender y formarse continuamente. Por ejemplo, necesita formación respecto a la evaluación del trabajo en equipo respondiendo a la realidad de cada estudiante, o respecto a la de la atención a la diversidad o necesidades especiales; pero no cree que los cursos de formación que se le ofrecen tengan un valor significativo ni identifica necesidades formativas respecto al modelo ETHAZI.

Además, se observan claras diferencias en el discurso entre el sujeto A (la persona que lidera el proceso de innovación metodológica en el centro y que trabaja en el equipo de la institución (Tknika) que ha coordinado el diseño del modelo de innovación ETHAZI) y el sujeto B (la persona que forma parte del mismo equipo, pero sin responsabilidades de liderazgo). Así, al terminar de responder a una pregunta, el sujeto B numerosas veces incide en la idea que el concepto lo puede explicar mejor el sujeto A por su rol en la implementación del modelo. Por ejemplo, el sujeto A resalta en su discurso la importancia que tiene el trabajo en equipo en el modelo ETHAZI y la debilidad que supone la poca formación del profesorado para preparar procesos de aprendizaje que precisen un trabajo colaborativo. A su vez, es en este aspecto donde pone énfasis cuando dice que la mayor dificultad que acarrea este modelo al grupo de profesores es en la comunicación, en la resolución de los conflictos que surgen a diario entre el grupo de profesores que diseñan y ejecutan los ciclos ETHAZI. Sin embargo, el sujeto B, aunque esté de acuerdo con que uno de los principales obstáculos que se identifican respecto al factor de éxito de la implementación del modelo es la dispersión de los profesores en diferentes Ciclos, se considera privilegiado por la cohesión y relación que tiene el equipo de profesores en su Ciclo.

Los dos sujetos coinciden en que en la expansión del modelo surgirán más impedimentos y la velocidad a la que se está extendiendo crea dudas sobre la forma en la que se lleva a cabo la idea original del modelo. Sin embargo, el sujeto B valora positivamente la autonomía de los centros y cree que las distintas formas que han conformado los ciclos que iniciaron la implementación del modelo se justifica en base a las decisiones que han tenido que tomar frente a las dificultades y obstáculos que se enfrentaban en cada momento, atendiendo a las necesidades de cada uno de los centros.

Respecto a las bases del modelo, el sujeto A identifica el aprendizaje basado en el trabajo colaborativo como metodología, lo cual incluye el trabajo en equipo, el alumnado como protagonista de su aprendizaje y los retos como método. A su vez, identifica cuatro pilares: la intermodularidad, el equipo docente, la evaluación de las competencias técnicas y transversales y la flexibilidad tanto del espacio como del equipo docente. El sujeto B, sin embargo, describe el modelo como un modelo basado en la resolución de retos en los que el alumnado necesita saber buscar, aprender, gestionar la información, trabajar en equipo, crear relaciones positivas, gestionar conflictos y cooperar.

Con el nuevo modelo y frente a la incertidumbre que emerge de los nuevos escenarios de enseñanza y aprendizaje, se apunta como eje central el equipo de profesores. Se destaca que el equipo docente requiere más implicación que en el modelo previo, y se valoran positivamente la autonomía del equipo y la dedicación exclusiva para atender el ciclo, aunque se reconocen las dificultades para lograrlo. Ambos sujetos estiman el desarrollo personal y profesional que les brinda el trabajar en equipo, aunque ven dificultades si alguno de los miembros no se implicara, atribuyéndole a la implicación el significado de mostrar ganas, voluntad o ilusión. A su vez, señalan la importancia de cooperar y guiar a los nuevos docentes hacia este modelo de innovación.

El docente cobra un papel fundamental en la expansión del modelo ya que en el caso analizado son los docentes los que han asumido la responsabilidad de acercar el modelo a otros ciclos y otros docentes, ayudándoles en el cambio. En este sentido, las redes entre los centros y experiencias cobran especial importancia y se entienden como un espacio para aprender entre iguales, desde la honestidad y la cooperación para aprender juntos. Ambos sujetos coinciden en que para el éxito de la implementación es imprescindible el apoyo de la dirección y señalan la importancia de crear redes y aprender desde experiencias inter-centros. El sujeto A va más allá cuando visualiza el futuro del centro de innovación Tknika como creador y tejedor de redes.

Por último, aunque el cambio no se viera como una necesidad consciente que emergiera desde el profesorado, la necesidad identificada desde las empresas colaboradoras con el centro ha llevado a cambiar la concepción de los objetivos de aprendizaje y la balanza entre las competencias técnicas y transversales, aunque se reconoce la necesidad de desarrollar el marco de cara al futuro de la Formación Profesional Vasca y la evaluación dentro del marco competencial.

5 Conclusiones

En la fase de investigación preliminar realizada se contrasta la hipótesis de partida y se identifica la conciencia del marco teórico del modelo ETHAZI, si bien el sujeto A, involucrado en el liderazgo de la implementación del modelo, teóricamente coincide en mayor grado en la mención de los elementos que caracterizan el modelo desde el discurso de la institución (Tknika), el sujeto B los enumera partiendo de su experiencia como docente.

Según se desprende de las entrevistas llevadas a cabo hasta el momento en este proyecto de investigación, dos son los elementos que cobran mayor importancia: el equipo docente y el equipo directivo. Por un lado, el modelo no implica necesariamente el tránsito obligatorio desde el individualismo a la cultura colectiva y es este aspecto lo que preocupa a los entrevistados, ya que se entiende el equipo docente como una variable significativa en los procesos de éxito. Este cambio en la cultura docente depende en gran parte del modo en el que se está percibiendo el modelo ETHAZI por parte del profesorado, de manera que se intuye un alto riesgo en la desfiguración de este modelo educativo si no se atiende a los requerimientos de los grupos de profesores autogestionados responsables de diseñar y ejecutar los ciclos ETHAZI. Para transitar desde lo individual a la cultura colectiva e incidir en este factor de éxito (Bolívar, 2006), los docentes han de desarrollar los valores que el modelo pide al alumnado: ganas, ilusión y voluntad, además de cooperación y capacidad para la gestión de conflictos. Por otro lado, el equipo directivo se define como el órgano que respalda y apoya al equipo docente, otorgándole flexibilidad y autonomía para tomar sus propias decisiones, crear redes y gestionar su propio Ciclo Formativo.

Finalmente, a partir de los resultados de este estudio se concluye la necesidad de volver a entrevistar a los docentes para indagar en los factores que inciden en esas incongruencias cognitivas que se observan en los discursos que construyen los sujetos a partir del diálogo (Bolívar, 2006). Esto permitirá diagnosticar los factores de éxito que ayudarán en la mejora de la implementación del modelo ETHAZI, especialmente los factores relacionados con el cambio en la concepción de la docencia y su praxis, necesarios para el tránsito hacia una cultura docente colectiva.

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Entrepreneurial Vision of the Universities in Latin America in the Training of Engineers

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Abstract

The global economic context and labor market trends indicate that more than 70% of jobs will be independent or temporary, which shows that more people will work on their own, a situation that is generating a broad debate about the future of jobs, scenario that becomes more critical in Latin America where high unemployment prevails, with the consequences of reducing the generation of jobs and citizens have to start their own businesses. In this context we ask ourselves if universities are training professionals who have an entrepreneurial intention. For this reason, the present study aims to investigate the degree to which Latin American universities in their professional careers in the field of engineering have a curricular design oriented towards entrepreneurial intention. The methodology will be exploratory based on secondary information obtained from the web pages of each university and the website of the ranking of universities. The results show us that the universities best located in the web ranking of Universities also have an entrepreneurial vision valued according to the subjects taught in the field of entrepreneurship, among which we can mention the University of São Paulo USP, the National Autonomous University of Mexico, the University of Chile, the University of Buenos Aires and the National University of Colombia. In the future, it is suggested to carry out research to evaluate the effectiveness of the subjects in the field of entrepreneurship, with respect to the entrepreneurial intention of the new professionals graduated in universities with an entrepreneurial vision.

Keywords: Entrepreneurial Intention, TPB, Entrepreneurial Education, Universities, Latin America, Curricular design.

Visión Emprendedora de las Universidades en América Latina en la Formación de los Ingenieros

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Resumen

El contexto económico mundial y las tendencias del mercado laboral indican que más del 70% de los puestos de trabajo serán independiente o temporales, lo que muestra que más personas trabajaran por cuenta propia, situación que está generando un amplio debate sobre el futuro de los empleos, escenario que se hace más crítico en América Latina donde prevalece las altas tasas de desempleo, con las consecuencias de reducción en la generación de fuentes de trabajo y los ciudadanos tienen que emprender sus propios negocios. En este contexto nos preguntamos si las universidades están formando profesionales que cuenten con una intención emprendedora. Por este motivo el presente estudio tiene como objetivo investigar en qué grado las universidades de América Latina en sus carreras profesionales en el campo de ingeniería cuentan con un diseño curricular orientado hacia la intención emprendedora. La metodología será exploratoria a partir de información secundaria obtenida de las páginas web de cada universidad y la página web del ranking de universidades. Los resultados nos muestran que las universidades mejor ubicadas en el ranking web de Universidades también tienen una visión emprendedora valorada en función a las asignaturas impartidas en el campo del emprendimiento, entre ellas se pueden mencionar a la Universidad de São Paulo USP, la Universidad Nacional Autónoma de México, la Universidad de Chile, la Universidad de Buenos Aires y la Universidad Nacional de Colombia. A futuro se sugiere realizar investigaciones para evaluar la efectividad de las asignaturas en el campo del emprendimiento, respecto a la intención emprendedora de los nuevos profesionales titulados en universidades con visión emprendedora.

Palabras-Clave: Intención emprendedora, TPB, Educación emprendedora, Universidades, América Latina, Diseño Curricular

1 Introducción

El contexto económico a nivel mundial y las tendencias del mercado laboral expresados en el Foro Económico Mundial en Enero del año 2017, indicaron que en el año 2030 en los países industrializados más del 70 % estarán compuestos por trabajadores independientes o temporales, es decir cada vez más gente trabajara por cuenta propia con una alta influencia de la iniciativa personal y adaptada a las nuevas tecnología. Este contexto global de cambio en la generación de empleo ha generado bastante debate respecto al futuro de los empleos en los diferentes países. Situación que se manifiesta de manera más crítica en países que tienen un contexto donde prevalece las altas tasas de desempleo como es América Latina (Pizarro 2001), donde el efecto de esta falta de empleos formales ofrecidos por empresas conlleva a que los ciudadanos emprendan sus propios negocios. El espíritu emprendedor ha surgido como posiblemente una fuerza económica más potente que se haya experimentado y trata de innovación y creatividad continuas (Kuratko 2005).

Aunque diversos factores pueden influir en el comportamiento emprendedor (Bohnenberger, Schmidt, and Freitas 2007), se sabe que la formación del estudiante universitario direccionada a la actitud emprendedora puede promover experiencias más provechosas para el individuo. La formación efectiva de capital humano a través de la educación y la capacitación en emprendimiento es una preocupación creciente para los gobiernos (Martin, McNelly, and Kay 2013) ya que se está creciendo rápidamente en todo el mundo.

Maresch et al. (2016) manifiesta que los estudiantes de ciencia e ingeniería cuyas actividades empresariales crea empresas de alta calidad, que en última instancia contribuyen al crecimiento de empleo y que el fortalecimiento de este capital humano para el emprendimiento basado en la tecnología puede ser vital, especialmente para aquellas regiones afectadas por una crisis económica.

Así, conocer los currículos de las universidades y comprender su adherencia a la actitud emprendedora, se hace necesario para comprender más a cerca de la enseñanza de estos valores en la formación estudiantil y nos preguntamos si las universidades de América Latina están formando profesional del área tecnológica con intención emprendedora.

Este tema se justifica socialmente por la importancia de la generación de nuevas fuentes de trabajo y los cambios que se están presentando en el mercado laborar y el nuevo contexto de la Industria 4.0 que se ira introduciendo en América Latina. Por este motivo, el presente estudio tiene como objetivo investigar en qué grado las universidades de América Latina, en sus carreras profesionales del campo de ingeniería, cuentan con una malla curricular adecuada hacia la intención emprendedora.

Para alcanzar este objetivo se realizará una selección de las universidades más destacadas según la calificación en el Ranking Web de Universidades (http://www.webometrics.info/es), de las cuales se efectuará una revisión minuciosa de sus mallas curriculares para identificar si cuentan con asignaturas enfocadas en el campo del emprendimiento.

2 Fundamentación teórica

El espíritu emprendedor o emprendimiento ha sido estudiado por varios autores, de este modo (Gartner 1989) considera que en el enfoque conductual del emprendimiento, un emprendedor es visto como un conjunto de tareas inmersas en la creación de una organización. Sin embargo, el termino emprendimiento ya fue tratando en el trabajo de Richard Castillon en 1734 (Sharma and Chrisman 1999) y años posteriores el emprendimiento era considerado como el autoempleo. Una comprensión de la relación entre la iniciativa empresarial y las intenciones empresariales requiere una comprensión de la educación en emprendimiento, ya que podría ser un motor más eficaz de las intenciones empresariales (Bae et al. 2014).

2.1 Educación en Emprendimiento

Según Bae et al. (2014) la educación para el emprendimiento consiste en un proceso de enseñanza en las actitudes y habilidades empresariales, donde la mayoría de los programas a nivel universitario están destinados a aumentar la conciencia empresarial y preparar a los estudiantes como futuros emprendedores. Para Boh, De-Haan, and Strom (2016) la educación en emprendimiento es fundamental para inspirar a los estudiantes a que busquen el espíritu emprendedor y para proporcionar conocimientos que faciliten el desarrollo exitoso . El emprendimiento se ha desarrollado en las universidades como un complemento a la educación empresarial, como una asignatura electiva (Kuratko 2005). Sin embargo, los nuevos modelos de educación superior, particularmente en el área de educación superior europea han contribuido a la incorporación del emprendimiento como una parte inevitable de los programas académicos (Iglesias-sánchez et al. 2016). Considerándose a las universidades como las organizaciones que desempeñan un papel clave dentro de las sociedades contemporáneas al educar a grandes proporciones de la población y generar conocimiento (Perkmann et al. 2013).

La literatura ha identificado dos perspectivas teóricas que sostienen que la educación en emprendimiento se relaciona positivamente con las intenciones empresariales: 1.- la teoría del capital humano de Becker y la auto eficiencia empresarial de Chen, Greene y Crick (Bae et al. 2014). Por su parte Martin, McNelly, and Kay (2013) encontraron una relación estadísticamente significativa entre la educación para el emprendimiento y los resultados de capital humano, como el conocimiento y las habilidades relacionadas con el emprendimiento y una percepción positiva del emprendimiento y las intenciones.

Martin, McNelly, and Kay (2013) manifiesta que algunas investigaciones sugieren que las personas que han recibido capacitación y educación sobre el espíritu emprendedor también tienen más probabilidades de iniciar un emprendimiento, que aquellas que no han recibido educación y capacitación sobre el espíritu empresarial y de igual manera pueden tener más éxito en las tareas de identificación de oportunidades que aquellos que no han recibido educación o capacitación en emprendimiento. La educación para el emprendimiento que enfatiza la creación de empresas proporcionará a los estudiantes una experiencia más práctica, así como habilidades para crear empresas que las que utilizarán la planificación empresarial (Bae et al. 2014).

2.2 Intención emprendedora

Koe et al. (2012) junto a otros investigadores indican que los emprendedores no nacen sino se hacen, por lo que pueden ser entrenados p.198. De esta manera los emprendedores se moldearan a partir de cualidades innatas fortalecidas con un entrenamiento, pero para dar este paso deberán están convencidos de ser emprendedores lo que hace que sea planificado. De la misma manera Krueger, Reilly, and Carsrud (2000) manifiestan que las actividades de emprendimiento son intencionales, que comienza con cierto grado de intención empresarial antes de ser un emprendedor.

En síntesis, el emprendimiento o espíritu emprendedor comprende los actos de creación, renovación o innovación organizacional, que ocurren dentro o fuera de una organización (Sharma and Chrisman 1999) y es una forma de pensar que resalta las oportunidades frente a las amenazas. Para Krueger, Reilly, and Carsrud (2000) es un tipo de comportamiento planificado, siendo los modelos de Shapero 1982 de las intenciones empresariales y de Ajzen 1991 de la conducta planifica, herramientas valiosas para comprender y predecir los procesos empresariales.

En este sentido, Ajzen (1991) desarrollo su teoría de comportamiento planificado (TPB), donde la intención de realizar comportamientos de diferentes clases puede predecirse con la actitud hacia el comportamiento, las normas subjetivas y el control del comportamiento percibido, siendo un modelo importante del proceso cognitivo para la evaluación de la intención empresarial que es el resultado de un comportamiento intencional y planificado (Krueger, Reilly, and Carsrud 2000), por lo que el uso de TPB para investigar la intención empresarial es viable. Por otra parte, Koe et al. (2012) manifiestan que es importante integrar al modelo TPB otras variables relevantes para incrementar la capacidad de explicar y predecir la intención. Adicionalmente Delgado Piña et al. (2008) manifiestan que el deseo de crear un negocio está relacionada con la posibilidad de crear un negocio, otros factores sociales, la autoeficiencia y la edad.

Por su parte, Liñán, Rodríguez-cohard y Rueda-Cantuche (2011) consideran que el conocimiento personal de los emprendedores influye significativamente en la decisión de creación de empresas.

3 Métodos

Se realizó una revisión sistemática de la información disponible en la página de Internet Ranking Web de Universidades (http://www.webometrics.info/es) identificándose 3695 Universidades en 48 países de América Latina, de las cuales se consideraron la 500 mejores posicionadas en el ranking de universidades y finalmente se seleccionaron hasta las 10 mejores universidades de cada pais que se encontraban dentro de las 500 mejores universidades, quedando para el análisis 125 universidades en 25 países de América Latina. Argentina, Brasil, Chile, Colombia, Mexico y Peru son los países que tienen las 10 universidades cada uno dentro las 125 universidades seleccionadas.

Posteriormente se buscó que universidades tienen en su facultad de Tecnología y/o Ingeniería las carreras de Ingeniería Industrial, Ingeniera Química o Ingeniería de la producción, carreras que por su naturaleza están orientadas al desarrollo industrial y por tanto a la creación de una industria, consideradas para el análisis "Carreras Claves".

Finalmente se procedió a revisar cada uno de los planes de estudios para identificar si se tiene en estas carreras las asignaturas relacionadas con el conocimiento en emprendimiento o el proceso de aprender a redactar un plan de negocios que según Bae et al. (2014) tiene la intención de inculcar el conocimiento y las habilidades para fortalecer las intenciones empresariales, como por ejemplo asignaturas con el nombre de "Emprendimiento", "Emprendedurismo", "Innovación y Emprendimiento", "Creación de Empresas", "Planificación Estratégica", que las consideramos "asignaturas claves"

El análisis se realizó en tres etapas: Análisis de universidades que cuentas con las carreras claves, análisis de carreras que cuentan con asignaturas claves y el análisis de datos. De la base de datos se identificó que 6 países no cuentan en sus universidades con las carreras consideradas claves para el presente estudio.

4 Resultados y Análisis

PAíS	MEJORES UNIVERSIDAD	Ranking LATAM
BRASIL	Universidade de São Paulo USP	1
MEXICO	Universidad Nacional Autónoma de México	2
CHILE	Universidad de Chile	5
ARGENTINA	Universidad de Buenos Aires	8
COLOMBIA	Universidad Nacional de Colombia	12
PUERTO RICO	Universidad de Puerto Rico	17
COSTA RICA	Universidad de Costa Rica	31
PERU	Pontificia Universidad Católica del Perú	36
VENEZUELA	Universidad Central de Venezuela	72
ECUADOR	Universidad San Francisco de Quito	89
TRINIDAD Y TOBAGO	University of the West Indies at St Augustine	100
CUBA	Universidad de la Habana	105
GUATEMALA	Universidad de San Carlos de Guatemala	137
GRANADA	Saint George's University	155
URUGUAY	Universidad de la República	157
PARAGUAY	Universidad Nacional de Asunción	170
BOLIVIA	Universidad Mayor de San Andrés	203
ISLAS VIRGENES	University of the Virgin Islands	254
BARBADOS	University of the West Indies Cave Hill Campus Barbados	259
DOMINICA	Ross University	262
PANAMA	Universidad de Panamá	268
JAMAICA	University of the West Indies Mona Jamaica	289
EL SALVADOR	Universidad Nacional Autónoma de Honduras	336
REP. DOMINICANA	Pontificia Universidad Católica Madre y Maestra	389
HONDURAS	Escuela Agrícola Panamericana Zamorano	455

Tabla 1. Mejores Universidades de cada país en América Latina

El Ranking Web de Universidades nos muestra que la mejor Universidad de América Latina es la Universidad de Sao Paulo de Brasil, seguida de la Universidad de Nacional Autónoma de México. En la tabla 1 se puede obsevar las mejores universidades de cada país.

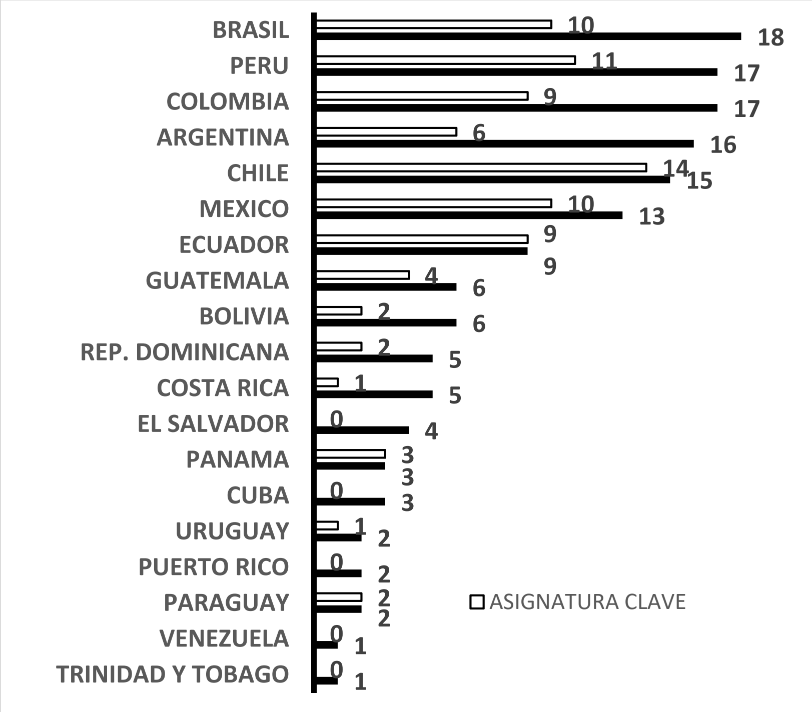

Figura 1. Carreras y Asignaturas Claves por País

En la figura 1 se puede observar el número de carreras claves en las universidades con mejor Ranking de cada país y las carreras que cuentan alguna asignatura clave, como ejemplo podemos observar que en Brasil se tienen 18 carreras claves en sus 10 mejores universidades de las cuales solo 10 cuentan con la asignatura clave que equivale a un 56 % de las carreras clave que tienen una enseñanza con visión emprendedora.

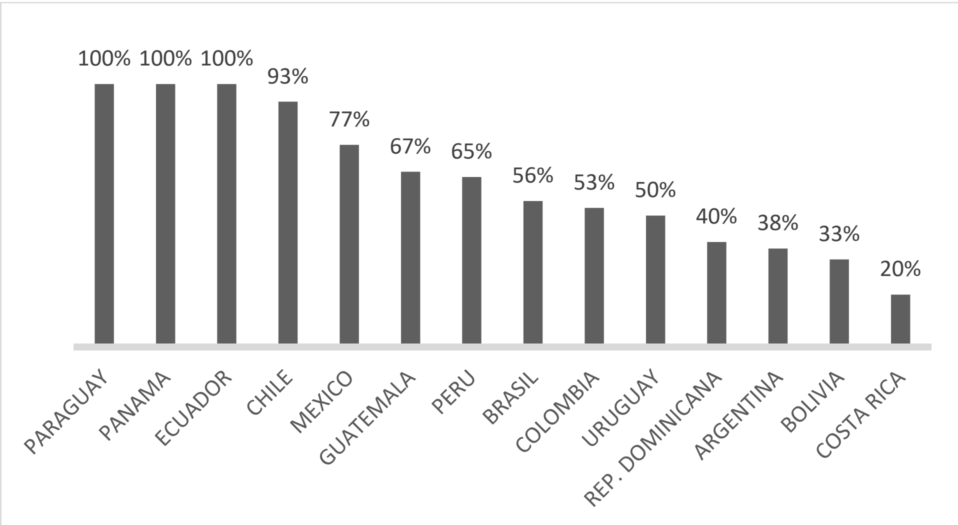

Figura 2. Carreras con Visión Emprendedora

En la figura 2 podemos observar que en América Latina se tiene 14 países en las que sus mejores universidades tienen una carrera clave en Ingeniería con visión emprendedoras y el 58% de las Universidades que cuenta con una carrera de ingeniería tienen alguna asignatura en el área de emprendimiento. La educación para el emprendimiento que enfatiza la creación de empresas proporcionará a los estudiantes una experiencia más práctica, así como habilidades para crear empresas que las que utilizarán la planificación empresarial (Bae et al. 2014). En el caso de Reino Unido en las áreas de ciencias físicas y de ingeniería Perkmann et al. (2013)

manifiesta que el 12 % de los investigadores participaron en emprendimientos académicos y en el caso de Suecia e Irlanda entre el 12 a 19% se involucraron en la creación de Spin off en al menos una vez durante su carrera académica.

En la figura 2 se puede observar que Ecuador con nueve carreras claves en ingeniería, todas tienen alguna asignatura en el campo de emprendimiento. Por su parte, Chile con el 93% de sus 14 carreras claves tienen en su plan de estudios alguna asignatura en el campo del emprendimiento, mostrando que son los países que tienen una mayor visión emprendedora en la formación de sus profesionales en América Latina, podemos destacar un segundo grupo a Mexico, Brasil, Peru y Colombia que tienen más del 50% de sus carreras de ingeniería con una visión emprendedora. Koe et al. (2012) indican que los conocimientos que adquieren los estudiantes a través de su formación en su carrera profesional adicionales a los conocimientos sobre emprendimiento, cursos empresariales y otras habilidades empresariales especiales mejoran las intenciones empresariales de los individuos. Por su parte, Devonish et al. (2010) mencionan que los empresarios pueden aplicar sus conocimientos para influir en sus propios hijos y puedan desarrollar sus negocios familiares o para desarrollar nuevos negocios. Mariano, Ayaviri-panozo y Rocha (2018) consideran que se hace necesario adecuar los planes de estudios en Ingeniería con asignaturas y actividades extra curriculares como talleres y seminarios, que permitan ampliar el conocimiento empresarial para fortalecer la intención emprendedora de los estudiantes.

5 Conclusiones, limitaciones y futuras líneas de investigación

El objetivo de la investigación fue conocer cuál es la visión emprendedora de las Universidades de América Latina en la formación de profesionales ingenieros con intención emprendedora, puesto que la educación en emprendimiento es una herramienta pedagógica comparativamente más efectiva para mejorar las intenciones emprendedoras de los estudiantes (Bae et al. 2014). Los resultados nos muestran luego de una revisión sistemática de los planes de estudios que las universidades con mejor visión emprendedora están mejor posicionadas en el ranking de universidades.

La Universidad de São Paulo USP, la Universidad Nacional Autónoma de México, la Universidad de Chile, la Universidad de Buenos Aires y la Universidad Nacional de Colombia, que son las mejores universidades posicionadas en el ranking de universidades y cuentan con carreras de ingeniería, tienen una visión emprendedora en la formación de sus profesionales ingenieros.

Las universidades que no tienen visión emprendedora, es decir que sus carreras de ingeniería no tienen una asignatura en el campo del emprendimiento alcanzan al 42 % , estas deben adecuar sus programas académicos de los diferentes títulos para que cuenten con conocimiento que permita desarrollar el espíritu emprendedor como una competencia interdisciplinaria (Iglesias-sánchez et al. 2016), puesto que la adecuación del plan de estudios en ingeniería incorporando asignaturas empresariales para potenciar su intención emprendedora permitirá formar profesionales capaces de crear una nueva empresa (Mariano, Ayaviri-panozo y Rocha 2018).

Esta investigación tuvo sus limitaciones en el momento de revisar las páginas web de cada universidad, algunas de ellas no contaban con planes de estudio o sus dirección URL no estaba disponible.

Para futuras investigaciones se sugiere evaluar la efectividad de las asignaturas en el campo del emprendimiento, respecto a la intención emprendedora de los nuevos profesionales titulados en las universidades consideradas con visión emprendedora.

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Engineering competence in the changing society

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Abstract

The continuous socio-economic changes in our society have strongly affected sectors such as business and education. The employability skills -the new engineers require to have- show the gap between what university education provides and what society needs. It is because changes happen more quickly before the university responds to the need. It involves preparing teachers and students for the changing times. We are conscious of this reality and, for this reason, in the General Chemistry course (QG2) at Universidad de Piura-Campus Lima; we are working with an active methodology based on PBL. This methodology focuses on the development skills like metacognitive and critical thinking skills, capacity for teamwork and assertive communication. Every semester the students work on a global project or one for each unit of the course (four). In the assertive communication context, the knowledge of another language is one of the most important skills. During the 2018-II semester, students worked on two projects, one for the first two units and the other one for the last two. We coordinated with the Language Center of the university and implemented that, as part of the projects, students had to hand in an essay in English supporting their opinion after the analysis of a case and they had to critique a paper. As a graduation requirement, students must demonstrate the domain of this foreign language in an intermediate level. We grouped students taking into account their specific level of English. Also, they were guided through the assignments and received feedback. This article reports the difficulties found in the process and the feasibility to implement this type of work in other courses.

Keywords: Engineering skills, learning and competences, PBL and skills.

Competencias ingenieriles en una sociedad cambiante

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Resumen

Los continuos cambios socio-económicos, de nuestra sociedad, vienen afectando fuertemente a sectores como el empresarial y consecuentemente a la educación. Las competencias de empleabilidad, requeridas a los nuevos ingenieros, ha puesto en evidencia la brecha entre lo que la educación universitaria provee y lo que la sociedad necesita. Esto, se debe a que estos cambios ocurren a mayor velocidad de lo que las universidades vienen respondiendo, lo cual implica preparar a docentes y estudiantes para éstos tiempos de cambio. Conscientes de las carencias, en el curso de Química General 2, en la universidad de Piura en Lima, se viene trabajando desde hace algunos años con metodología activa basada principalmente en Aprendizaje Basado en Problemas (ABP) enfocada en el desarrollo de algunas habilidades, tales como pensamiento crítico, capacidad para trabajar en equipo, habilidades metacognitivas y comunicación asertiva. Cada semestre, los estudiantes trabajan un problema o proyecto global o bien cuatro, uno por cada unidad del curso. En el contexto de la comunicación efectiva, el dominio de un segundo idioma es una competencia clave. De modo que, el semestre 2018-II se optó por que los estudiantes trabajaran en dos proyectos, uno para las dos primeras unidades y el otro para las dos últimas. Se realizaron coordinaciones con el Centro de Idiomas de la universidad y se implementó que, dentro de los proyectos, debían presentar un ensayo y realizar la critica a un paper en idioma inglés. El plan curricular de la carrera de Ingeniería, considera el idioma inglés como un requisito para egresar, sin embargo, cada estudiante lo hace a su ritmo. De modo que, en aula, se contaba con diferentes niveles de conocimiento, razón por la cual, los estudiantes, fueron agrupados tomando en cuenta el nivel y fueron orientados y asesorados según su situación específica. Esta comunicación habla de las dificultades encontradas en el proceso y de la factibilidad de implementar, esta forma de trabajo, en cualquier materia.

Keywords: competencias ingenieriles, aprendizaje y competencias, ABP y las competencias.

1 Introducción

Al pensar en Ingeniería, se le atribuyen una serie de significados y creencias. En general, se puede decir que se piensa que, los ingenieros, serán capaces de dar solución a problemas complejos, ante cualquier situación que involucre a nuestro entorno (Ortiz, 2016). En nuestra sociedad, se asocia la ingeniería no solo con los avances de la ciencia y tecnología, sino más como un arte. Se piensa en el ingeniero como aquel que será capaz de aplicar técnicas y conocimientos para mejorar, proponer, innovar y que lo hará con creatividad y responsabilidad. En realidad, se piensa que dispone de habilidades en todos los ámbitos y que puede solucionar cualquier situación problemática de la sociedad.

Si hablamos de conocimientos y habilidades en todos los ámbitos, esa competencia a la cual nos referimos, resulta ser una habilidad en acción, es emplear recursos para generar soluciones en el momento oportuno y transformar, de ser necesario (Lévy-Leboyer, 2000).

La literatura reporta varias perspectivas deseables para un ingeniero. Evidentemente, a nivel técnico, hay algunas diferencias si se trata de un ingeniero civil. informático, industrial, etc. Sin embargo, hay aspectos que son comunes a todos ellos y que deben caracterizar a un ingeniero en el siglo XXI.

¿Cuáles son los factores clave que se están considerando en el perfil de un ingeniero? *Un ingeniero, en nuestra sociedad cambiante, integra conocimientos profesionales con destrezas y actitudes en el contexto específico en que se desempeña.*

Se trata entonces de competencias genéricas; instrumentales, interpersonales y sistémicas. Las primeras hacen alusión a aquellas que les permiten usar su conocimiento en diferentes entornos, las segundas se refieren al enfoque social, en especial las habilidades comunicativas y las últimas son las que le permiten entender el conjunto de complejidades para trabajar más allá de objetivos inmediatos (Gutierrez, 2017).

Tenemos claro que, los primeros años de la carrera universitaria, son una oportunidad para la formación en competencias de los estudiantes. Esto, es especialmente cierto en países como Perú, donde los ingresantes tienen edades entre 16 y 17 años, por tanto, están aún, en una edad que facilita esta formación. Es nuestra responsabilidad buscar oportunidades para hacerlo y al emplear metodología activa, tipo ABP o proyectos, se proporciona un medio adecuado para llevarlo a cabo, tal como lo siguen demostrando las publicaciones al respecto.

Los hechos, respaldados por la literatura, mencionan una serie de competencias que debe cumplir el ingeniero del siglo XXI, estas pueden variar incluso entre universidades y países, pero, algunas de ellas son comunes en todos los casos. Cinco son los aspectos en que más se coincide, incluso con los criterios de calidad de acreditadoras internacionales (ABET, 2017; ICACIT 2019):

- Capacidad para trabajar en equipo.
- Comunicación efectiva.
- Capacidad de investigación, innovación y liderazgo
- Resolución de problemas complejos.
- Compromiso ético.

Se reconoce al ingeniero como un profesional que se desempeña en equipos de trabajo, de tal forma que requiere interactuar en grupos heterogéneos. En ese entorno, sólo si se establecen buenas relaciones con colegas y compañeros, será posible explotar al máximo la capacidad de los equipos (Lazzarini y Pérez, 2018). De modo que, la comunicación efectiva está involucrada en todo trabajo en equipo. Cuando se trabaja en forma cooperativa, el intercambio de ideas es permanente, además se respeta y escuchan las ideas de otros y todos contribuyen con diversos enfoques de la situación, permitiendo soluciones más creativas.

De la misma forma, en la actualidad, se requiere un ingeniero comprometido, diferente a aquel que únicamente se limita a saber y hacer, dejando de lado el ser (Velásquez, 2015).

Dentro de esta comunicación efectiva, debemos tomar en cuenta la actual internacionalización y globalización de la educación superior y el mundo laboral. Muchas empresas son transnacionales o bien mantienen relaciones con otras en el extranjero. En este contexto, el dominio de un segundo idioma se hace, cada vez más, una necesidad. Un ingeniero que domine, además de su lengua materna, un segundo idioma tiene una ventaja significativa y, de todos es conocido, que el idioma más empleado para comunicarse internacionalmente es el inglés.

En nuestra universidad, el idioma inglés es un requisito a cumplir para egresar de la carrera de Ingeniería. Los estudiantes deben demostrar que tienen cierto nivel de inglés en cada etapa de su currículo. Esto implica que, de no tener conocimientos previos, deberán ir matriculándose en los cursos de inglés, cosa que hacen a su ritmo. Pero, tal como ocurre con muchos cursos, éstos resultan ser tratados como si estuvieran desvinculados de su carrera. Es cierto que en algunas universidades se dictan algunos cursos en inglés y en la nuestra se piensa incursionar también en esta experiencia, sin embargo, esta práctica implica que el estudiante ya hablé el idioma.

En el semestre 2018-II se decidió, junto con el Centro de Idiomas de la Universidad, incluir el ~~idioma~~ inglés en algún aspecto del curso Química General 2 (QG2). Dentro de dicha materia se trabajan los denominados Proyectos Globales, de modo que se optó porque en ellos, se tendría un espacio donde los estudiantes debían mostrar su capacidad para integrar el aprendizaje de química con el idioma inglés.

Esta decisión, resultó relevante pues permitió integrar aspectos tales como:

- Aunque no todos los alumnos tenían el mismo nivel, sin embargo, pudieron interactuar en el idioma y responder a los requerimientos del curso, respetando su nivel de conocimiento.
- El estudiante aprendió a aplicar los conocimientos adquiridos y a expresarlos en un idioma diferente.

- Los estudiantes pudieron adquirir o iniciar el desarrollo de una competencia transversal de manera lúdica.

En los siguientes párrafos se abordará la manera cómo fue implementado el proyecto y los resultados obtenidos, hasta el momento.

2 Contexto de trabajo

Desde hace diez años, en los cursos de química de la Universidad de Piura-sede Lima, ve viene implementando metodología activa, principalmente basada en problemas tipo ABP y proyectos. La elección de esta metodología basada en ABP, para los cursos de química, se basó principalmente en que, de esta forma el estudiante asume la responsabilidad de su propio aprendizaje, lo que en consecuencia incrementa la motivación, la capacidad para auto-aprender y trabajar en equipo (Bueno, 2004); más aún si a ello añadimos que en las últimas décadas se han incrementado las iniciativas para evaluar las competencias de los graduados (Rodríguez y Peña 2015). De modo que, al emplear este tipo de metodología se favorece el desarrollo de diversas competencias.

El primer día de clase se conversa en torno a la metodología que se empleará, ese día se forman grupos de trabajo de cuatro estudiantes. Para la formación de grupos se han empleado diversas técnicas: afinidad o amistad, cercanía, azar, juegos previos o notas, donde se selecciona un integrante de cada cuartil, etc. En el caso de la innovación propuesta en este paper, la formación de grupos se basó en que debían coincidir en su nivel de dominio de inglés. Una vez formados los grupos, por lo general se demuestra la importancia de trabajar en equipo mediante alguna actividad lúdica. Con los grupos formados, se presenta el problema/proyecto global en el cual trabajaran durante todo el semestre. Ese mismo día se discute sobre aquello que conocen y lo que deberán investigar para resolver la situación problema y las implicancias de su solución. Se discuten plazos, condiciones de entregables y se presentan las rúbricas generales de evaluación. Éste, se realiza generalmente en etapas y suele consistir en alguna dificultad en plantas industriales, siempre con alguna connotación ambiental, donde los estudiantes deben analizar situaciones y proponer soluciones argumentando sus decisiones públicamente. Ocasionalmente se realizaron cuatro mini-proyectos, uno por cada unidad del curso.

El proyecto global se trabaja fuera del aula, mientras, en las sesiones presenciales, el mismo grupo de estudiantes, trabaja en base a actividades prediseñadas por el docente, con objetivos diversos ya sea formar conceptos, aplicarlos o evaluarlos. La finalidad, de las actividades es ir cubriendo los contenidos del curso, es donde van adquiriendo conocimientos y algunas habilidades, tales como el respeto y la tolerancia, como se aprecia en la figura1. Estas actividades, presentan la información empleando posibles situaciones en la vida real. Los estudiantes pueden encontrar, la actividad correspondiente, en el aula virtual del curso y deben llevarla impresa a la sesión de clase, algunas de ellas son evaluadas. Sin embargo, durante estas sesiones la labor del docente consiste en monitorear el trabajo del estudiante, su exposición rara vez pasa de 15 minutos y puede interrumpir ocasionalmente si ve la necesidad de hacer aclaraciones, cuando observa que las dudas de los grupos de repiten.

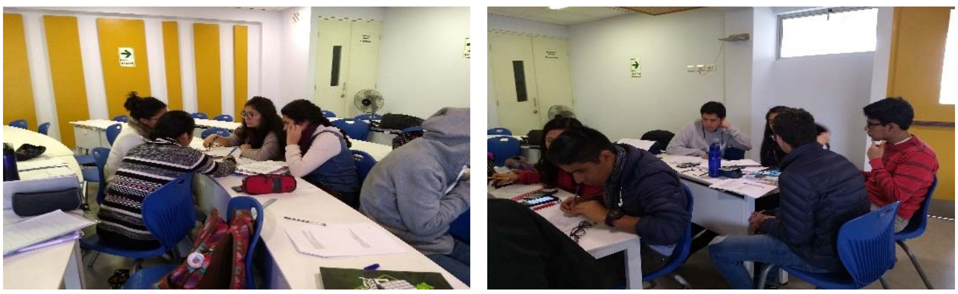

Figura 2. Estudiantes en una sesión de clase.

En base a la metodología activa aplicada, durante este tiempo, se han venido obteniendo resultados interesantes en la percepción del estudiante y su desempeño (Cano 2017). La información cualitativa y cuantitativa recogida da cuenta de los beneficios del trabajo en equipo y el rápido desarrollo de habilidades metacognitivas (Cano, 2018). Con el tiempo, se han venido implementando adicionalmente cambios tales como: laboratorios más autónomos, integración de laboratorios de física y química, evaluaciones mixtas (experimental- teórico), etc.

El curso QG2, en el cual se ha realizado la inclusión del idioma inglés, se encuentra en el segundo año, tercer semestre, del currículo de la carrera de Ingeniería Industrial y Sistemas. Durante el semestre 2018-II se optó por trabajar dos proyectos, A y B, uno para las dos primeras unidades, termodinámica y cinética y el segundo para las dos últimas, equilibrio químico y electroquímica:

1. El escándalo de la Volkswagen, ocurrido en el año 2015 que involucró millones de autos diésel trucados y millonarias multas y pérdidas para la compañía alemana, sirvió como escenario para el primer proyecto. El trabajo del estudiante se basó en el análisis de los factores termodinámicos y cinéticos involucrados en los autos, pero, fue también aprovechado en el sentido de la responsabilidad del ingeniero y los factores ético-sociales involucrados en el caso. En ese sentido, parte del trabajo de los estudiantes consistió en la elaboración de un ensayo de opinión, en inglés, En este ensayo debían asumir una posición y sustentarla en base a literatura y a sus propias opiniones.

2. La elaboración de una revista especializada, donde cada grupo se hacía cargo de un tema específico. La revista debía cumplir con una serie de criterios, entre ellos contener al menos cuatro artículos, de origen bibliográfico (académico o periodístico), los que debían sintetizar y analizar. Uno de los artículos debía ser original en inglés y la crítica debía hacerse en el mismo idioma. Fueron siete grupos de trabajo, por tanto, siete especialidades para la revista, según se muestra en la tabla1.

Tabla 1. Especialidades en la revista

Grupo	Especialidad
1	Contaminación del aire
2	Contaminación del agua
3	Otros tipos de contaminación, suelos, sonora, etc.
4	Impacto de la corrosión
5	Autos eléctricos
6	Pilas, sus aplicaciones e implicancias ambientales
7	Energías renovables ¿Contaminan?

En cuanto a la distribución de la nota final del curso, el proyecto global correspondió al 15%, según se indica en la figura 2, mostrada a continuación

Figura 2. Distribución porcentual de la nota final

El tiempo empleado, para cada proyecto, fue de dos meses aproximadamente y en todos los casos, se contó con rúbricas de evaluación generales y específicas, así como autoevaluación, evaluación por pares y hetero-evaluación.

Somos conscientes de la necesidad de comunicación efectiva en nuestra sociedad globalizada, por esa razón, en unión con el Centro de Idiomas se decidió integrar aprendizaje bilingüe durante el curso de QG2.

3 Implementación

Tal como se ha mencionado, el curso se evaluó en base a cinco aspectos donde, el examen y las prácticas calificadas corresponden al desempeño individual del estudiante, mientras las actividades, laboratorios y proyectos globales son trabajados por el mismo equipo durante todo el semestre. Esta interacción permanente es fundamental para el desarrollo de las competencias buscadas.

El esquema, que aparece en la figura 3, muestra el diseño empleado y los porcentajes considerados en la evaluación de los proyectos

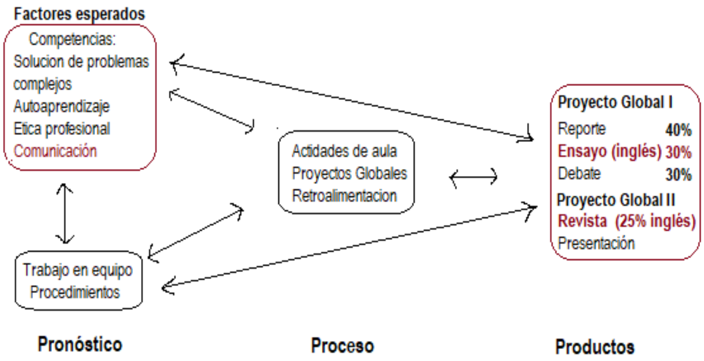

Figura 3. Modelo empleado en el diseño-evaluación de proyectos.

3.1 Proyecto Global 1

El escándalo de la Volkswagen fue el escenario en que se trabajó este proyecto durante dos meses. Los estudiantes debían entregar tres evidencias de su aprendizaje, cada uno de ellos con un peso sobre la evaluación final, tal como se aprecia en la figura 2

El ensayo

Con relación a la manera sobre cómo se trabajó el ensayo. Cuando se inició el curso, la docente del centro de idiomas visitó la clase y comunicó en inglés la forma cómo se trabajaría el ensayo sobre el caso Volkswagen: podían trabajar en grupos de acuerdo a su nivel de conocimientos en el inglés, tenían que sustentar una opinión y seguir una estructura para la redacción del documento. Asimismo, se hizo un sondeo sobre el nivel del dominio del idioma donde los estudiantes comunicaron su experiencia en este aprendizaje. Seguidamente, la docente comunicó el día y hora de las asesorías para la retroalimentación. Tuvieron también el recurso de solicitar retroalimentación vía internet.

Los días martes y por espacio de dos meses, los grupos se acercaron a la oficina de idiomas para conversar acerca de los problemas que estaban enfrentando en la redacción del ensayo. El aspecto que más les preocupaba era el poder sustentar su opinión, otros reconocían sus limitaciones para expresar sus puntos de vista en otro idioma, algunos -muy pocos en realidad- estuvieron ausentes en estas asesorías.

El reporte/informe

Los estudiantes contaron con una rúbrica y una plantilla donde tenían opción a seleccionar su propio enfoque, respetando el formato pedido. Debían analizar los procesos, en los autos trucados, desde el punto de vista de la termodinámica y la cinética y relacionarlo con los problemas ambientales involucrados. Dispusieron de un horario de asesoramiento y oportunidades para ir mejorando sus avances. En general, al igual que en la elaboración del ensayo, la mayor parte de grupos, a excepción de uno, aprovechó las oportunidades de retroalimentación.

La presentación del ensayo y del reporte fue realizado a través del aula virtual del curso.

El debate

Una vez entregados tanto el ensayo como el informe técnico, debían prepararse para debatir. Debían exponer con claridad su posición frente al problema, argumentar y fundamentar sus percepciones o propuestas. Se dedicó a esta actividad un tiempo de una hora y media, donde los estudiantes se turnaron para expresar sus ideas y refutar algunas de las opiniones de sus compañeros, abordando la problemática principalmente desde aspectos éticos y de compromiso con la sociedad.

3.2 Proyecto Global 2

El encargo de elaborar una revista especializada constituyo el segundo proyecto del semestre. Esta vez fueron dos las evidencias que los estudiantes entregaron, tal como se ve en la figura 2.

La revista

Debía cumplir con una estructura (editorial, artículos, entrevistas, noticias, amenidades, etc.) y una serie de criterios. Uno de los criterios fue que, tendría al menos cuatro artículos, cuya fuente fuera académica o periodística. Con esos artículos, realizaron su síntesis y volcaron su propia opinión al respecto.

Dentro de la revista, uno de los artículos tenía que ser original, en inglés, y debían realizar la síntesis y crítica también en el mismo idioma. En este caso, contaron con el apoyo del centro de idiomas, de la misma forma que para la elaboración del ensayo. El peso asignado a este aspecto de la revista fue del 25% del total del proyecto global 2.

Presentación/defensa

Una vez entregada la revista, a través del aula virtual, la última sesión de clase, se dedicó a la presentación de las revistas elaboradas, donde justificaron el enfoque seleccionado. Cada grupo eligió el artículo, que les pareció más interesante, para compartir con sus compañeros y respondieron a sus preguntas.

4 Resultados

Como se hace cada año, en el semestre 2018-II, los estudiantes completaron una encuesta anónima, En esta oportunidad, la encuesta fue modificada para incluir preguntas que indagaran sobre la experiencia en inglés. A continuación, se muestran algunos de los resultados que se consideran más relevantes.

En la siguiente gráfica, figura 4, se muestra qué opinión tenían sobre el hecho de tener que escribir un ensayo y una crítica en idioma inglés. Se empleó una escala de 1 a 3 donde 1 fue en desacuerdo y 3 de acuerdo.

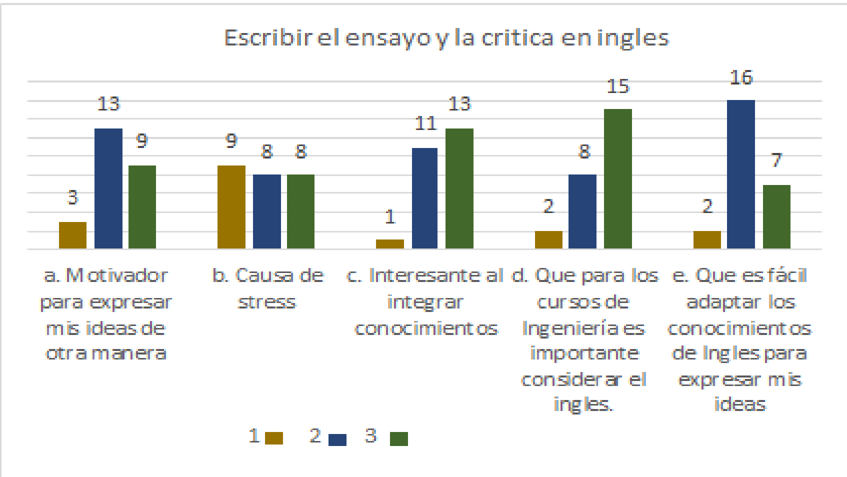

Figura 4. Percepción del estudiante sobre escribir un ensayo y una crítica en ingles en el curso de QG2

Como se puede apreciar la mayoría considera que, para los cursos de ingeniería es importante incluir el inglés.

En cuanto a cuál fue la mayor dificultad para elaborar el ensayo y hacer la crítica al paper con otra persona, el 68% opinó que fue planificar y disponer los tiempos adecuados.

En relación a la motivación involucrada en la experiencia bilingüe, para el 40% fue que aprender algo nuevo les daba gratificación inmediata, mientras para el 28% las notas son lo más importante y para otro 28% que hacer la tarea fortalece la confianza en sí mismo.

Cuando evaluaron los aspectos que consideraron más útiles para enfrentar la tarea, se les pidió seleccionar las dos que consideran como las más relevantes, los resultados se muestran en la figura 5.

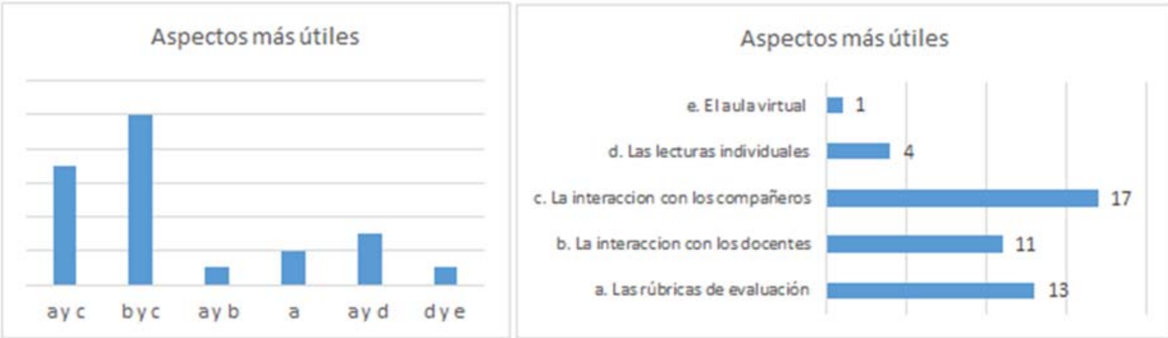

Figura 5. Aspectos considerados más útiles para enfrentar la tarea (escribir ensayo y crítica)

Los resultados muestran que las interacciones con docentes y principalmente con compañeros, fueron de utilidad para enfrentar la tarea, lo mismo que las rúbricas de evaluación.

Cuando, preguntamos acerca de qué aprendizaje consideran que les dejó la experiencia bilingüe, los porcentajes se reparten equitativamente. Aunque podían marcar las dos opciones más reales para ellos, aproximadamente el 50% considera que:

Dentro de las competencias ingenieriles hablar un segundo idioma es relevante.

La comunicación en otro idioma enriquece mi aprendizaje.

La encuesta incluyó preguntas abiertas, donde el estudiante podía dar sus opiniones y sugerencias libremente. Coincidieron en cómo la metodología, materiales y trabajo en equipo, empleados en el curso, ayudaron a su aprendizaje, También valoraron la retroalimentación recibida, tanto en centro de idiomas como en la facultad de Ingeniería. Algunos de los comentarios:

“Te ayuda a tener mayor visión y darle otro enfoque al problema, ir más allá de la moral, ética y legal”

“…. informarse sobre noticias actuales que se conectan con los temas del curso...”

“Me ayudó a darme cuenta de hechos importantes y relacionarlos con mi carrera”

“ .. en cómo ver los problemas por los que está pasando el mundo y las formas de contribuir a darles solución”

“… me ayudaron en algunos aspectos lo cual facilitó el trabajo “

La retroalimentación, en el momento adecuado, resulta ser un aspecto de gran relevancia.

Las horas dedicadas a las asesorías para la redacción del ensayo, fueron espacios valiosos para la reflexión. Los estudiantes tuvieron que buscar datos, evidencias, ejemplos para sustentar su opinión. Los que tenían muy pocos conocimientos en el idioma reflexionaron en el reto de aprenderlo para impulsar sus competencias profesionales. A los que dominaban el idioma les pareció muy interesante utilizarlo para explicar un tema de química, a quienes no, les pareció causa de stress. El mayor problema que tuvieron que enfrentar los estudiantes para el desarrollo de esta tarea, fue planificar y organizar sus tiempos.

4 Conclusiones y recomendaciones

La información, comentarios y vivencias permiten concluir que:

- Los estudiantes generalmente se muestran dispuestos a ser involucrados en tareas grupales y a asumir retos; lo que se necesita es el diseño de proyectos que impulsen las competencias que se desea tengan los profesionales de la sociedad de hoy y docentes comprometidos para impulsar estas competencias en el aula, desde los primeros ciclos.
- El trabajo en equipo no sólo debería aplicarse a los estudiantes, son los docentes de quienes se requiere también un trabajo en conjunto para programar acciones didácticas específicas que impliquen la integración de las áreas para el desarrollo de competencias transversales.
- Es posible desarrollar competencias; la integración de áreas permite que los estudiantes salgan de la idea de que los cursos son independientes unos de otros, incluido el aprendizaje en inglés que forma parte de su currículo.

Las rúbricas y la retroalimentación, resultan ser aspectos de gran relevancia. Aunque se trata de que las rúbricas sean lo más claras posibles, aun así, pueden surgir algunas dudas en su interpretación. Estas dudas, en general, pudieron ser despejadas cuando aprovecharon las oportunidades para asesorarse. Cabe resaltar que se adaptaron y respetaron los horarios. Por otro lado, el asesoramiento directo, ofrece una buena oportunidad para conocer mejor a los estudiantes y sus necesidades.

Es evidente los beneficios de aprendizaje que dejan, en los estudiantes de ingeniería, el diseño de proyectos que incorporan el trabajo en equipo y que a la vez tienen por objetivo potenciar la comunicación efectiva. Sin embargo, el contexto actual y los requerimientos que se imponen para la adquisición de las competencias deseables de los futuros ingenieros, indican que la efectiva comunicación de estos profesionales en grupos culturales heterogéneos, requerirá, entre otras demandas, el pleno dominio del idioma inglés. Por lo tanto, se recomienda que en los cursos de ingeniería:

- Los estudiantes sean concientizados sobre la necesidad del dominio del idioma inglés para impulsar sus competencias profesionales.
- Se diseñen proyectos que demanden la utilización del idioma de tal manera que conlleve a los estudiantes a plantearse retos.
- Se establezcan horas de asesoría personalizada para ayudar a los estudiantes a enfrentar sus retos

La experiencia bilingüe ha mostrado que es posible integrar diversas materias con un mismo fin de aprendizaje, en este caso, se buscó una comunicación efectiva tomando en cuenta todas sus aristas. De tal forma que, sería posible integrar cursos evaluando qué competencias se buscan en común, Luego, elaborar las actividades y el sistema de evaluación pertinente para su implementación.

5 Reflexión

Sin perder de vista que se trató de una experiencia en un contexto especifico y que durante el semestre 2018-II fueron 26 los estudiantes matriculados en el curso, aun así, la experiencia ha dejado enseñanzas importantes.

Los estudiantes y los docentes requerimos entrenamiento. Los docentes para prepararnos para diseñar los proyectos y retroalimentar de manera adecuada a nuestros estudiantes. Los estudiantes para asumir su responsabilidad en su propio aprendizaje y asumir los retos. Por otro lado, la retroalimentación juega un papel fundamental para motivarlos, aunque al inicio les costó buscarla, poco a poco fueron entrando en confianza y resultó ser un momento donde los estudiantes se manifestaron con sinceridad y entusiasmo. De la misma forma, los docentes vamos adquiriendo habilidad para orientarlos de mejor manera.

Aunque el aporte de la cuota de inglés a la nota final del curso fue de 5%, resulta realmente significativo por todo lo que involucro, sobre todo en cuanto a la integración y coherencia en el desarrollo de habilidades.

La experiencia ha demostrado la posibilidad de que se pueden integrar conocimientos y al mismo tiempo desarrollar habilidades buscadas. En nuestro caso la habilidad que se buscó, en conjunto, con el Centro de Idiomas fue comunicación efectiva.

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Pre-elaboration of flowcharts by the students as support in the accomplishment of practices in chemistry laboratories of higher education

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Abstract

The use of flow charts in the teaching of various subjects of higher technical careers such as those related to computer science or engineering processes in its different branches is very useful to facilitate the understanding of its contents, since they support procedural knowledge and facilitate the teacher to act as modeler in a constructivist way, to achieve their educational objectives. A large part of university engineering and science careers include the teaching of chemistry within their curricula, including, most of the time, chemistry lab experiments, generally described in a lab manual experiments, consisting of a series of specific activities, in accordance with their learning objectives. Although the instructions of the lab manual experiments must be written in a clear and understandable way for the students and make it easier to the instructor to explain the development of each of them, the use of flow charts in a similar way to other technological subjects, outlining the activities to be carried out during this process, can be of great help because it allows visualizing all or part of it. Flow charts are sometimes part of the reports of the chemistry lab experiments requested to the students to evaluate their work, or they are elaborated and presented by the instructors, but in this case, each of the students should bring a previous flow chart describing step by step all their activities, with very good results, what was observed during lab work as well as in the contents of its reports and in their grades.

Key words: Educational Innovation, Flow chart, Chemistry, Lab experiments

Elaboración previa de diagramas de flujo por los alumnos como apoyo en la realización de prácticas en laboratorios de química de educación superior

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Resumen

El uso de diagramas de flujo en la enseñanza de diversas materias de las carreras del área técnica superior como las relacionadas con la informática o con los procesos de ingeniería en sus diferentes ramas es de gran utilidad para facilitar la comprensión de sus contenidos, ya que apoyan el conocimiento procedimental y facilitan al profesor actuar como modelador de una forma constructivista, para lograr sus objetivos educativos. Gran parte de las carreras universitarias de ingeniería y ciencias contemplan la enseñanza de química dentro de sus planes de estudio, incluyendo la mayoría de las veces, la realización de prácticas en sus laboratorios, generalmente descritas en manuales de diversos tipos, consistentes en una serie de actividades específicas, acordes con los objetivos de aprendizaje de las mismas. Si bien, las instrucciones que aparecen en cada una de las prácticas de estos manuales, deben estar redactadas de una manera clara y comprensible para los alumnos quienes las ejecutaran, adicionalmente son un auxiliar del profesor durante el desarrollo de cada una de ellas, el uso de los diagramas de flujo de una manera similar a otras materias tecnológicas, esquematizando las actividades a realizar durante este proceso, puede ser de gran ayuda pues permite visualizar todo el procedimiento o en partes específicas. Los diagramas de flujo forman parte ocasionalmente de los reportes de las prácticas de química solicitados a los alumnos, con la intención de evaluar su desempeño en el laboratorio, en otros casos son elaborados y presentados por los docentes; sin embargo, en este caso específico se les solicitó a los alumnos como un requisito para iniciar las prácticas, la presentación individual de un diagrama de flujo que describiera paso a ´paso todas las actividades de las mismas, con muy buenos resultados, el resultado se observó tanto durante el desarrollo de la práctica y se corroboro en los contenidos de sus reportes y sus comentarios.

Palabras clave: Innovación Educativa, Diagrama de flujo, Química, Practicas

1 Introducción

Un diagrama de flujo es la representación gráfica de una secuencia de pasos a seguir para llevar a cabo una actividad o resolver un problema; en otras palabras, es una estructura organizativa dividida en varias fases visuales que permiten la definición, formulación, análisis y solución de problemas como lo establece Manene (2016).

Para la elaboración de los diagramas de flujo se consideran una serie de pasos, cuya estructura debe ser organizada y objetiva para facilitar la lectura y la comprensión global de un proceso o un procedimiento de acuerdo con Aiteco (2018)

Terán (2015) plantea que el contar con organizadores gráficos como los diagramas de flujo en los procesos de enseñanza-aprendizaje, estos apoyan el aprendizaje significativo y permiten el desarrollo de ciertas habilidades que contribuyen en habilidades y competencias como aprender a pensar, así como aprender a aprender.

En cuanto al aspecto educativo, el diagrama de flujo requiere de la elaboración del pensamiento que permite optimizar información y acciones por medio de un proceso de abstracción, separando las propiedades de un objeto través de una operación mental, organizando los procesos y conceptos de una manera simple, ordenada y lógica al analizar y extraer ideas específicas de una idea en conjunto, representándolas gráficamente por medio de ideas resumidas (Educación 3.0, 2018).

Generalmente, las prácticas de laboratorio de química están contenidas en manuales con formatos explícitos, incluyendo las especificaciones de los procedimientos, los materiales necesarios, las cantidades de sustancias que se usaran; sin olvidar el contexto teórico que sustenta el tema de la misma, así como sus objetivos, además se indica como deberá hacerse el reporte (Alcázar, 2016, Millán,2016).

La combinación de los diagramas de flujo con los procedimientos que se llevan a cabo durante la realización de las prácticas es elaborado en ocasiones por el docente como lo refiere Bahadir (2009) para explicar el desarrollo de las mismas y también se presentan en algunos manuales, pero esto sucede normalmente como una parte del reporte de las prácticas realizadas por los alumnos como el manual de Valdés (2016) o en el manual de la Universidad de las Américas (2016) aunque cabe aclarar que también hay docentes que piden un diagrama de flujo, un diagrama de bloques o un esquema, como lo indica el manual de Esteban (2014), en el que se requiere un pre-reporte que incluye el título de la práctica, un fundamento teórico complementario y un diagrama de flujo o un esquema grafico que presente de una manera resumida el procedimiento descrito en la metodología a seguir, o como en el caso de Kuwata (2005), que penaliza a los alumnos que no se presenten con un diagrama de flujo de los procedimientos experimentales hecho a mano en sus cuadernos de trabajo del laboratorio.

En este trabajo se analiza la conveniencia de solicitar a los alumnos que van a realizar prácticas de química en un laboratorio, un diagrama de flujo o de bloques con los procedimientos respectivos antes de dar inicio cada práctica, es decir que el estudiante deberá hacer una lectura previa a cada sesión.

2 Metodología

Se seleccionó un grupo de estudio con alumnos que cursaban un laboratorio del área química a los que como en cualquier curso de laboratorio se le dieron las instrucciones y las políticas de trabajo al inicio del mismo.

A diferencia de otras ocasiones con cursos similares a este grupo de estudio, se les solicitó que cada alumno integrante de los equipos de trabajo de laboratorio, debería elaborar un diagrama de flujo que incluyera todos los procedimientos para llevar a cabo los experimentos concernientes a cada una de las diferentes sesiones de laboratorio a lo largo del curso.

A los estudiantes se les indicó que los diagramas de flujo podían ser elaborados con diversos símbolos o solo con bloques, pero que deberían ser presentados de una forma impresa antes de iniciar cada una de las sesiones de las prácticas de laboratorio.

La indicación anterior fue una consideración importante, para que los alumnos demostraran que habían elaborado el diagrama de flujo de cada una de las practicas que iban a desarrollar con la lectura previa y detallada de cada una y podía ser elaborado a mano o con ayuda de la computadora; la siguiente instrucción fue que cada diagrama debería estar impreso, esta solicitud fue hecha con el fin de promover su elaboración con la anticipación adecuada y de esta forma minimizar al máximo la elaboración de última hora como en ocasiones algunos estudiantes acostumbran hacer con algunas tareas.

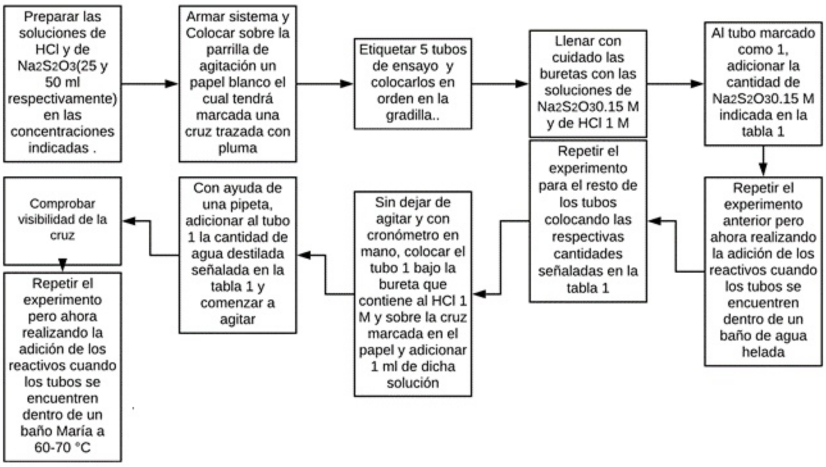
Al inicio de la clase de laboratorio de química, el docente reviso y firmo el diagrama presentado por cada uno de los alumnos y la sesión de clase no daba inicio hasta haber revisado a todos, indicándoles que el diagrama firmado debía ser incluido en el reporte obligatorio de cada una de las prácticas de laboratorio, este diagrama aportaba un diez por ciento de la calificación total, de acuerdo a la rúbrica de evaluación institucional de las practicas, si el diagrama es presentado a mano, el valor máximo asignado es del cinco por ciento.

La elaboración de los diagramas de flujo previos tuvo como objetivo fomentar inicialmente la lectura del manual, adicionalmente la investigación más detallada acerca del tema de la práctica, con el fin de comprender conceptos específicos que se encuentran en las descripciones de las prácticas y de esta forma ayudar a entender su objetivo concreto, determinando su enfoque y la finalidad de la práctica, pero principalmente facilitar y clarificar la secuencia de las diferentes actividades experimentales que se llevaran a cabo durante la sesiones del laboratorio.

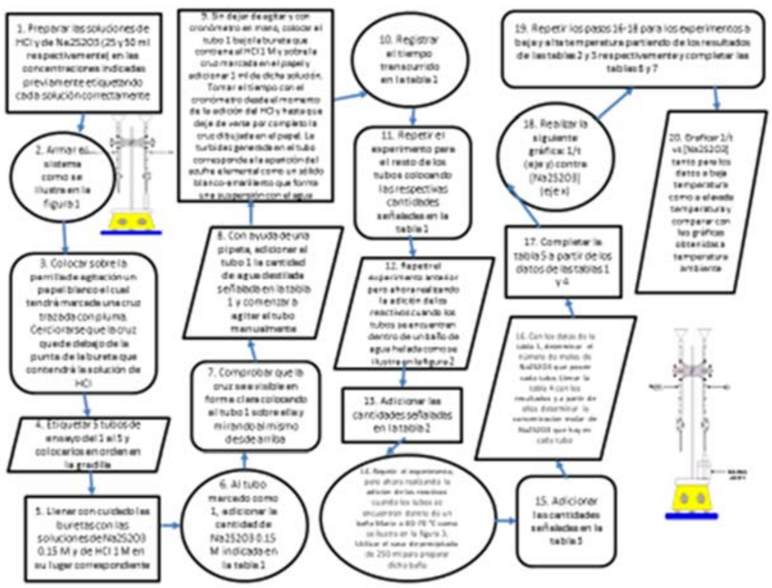
Adicionalmente, con el propósito de sondear el grado de aceptación de esta herramienta que se aplica en diversos campos de la ingeniería como la informática o en el desarrollo de diferentes procesos, se aplicó una encuesta orientada hacia una investigación cualitativa tendiente a mixta, como las planteadas por Fernández (2002) y Quecedo (2012), entre los estudiantes que cursaron esta materia, centrada básicamente en la utilidad que les podía proporcionar durante su desarrollo en el laboratorio, indagando la influencia de la visualización de los diferentes procedimientos del laboratorio de una manera resumida, simplificada y organizada para logar un aprendizaje significativo, los resultados se presentan a continuación.

3 Resultados

Los alumnos entregaron al inicio de cada sesión de laboratorio el respectivo diagrama de flujo elaborado en computadora, como puede observarse en los siguientes ejemplos, el diseño y formato fueron totalmente libres solo debieron cubrir todo el procedimiento, paso a paso, sin olvidar materiales, reactivos utilizados y sus cantidades, así como las actividades complementarias como marcaje, elaboración de tablas para recopilar información; es importante mencionar que los estudiantes practican sus habilidades para analizar y sintetizar la información que está en sus manuales y lo hace para cada práctica, es decir que esta actividad la realizan al menos 25 veces cada uno de ellos durante todo el curso; motivo por el cual en este trabajo solo se incluyen dos de los muchos diagramas aportados por los estudiantes.



Ejemplo de Diagrama de Flujo1. Cinética química



Ejemplo de Diagrama de Flujo 2. Cinética química

Cabe mencionar que para algunos estudiantes no es sencillo sintetizar los contenidos en los que se describen los procedimientos, algunos otros incluyen figuras o esquemas descriptivos del material de laboratorio utilizado en cada práctica, suponiendo que con esto se mejora la presentación de la información.

En general se pudo observar que los estudiantes consultaban el manual durante las sesiones esporádicamente, concentrando más su atención en el uso del diagrama de flujo, incluso algunos estudiantes solo trabajaron con este.

Finalmente, con el propósito de conocer la opinión de los estudiantes se hizo un sondeo cualitativo y se recabaron las siguientes respuestas de las preguntas más representativas, todas relacionadas con la elaboración previa de los diagramas de flujo de las prácticas de laboratorio.

Conceptos importantes de cada pregunta	**% Aceptación**	**% Rechazo**
Facilidad para comprender conceptos teóricos	84	16
Desarrollo de la práctica solo con el manual	69	31
Desarrollo de la práctica solo con el diagrama de flujo	29	71
Desarrollo de la práctica con el manual y el diagrama	75	25
Utilidad del diagrama de flujo elaborado por cada estudiante	92	8
Relación entre aprendizaje y la elaboración del diagrama de flujo	80	20

Como pueden observarse las respuestas breves ante este cuestionario informal, los alumnos reconocen que la elaboración de un diagrama de flujo les facilita la comprensión de los conceptos teóricos de cada practica; y a pregunta expresa sobre sus preferencias para trabajar con el manual o el diagrama de flujo solamente, refieren que es mejor que ambas herramientas se utilicen simultáneamente en cada sesión y finalmente confirman la utilidad de elaborar su propio diagrama y presentarlo al inicio de cada sesión practica pues desde su punto de vista si creen que hay una relación entre su aprendizaje y esta actividad.

El noventa por ciento de los estudiantes presentó a tiempo el diagrama de flujo solicitado de la manera especificada en las instrucciones iniciales, esta actividad se llevó a cabo durante todo el curso, siempre haciendo la entrega del mismo al inicio de cada sesión de laboratorio.

Es importante señalar que los estudiantes hicieron mucho menos preguntas acerca de los procedimientos experimentales durante el desarrollo de las prácticas de química en el laboratorio que en los otros grupos, que solo se basaron en las instrucciones del manual de laboratorio.

Un ochenta y cuatro por ciento de los alumnos opinaron que la realización de un diagrama de flujo previo a la realización de una práctica de laboratorio, facilitaba la comprensión de los conceptos teóricos involucrados en las mismas.

Algunas otras respuestas mostraron la siguiente información, el veintinueve por ciento de los alumnos preferiría trabajar únicamente con el diagrama que realizó previamente, comparado con el setenta y cinco por ciento que combinó el diagrama con el manual de laboratorio; aunque el cuarenta y cinco por ciento consideraba que el diagrama lo debería realizar el profesor o en su defecto, que viniera incluido en el manual de prácticas

Otra consideración fue hecha por el noventa y dos por ciento de los alumnos, quienes mencionaron que contar con un diagrama de flujo, aunque no fueran ellos mismos los autores, era de gran ayuda para la realización de las practicas pues les facilitaba llevar a cabo los diferentes procedimientos de cada practica en un menor tiempo al establecido para cada sesión.

El ochenta por ciento de los estudiantes estuvieron de acuerdo en que era mejor hacer los diagramas por computadora, que a mano pues lo inducia a hacerlo con anticipación en cada una de las sesiones de laboratorio y les era de gran utilidad contar con el diagrama previo elaborado por ellos mismos, aunque solo el sesenta por ciento creía conveniente que se aplicará el mismo procedimiento en otros laboratorios que estuvieran cursando.

El grupo de alumnos que trabajó de esta forma, tuvo un mejor desempeño académico que los alumnos que solo utilizaron el manual de laboratorio, lo que se corroboró con las calificaciones obtenidas y comparadas entre ellos, adicionalmente se observaron diferencias en el tipo de preguntas que realizaban y en el manejo de los conceptos de los diferentes temas involucrados en las prácticas que llevaban a cabo, se puede suponer que se debió a la forma constructivista de aprendizaje que se presenta cuando los alumnos llevan a cabo el análisis de las diferente etapas de las prácticas y que plasman en los bloques que conforman los diagramas o esquemas de flujo que elaboran, una vez comprendidos los conceptos, acentuando su capacidad de análisis y de síntesis .

4 Conclusiones

La preparación de los diagramas de flujo previos a la realización de las prácticas de laboratorio de química consiste básicamente en describir con antelación de una forma clara y gráfica los procesos inherentes a las mismas, es decir que, para realizar un diagrama de flujo es necesario analizar y comprender los pasos secuenciales a seguir y la relación entre ellos, dirigidos al cumplimiento de los objetivos de las prácticas, para obtener los productos deseados.

La elaboración de un diagrama de flujo previamente al desarrollo de una práctica de laboratorio de química experimental es de gran ayuda para desarrollar un pensamiento más estructurado en los estudiantes, ya que el proceso de elaboración de un diagrama de flujo requiere de otros procesos de comprensión y análisis más profundo, en otras palabras hay un aprendizaje significativo, basado en el constructivismo, que les permiten sintetizar cada una de las partes de un proceso a realizar en el laboratorio.

Debido al análisis que se requiere realizar de los diferentes pasos que se presentan en las prácticas de química , el diagrama de flujo permite aprender y conceptualizar sobre los fenómenos llevados a cabo en la experimentación y comprender cómo es que estos forman parte de un producto a mayor escala y su relación con los demás pasos a tomar, permitiendo la identificación de aquellos procesos que se deben controlar y desarrollar por cuenta de los alumnos y por lo tanto fortalecen en los mismos la toma de decisiones, de la misma forma que la comprensión de conceptos y la secuencia lógica de las actividades a seguir para alcanzar los objetivos de las diversas prácticas de un curso de laboratorio de química.

La mayoría de los alumnos del curso de laboratorio, reconocieron la utilidad de la elaboración previa de los diagramas de flujo de las prácticas de química, facilitando su comprensión y realización en combinación con el manual de prácticas.

En general, se puede decir que los estudiantes en el laboratorio de química que elaboraron previamente sus diagramas de flujo, trabajaron de una forma más eficiente a lo largo del curso que los que no lo hicieron en otros cursos similares y también se puede observar que sus evaluaciones finales fueron más altas, debido a un mejor desempeño académico.

La epistemología asociada a esta forma de trabajo, parece inducir inicialmente a un aprendizaje heurístico en los alumnos ya que el comportamiento del profesor promueve el constructivismo en ellos, aunque posteriormente se puede comportar más bien como modelador ya que el aprendizaje en un curso de este tipo, se basa gran parte en algoritmos, que al complementarse mutuamente se orienta hacia un aprendizaje significativo.

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Tracking the utilization of Project based learning by the students of the Chemical Engineering School at Autonomous University of Yucatan

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Abstract

The present work consisted in a descriptive tracking of the students at the School of Chemical Engineering of the Autonomous University of Yucatan during de period 2016 to 2018 in the companies where they carried out their professional practices (internship) which must be done in a mandatory way in two period of 480 hours depending on their bachelor. A format was applied at the beginning of the internship to know what the assignment was for the student: being able to be a project or activities to be carried out during their stay. Preliminary results indicate that the percentage is greater in the allocation of activities than projects. Therefore, it can be concluded that companies should be approached to promote the use of the PBL with the interns.

Keywords: Professional practices; internship; projects; project-base learning; activities.

Seguimiento de la aplicación del aprendizaje basado en proyectos durante las prácticas profesionales en los estudiantes de la Facultad de Ingeniería Química de la Universidad Autónoma de Yucatan

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Resumen

La presente investigación en un trabajo descriptivo que consistió en el seguimiento de las prácticas profesionales de los estudiantes la Facultad de Ingeniería Química de la Universidad Autónoma de Yucatán durante el período 2016 a 2018 en las empresas donde realizaron sus prácticas profesionales, las cuales se realizan de manera obligatoria en dos periodos de 480 hs dependiendo de la licenciatura. Se aplico un formato al inicio de las prácticas para conocer cuál fue la asignación para el estudiante: pudiendo ser proyecto o actividades a realizar durante su estancia. Los resultados preliminares indican que el porcentaje es mayor en la asignación de actividades que proyectos. Por lo anterior se puede concluir que se debe tener un acercamiento con las empresas para promover el uso del PBL durante la estancia de los estudiantes en las mismas.

Keywords: prácticas profesionales; estancia laboral; aprendizaje basado en proyectos; actividades.

1 Introducción

La Universidad Autónoma de Yucatán (en adelante UADY) en el año 2001 tras un proceso de planeación estratégica declara su Modelo Educativo y Académico (UADY, 2012), el cual está basado en nueve principios educativos de los cuales cabe resaltar el cuatro, seis y siete que se basan respectivamente en lo siguiente:

- La educación está dirigida a la totalidad del ser humano; centra su atención en el alumno como sujeto de su propia educación, y crea las condiciones para que esto suceda.
- El aprendizaje se facilita cuando el estudiante participa responsablemente en el proceso mismo, asignando a la enseñanza el papel estimulador.
- La participación activa y responsable del alumnado es indispensable para que fortalezca su capacidad de pensamiento crítico y reflexione sobre sus sentimientos, valores, convicciones y acciones como profesionales regidos por principios éticos.

Además este modelo tiene como ejes la *flexibilidad y la innovación* con ocho componentes, siendo dos los que principalmente refuerzan el rol del estudiante en la construcción de su aprendizaje: el que promueve que el estudiante debe tener menor actividad presencial y mayor tiempo dedicado al aprendizaje y el que fortalece la vinculación con el medio extra institucional.

Para el año 2012 la Universidad redefine su modelo educativo al actual denominado Modelo Educativo para la Formación Integral (en adelante MEFI) complementando los ejes anteriormente mencionados adecuándolos al contexto internacional en lo referente a las tendencias internacionales y nacionales en el ámbito educativo.

En la siguiente tabla se muestran las características y elementos del Modelo Educativo y Académico (en adelante MEyA) que se mantienen o replantean en el MEFI.

Tabla 2. Rol del profesor y del Estudiante en el MEyA y MEFI. Fuente: adaptación (UADY, 2012)

	MEyA	MEFI
Rol del profesor	• Facilitador(a) y promotor(a) del aprendizaje y trabajo en grupo.	• Además de facilitador)a) y tutor(a), es asesor(a) y gestor(a). • Se defini el perfil de la y el profesor UADY.
Rol del estudiante	• El estudiante es el actor principal del proceso de enseñanza y aprendizaje. • Menor actividad prescencial y mayor tiempo dedicado al aprendizaje fuera del aula.	• El estudiante sigue siendo el actor principal del proceso de enseñanza y aprendizaje. • Se definen las competencias genéricas que debe desarrollar la o el estudiante UADY. • Se fortalece la menor actividad presencial y mayor actividad fuera del aula.

Por otra parte el MEFI define dentro de sus planes de estudio lo que son las competencias genéricas como la base para la construcción de otras, y las profesionales como aquellas que serán útiles para la práctica profesional que de acuerdo con Larraín y González (2005) citado por (UADY, 2012), se consideran capacidades asociadas a la realización eficaz de tareas determinadas de tipo profesional.

La Facultad de Ingeniería Química de la UADY declara en sus mallas curriculares las prácticas profesionales como asignatura obligatoria asignándole un valor alto de créditos y posicionándolas en los últimos dos semestres para el logro de las competencias profesionales.

Justifica la práctica profesional dentro del programa educativo como un ejercicio guiado y supervisado, en el que se le permite al estudiante utilizar las competencias que ha desarrollado y/o desarrollar otras nuevas asociadas con el perfil de egreso como habilidades profesionales a través de la participación en la elaboración de proyectos que contribuyan a la detección y solución de problemas específicos de una empresa, proporcionando experiencia laboral a los futuros egresados para incrementar su competitividad y con esto promover su integración al campo laboral. (Facultad de Ingeniería Química, 2014a)

Las Licenciaturas de Ingeniería Industrial Logística (en adelante IIL) e Ingeniería Química Industrial (en adelante IQI) cuentan con dos módulos cada una denominados *Módulo o Taller de Experiencia en el Trabajo* respectivamente de 480 horas cada uno (Facultad de Ingeniería Química, 2014b); en el caso de las Licenciaturas Ingeniería en Alimentos (en adelante IA) (Facultad de Ingeniería Química, 2010a) e Ingeniería en Biotecnología (en adelante IB) (Facultad de Ingeniería Quimica, 2010b) cuentan con un único módulo denominado *Estancia Laboral* y la Licenciatura en Química Industrial (QI) (Facultad de Ingeniería Química, 2006) el módulo se denomina Taller de Experiencia en el Trabajo de 480 horas.

La asignatura está bajo la responsabilidad de dos profesores quienes se encargan de realizar la difusión entre las empresas de la apertura del período de prácticas de los estudiantes y convocarlas para el reclutamiento de los mismos. Por otro lado la empresa es la encargada de asignarles el programa de *actividades* o el *proyecto* a desarrollar así como el nombramiento de un supervisor por parte de la empresa. Los estudiantes laboran en la empresa seleccionada, al menos cinco horas diarias y deben elaborar reportes periódicos y un reporte final, que deberán contar con el visto bueno de la empresa y serán calificados por el profesor. Al finalizar el período, los estudiantes reciben de la empresa una constancia por el número de horas realizadas de experiencia laboral, (Facultad de Ingeniería Química, 2004).

Algunos programas profesionales han adoptado el aprendizaje basado en proyectos (en adelante PBL), estrategia educativa que pone énfasis en el aprendiz, para desarrollar profesionales de nivel básico con habilidades sólidas en las áreas de pensamiento crítico, resolución de problemas, comunicación, trabajo en equipo, autodirección y aprendizaje permanente. En el PBL, el problema (que viene primero) sirve como base para la construcción del conocimiento por parte de los estudiantes. Si bien el contenido es importante, el PBL también enfatiza el proceso: buscar información a través de la investigación de un tema, aplicar información a un problema en particular y generalizar el contenido y el proceso a situaciones y personas similares, como menciona (Luebben, 2005).

2 Objetivo

Conocer si el programa de trabajo asignado por la empresa a los estudiantes durante la realizacion de sus practicas profesionales corresponde al desarrolo de un proyecto o actividad e identificar el area en el cual se aplico dicho proyecto.

3 Metodologia

Se realizo una investigacion de tipo descriptiva y exploratoria ya que se mostrara mediante la recopilacion de datos las caracteristicas de la muestra. La aplicacion del instrumento (encuesta) se realizo una sola vez por semestre a la poblacion de estudiantes cursando la asignatura de practicas profesionales. El instrumento fue validado por los profesores ur imparten la asignatura el cual consitio en un cuestionarios de tipo abierta para la recopilacion de datos generales, cerrada dicotomica principalmente para conocer sobre el tema u objeto de estudio y de opcion multiple. El instrumento se aplico de forma directa-personal via web.

4 Resultados

En la siguiente tabla se muestra la distribución del total de la población de estudiantes (279) que realizaron sus prácticas en alguno de los períodos comprendidos entre junio de 2016 a junio de 2018, y las funciones desempeñadas en la empresa por módulo.

Tabla 2. Estadística descriptiva de la muestra.

	Funciones desempeñadas		**Total alumnos**
Módulo	Actividades	Proyecto	
I	34%	14%	48%
II	30%	14%	44%
Único	4%	4%	8%
	68%	32%	100%

De acuerdo a la tabla anterior se puede segmentar la información obtenida observando que el 12% del total de los estudiantes que realizaron proyecto pertenecía al módulo único y el resto a los módulos I y II con 44% cada uno.

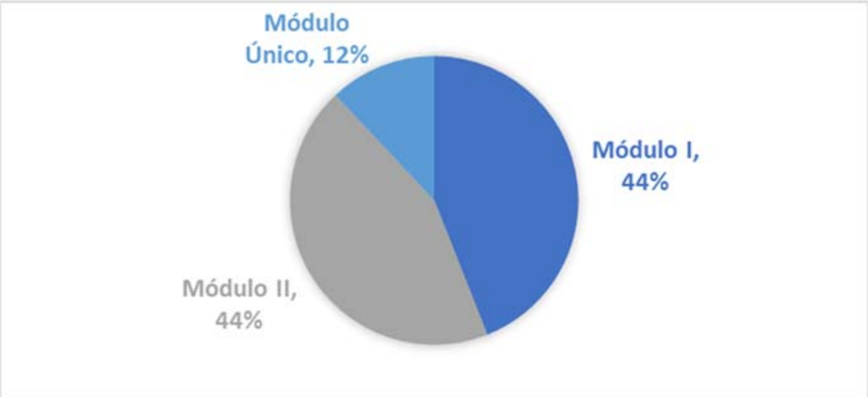

Figura 2. Segmentación de la población por módulo que realizó Proyecto.

Módulo único

Con respecto a los practicantes que cursan un único módulo se observa en la siguiente figura que los estudiantes de la licenciatura de IB son quienes más desarrollan proyectos durante sus estadías con un 90% conformado por un 50% hombres y 40% mujeres, en segundo lugar, se encuentran los QI conformado únicamente por hombres representando el 10% restante. Cabe señalar que los IA de la muestra únicamente realizaron actividades durante su estadía y no fue representativo el número de estudiantes.

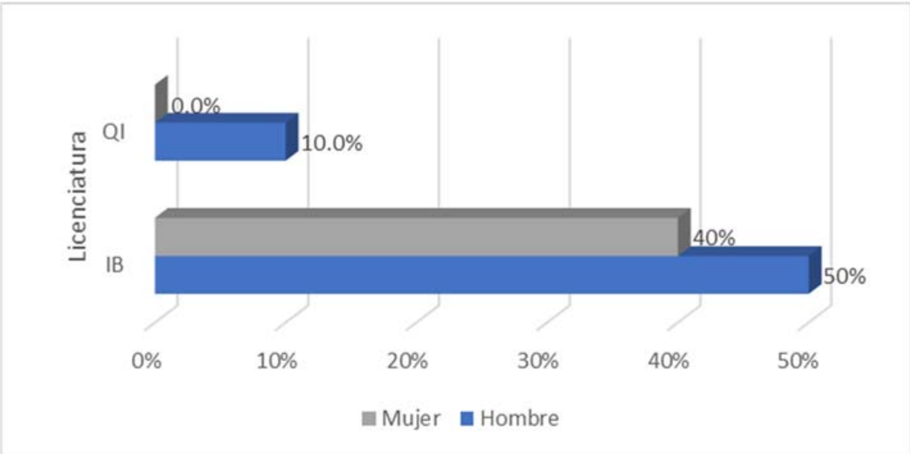

Figura 3. Segmentación del módulo único por género.

Con respecto a las áreas donde se realizaron los proyectos: en la figura 3 se observa que el porcentaje más alto con un 30% corresponde al área de investigación y desarrollo que es donde se ubicaron en su mayoría a los IB y las demás áreas tuvieron el mismo porcentaje con un 10% ubicando a los QI en producción.

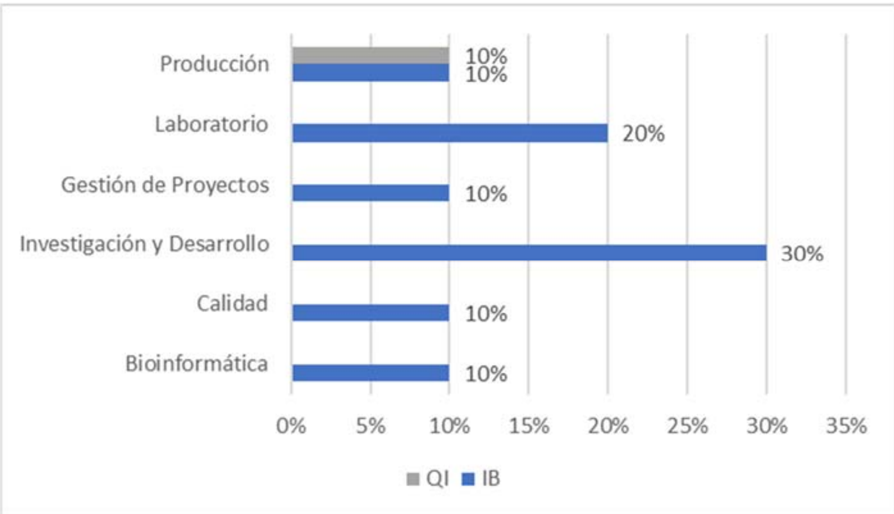

Figura 4. Áreas donde se realizaron proyectos en el módulo único.

Módulo I

Con respecto a los practicantes que cursaron el módulo I se observa en las siguientes figuras que los estudiantes de la licenciatura de IIL son quienes más desarrollan proyectos durante sus estadías con un 58%

conformado por un 42% hombres y 16% mujeres. Los IQI representan el 42% restante conformado por un 16% hombres y 26% mujeres.

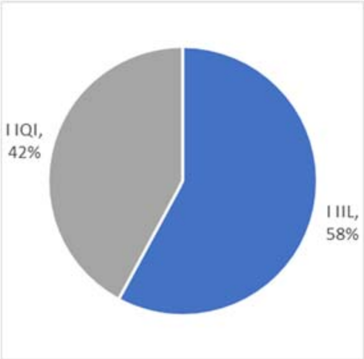

Figura 4 Segmentación de la población del módulo I por licenciatura

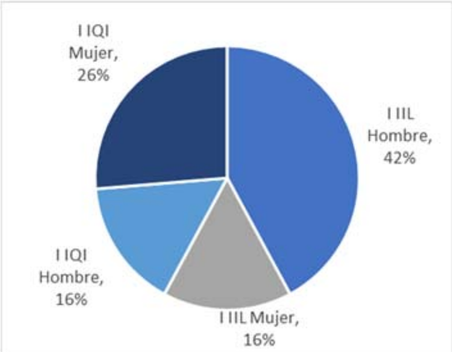

Figura 5 Segmentación de la población del módulo I por genero

Con respecto a las áreas donde se realizaron los proyectos: en la figura 6 se observa que el porcentaje más alto con un 13% corresponde al área de Producción que es en donde se ubicaron en su mayoría los IQI. Para los IIL el porcentaje más alto corresponde al área de ingeniería de procesos.

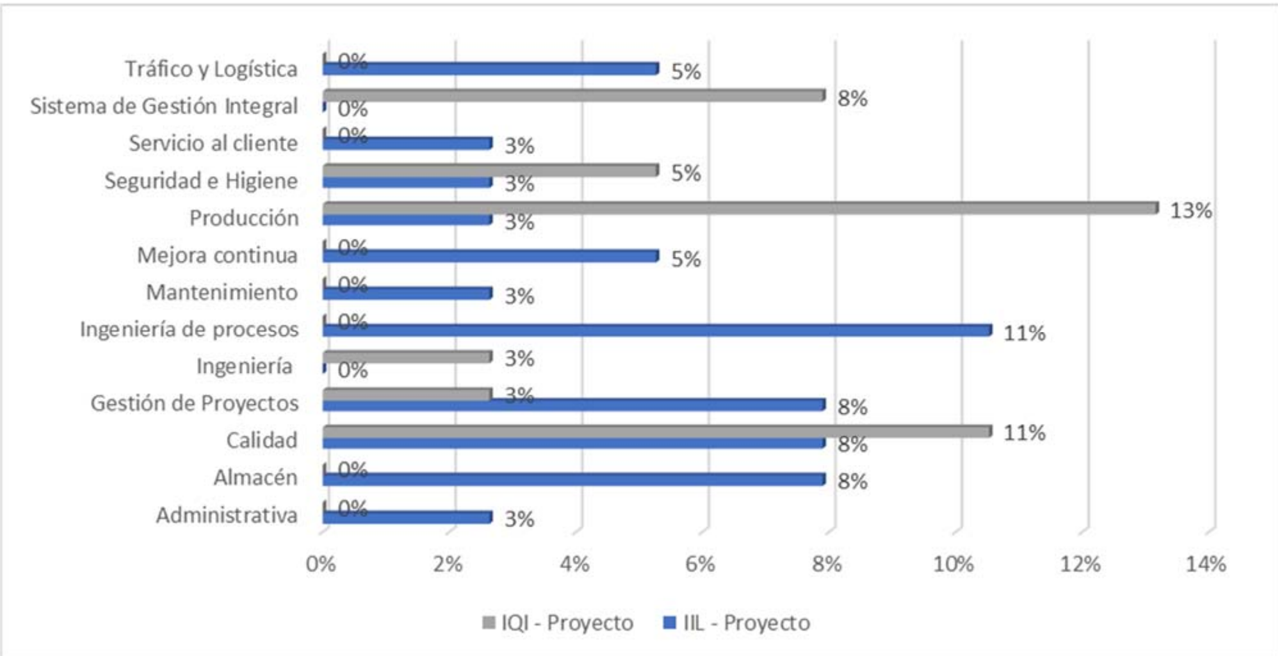

Figura 6 Áreas donde se realizaron los proyectos en el módulo I

Cabe señalar que de las trece áreas en cuestión los IQI únicamente se desempeñaron en seis mientras los IIL lo hicieron en 11.

Módulo II

Con respecto a los practicantes que cursaron el módulo II se observa en las siguientes figuras que los estudiantes de la licenciatura de IIL son quienes realizan más proyectos durante sus estadías con un 53% conformado por 40% hombres y 13% mujeres. Los IQI representan el 47% restante conformado por 13% hombres y 34% mujeres.

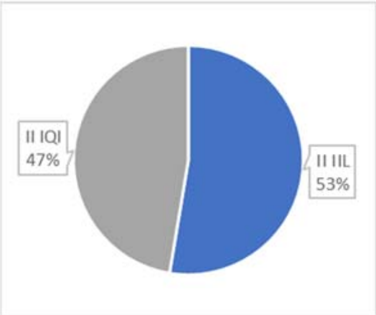

Figura 7. Segmentación del módulo II por Licenciatura.

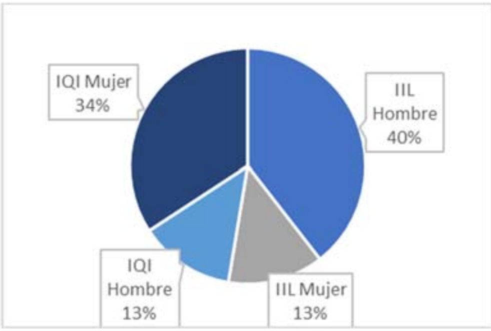

Figura 8. Segmentación del módulo II por género.

Con respecto a las áreas donde se realizaron los proyectos: en la figura 9 se observa que el porcentaje más alto con un 16% corresponde al área de tráfico y logística donde únicamente se ubicaron los IIL. Para los IQI los porcentajes más altos correspondieron a las áreas de calidad y producción con un 11% cada una.

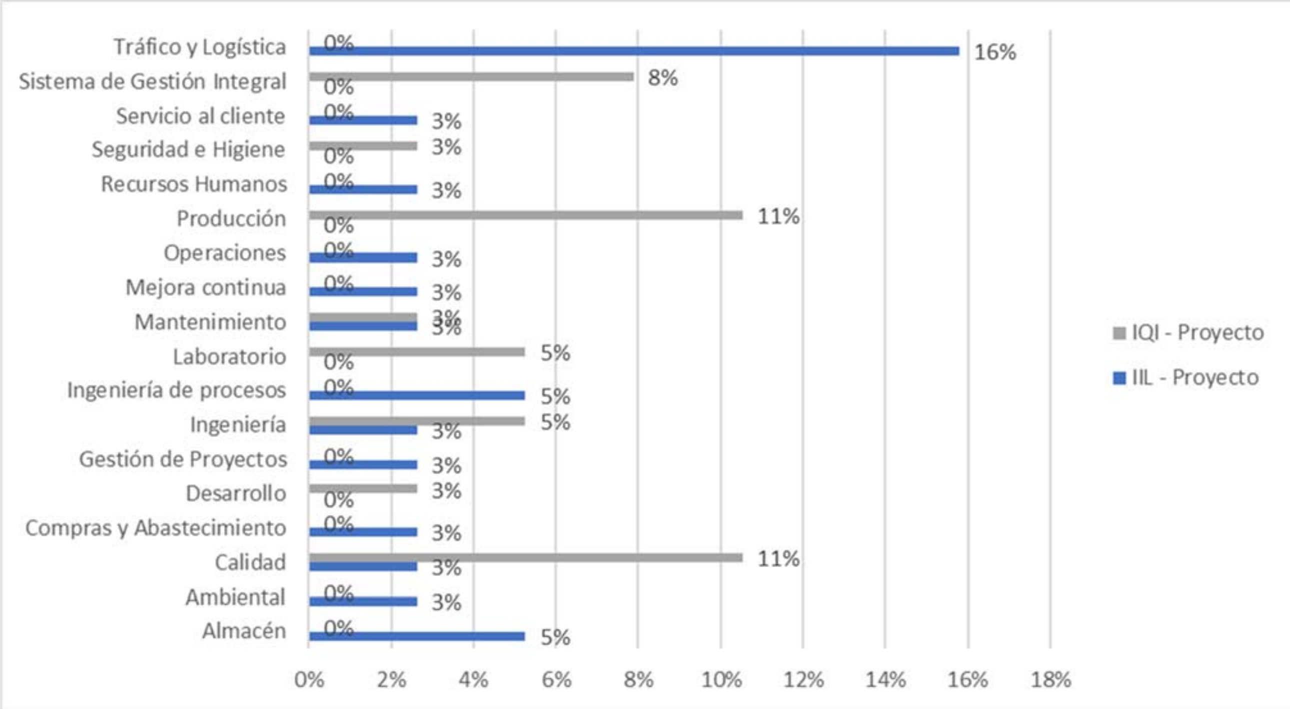

Figura 9 Áreas donde se realizaron los proyectos del módulo II por licenciatura.

Cabe señalar que de las 18 áreas los IQI se desempeñaron en ocho mientras los IIL lo hicieron en 13.

5 Conclusiones

De acuerdo a alos resultados obtenidos del seguimiento de los estudiantes en sus practicas profesionales durante el periodo evaluado se puede concluir que las empresas estan asignando con mayor frecuencia actividades de tipo rutinaria a los estudiantes observandose en todas las licenciaturas de forma general; sin embargo aquellas empresas que involucran a los estudiantes en el desarrollo o participacion en un proyecto lo desarrollan en areas que estan directamente relacionadas con sus licenciaturas.

El presente trabajo unicamente se enfoco en conocer si estan realizando algun proyecto sin precisar el tipo de metodologia que utilizan, se sugiere continuar con este trabajo para poder conocer si los estudiants utilizan el PBL y si logran aplicar los conocimientos adquiridos durante su formacion asi como adquiriri nuevos que complementen su formacion. Por otro lado el conocer que tipo de proyectos estan realizando permitiria a la institucion saber si los estudiantes estan desempeñandose de acuerdo al perfil de egreso declarado en el plan de estudios.

La retroalimentacion del desempeño del etudiante en el proyecto por parte del supervisor dentro de la empresa es un aspecto de suma importancia que podria ser un factor clave para la insercion del estudiante en el mundo laboral de forma inmediata aunque este no haya egresado, ya que habran desarrollado habilidades y competencias tanto genericas como especificas que no logran desarollar los estudiantes que unicamente realizaron actividades durante su estadia en la empresa.

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Identification of entrepreneurial skills through group analysis

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Abstract

At present, there is great interest on the part of the government to support the formation of entrepreneurs in higher education institutions. The teaching of entrepreneurial abilities and skills among upper level students is considered a priority to contribute to economic and social development, however on the one hand it must be recognized that for the correct development of skills in students of this type of courses, it is required of interactive strategies that predominate over conventional ones, it is not enough to do exercises or paper projects, it is necessary to move on to reality, but also a fundamental aspect is evaluation. The group of academics presenting this work has developed and applied different strategies to develop entrepreneurial skills in the aforementioned terms, but also advances in the sense of evaluation. Previously a study was developed to evaluate the competences acquired by the students and now the objective of this work is to evaluate the activities carried out for the acquisition of those competences from the student's perception. A questionnaire was applied to all participants of the entrepreneurship course taught in the 2018 cycle at the Chemical Engineering School (FIQ) of the Autonomous University of Yucatan (UADY). The results make it possible to appreciate which activities contribute to the achievement of each competence and which ones should serve the teachers to confirm, redesign or, where appropriate, withdraw activities that do not contribute to the development of necessary competences for entrepreneurs.

Keywords: Entrepreneurs, competences, learning activities, project-based learning, evaluation.

Identificación de competencias emprendedoras a través del análisis de grupos

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Resumen

En la actualidad existe gran interés por parte del gobierno en respaldar la formación de emprendedores en las instituciones de educación superior. La enseñanza de habilidades y capacidades emprendedoras entre los estudiantes de nivel superior se considera prioritaria para que puedan contribuir al desarrollo económico y social, sin embargo por un lado hay que reconocer que para el correcto desarrollo de habilidades en los alumnos de este tipo de cursos, se requiere de estrategias interactivas que predominen sobre las convencionales, no basta con hacer ejercicios o proyectos de papel, se requiere pasar a la realidad, pero además un aspecto fundamental es la evaluación. El grupo de académicos que presenta este trabajo ha desarrollado y aplicado diferentes estrategias para desarrollar competencias emprendedoras en los términos antes mencionados, pero también avanza en el sentido de la evaluación. Anteriormente se elaboró un estudio para evaluar las competencias adquiridas por los estudiantes y ahora el objetivo de este trabajo, es evaluar las actividades realizadas para la adquisición de esas competencias desde la percepción del estudiante. Se aplicó un cuestionario a todos los participantes del curso de emprendedores impartido en el ciclo 2018 en la Facultad de Ingeniería Química (FIQ) de la Universidad Autónoma de Yucatán (UADY). Los resultados permiten apreciar que actividades contribuyen al logro de cada competencia y cuales deben servir a los profesores para confirmar, rediseñar o en su caso retirar actividades que no contribuyan al desarrollo de competencias necesarias para los emprendedores.

Palabras clave: Emprendedores, competencias, actividades de aprendizaje, aprendizaje basado en proyectos, evaluación.

1 Introducción

El interés por incrementar las capacidades emprendedoras entre los estudiantes de nivel superior se debe a la relación que existe entre el emprendedor como realizador de innovaciones y su aplicación a los problemas que implica el desarrollo económico y social, Joseph Schumpeter, al introducir el concepto de innovación refiere que son los emprendedores quienes la convierten en realidad (Schumpeter, 2017).

La preocupación por lograr una educación emprendedora tiende a estar cada vez más integrada en la agenda de los gobiernos dado que se considera fundamental e incluye acciones que van desde la escuela primaria hasta la universidad, en países como Australia, Países Bajos, Reino Unido, Estados Unidos, Finlandia y Canadá los ministerios de Economía o Industria ya han hecho esfuerzos para introducir actividades de formación de vocaciones y competencias emprendedoras a lo largo de los programas de estudio (Ellingson & Noe, 2017; Kantis, 2017).

En América Latina y el Caribe los esfuerzos para introducir la educación empresarial en los niveles primario y secundario del sistema formal de educación aún son incipientes, pero en las universidades, se comparte la opinión de que la educación emprendedora debe impartirse en todas las carreras y facultades, no sólo en las escuelas de negocios o de administración (Alarc & Serrano, 2017; Carlos, Castillo, Lira, & Iuit, 2014; Kantis, 2017). La incorporación de cursos de "entrepreneurship" en las universidades es un proceso que inició en estados unidos hace más de 25 años y ha crecido de manera significativa en todo el mundo, así en Latinoamérica la lista de universidades que han seguido esta tendencia es extensa y en permanente crecimiento (Fuertes Sanchez et al., 2015; Kokotsaki, Menzies, & Wiggins, 2016). En 1919, inicia operaciones en Estados Unidos la *Junior Achievement*, organización no lucrativa dedicada a la generación del "espíritu emprendedor" en niños y jóvenes desde primaria hasta la universidad; en México, Desarrollo Empresarial

Mexicano "DESEM", filial de esta misma organización introduce sus programas en 1974, mientras que en el caso de la Universidad Autónoma de Yucatán (UADY), ocurrió en 1997 (Santibañez, 1996).

2 Objetivo

El presente trabajo reconoce que en la Facultad de Ingeniería Química de la UADY, se aplican y diseñan programas, modelos y actividades que pretenden contribuir a la formación emprendedora pero se considera que un aspecto fundamental es la evaluación, se tiene avances importantes en la evaluación de competencias adquiridas por los estudiantes pero se debe profundizar evaluando las actividades que generan estas competencias y ese es el objetivo del presente estudio.

3 Materiales y métodos

3.1 Materiales

Se elaboró un cuestionario que se aplicó a los alumnos de la facultad de ingeniería química que cursaron el taller de emprendedores en un ciclo académico en donde se les pidió asociar las competencias que pretende aportar el curso y en consecuencia a su formación. Esta relación asociando cuales de las actividades de aprendizaje realizadas en el taller consideraban que tenían una mayor contribución al logro de cada una de las competencias cuyo aprovechamiento fue evaluado previamente. Es importante destacar que las actividades se clasificaron en cuatro grupos: a) Producto que abarca la decisión de que producir, su desarrollo conceptual y su estandarización. b) Mercado que implica las pruebas que se realizan en expos y feria, decisiones de oferta, precio, realizar ventas y concursos. c) estratégicas que abarcan la búsqueda de ideas de negocio aplicando técnicas de creatividad, análisis de resultados, reflexión y planes de mejora. Y d) Administración que tienen que ver con la operación de la empresa en aspectos como la elaboración de presupuestos, financiamiento del proyecto, juego de roles e integración de conocimientos por áreas. Precedentes similares y otras experiencias también los podemos encontrar en (Alves et al., 2016; Lima, Andersson, & Saalman, 2017; Lima, Carvalho, Assunção Flores, & Van Hattum-Janssen, 2007), entre otros.

3.2 Métodos

El objetivo principal de los siguientes métodos es analizar la estructura común de las distintas tablas de datos, poniendo de manifiesto cuáles son los elementos heterogéneos, es decir diferentes al resto. Además de los resultados clásicos las medidas globales de relación entre los grupos, permiten cuantificar la semejanza global existente entre ellos con indicadores parciales de acuerdo con el enfoque de estadística descriptiva.

4 Resultados

Al hablar de resultados resulta imposible dejar de mencionar que los estudiantes de este taller enseñan a la sociedad en su conjunto las ideas innovadoras que impulsan como emprendedores y que muchas veces demuestran con sus productos que existen nuevas opciones en diversos campos de la producción, entre los principales productos desarrollados se encuentran: jarabes de maracuyá, pitahaya, mango, galletas de arroz, de semilla de girasol, quesos, jamones, aderezos, y otros productos como bioinsecticida a base de hongos, telescopios, tapetes de uso rudo elaborados con residuos que provienen de la fabricación de neumáticos, placas ecológicas reciclando tetrapack, cursos de TIC's, nuevas formulaciones de bloqueador solar, cremas, jabones, tintes y shampoo de productos naturales de la región, etc.

En referencia a las competencias que los estudiantes adquieren o mejoran en el taller. Cabe destacar que en todas las competencias los estudiantes reconocen un beneficio de aprendizaje en la tabla 2 del trabajo publicado por (G. Canton, Lira, & Iuit, 2014) cuya encuesta fue aplicada a este mismo grupo de estudiantes, en ese estudio se demuestran los beneficios de aprendizaje, aunque en diferentes porcentajes pero en todas las competencias los estudiantes admiten un beneficio de aprendizaje.

Considerado lo anterior por la relación que implica con el taller y porque se trata de las mismas competencias pero con el objetivo de saber la contribución de las diferentes actividades de aprendizaje para su adquisición, se aplicó un nuevo cuestionario que además de verificar aspectos de la participación individual y otras percepciones, pide al estudiante asociar las competencias adquiridas con cada actividad realizada en el taller según su percepción. Los resultados de la descripción de la población se presentan en la siguiente tabla.

Tabla 3. Estadística descriptiva del perfil de la muestra.

Grupos	No	Programa	Semestre		*G1	
*1	15	IIL-IQI	7		IQI	6
2	32	IIL	5	Edad	IIL	7
					Movilidad	2

Se pueden observar algunas caracteristicas entre los grupos, por ejemplo el grupo 1, es heterogeneo y multidisciplinar. Ya que está conformado por estudiantes de dieferentes programas y estudiantes de movilidad. Además que forma parte de un lan de estudios en liquidación. En contraste con el grupo 2, con un modelo educativo en de reciente incorporación, además que la asignatura se ubica dos semestres atrás.

Tabla 4. Percepción de los estudiantes sobre la contribución de las actividades realizadas en el taller para el desarrollo de competencias 1-2.

Competencia	Actividad	Porcentaje
Búsqueda de oportunidades	Producto	41%
	Mercado	67%
	Estratégicas	39%
	Administración	26%
Perseverancia	Producto	36%
	Mercado	43%
	Estratégicas	48%
	Administración	38%
Cultura de calidad	Producto	84%
	Mercado	31%
	Estratégicas	34%
	Administración	25%
Toma de riesgos de forma calculada	Producto	50%
	Mercado	90%
	Estratégicas	4%
	Administración	55%
Capacidad de negociar	Producto	9%
	Mercado	100%
	Estratégicas	14%

	Administración	34%
Tolerar la incertidumbre	Producto	26%
	Mercado	67%
	Estratégicas	20%
	Administración	35%
Trabajar por objetivos	Producto	32%
	Mercado	45%
	Estratégicas	35%
	Administración	70%
Planificar y dar seguimiento	Producto	50%
	Mercado	40%
	Estratégicas	54%
	Administración	61%
Capacidad de gestionar recursos	Producto	14%
	Mercado	55%
	Estratégicas	22%
	Administración	100%
Búsqueda de información	Producto	59%
	Mercado	51%
	Estratégicas	55%
	Administración	46%
Capacidad de persuasión	Producto	5%
	Mercado	100%
	Estratégicas	8%
	Administración	22%
Capacidad de trabajar en equipo	Producto	32%
	Mercado	48%
	Estratégicas	25%
	Administración	100%

Tabla 5. Percepción de los estudiantes sobre la contribución de las actividades realizadas en el taller para el desarrollo de competencias 2-2.

Competencia	Actividad	Porcentaje
	Producto	16%
	Mercado	28%

Capacidad de solucionar problemas	Estratégicas	60%
	Administración	68%
Orientación al logro	Producto	25%
	Mercado	54%
	Estratégicas	41%
	Administración	50%
Iniciativa	Producto	76%
	Mercado	67%
	Estratégicas	23%
	Administración	46%
Tener criterio independiente	Producto	31%
	Mercado	55%
	Estratégicas	36%
	Administración	55%
Tener autoconfianza	Producto	22%
	Mercado	100%
	Estratégicas	16%
	Administración	33%

En general se puede afirmar que la contribución de las actividades del taller en el desarrollo de competencias, queda demostrada en la mayoría de los casos y por supuesto en mayor o menor medida según la percepción de los estudiantes.

Analizando de manera particular los resultados de la tabla 3-2 competencia y actividades por competencia, se puede observar que:

En el caso de la competencia "búsqueda de oportunidades", las actividades que más aportan a su adquisición son clasificadas en el grupo de actividades de "mercado", estas son, las pruebas que se realizan en las expociones y la feria, donde los participantes ejercitan el proceso para la toma de decisiones respecto a cuanto ofertar, a qué precio, realizar ventas a mercado abierto y participar en concursos donde son evaluados por jurados externos a la institución. El 67% de los estudiantes así lo considera.

En lo que se refiere a la competencia "Perseverancia", el 48% de los estudiantes considera que las actividades que más aportan al aprendizaje de esta competencia son las clasificadas como "Estratégicas", estas incluyen la búsqueda de ideas de negocio aplicando técnicas de creatividad, análisis de resultados por evento y reflexión e instrumentación de planes de mejora.

En cuanto a la competencia "Cultura de calidad" las actividades que más impactan de acuerdo al 84% de los estudiantes son las inherentes al producto, estas abarcan la decisión de que producir, el desarrollo conceptual del producto y su estandarización.

En cuanto a la competencia "Toma de riesgos calculada", el 90% de los estudiantes considera que las actividades que más aportan son las de mercado. Asimismo el 100% considera que este mismo grupo de actividades es el que más aporta al aprendizaje de la competencia "Capacidad de negociar" y el 67% opina que es el que más aporta para aprender la competencia "Tolerar la incertidumbre".

En el caso de la competencia "Trabajar por objetivos", el 70% considera que las actividades clasificadas en el grupo de "administración" son las que más contribuyen a la adquisición de esta competencia. Asimismo el 61% considera que este mismo grupo de actividades es el que más ayuda para adquirir la competencia "Planificar y dar seguimiento" y el 100% opina que este mismo grupo el que más aporta en la adquisición de la competencia "Capacidad de gestionar recursos".

En lo que respecta a la competencia "Búsqueda de información", el 59% de los estudiantes indica que el grupo de actividades clasificado en "producto" es el que más aporta.

En referencia a la competencia "Capacidad de persuasión", el 100% de los estudiantes considera que las actividades que más aportan son las de "mercado".

En cuanto a la competencia "Trabajo en equipo", el 100% considera que las actividades que más aportan son las de "administración" y el 68% opina que este mismo grupo de actividades en el que más ayuda a desarrollar la competencia "Capacidad para solucionar problemas".

En lo que se refiere a la competencia "Orientación al logro", el 54% de los encuestados considera de mayor influencia en el logro de esta competencia las actividades de "mercado".

Con respecto a la competencia "Tener Iniciativa", el 76% considera que las actividades de "producto" son las que más aportan.

En el caso de la competencia "Tener criterio independiente" el 55% considera que las actividades que más influyen son las de "mercado" y "administración".

Por último en el caso de la competencia "tener autoconfianza", el 100% considera que las actividades que más apoyan el desarrollo de esta competencia son las de mercado.

Es importante considerar que para el análisis antes expuesto solo se consideró los porcentajes más altos en cada competencia, por tanto para profundizar es importante analizar cada competencia con el grupo de actividades que se presenta en la tabla II.

5 Conclusiones

Las actividades de aprendizaje del taller, en su mayoría son útiles para la adquisición de competencias emprendedoras por parte de los estudiantes.

El taller sigue siendo vigente para lograr los objetivos para los cuales fue creado y es acorde a las tendencias tanto de la propia UADY como las que establecen diversos organismos.

Este trabajo contribuye al avance y liderazgo que el cuerpo académico ha logrado en el desarrollo de programas y modelos de emprendimiento a nivel local, nacional e internacional.

El estudio también contribuye al avance del conocimiento en la temática de los programas para el desarrollo de emprendedores.

La información generada por el estudio será de utilidad para la confirmación, rediseño, retiro y adición de nuevas actividades de aprendizaje.

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SCRUM methodology to manage complex projects

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Abstract

This research describes the results obtained in the different phases of the implementation process of the SCRUM methodology as an axis model for the management and evaluation of complex projects. The research was conducted during two semesters January-May and August-December 2018. The population was made up of a selection of courses within the framework of the degree in Industrial Engineering Logistics and Industrial Engineering. Within the program of engineering of methods 2 and Planning and Design of Installations, the sample consisted of 345 students of second, fifth, sixth and seventh semesters for two undergraduate programs of industrial engineering of the Universidad Autonoma de Yucatan (UADY) and Instituto Tecnológico de Mérida (ITM), respectively. During the research, we have placed a special interest in documenting the collection, organization, synthesis and experiences of the participants for analysis to complex solutions in real learning environments. The activity fosters the search for solutions to real problems, with support throughout the process and with the purpose of enhancing the learning capacity of the participants, finally promoting their participation and empowerment as important actors in the management of the project. Other teaching strategies that were also incorporated into the process were: reflexive autonomous learning and cooperative work. Likewise, resources such as: didactic planning, calendar of activities, evaluation rubrics by phases, the online platform for accessing the contents of the course, entrance and exit surveys, as well as three evaluation instances. The results suggest important findings using descriptive statistics tools and multivariate methods. Where more than 95% of the students surveyed positively evaluated the SCRUM methodology to improve project management and to strengthen their leadership profile. In this same sense, 90% say that the methodology and complementary resources were decisive to improve their management skills. More than 90% said that the project also allowed them to test their initiative to explore alternatives for improvement, demonstrate their enthusiasm and confidence towards the challenges presented to them. Today the project continues in its sixth edition (UADY) and first for the (ITM), both during the academic cycle January-May 2019. Future research guides us to explore new findings such as, for example, the differences and similarities in the processes of learning between the two groups.

Keywords: Cooperative learning, Project-based learning, SCRUM methodology.

Metodología SCRUM para la gestión de proyectos complejos

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Abstract

Esta Investigación describe los resultados obtenidos en las diferentes fases del proceso de implementación de la metodología SCRUM como modelo eje para la gestión y evaluación de proyectos complejos. La investigación se realizó durante dos semestres Enero-Mayo y Agosto-Diciembre de 2018. La población la conformaron una selección de cursos en el marco de la licenciatura en Ingeniería Industrial Logística e Ingeniería Industrial. En el marco programa de ingeniería de métodos 2 y Planeación y Diseño de Instalaciones, la muestra la conformaron 345 estudiantes de segundo, quinto, sexto y séptimo semestres para dos programas de licenciatura de ingeniería industrial de la Universidad Autónoma de Yucatán (UADY) e Instituto Tecnológico de Mérida (ITM), respectivamente. Durante la investigación hemos puesto un especial interés en documentar la recolección, la organización, la síntesis y experiencias de los participantes para en análisis a soluciones complejas en entornos reales de aprendizaje. La actividad propicia la búsqueda de soluciones a problemas reales, se les brinda el soporte a lo largo del proceso, con la finalidad de potenciar la capacidad de aprendizaje de los participantes, finalmente promover su participación y empoderamiento como actores importantes en la gestión del proyecto. Otras estrategias de enseñanza que también fueron incorporadas al proceso fueron: el aprendizaje autónomo reflexivo y el trabajo cooperativo. Asimismo, recursos como: la planeación didáctica, calendario de actividades, rúbricas de evaluación por fases, la plataforma en línea para el acceso a los contenidos del curso, encuestas de entrada y de salida, así como tres instancias de evaluación. Los resultados sugieren hallazgos importantes empleando herramientas de estadística descriptiva y métodos multivariantes. Donde más del 95% de los estudiantes encuestados evaluaron positivamente la metodología SCRUM para mejorar la gestión de proyectos y para fortalecer su perfil de liderazgo. En este mismo sentido, el 90% refieren que la metodología y los recursos complementarios fueron determinantes para mejorar sus competencias de gestión. Más del 90% refirió que el proyecto también les permitió poner a prueba su iniciativa para explorar alternativas de mejora, demostrar su entusiasmo y confianza hacia los retos que se les presentaron. Hoy día, el proyecto continúa en su sexta edición (UADY) y primera para el (ITM), ambos durante el ciclo académico Enero-Mayo de 2019. Futuras investigaciones nos orientan a explorar nuevos hallazgos como, por ejemplo, las diferencias y similitudes en los procesos de aprendizaje entre los dos grupos.

Palabras clave: Aprendizaje cooperativo, Aprendizaje basado en proyectos, Metodología SCRUM.

1 Introducción

La motivación de la investigación subyace en la necesidad de fortalecer el desarrollo de competencias en los estudiantes en el marco de la propuesta e implementación del Modelo Educativo para la Formación Integral (MEFI) en la Universidad Autónoma de Yucatán (UADY). La investigación propuso la utilización de diversas tecnologías y el diseño de materiales pertinentes para la construcción del aprendizaje en la modalidad presencial. Las asignaturas que fueron incorporadas al estudio fueron: Teoría General de Sistemas (TGS), Ingeniería de métodos 1 y 2 (IM) y Planeación y Diseño de Instalaciones (PDI). Esta selección de contenidos fueron el marco para la implementación y la documentación de las experiencias de enseñanza-aprendizaje. Algunas diferencias propias de los cursos fueron: las configuraciones de los cursos establecen diferentes números de horas presenciales y no presenciales. El modelo marco para la formación de los estudiantes en las disciplinas, estuvieron acompañados una plataforma en línea, UADY-Virtual (FIQ, 2016) y Edmodo (véase la Figura 1). Ambas permitieron la administración de los recursos, la gestión de las actividades de aprendizaje, el acopio de registros mediante diversos instrumentos y durante diferentes momentos específicamente al inicio, intermedia y al finalizar el curso, todas ellas fueron clave para el seguimiento académico de los estudiantes.

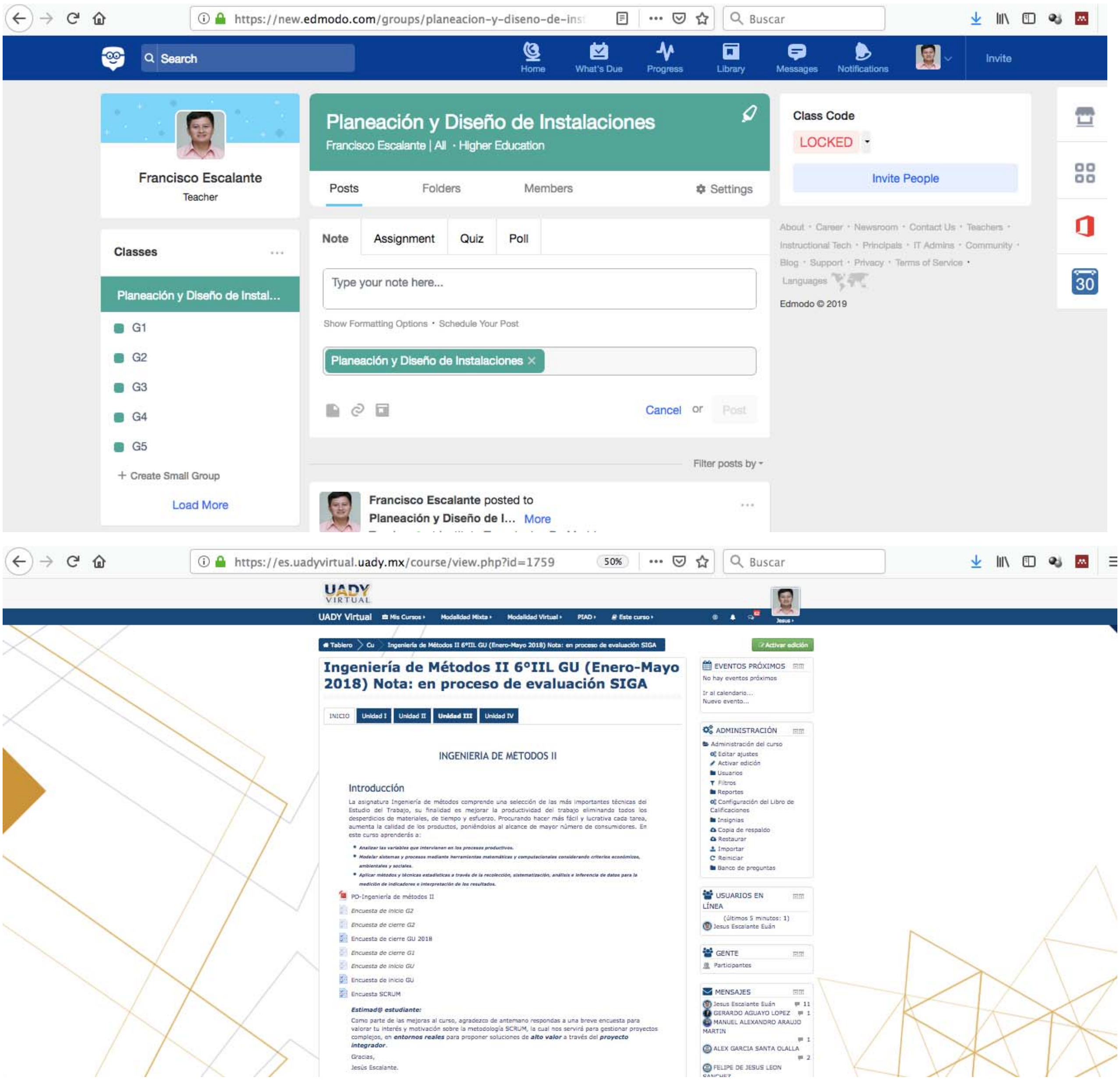


Figura 3. Plataforma Edmodo & uady virtual.

2 Objetivo

El propósito de la investigación ha sido conceptualizar y valorar los resultados obtenidos en las fases de gestión de proyectos complejos mediante el modelo SCRUM.

Esta experiencia, nos ha permitido también analizar la percepción de los estudiantes al termino de lograr implementar un programa de mejora continua en un escenario real de aprendizaje. Finalmente, hemos generado un marco metodológico propicio para documentar de forma sistemática los datos en las diferentes etapas de evaluación (véase la Figura 2), y obtener información pertinente para estimar el impacto del PBL bajo el enfoque del modelo SCRUM.

Mediante este ejercicio de investigación, hemos documentado las experiencias y lecciones aprendidas derivadas de las diferentes fases del proceso, hemos puesto un especial interés a algunos de los beneficios que sugieren (Guillot & Barceló, 2014) siendo:

- Permitir la recolección, la organización, la síntesis, la utilización y el compartir el conocimiento local y científico presentes en un proyecto.

- Desarrollar la capacidad de aprendizaje de los participantes.
- Promover la participación y empoderamiento de los actores que intervienen en el proyecto.

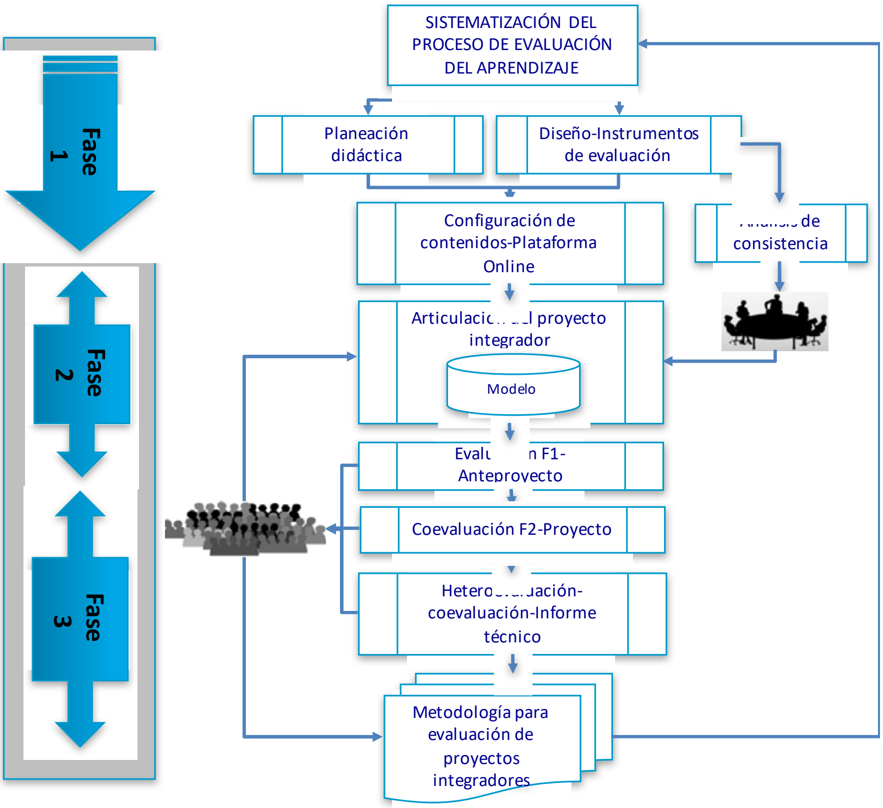


Figura 4. Modelo conceptual para la evaluación del aprendizaje.

2.1 Aprendizaje basado en proyectos

La adopción de métodos ágiles para la gestión de proyectos complejos ha crecido ampliamente en los últimos años por sus aportes significativos en la productividad, calidad y satisfacción del cliente (Oyola, 2013). Dentro de los métodos ágiles, Scrum es el método más utilizado por estar especialmente enfocado en la gestión de proyectos y por haber demostrado efectividad en el desarrollo de los mismos en pequeña y mediana escala.

Los modelos utilizados tradicionalmente se centran la evaluación en cogniciones aisladas sin considerar su conexión con el marco de conocimientos general y personal del alumno, esta tendencia no favorece la construcción del conocimiento y se vuelve obsoleto dada las tendencias y necesidades actuales en la educación, véase (Alves et al., 2016).

Un modelo de evaluación que encaja con el PBL es aquel por competencias. Éste se orienta a evaluar las competencias en los estudiantes teniendo como referencia el desempeño de estos ante las actividades y problemas del contexto profesional, social, disciplinar e investigativo. Esto privilegia el desempeño del estudiante ante actividades reales o simuladas propias del contexto. De igual manera ofrece resultados de retroalimentación cuantitativa, así como cualitativa según (Brown & Pickford, 2013) y muy recientemente (Fuertes Sanchez et al., 2015). A continuación, se formulan algunas preguntas de reflexión que motivaron la investigación:

1. ¿Cuál es la propensión del estudiante para utilizar el modelo Scrum?
2. ¿Cómo valora el modelo Scrum respecto a experiencias previas con otros enfoques?
3. ¿Cómo percibe la utilidad para gestionar proyectos a través del modelo SCRUM?

Partiendo de estas reflexiones declaramos como objetivo de investigación evaluar el alcance y los resultados del modelo propuesto para la sistematización del proceso de evaluación del aprendizaje basado en Proyectos como instrumento para la gestión de proyectos complejos.

3 Materiales y métodos

3.1 Materiales

Para el análisis de los resultados utilizamos el software RStudio (versión 0.99.491). El acopio de los datos analizados corresponde a un conjunto de variables que se obtuvieron al inicio del curso, durante la presentación de la metodología y al finalizar la implementación del proyecto. El instrumento recoge las variables de Propensión (Prop), Contraste (Cont) y Logro (Log). En relación a la valoración del proyecto incorporamos las siguientes variables: si el proyecto resultó Estimulante (Estim), las características y desafíos permitió el Compromiso (Comp), Responsabilidad (Resp) y Liderazgo (Lid).

3.1.1 Diseño de la herramienta para el acopio de información

Los instrumentos de evaluación antes de ser alojados en las plataformas virtuales, fueron valorados por un panel de profesionales expertos del área, y administrados mediante las plataformas virtuales durante dos semanas al inicio de cada curso durante los ciclos académicos 2017-2019.

A través de los pre test se verificaron la coherencia semántica y discriminación de aquellos reactivos que resultaron confusos o inconsistentes. La estructura de la encuesta incluyó el perfil del participante (4 reactivos), y una selección de variables para medir la experiencia previa en proyectos afines, el cumplimiento de sus expectativas al finalizar el proyecto, entre otros aspectos vinculados con la dinámica del proyecto (7 reactivos), todos ellos acorde a una escala de Likert (véase la Tabla 1).

Tabla 6. Variables identificadas.

Ítem	Descripción
Liderazgo	Dirigir e implicar a las personas, tomando decisiones responsables, para conseguir los objetivos comunes asumiendo las responsabilidades y los riesgos.
Compromiso	Demostré fuerte y constante compromiso en el desarrollo de mi propio conocimiento y en las metas como grupo.
Responsabilidad	Atendí en tiempo y forma a las actividades y reuniones programadas.
Propensión	Inclinación o disposición natural hacia las características que definen el modelo SCRUM.
Contraste	Diferencia notable entre el modelo SCRUM y experiencias previas.
Logro	Resultado altamente satisfactorio de acuerdo a los objetivos declarados en el proyecto.

3.1.2 Dimensiones de la evaluación

La herramienta se diseñó en tres dimensiones, la primera responde al perfil del encuestado, siendo el género, grado académico, nota alcanzada en el proyecto, la segunda estudiamos la propensión, contraste y el logro de los objetivos, finalmente en la tercera valoramos la estructura, organización y el alcance del proyecto, a través de lo estimulante que resultó la gestión, el compromiso, la responsabilidad y liderazgo ante situaciones que impliquen la toma de decisiones. Además, que la metodología propicie las estrategias que impulsen los cambios sustanciales en las fases de mapeo de procesos, implementación de un programa de mejora continua o estudios de localización.

La segunda dimensión fue útil para determinar en qué medida el proyecto fortaleció el perfil de liderazgo, en contraste con los indicadores de desempeño declarados en el objetivo marco del proyecto (véase la Figura 1). La tercera dimensión valora el compromiso, la responsabilidad y en qué medida el estudiante valoró los retos que demanda un proyecto con estas características.

3.2 Métodos

El objetivo principal de los siguientes métodos es analizar la estructura común de las distintas tablas de datos, poniendo de manifiesto cuáles son los elementos heterogéneos, es decir diferentes al resto. Además de los resultados clásicos las medidas globales de relación entre los grupos, permiten cuantificar la semejanza global existente entre ellos con indicadores parciales de acuerdo con la metodología de (Bécue-Bertaut & Pagès, 2008).

3.2.1 Análisis factorial múltiple (AFM)

Es un método factorial que permite el análisis simultáneo de varios grupos de variables dado un conjunto de individuos véase (Abdi, Williams, & Valentin, 2013) y (Escofier, 2003). El AFM es considerado como un Análisis de Componentes Principales ACP, dada la influencia y equilibrio entre los grupos y las variables, éstas últimas pueden ser diferentes incluso en naturaleza y número. La única restricción es que las variables que integran un grupo sean de la misma naturaleza, cuantitativa o cualitativa. El AFM tiene como objetivo comparar las tipologías de los individuos a nivel global y grupal. El objetivo del análisis es valorar la estabilidad de los resultados obtenidos en un ACP. La estructura de los datos parte de una tabla X compuesta de I filas y K columnas que proporcionan cada uno de los i individuos de una población de las medidas de K variables. Los pasos para este análisis son los siguientes:

1. Análisis parcial. Efectúa un ACP normado de cada tabla de datos $(k=1, \ldots, K)$ y retiene el primer valor propio de cada una de ellas.
2. Análisis global. Realiza un ACP de la tabla global que resulta de yuxtaponer todas las tablas, a las que previamente a cada una se las ponderó por el inverso del primer valor propio obtenido en la primera etapa. Mediante esta ponderación es posible mantener la estructura de cada tabla, ya que todas las variables han recibido la misma ponderación, pero consigue equilibrar la influencia de los grupos, ya que la inercia máxima de cada una de las nubes de individuos definida por los distintos grupos, con valor de 1 en cualquier dirección.

El coeficiente RV puede ser utilizado como medida de similitud entre dos configuraciones; se define como el producto escalar entre pares de matrices (el producto de Hilbert-Schmidt), (véase también (Bécue-Bertaut & Pagès, 2008; Lebart, L., Salem, A., 2000) este producto escalar induce una norma y, por lo tanto, una distancia.

Si la correlación vectorial entre dos matrices es igual a la unidad, eso significa que ambas matrices son equivalentes en el sentido de que ambas estructuras son congruentes, es decir cuanto más próximo a uno, más similares serán las estructuras. En contraste, si los resultados son iguales a cero significa que no existe relación entre las variables de los dos grupos considerados. Esta medida es completada con los coeficientes Lg que pueden ordenarse en una matriz de orden KxK y que miden la dimensionalidad (número de factores de inercia considerable) de cada grupo.

4 Resultados

La población la conformaron 345 estudiantes de las asignaturas Teoría General de Sistemas (TGS), Ingeniería de métodos 1 y 2 (IM) y Planeación y Diseño de Instalaciones (PDI). La Tabla 3 describe otras características relevantes respecto al perfil de los participantes, grupos y semestres equivalentes, ambos pertenecientes al modelo educativo para la formación integral (MEFI) véase (FIQ, 2018) y modelo por competencias (ITM).

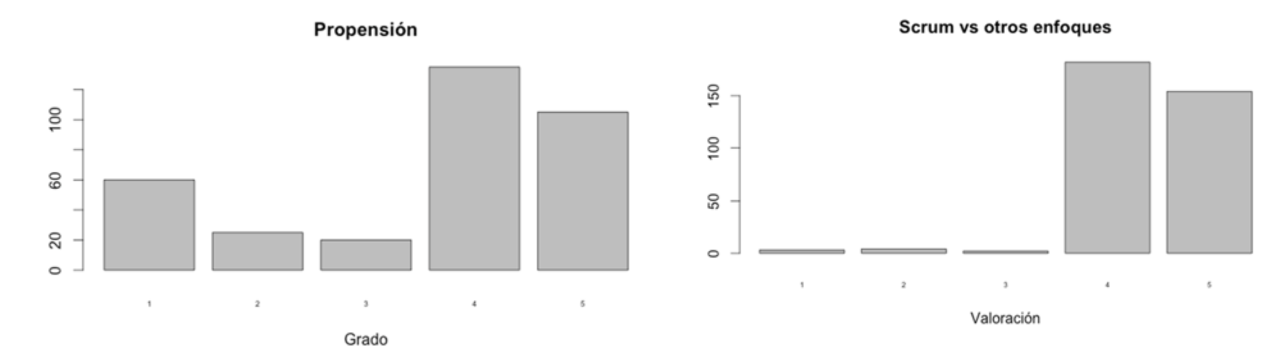
Tabla 7. Estadística descriptiva del perfil de la muestra.

Género	No	Notas	No	Grado	No
Hombres	137	A	58	2	21
Mujeres	208	B	182	5	97
		C	93	6	198
		D	12	7	29

De acuerdo a la encuesta de inicio del curso el 98% de los participantes refirió no haber tenido experiencia previa participando en proyectos integradores bajo el enfoque SCRUM. La primera sección de la encuesta indagamos respecto a qué tan dispuesto estaría de experimentar un nuevo enfoque de gestión de proyectos, en base a una escala de Likert, siendo Sin interés, Poco interés, Indiferente, Interesado y Muy interesado.

Podemos observar que la propensión a experimentar este enfoque se ubicó en la escala 3 y 4. En esta misma sección, evaluamos el contraste respecto a la estructura de esta metodología y otras afines que habían experimentado antes. Ante la cuestión: valore el enfoque SCRUM respecto al método tradicional, la pregunta se valoró positivamente entre la percepción de cambios importantes y estimulante. Los resultados los podemos observar en la figura 3(a) y 3 (b), respectivamente.

Respecto a si la configuración del proyecto les permitió cumplir sus expectativas (CE), así como si la configuración y estructura del proyecto integrador les resultó estimulante (E), ambos rubros fueron valorados positivamente con un 92%. La Figura 3 describe otros aspectos importantes relacionados con la estructura del proyecto integrador.



(a) Propensión hacia el enfoque SCRUM.

(b) Contraste entre el enfoque SCRUM y otros métodos

Figura 5. Perfil de la población de estudio.

En la Figura 4, se identifican las variables de estudio bien representadas en cada una de las dimensiones. Observamos en primera instancia, que la variable género es relevante, la calificación sobresale como un elemento importante a estudiar. Finalmente, también es posible identificar el agrupamiento de las variables Liderazgo, Compromiso, Responsabilidad, Propensión, Contraste y Logro.

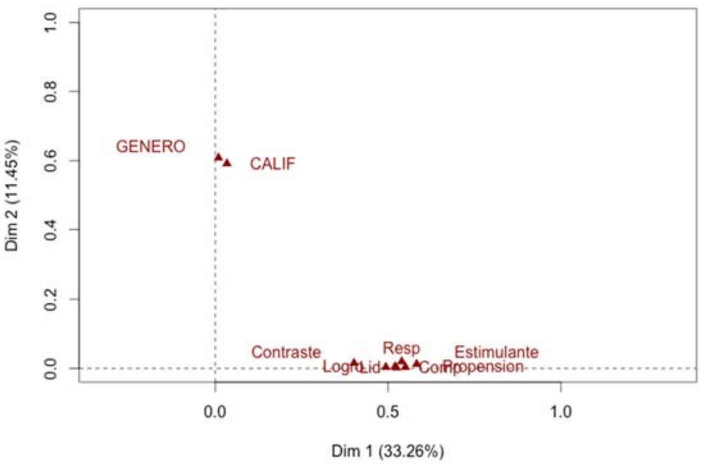


Figura 4. Grupos de variables de análisis

La figura 5 describe la representación de la nube de puntos para cada grupo de análisis, la similitud entre sus estructuras internas de acuerdo a cada una de las dimensiones y factores de interés.

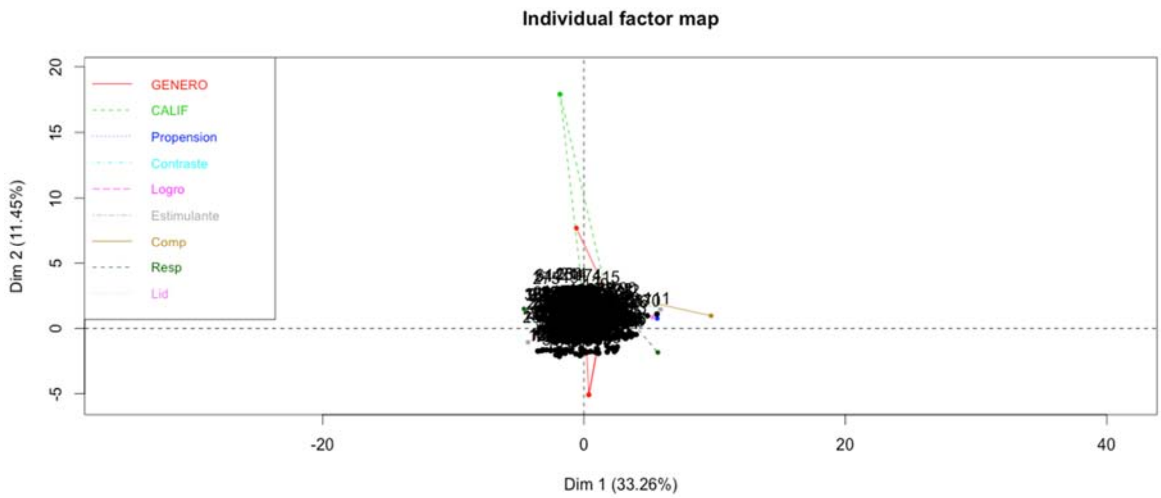


Figura 5. Nube de puntos

De acuerdo a la etapa 1 descrita en la Figura 2, realizamos un ACP normado sobre cada tabla de datos. En la figura 6 se describen los doce autovalores siendo el primero el más importante y de mayor representatividad. Por lo cual los primeros resultados de salida nos permitieron concluir que el 79% de las variables se explican y corresponden a los primeros siete componentes. Esta característica es relevante para el estudio, ya que nos permite discriminar los primeros ejes factoriales, seguidamente analizar su impacto y su correlación.

	Autovalor	% Var	% Var Acum
comp 1	3,21	24,68	24,68
comp 2	2,00	15,38	40,06
comp 3	1,25	9,61	49,67
comp 4	1,14	8,76	58,43
comp 5	0,99	7,65	66,08
comp 6	0,92	7,10	73,17
comp 7	0,80	6,18	79,36

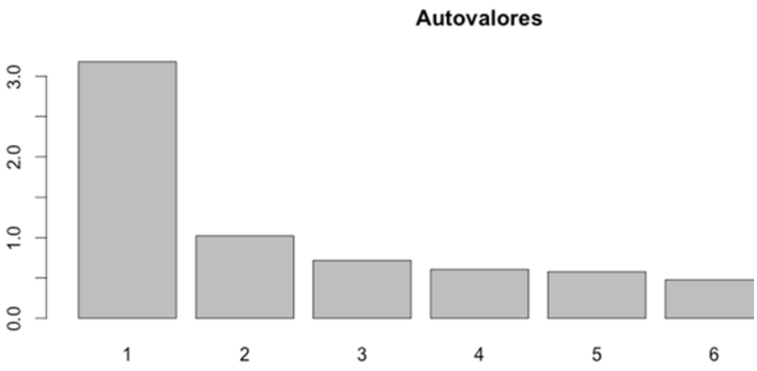


Figura 6. Autovalores globales

Para analizar la correlación entre los factores parciales de cada una de las variables y las componentes principales donde los resultados de salida los resumimos en la Tabla 4. En ella se observa que en el primer eje están representados las principales características, semejanzas y diferencias entre las variables: Propensión (0.604), Logro (0.728), Estimulante (0.786), Responsabilidad (0.733), y Liderazgo (0.725).

La segunda dimensión la define el Contraste entre los enfoques de gestión (0.942), el eje 3 Propensión (.0.701), entre los más importantes. Para este trabajo de investigación hemos discriminado los últimos dos ejes factoriales, ya que las variables están representadas particularmente en los primeros tres ejes.

Tabla 4. Coeficientes de correlación entre los factores parciales

	Eje 1	Eje 2	Eje 3	Eje 4	Eje 5
Prop	0.604	0.260	-0.701	-0.035	0.258
Cont	0.161	0.942	0.274	0.104	0.008
Log	0.728	-0.014	0.207	-0.515	0.072
Estim	0.786	-0.009	-0.025	-0.183	-0.230
Comp	0.757	-0.040	-0.041	0.132	-0.524
Resp	0.733	-0.156	0.069	0.523	0.097
Lid	0.725	-0.201	0.316	0.054	0.409

En la figura 6 se observa que la mayoría de los vectores que representan la variable de estudio (L) ilustran un ángulo con un comportamiento estable en los dos entornos. En relación al plano de los individuos, la figura 7 describe la trayectoria de cada una de las dimensiones vinculadas al factor de liderazgo respecto a cada enfoque de dirección, mismos que se encuentran proyectados en los dos primeros ejes factoriales. A este respecto se infiere que las dimensiones (1, 2, 4 y 5) describen los siguientes rasgos: los participantes argumentaron que el proyecto les permitió ser un referente de motivación para sus compañeros, consolidar su participación activa en las diferentes fases, presentar ideas de forma clara y articulada, finalmente es posible deducir que la estructura del proyecto les permitió demostrar sus destrezas de liderazgo ante situaciones difíciles.

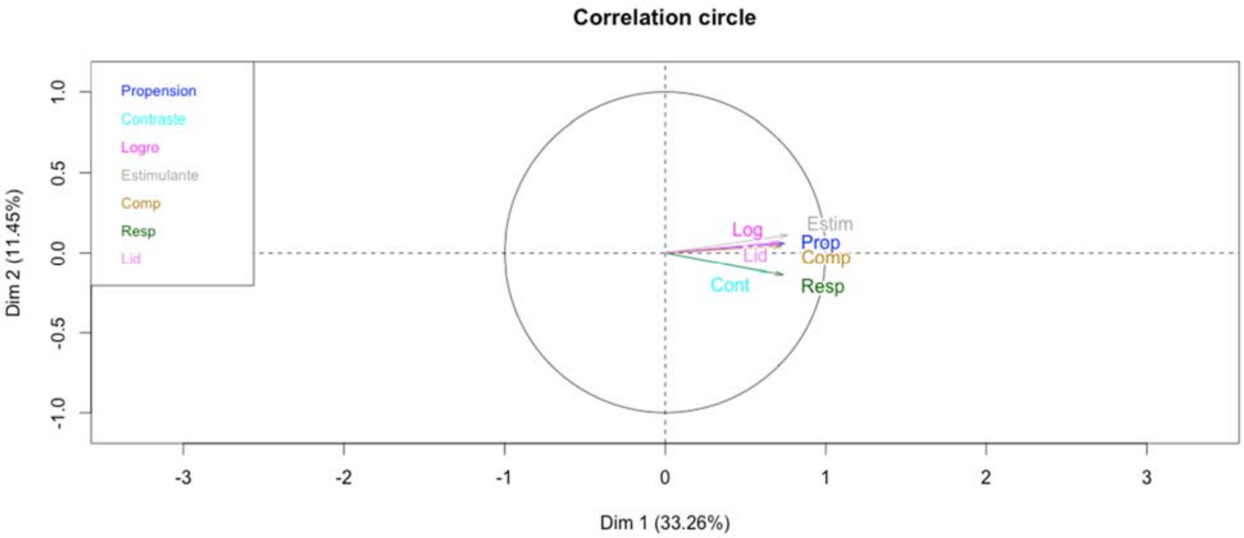


Figura 6. Proyección de las variables sobre los dos primeros ejes factoriales

En síntesis, podemos concluir que las representaciones de los dos grupos de análisis sobre los dos primeros ejes globales recogen una realidad común para las variables de estudio. Los dos factores globales que fueron extraídos para el análisis están igualmente afectados por los dos enfoques vinculados al Logro, Propensión y Contraste durante las etapas de evaluación de los proyectos integradores. Además, los valores próximos a la unidad explican una dirección de inercia importante para cada una de las variables compromiso, responsabilidad y liderazgo. También es posible explicar la trascendencia del segundo eje global, pero su relación es en menor proporción.

Finalmente, los comportamientos de las variables latentes se explican en la proyección global de los planos principales. Hemos incorporado y desagregado al estudio las variables respuesta tales como si el proyecto resultó estimulante y contraste entre los dos enfoques para la gestión de proyectos, así como la relación, por ejemplo, con la experiencia de los participantes en proyectos previos. A partir de los resultados representados en la Figura 6 se desprende de que para más del 95% de los participantes expresaron que la actividad les resultó estimulante y que la articulación de las actividades a través del enfoque Scrum cumplieron con sus expectativas.

5 Conclusiones

Este procedimiento de combinación de técnicas factoriales nos permitió el tratamiento simultáneo desde un punto de vista descriptivo y comparativo de individuos en los que se ha medido la misma información a través de variables nominales. La naturaleza exploratoria de la técnica tuvo la ventaja de que los datos expresan de forma factorial la relevancia de los mismos para cada grupo de individuos, dotando al estudio importancia relativa y global. La metodología ha proporcionado indicadores y gráficos que midieron la similaridad entre los perfiles de los grupos de estudio respecto a las variables dependientes e independientes vinculadas al perfil de los encuestados. Futuras investigaciones nos orientan a explorar nuevos hallazgos incorporando al estudio nuevas variables, así como extender este estudio hacia los impactos de estos mismos factores en la gestión de proyectos en los módulos de las prácticas profesionales.

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Dissemination of educational applications through the technological tools provided by the Autonomous University of Yucatan for the strengthening of basic science subjects in engineering.

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Abstract

The present work is the result of the application of the Ki Wo Tsukau® Methodology "Concern for", which is an improvement tool accessible to all levels of the organization chart and easy to implement. The idea generated and accepted consisted in the diffusion of the educational applications that can be supported in the subjects of the basic sciences block through the technological tools that the account in the institution of the students of the Faculty of Chemical Engineering of the Autonomous University of Yucatan. An instrument is created that allows to know the subjects of the area of basic sciences and that wish to strengthen their competencies through the use of digital applications. 31% expressed interest in strengthening Chemistry and 12% Physics. Finally, a repository was created for the storage of the applications and was carried out. In the previous part, it is concluded that the number of students that accessed the repository was greater among the first semesters than the intermediate and advanced media.

Keywords: Apps; Basic Sciences in Engineering Education.; Continuous improvement; Repository; ICTs.

Difusión de aplicaciones educativas a través de las herramientas tecnológicas que provee la Universidad Autónoma de Yucatán para el fortalecimiento de las asignaturas de ciencias básicas en ingeniería.

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Resumen

El presente trabajo es el resultado de la aplicación de la Metodología Ki Wo Tsukau® "Preocuparse por", que es una herramienta de mejora asequible a todos los niveles del organigrama y de fácil implementación. La idea generada y aceptada consistió en la difusión de las aplicaciones educativas que puedan apoyar en las asignaturas del bloque de ciencias básicas a través de las herramientas tecnológicas con las que cuenta la institución entre los estudiantes de la Facultad de Ingeniería Química de la Universidad Autónoma de Yucatán. Se elaboró un instrumento que permitió conocer las asignaturas del área de ciencias básicas en las que desean fortalecer sus competencias mediante el uso de aplicaciones digitales. Los resultados mostraron que el 56% tiene interés en fortalecer el razonamiento lógico y razonamiento matemático, así como pensamiento estructurado, el 31% manifestó su interés en fortalecer Química y el 12% Física. Finalmente se creó un repositorio para el almacenamiento de las aplicaciones (apps) y se llevó a cabo la difusión y medición de su aceptación de acuerdo al parámetro número de personas que accedieron al sitio. Por lo anterior se concluye que el número de estudiantes que accedieron al repositorio fue mayor entre los primeros semestres que los semestres intermedios y avanzados.

Palabras clave: Apps, ciencias básicas en la educación de ingenierías, mejora continua, repositorio, TICs

1 Introducción

La Facultad de Ingeniería Química de la Universidad Autónoma de Yucatán (FIQ-UADY), a través de su Modelo Educativo para la Formación Integral (MEFI), promueve la educación basada en competencias procurando que el estudiante use las Tecnologías de Información y Comunicación (TIC) integrando un aprendizaje de manera responsable y pertinente en la aplicación de los conocimientos teóricos (UADY,2012).

Como parte de las estrategias de formación integral del estudiante, la facultad cuenta con el apoyo de las academias que están conformadas por un grupo colegiado de profesores respecto a un área de conocimiento (FIQ, 2016). A través del análisis, discusión y reflexión las academias definen tácticas para mejorar el desempeño de los estudiantes; en estas reuniones se ha reportado que un 80% de los estudiantes tienen problemas de razonamiento lógico y matemático, pensamiento rápido y estructurado y planteamiento y resolución de problemas. Adicionalmente este grupo colegiado sugiere la utilización de estrategias que motiven a los estudiantes en la práctica de las matemáticas, física y química.

“Las TIC pueden ser utilizadas para crear situaciones de aprendizaje que estimulen a los estudiantes a desafiar su propio conocimiento y construir nuevos marcos conceptuales”. (Morrissey, 2008).

En este proceso la UADY proporciona herramientas digitales a los estudiantes a través de los servicios en la nube de Microsoft Office 365, facilitando la colaboración y comunicación, obteniendo este beneficio a través de una cuenta de correo institucional.

Particularmente la herramienta de SharePoint (contenida en la suite de Microsoft Ofice365), permite crear y compartir contenido en un sitio de comunicación al cual se puede acceder desde cualquier dispositivo móvil, como smartphones, tablets o Laptops, teniendo actualmente un crecimiento en su demanda ya sea por su bajo costo o por sus diferentes capacidades. Churchil (2017) señala que las tecnologías móviles emergentes son plataformas efectivas para la entrega de recursos de aprendizaje digital, en cualquier momento y en cualquier lugar. En el marco presentado brinda una ventaja y permite ser utilizados para la entrega de las nuevas y diferentes aplicaciones (APPs) que existen en diversos sectores del mercado incluyendo el sector educativo.

Glahn, Gruber y Tartakovski (2015) concluyen que los estudiantes contemporáneos están viviendo incrustados en un ecosistema tecnológico y están dispuestos a utilizar diferentes herramientas para hacer eficiente el tiempo de estudio enriqueciendo y equilibrando la experiencia de aprendizaje en general.

Al utilizar las herramientas que proporciona la UADY y la gama de dispositivos móviles actuales, existe una coyuntura para conseguir un rol activo por parte del estudiante en la implementación de un repositorio, como señalan Dávila et al. (2006) los repositorios son servicios centrados en las necesidades de una comunidad con la capacidad de publicar contenido y con la ventaja de la amplitud para su difusión… (p.26).

Bajo esa premisa se construye un repositorio de fácil acceso en un sitio de SharePoint, como medio de alternativas para la difusión de aplicaciones educativas, *ad hoc* en el apoyo de las asignaturas del bloque de ciencias básicas que permitan fortalecer el proceso de enseñanza-aprendizaje fomentando el rol activo del estudiante.

2 Objetivo

Difundir las aplicaciones educativas que contribuyan al reforzamiento de las competencias en las asignaturas del bloque ciencias básicas entre los estudiantes de la Facultad de Ingeniería Química de la UADY a través de las herramientas tecnológicas que provee la Universidad.

3 Metodología

La Facultad de Ingeniería Química ha implementado en su organización la metodología denominada Ciclo Dinámico de Mejoras Ki Wo Tsukau®, "Preocuparse por…", cuyo nombre proviene del japonés y está basado en el modelo de sociedad de ese país patentada por el MBA. Alejandro Kasuga Sakai director general de la empresa Yakult México en el año 2010, con el objetivo de proporcionar una herramienta de mejora asequible a todos los niveles del organigrama y de fácil implementación, dando la oportunidad a los colaboradores de aportar ideas de mejora que a lo largo de su experiencia logran identificar dentro de sus funciones básicas de trabajo. (KWT Consulting, 2012).

Dentro del ciclo de la tercera ola se aportó la idea objetivo de este trabajo al comité del KWT y una vez aprobada la misma se realizaron las siguientes acciones:

1.Elaboración de un instrumento de evaluación.

2.Aplicación del instrumento de evaluación.

3.Interpretación de los resultados obtenidos.

4.Creación del repositorio en un sitio de SharePoint.

5.Difusión del repositorio

6.Medición del acceso al repositorio.

4 Resultados

4.1 Elaboración del instrumento de evaluación

Se elaboró una encuesta en línea que consistió en seis preguntas dirigido a los estudiantes como se aprecia en la tabla 1.

Tabla 1. Preguntas de la encuesta

Numero	Pregunta	Escala
1	Licenciatura:	Categórico
2	¿El sistema operativo de tu dispositivo móvil es?	Categórico
3	¿Utilizas aplicaciones educativas en tu dispositivo móvil?	Dicotómico
4	¿Qué aplicaciones educativas utilizas?	Texto Libre
5	De la siguiente lista, señala las asignaturas de interés a fortalecer a través de aplicaciones para dispositivos móviles:	Categórico
6	¡Nos interesa tu opinión! Agradecemos tus comentarios:	Texto Libre

Fuente: Propia

4.2 Aplicación e interpretación del instrumento

La encuesta fue enviada vía correo electrónico con la liga de acceso a los estudiantes de los planes de estudio de la Facultad. El periodo aplicado fue de una semana.

Se analizaron dos variables de la encuesta, por una parte; lo relacionado con el propósito de conocer el interés de las asignaturas del bloque de ciencias básicas que desean fortalecer a través de aplicaciones, el 56% de los encuestados quiere fortalecer práctica de las matemáticas, razonamiento lógico y razonamiento matemático, así como pensamiento estructurado; 31% le interesa fortalecer práctica de la Química y finalmente 12% práctica de la Física (Figura 1).

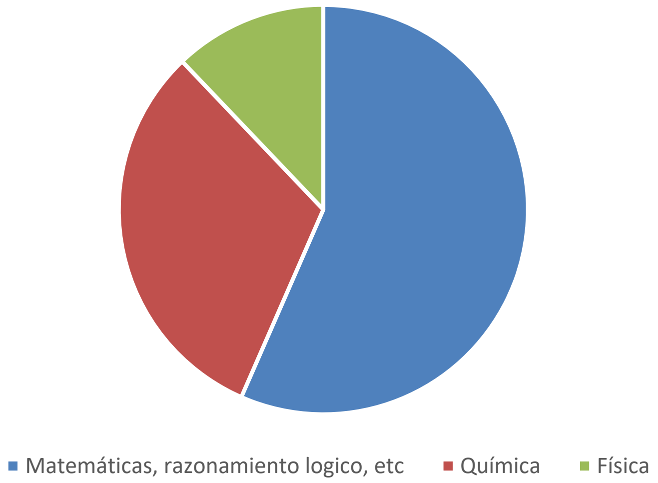

Figura 1. Área de interés a fortalecer a través de aplicaciones para dispositivos móviles.

Por otra parte; la característica técnica del sistema operativo de sus dispositivos móviles mostro que el 76% de los estudiantes utiliza Android, 23% IOS y 1% Windows Phone (Figura 2). Los resultados permiten concluir que las apps que serán difundidas en el repositorio deberá ser compatibles con los sistemas operativos antes mencionados.

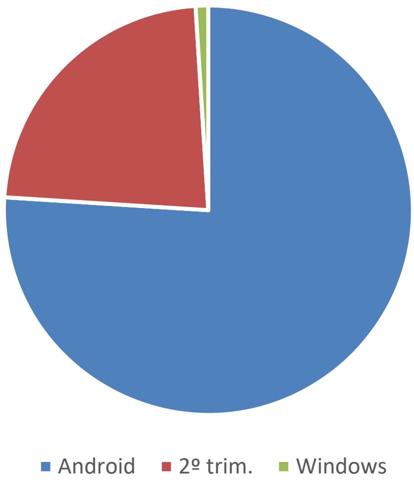

Figura 2. Sistema operativo del dispositivo móvil.

4.3 Creación del repositorio

Como se muestra en la Figura 3, con la información obtenida se desarrolló un repositorio en un sitio de SharePoint, con las siguientes secciones:

- Aplicaciones en el área de las Ciencias Básicas (Física, Matemáticas y Química)
- Aplicaciones para el fortalecimiento del razonamiento
- Aplicaciones de pensamiento rápido
- Juegos *ad hoc*

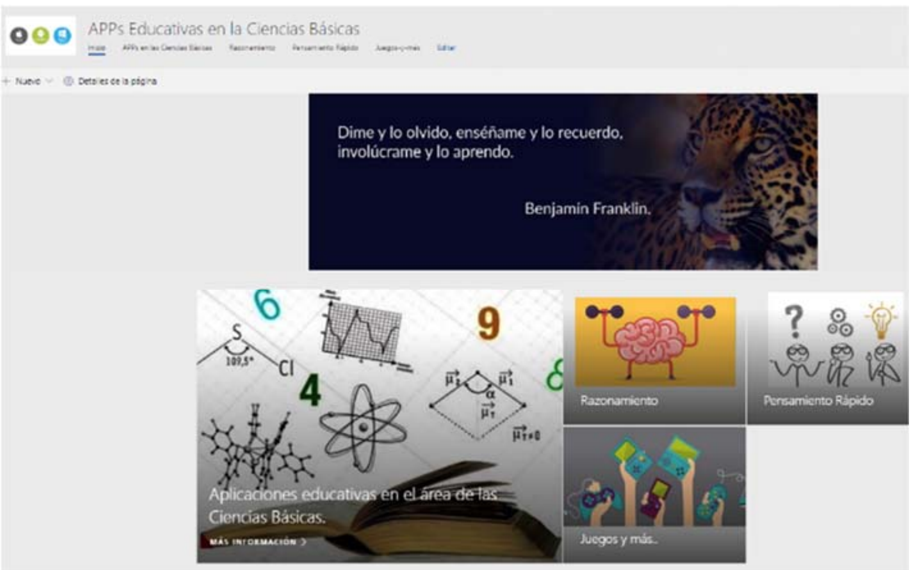

Figura 3. Repositorio de aplicaciones educativas en las ciencias básicas

En cada una de las secciones antes mencionadas el estudiante podrá encontrar aplicaciones educativas que pudieran ser de interés para el fortalecimiento de las asignaturas del bloque de ciencias básicas mencionadas. (Figura 4)

Figura 4. Aplicaciones en asignaturas del bloque de ciencias básicas

Al acceder a las imágenes representativas de las aplicaciones el estudiante podrá visualizar una descripción de la APP, la disponibilidad para el Sistema Operativo y la fuente correspondiente para su descarga.

Finalmente se realizó la difusión del repositorio enviando una invitación vía correo electrónico, enlistando las secciones del repositorio y la liga de acceso, efectuando una primera campaña. La tabla 2 refleja los resultados de visualizaciones obtenidos por parte de los estudiantes.

Tabla 2. Visualizaciones del repositorio.

Repositorios		Visualizaciones
Asignaturas del área de ciencias básicas.	Física Matemáticas Química	55
Otras áreas de apoyo	Razonamiento	27
	Pensamiento rápido	23
	Juegos	30

5 Conclusiones y futuros trabajos

El presente trabajo tuvo como objetivo la difusión de aplicaciones educativas a través de las herramientas de tecnologías de información y comunicación (TICs) que proporciona la Universidad Autónoma de Yucatán, permitiendo acercar APPs *ad hoc* en apoyo a lo reportado por las academias en problemas de razonamiento lógico y matemático, pensamiento rápido y estructurado y planteamiento y resolución de problemas, así como la motivación de los estudiantes en la práctica de las matemáticas, física y química de los conocimientos adquiridos en el aula en medios de fácil acceso, como el repositorio producto de este trabajo, mostrando un interés al visualizar las APPs colocadas teniendo un mayor número de visualizaciones las asignaturas de ciencias básicas.

Se reconoce el valor potencial que aportan las herramientas tecnológicas para el proceso de formación generando competencia para el uso de las TIC en el proceso de enseñanza aprendizaje, de igual manera el gran aporte de la metodología KWT que permite a los colaboradores de una organización, autores de este trabajo, aportar ideas de mejora acorde a su experiencia en sinergia del ámbito pedagógico, tecnológico y administrativo.

Los estudiantes de las nuevas generaciones entran en un rol activo al consultar y tener la oportunidad de instalar las APPs en sus dispositivos móviles, sobre todo en los primeros semestres de nivel universitario, lo llamados "nativos digitales".

La difusión de aplicaciones educativas suma como estrategia en las asignaturas del área de ciencias básicas, extrapolable a otras áreas de la currícula así como también para otros ámbitos e instituciones dadas las oportunidades de colaboración y comunicación que se encuentran en Internet y la variedad de APPs que existen en el mercado.

Como en cualquier otro proyecto de investigación queda abierta la posibilidad de continuar trabajando en líneas que se dejan abiertas y que se espera seguir trabajando, entre ellas, realizar un estudio y analizar el nivel de fortalecimiento derivado del uso de las APPs difundidas en el repositorio.

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Implementing Project Based Learning Approach in a public Engineering school: the case of ESATIC

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Abstract

The African School of Information and Communication Technologies (ESATIC) in the major interests of training highly qualified engineers, has decided to integrate in its traditional training environment the Project Based Learning (PBL). The following article presents the implementation of that new pedagogical approach in Licence 1, Computer Network Systems and Telecommunications (SRIT), under three (3) aspects. First of all, it shows the different stages for the integration of the PBL at ESATIC, then it presents a new programming of the traditional courses and finally, highlights the testing of students in PBL environment. As major results, we observe an improvement in the annual success rate for this training level to 87.47 % for the academic year 2017-2018 and a favorable feedback to more than 90 % from learners about this new learning approach.

Keywords: Active Learning, Project Based Learning, Public Engineering School

Mise en place de l'Apprentissage Par Projet dans un établissement public d'ingénieur: cas de l'Ecole Supérieure Africaine des Technologies de l'Information et de la Communication (ESATIC)

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Resume

L'Ecole Supérieure Africaine des Technologies de l'Information et de la Communication (ESATIC) dans le souci majeur de former des ingénieurs de qualité, a décidé d'intégrer dans son environnement de formation traditionnelle l'Apprentissage Par Projet (APP). L'article présente la mise en œuvre de cette nouvelle approche pédagogique en Licence 1, Systèmes Réseaux Informatiques et Télécommunications (SRIT), sous trois (3) aspects. Il montre les différentes étapes de l'intégration de l'APP à l'ESATIC, ensuite expose une nouvelle programmation des cours classiques et pour terminer met en exergue l'évaluation des étudiants dans l'environnement APP. Comme résultats majeurs, il est observé un taux de réussite annuel pour le niveau de formation Licence 1 de 87, 47 % pour l'année 2017-2018. Aussi a-t-il été notifié un retour d'informations favorables à plus de 90 % des étudiants suite à la mise en œuvre de cette nouvelle forme d'apprentissage.

Mots clés: Apprentissage actif, Apprentissage Par Projet, école publique d'ingénieur

1 Introduction

L'Ecole Supérieure Africaine des Technologies de l'Information et de la Communication (ESATIC) est un Etablissement Public National (EPN). Elle est chargée d'assurer les missions d'intérêt général de formation initiale, continue et de recherche dans les métiers des Technologies de l'Information et de la Communication (TIC). Pour assurer la bonne mise en œuvre des missions instituées par l'Etat de Côte d' Ivoire, bien affiner la qualité de la formation dispensée et garantir des offres de formation en adéquation avec le milieu professionnel, l'ESATIC a décidé d'intégrer dans ses enseignements l'Apprentissage Par Projet (APP).

Après la sortie de la première promotion (2012-2017) et son intégration dans le milieu professionnel, l'école a mené une enquête permettant de jauger l'adéquation entre les compétences des étudiants et les besoins du marché professionnel. Cette enquête a révélé que, bien que les étudiants soient techniquement performants, ils manquent cependant de compétences avérées dans le travail en équipe et restent hésitants quant à la prise d'initiatives personnelles une fois dans l'environnement professionnel.

Le défi de l'école face à cette situation, était de parvenir à définir une approche pédagogique innovante qui permettrait de renforcer efficacement les compétences des étudiants au niveau interpersonnel et leur garantir une meilleure autonomisation pour une bonne intégration professionnelle. Le présent article intitulé : « ***Mise en place de l'Apprentissage Par Projet dans un établissement public d'ingénieur : cas de l'Ecole Supérieure Africaine des Technologies de l'Information et de la Communication*** » s'inscrit dans le cadre de la redynamisation des enseignements et du renforcement des compétences attendues. La mise en œuvre d'un tel projet suscite en revanche quelques interrogations :

- comment renforcer les compétences des étudiants pour le travail d'équipe et la prise d'initiative ?
- comment intégrer l'APP dans leurs enseignements?

- comment concilier efficacement la pédagogie traditionnelle, où le maître dispense quasi totalement le savoir et la pédagogie active, où le transfert et la mobilisation des ressources cognitives, (Philippe Perrenoud, 2002) préconisent que l'étudiant-apprenant ait un rôle actif et central ?
- Comment s'assurer que cette « pédagogie alternative » (Philippe Perrenoud, 2002) développe à terme les qualités interpersonnelles de l'étudiant de l'ESATIC tout en améliorant ses compétences techniques ?

Afin de nous permettre de vérifier l'hypothèse selon laquelle l'APP favorise effectivement le travail en équipe et l'autonomisation des étudiants, cet article est organisé en quatre (4) parties. La première décrit le fonctionnement de l'ESATIC avant la mise en place de l'apprentissage par projet (APP). La deuxième, rend compte de la formation des formateurs sur la pédagogie active avec un l'accent particulier sur la contribution de la formation comme fondement de l'APP. La troisième présente le processus de mise en œuvre effective de l'APP avec les apprenants. Enfin la dernière, met l'accent sur l'évaluation dudit processus.

2 Methodologie de La Mise en Œuvre de L'app

2.1 Fonctionnement de l'ESATIC avant l'apprentissage par projet (APP)

2.1.1 L'organisation des enseignements

Créée en 2012, l'Ecole Supérieure Africaine des Technologies de l'Information et de la Communication (ESATIC) est un établissement public qui a pour mission de former des techniciens supérieurs et des ingénieurs dans les métiers de l'informatique et des télécommunications. Très vite, elle se soumet à la volonté du gouvernement de faire d'elle un pôle d'excellence sous régional.

Ainsi se lance-t-elle dans la formation des étudiants issus des baccalauréats scientifiques et techniques. Le système de formation adopté jusque-là est le modèle Licence, Master et Doctorat (LMD). Sous ce modèle, ont été déjà formés environ six cent (600) étudiants de la première année de Licence entre 2012 et 2017. La formation est exclusivement axée sur des Cours Magistraux (CM), des Travaux Dirigés (TD) et des Travaux Pratiques (TP). Les classes sont constituées de vingt-cinq (25) étudiants pour un volume annuel de 671 heures en présentiel, reparties en 394 heures CM, 218 heures TD et 79 heures TP.

2.1.2 Le système LMD

Dans le système LMD (Ahmed Ghouati, 2009), l'accent est mis sur le travail personnel de l'étudiant. Dans le cas de son application, les enseignants doivent mettre à disposition les supports de cours afin que les étudiants les consultent avant le début des enseignements. Cette disposition permet d'orienter la formation autour d'un échange enrichissant, mettant en relief les aspects du cours considérés comme acquis et ceux devant faire l'objet d'une explication.

2.1.3 l'évaluation

La formation durant ces sept (7) dernières années s'est déroulée sur deux (2) semestres auxquels s'ajoutent quatre (4) grandes périodes d'examen en raison de deux (2) sessions par semestre. Elle s'est faite autour d'une charge d'enseignement d'environ 40 heures par semaine, réparti en 8 heures par jour, avec un travail personnel d'étudiant s'élevant à environ 800 heures.

L'évaluation des enseignements répond aux normes en vigueur dans le système LMD qui préconise 40% pour l'évaluation continue et 60% l'évaluation finale.

2.2 Mise en œuvre de l'apprentissage par projet à l'ESATIC

L'ESATIC décide de renforcer ses outils pédagogiques en se penchant vers l'apprentissage actif. Cet apprentissage vient à point nommé pour pallier les insuffisances du système. Elle stimule en réalité l'engouement de l'apprenant en le confrontant à une situation problème à laquelle il devrait probablement trouver des solutions pour satisfaire un certain objectif d'apprentissage, comme l'illustre ces propos :

« Le but principal du processus APP n'est pas réellement de résoudre le problème donné : il est beaucoup plus ambitieux que cela ! Il s'agit en effet d'acquérir des connaissances, des compétences, des attitudes et des comportements à l'occasion de la résolution du problème. Chaque problème posé dans un processus APP vise une série d'objectifs d'apprentissage explicites. » (E. Aguirre et al, 2001)

Pour une exploitation efficace de l'APP, l'ensemble du personnel d'encadrement sera la première entité par laquelle passe cette innovation pédagogique. Etudiants et formateurs seront donc amenés à : « • *À découvrir que certaines connaissances leur font défaut, • à identifier les connaissances à acquérir, • à acquérir ces connaissances, • à appliquer l'ensemble de leurs connaissances (anciennes et nouvelles) à la résolution du problème posé.* » (E. Aguirre, et al, 2001)

Cette démarche, certainement permettra de communiquer implicitement au personnel d'encadrement la volonté manifeste de révolutionner la formation en ajoutant au classique quelques reformes pédagogiques.

2.2.1 La formation des formateurs

2.2.1.1 Formation théorique

L'ESATIC sollicite l'appui de l'Ecole Supérieure Privée d'Innovation Technologique (ESPRIT) de Tunis, avec laquelle elle est en partenariat. Ainsi a-t-elle bénéficié de deux (2) séminaires de formation sur l'apprentissage actif. Ces formations ont permis de transformer progressivement les enseignements classiques en enseignements actifs. Certains contenus sont alors réorientés vers une approche plus active de sorte à impliquer davantage les apprenants afin de parvenir à leur autonomisation.

2.2.1.2 La mise en situation pratique

Suite aux formations théoriques, des missions ont été effectuées en Tunisie pour s'enquérir du modèle d'ESPRIT. D'abord par la responsable de la Formation Initiale et le Point Focal de la Pédagogie Active en février 2017, puis en septembre de la même année par le Point Focal et l'ensemble des Responsables d'Unités Pédagogiques (Langues, Mathématiques, Informatique, Réseaux informatique et télécommunication, Management, Physique et applications).

Ces différentes missions ont permis aux formateurs de mieux comprendre l'apprentissage actif en général, mais aussi et surtout les notions d'Apprentissage par Problème et par Projet. L'ESATIC parvient ensuite à initier la mise en œuvre effective de l'APP avec l'ensemble des enseignants à travers un séminaire de restitution.

L'ensemble des informations partagées avec les enseignants et leur mise en situation pratique a favorisé la compréhension des contours de l'APP. De même, les avantages identifiés ont suscité l'adhésion et l'implication des enseignants dans la réussite de l'intégration de cette nouvelle approche pédagogique à l'ESATIC.

2.2.2 L'apprentissage par projet avec les apprenants

2.2.2.1 La résolution de situation problème en APP0

Après la phase de formation et d'implication des enseignants, advient celle des apprenants. L'APP0 (initiation) en septembre 2017 regroupant environ 100 étudiants de la première année du tronc commun SRIT. En réalité, une situation problème qui avait fait l'objet de l'APP0 à ESPRIT (Kaouther Louati, Zied Alaya, et al, 2016) ; (Ghazi K, Zied Ayala et al, 2016) pour le compte de l'année académique 2017-2018 a été reconduite. Cette activité a permis de réunir sur quatre (4) jours des étudiants nouvellement inscrits et venants d'horizons divers après le baccalauréat. Regroupés en sous équipes de quatre (4) à cinq (5) étudiants maximum, et repartis en quatre (4) équipes / salle, ces étudiants ont travaillé à la résolution de situation problème.

Dans le but de permettre aux étudiants de se familiariser les uns avec les autres, une activité de brise-glace a été organisée la première demi-journée par les tuteurs. Ensuite, une plénière a présenté l'APP aux étudiants en mettant en relief ses caractéristiques, son fonctionnement, ses avantages, ses inconvénients et sa méthodologie de réalisation. La prochaine étape a consacré le lancement effectif du projet avec la présence de tuteurs (trois (3) par salle), chargés d'orienter et de coacher les apprenants. Se référer au tableau ci-dessous pour le planning.

Tableau: Planning APP0 ESATIC 2017-2018

	Matin (9h-12h)		Après midi (14h–17h)
Mardi 5 Sept 2017	Présentation APP et Quizz d'accueil (Plénière)		Répartition des équipes et lancement (Aller1)
Mercredi 6 Sept 2017	Retour 1 et Aller 2		Travail sans tuteurs
Jeudi 7 Sept 2017	Retour 2 et coaching		Travail sans tuteurs
Vendredi 8 Sept 2017	Evaluation		Résultats et Synthèse

Source : Cahier tuteur ESATIC, 2017

Ce programme a conduit au terme des quatre (4) jours à l'identification de diverses solutions proposées par les étudiants, qui ont fait l'objet de présentations publiques des quatre (4) meilleurs projets. Une cérémonie de remise de prix a été également organisée à l'issue de ces présentations pour galvaniser et rendre solennelle cette première phase.

2.2.2.2 Mise en œuvre du projet intégré (APP 1)

Lancé au début du deuxième semestre, le projet intitulé « **Concours d'entrée dans une grande école publique** », a été réalisé sur 12 semaines dont six (6) de travail sans tuteurs et quatre (4) en présence des tuteurs. Cette réalisation a également pris en compte le suivi et l'encadrement des apprenants, l'organisation de workshops. Le rôle des tuteurs a consisté à la gestion des conflits (problèmes de communication, d'intégration dans les équipes…), au suivi des équipes (gestion des absences, implication de tous les membres dans le travail, respect des délais, recherche d'information…) ainsi que les évaluations organisées en trois phases :

- une première réalisée à mi-parcours pour mettre en relief les différents niveaux de compréhension du sujet et les outils de sa mise en œuvre ;
- une deuxième évaluation technique pratiquement à la fin de la conception mettant l'accent sur l'ensemble des aspects techniques et sur la pertinence de la réalisation ;
- la troisième phase a mis en exergue la valeur commerciale du projet, prenant en compte tous les aspects communicationnels et publicitaires. Cette dernière étape du projet a été ouverte au grand public.

Après l'évaluation, une enquête a été réalisée pour recueillir le ressenti des étudiants relativement au processus APP.

3 Résultats

3.1 L'évaluation de l'approche APP par les étudiants

Dans l'objectif de recueillir le point de vue des apprenants, une enquête a été menée auprès d'un échantillon de 89/100 étudiants de la licence 1.

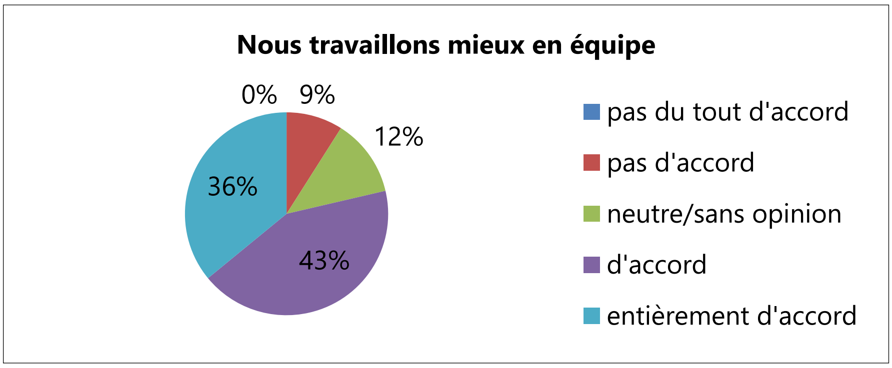
Les thèmes abordés au cours de cette enquête ont été regroupés en trois (3) points :

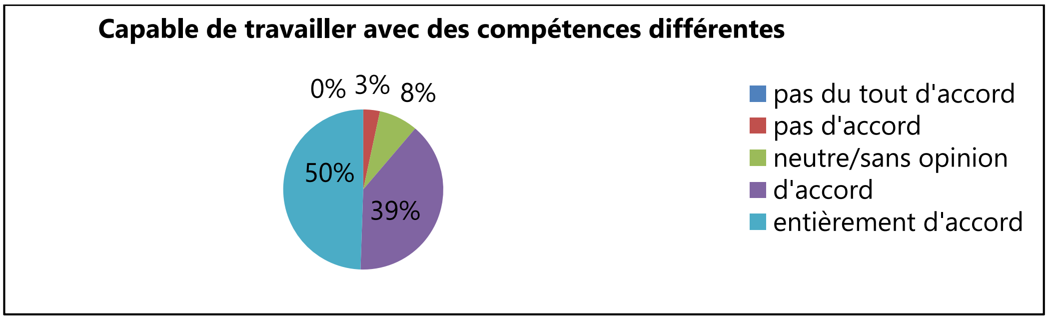
- le travail en équipe ;
- l'environnement de travail ;
- la satisfaction globale.

3.1.1 Le travail en équipe

Les informations majeures recherchées au niveau de cette partie étaient de savoir si les étudiants travaillaient mieux en équipe et s'ils étaient capables de travailler avec des compétences différentes. L'enquête révèle que 79 % des apprenants sont au moins d'accord de travailler mieux en équipe. En plus, 89 % disent être capable de travailler avec des compétences différentes.

Figures 1 : Questions et résultats de l'enquête sur le travail en équipe auprès des étudiants





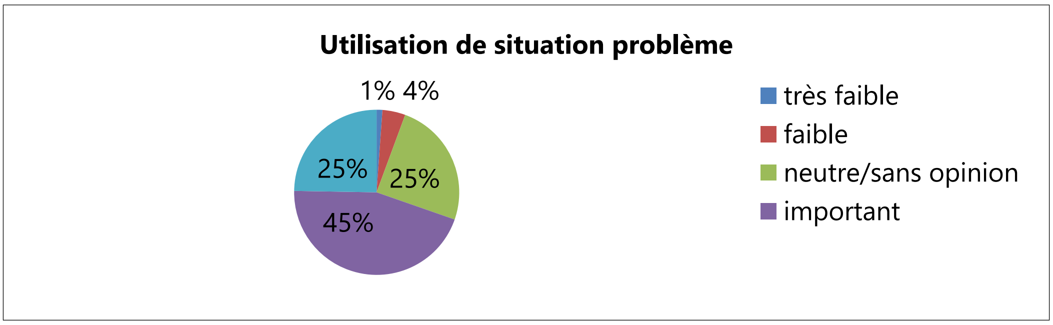
Source : Calculs des auteurs, 2018

3.1.2 L'environnement de travail

L'information recherchée dans l'environnement de travail était de savoir l'apport d'un nouvel élément dans le cadre de l'apprentissage.

Les apprenants dans leur majorité (au moins 70%) reconnaissent que l'utilisation de situation problème dans le cadre de l'enseignement facilite l'acquisition de certaines compétences.

Figure 2 : Questions et résultats de l'enquête sur l'environnement de travail auprès des étudiants

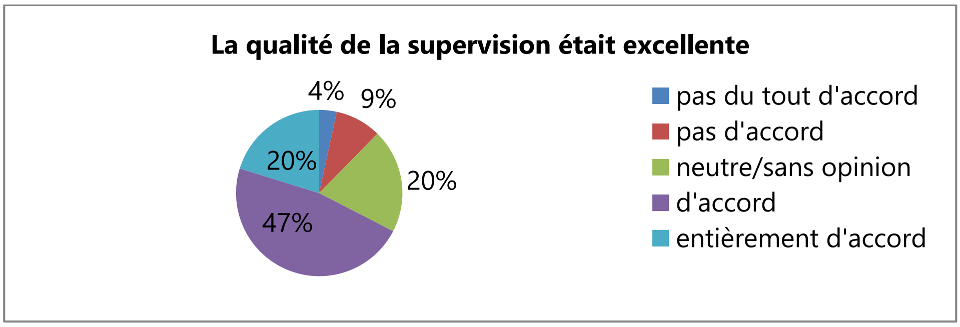


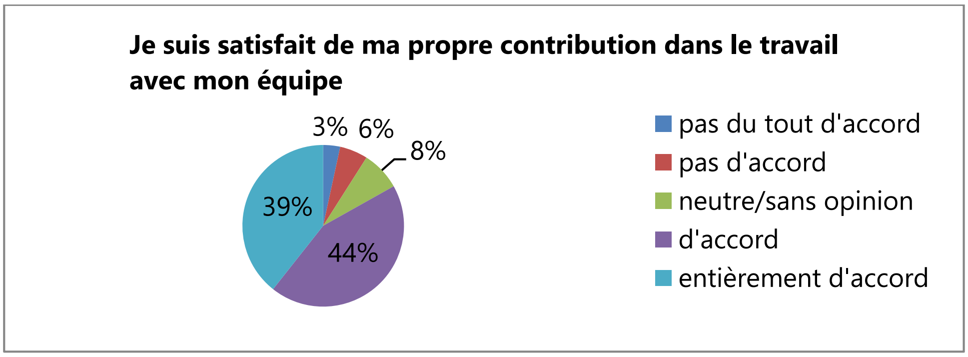
Source : Calculs des auteurs, 2018

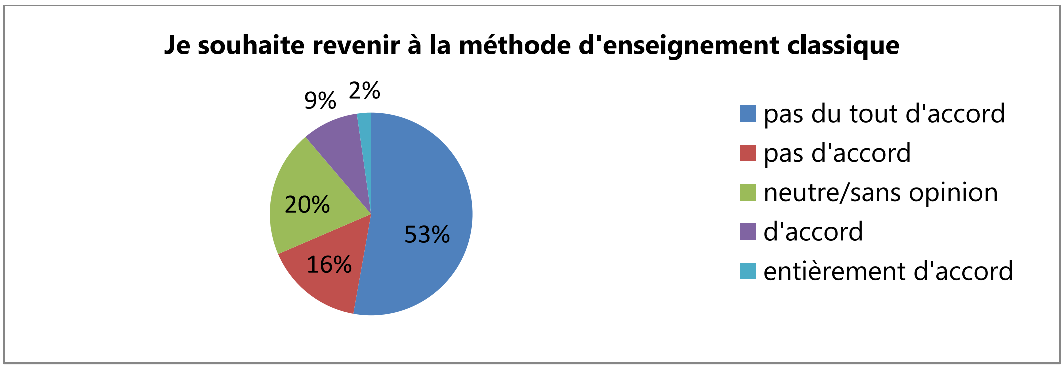
3.1.3 Satisfaction globale

L'avis des apprenants sur la qualité de leur relation avec le tuteur, leur contribution dans le travail en équipe, le choix entre la méthode d'enseignement classique et celle de l'APP montrent qu'au moins 56 % des apprenants apprécient le coaching. Concernant leur propre contribution dans le travail en équipe, 85 % sont satisfaits et 69 % souhaitent continuer avec l'APP.

Figures 3 : Questions et résultats de l'enquête sur la satisfaction globale auprès des étudiants







Source : Calculs des auteurs, 2018

3.2 Les impacts de l'APP

3.2.1 Les charges horaires

Dans notre ancien programme (deux semestres de 15 semaines auxquels s'ajoutent des semaines d'examen) l'encadrement des étudiants était d'environ 38 heures par semaine (CM, TD et TP) en plus d'une charge de Travail Personnel de l'Etudiant (TPE) estimée à plus de 800 heures l'année. Ici, c'est le lieu de rappeler que le Conseil Africain et Malgache de l'Enseignement Supérieur (CAMES) inscrit dans le système Licence-Master-Doctorat (LMD), exige que la Charge Totale de Travail (CTT) annuel se limite à 1500 heures repartie en 750 heures par semestre pour 30 crédits.

De façon générale, les hypothèses statistiques du système LMD correspondent à :

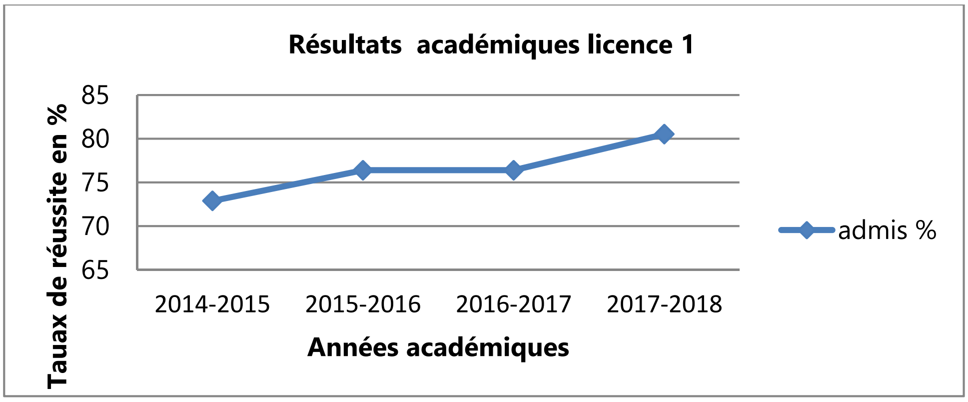
- 1 heure de CM = 1,5 à 2 heures de TPE (exercice à préparer ou à rédiger) ;
- 1 heure de Travaux Pratique = 1 heure de TPE (rédaction de compte rendu) ;
- activité moyenne de 38 heures par semaine ;

- le temps de TPE peut varier de 700 heures à 920 heures.

Dans notre nouveau programme, ce qui change fondamentalement, c'est que des plages horaires ont été identifiées pour les séances d'APP. Par semaine, il a été programmé une séance de 4 heures d'APP et le processus s'étale sur 12 semaines. Cela se solde par un volume annuel de 48 heures comme charge de travail en plus pour l'étudiant. Cependant, le TPE n'est pas estimé pour le projet APP.

3.2.2 Le taux de réussite

L'observation de la courbe des résultats académiques de la licence 1 à travers la variable taux annuel de réussite montre une augmentation pour l'année académique 2017-2018.



On note qu'après avoir évolué pendant 3 années successives dans le modèle classique le taux de réussite moyen annuel était de 70 %. Après l'introduction de l'APP, il y'a eu une amélioration de 10 % du taux de réussite moyen annuel qui ramène le résultat à plus de 80 %.

En somme, pour l'étape des résultats avec l'APP, il est observé que les étudiants travaillent mieux en équipe et sont capables de le faire dans un environnement composé de différentes compétences. Aussi sont-ils satisfaits de cette nouvelle approche et apprécient la relation de coaching apprenants-tuteurs. Cependant l'approche APP, dans sa mise en place, requiert des heures supplémentaires à la charge de travail existant et une difficulté majeure s'impose quant à l'estimation du travail personnel de l'étudiant pour le projet APP.

4 Conclusion

L'objet de cet article est de décrire la mise en place de l'APP dans l'école publique d'ingénieurs ESATIC. La première étape a été celle de la sensibilisation et de la formation des acteurs clés, notamment le personnel d'encadrement. S'en suit son application effective avec les étudiants à travers de deux (2) phases : *une situation problème* avec l'APP0 et le *projet intégré* appelé APP1.

L'évaluation de l'APP par les apprenants, son impact sur les charges horaires et le taux de réussite annuel, sont les aspects autour desquels tournent les résultats de sa mise en œuvre. Au niveau de l'évaluation de l'APP par les apprenants, trois points ont été retenus : le travail en équipe, l'environnement de travail et la satisfaction globale des étudiants relativement au processus. De façon globale, il ressort des enquêtes menées auprès des étudiants qu'ils apprécient travailler en équipe et expriment une grande satisfaction vis-à-vis du nouvel environnement de travail qu'offre l'APP.

En ce qui concerne l'impact, il est à noter que la charge horaire avec l'APP est nettement plus élevée que celle dans l'approche classique. Pour ce qui est des résultats académiques, il a été observé que les taux de réussites sont meilleurs à ceux des années antérieures.

Cette intégration ne s'est pas faite sans difficultés. Comme le relève si bien Juliette Payan, dans son article : *La résistance des matériaux en pédagogie active*, publié en 2013, la non-implication effective de l'apprenant dans la consolidation du savoir et son incapacité à travailler indépendamment de la supervision de l'enseignant trouve aussi un écho favorable à l'ESATIC.

Il a été remarqué que nos apprenants qui ont hérité d'environ dix (10) années d'enseignement traditionnel et directif avant leur entrée à l'ESATIC, ont beaucoup de mal à travailler correctement par eux-mêmes. Ainsi la non-participation ou la participation partielle de certains membres des équipes lors des travaux en équipes

est-elle à déplorer. Aussi, la difficulté de l'intégration de tous les enseignants dans l'APP ou encore la « transformation » des cours classiques sous l'angle actif/ APP a été également constatée.
Du côté des étudiants, un appui financier pour la réalisation pratique des projets a été sollicité. Ils évoquent également la difficulté d'adaptation à cette nouvelle méthode de travail. Le défi pour les années à venir reste à impliquer davantage le personnel d'encadrement et parvenir progressivement à remodeler tous les enseignements à l'ESATIC sous l'angle actif.

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Script design of a blended language course at the crossroads of critical thinking and digitalisation

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Abstract

Developing critical thinking has long been a goal of all learning process; the effervescence of digital brought it now to the forefront. Leading reasoning and selecting the right information becomes more and more difficult. In other words, what pedagogical and digital tools can be used to help understand how critical thinking works? How is critical thinking expressed and developed when languages become applied? In addition, using digital tools will also be a challenge for any teacher and especially language teachers practising active pedagogy in their class. The reflection of the analogy between pedagogy and didactics in the practice of the project approach as an example is the key to the success of this learning and is in itself a real challenge. Indeed, we will try to see how the subject content and their learning process affect the teaching style? We will also try to come back to the difficulties and obstacles encountered in an active pedagogy approach where the teacher's time, disciplinary division and posture are unstable. We will also see to what extent the teaching process is vector and dependent on the learning process? Active pedagogy is in essence a challenge offering the possibility of acquiring learners experiences of life and consequently of real responsibilities hence the difficulty of designing for the teacher/coach that adequacy between the resolution and the targeted objective. To what extent can we form a continuum in the various stages of the scripting of a language course?

Keywords: active learning, digitalisation, critical thinking, scripting

La scénarisation d'un cours de langue au croisement de la pensée critique et de la digitalisation

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Abstract

Développer l'esprit critique chez l'apprenant est depuis longtemps une finalité de tout apprentissage, il est aujourd'hui ardemment remis au devant de la scène face à l'effervescence du numérique. A l'ère du digital, conduire des raisonnements suivis et distinguer des informations devient de plus en plus difficile. En d'autres termes, quels outils pédagogiques et digitaux peuvent servir à faire comprendre le fonctionnement de la pensée critique ? De quelle manière s'exprime et se développe la pensée critique quand les langues deviennent appliqués? De surcroit, montrer à titre panoramique les perspectives et les difficultés ouvertes de la pédagogie active dans une classe de langue sera aussi un challenge pour tout enseignant qui basculera de son rôle de pédagogue à celui de didacticien du digital. La réflexion de l'analogie entre pédagogie et didactique dans la pratique de l'approche par projet à titre d'exemple est la clef de la réussite de cet apprentissage et est en elle-même un vrai défi. En effet, nous tenterons de voir comment les contenus disciplinaires et leur processus d'apprentissage influent sur le style d'enseignement ? Nous essayerons aussi de revenir sur les difficultés et les obstacles rencontrées dans une approche de pédagogie active où le temps, le découpage disciplinaire et la posture de l'enseignant sont instables. Nous verrons également dans quelle mesure le processus d'enseignement est vecteur et dépendant du processus d'apprentissage ? La pédagogie active est en son essence un challenge offrant la possibilité de faire acquérir aux apprenants des expériences de vie et par conséquence de vraies responsabilités d'où la difficulté de concevoir pour l'enseignant-coach cette adéquation entre la résolution et l'objectif visé. Dans quelle mesure peut-on donc former un continuum dans les différentes étapes de la scénarisation d'un cours de langue ?

Keywords: Apprentissage actif; digitalisation; pensée critique; scénarisation.

1. Introduction

La réflexion menée à la lisière de cet article a été motivée par un besoin intrinsèque de comprendre ce nouvel enjeu pédagogique, qu'est la transition digitale. Certes, le croisement entre la pédagogie et le digital reste aujourd'hui encore peu exploité. Beaucoup d'enseignants pensent que l'intégration du numérique est un simple maniement d'outils digitaux alors que le défi est réellement encore plus complexe qu'il n'y parait. L'expérience menée sur une classe de langue anglaise, décrite et analysée ci-dessous, nous a permis de comprendre que l'outil digital même s'il contribue à renforcer la motivation des apprenants, doit aussi faire partie intégrante de la conception d'un programme de cours. L'enseignant ne doit pas seulement l'utiliser comme simple support ou ressource mais il doit être un moyen de scénarisation pédagogique renforçant l'apprentissage par et pour le digital. L'impact de l'actualité sociopolitique et économique, dans le quotidien des apprenants, est soutenu par les médias, rendant leur approche critique de plus en plus délicate, mais non moins intéressante, de part la subjectivité et les a priori qu'ils véhiculent. Ainsi, il nous a semblé pertinent, dans le cadre de cet article, d'étudier l'esprit critique et la façon dont il peut être mobilisé en cours de langue dans le traitement des sujets d'actualité.

Si nous partons du fait que l'approche du CECR met en exergue la dimension culturelle, le cours de langue pourrait- ou devrait - être conçu tel le lieu de l'ouverture culturelle, de l'appropriation de nouveaux modes de vie à travers la découverte. L'esprit critique pourrait ainsi enrichir la perception des cultures concernées et en proposer une vision plurielle non biaisée, loin des clichés et des lieux communs, sans oublier l'acquisition/renforcement des compétences linguistiques et langagières qui en découlent. Dans les cursus non linguistiques, l'enseignement-apprentissage des langues rencontre encore une certaine résistance de la part des apprenants. Leur démotivation est accentuée par la priorité qu'ils accordent aux matières et aux projets techniques. Ceci est essentiellement dû à la vision utilitariste qu'ils se font de l'enseignement des langues en comparaison avec l'importance qu'ils accordent, et d'une manière légitime, aux Disciplines Non Linguistiques (DNL). Quelles stratégies doit-on alors mettre en place afin de rendre le cours de langue plus attrayant ? La question est de savoir comment mobiliser la pensée critique dans un contexte social et éducatif digitalisé. Dans quelle mesure peut-on rendre les cours de langue des disciplines utilitaires non pas seulement d'un point de vue linguistique et communicationnel mais essentiellement critique ? Aujourd'hui, le pédagogue-didacticien est confronté à un nouvel enjeu : comment réussir à exploiter un contenu digital tout en sensibilisant à l'importance de la pensée critique ? Jusqu'à quelle mesure l'enseignant peut initier ses apprenants à cette compétence clé du 21ème siècle ? Et comment réussir à réengager des apprenants-consommateurs dans une démarche de raisonnement critique ? C'est dans cette optique que nous allons proposer, dans un premier temps, une définition non exhaustive de la pensée critique et d'expliquer sa nécessité dans un monde hyper informatisé. Dans un deuxième temps, à partir de la taxonomie de Bloom, nous tenterons d'expliquer notre choix pédagogique du Blended Learning en tant qu'approche pédagogique mobilisant les quatre compétences d'expressions et de communications nécessaires à la maîtrise d'une langue. Enfin, la dernière partie sera consacrée à l'illustration d'une expérience pédagogique réalisée dans un cours d'anglais sur la pensée critique _ que nous avons appelé Cours 1 de Critical thinking _ où le scénario pédagogique basé sur le Blended Learning nous a permis de comprendre les nouveaux enjeux de l'enseignant-coach.

2. L'apprentissage des langues étrangères selon le CECR : l'exemple de la formation d'ESPRIT (Esprit une école d'ingénieurs et de managers)

Le cours proposé dans cet article s'inscrit dans le cadre du module d'anglais. Il nous a donc semblé judicieux et nécessaire de présenter le CECR comme référence essentielle à tout enseignement d'une langue européenne. Élaboré par les États membres du Conseil de l'Europe, le Cadre Européen Commun de Référence (CECR) est un outil proposant une base commune à plusieurs langues (environ 38 langues) pour faciliter la mise en place de programmes d'enseignement afin d'harmoniser l'évaluation des compétences en langues étrangères.

La perspective privilégiée par le CECR est dite actionnelle « Elle considère avant tout les usagers et les apprenants d'une langue comme des acteurs sociaux ayant à accomplir des tâches (qui ne sont pas seulement langagières) dans des circonstances et un environnement donnés, à l'intérieur d'un domaine d'action particulier. » Cette nouvelle approche associe la notion d' « action » à celle de « tâche » qui doit répondre à un contexte, poser un problème à résoudre, définir une intention ou un but et aboutir à un résultat ou à un produit. Ce qui contribue également à dépasser cette vision réductrice encore trop répandue aujourd'hui, qui consiste à limiter l'apprentissage de la langue à celui de la grammaire, du vocabulaire, plutôt que de l'inscrire dans une perspective interdisciplinaire, communicative et surtout décloisonnée.

3. La pensée critique : un vrai challenge pédagogique à l'ère du digital

Tout enseignement doit procurer aux apprenants des outils d'adaptation à ce monde en rapide mutation. C'est dans cette optique que la pensée critique prend tout son sens. Ainsi, la compréhension du sens exact de la pensée critique est primordiale à la fois pour l'apprenant mais aussi pour l'enseignant. Ce dernier doit être conscient lors de l'évaluation d'un exercice écrit ou oral quelconque qu'une « bonne » prestation doit être dénuée de toute subjectivité. Seul le raisonnement fondé sur des preuves avérées, la capacité à construire un raisonnement cohérent et convaincant de part les preuves qu'il contient, s'avère valable pour toute évaluation. C'est d'ailleurs une évaluation autonome d'un « fait » (chose ou personne) en ayant principalement recours à un argument de raison et non d'autorité. Nous nous basons sur ce premier sens de la pensée critique en délaissant sons sens second, entendu comme un dénigrement d'un fait pour cibler ses insuffisances.

C'est dans cette perspective que chaque grain pédagogique du scénario du Cours 1 de Critical thinking se base sur une évaluation ponctuelle et individuelle afin de s'assurer de l'acquisition des objectifs d'apprentissage inhérent à la pensée critique. L'exercice de la raison suppose, l'examen et la pratique d'une certaine ascèse de l'esprit qui nécessite de l'écoute active, de la logique et de la cohérence. Un exercice critique est un exercice où l'apprenant se met dans deux postures complémentaires : l'autonomie et l'écoute (penser par soi-même, prendre le temps de réfléchir) afin d'atteindre une pensée personnelle et fondée. D'ailleurs, les compétences de la pensée critique de base élaborées par Facione résument parfaitement la pertinence de toute démarche critique: l'interprétation, l'analyse, l'évaluation, l'inférence, l'explication, et l'autorégulation.

De surcroit, l'analyse critique peut être effectuée dans le cadre de tâches formelles ou d'activités informelles et continues (notamment la création d'une carte heuristique et d'une base de données dans le Cours 1). L'exercice de la pensée critique lors d'activités telles la prise de décision, l'analyse et la résolution de problème, l'investigation et l'autoévaluation, permet aux apprenants de passer de la réflexion élémentaire (ou fortement guidée) à une pensée de plus en plus complexe, élaborée et indépendante. D'où le choix de la taxonomie de Bloom comme pierre angulaire de ce travail. Nous verrons d'ailleurs dans les prochaines parties les avantages de la taxonomie de Bloom essentielle à l'élaboration de tout cours dans la mesure où elle peut s'appliquer parfaitement à un contenu digital.
L'engagement digital apparait d'ailleurs comme une nouvelle autorité qui influence fortement les pratiques pédagogiques. Autrement dit, la facilité et l'accessibilité au flux de données et d'informations, créant un véritable écosystème, permet un vrai cloisonnement de la conscience réflexive. En effet, on assiste de plus en plus à un assujettissement constant de la pensée et une limitation incessante de la conscience dus à la passivité inhérente au monde connecté. Nous assistons ad hoc à une sorte de contrôle de la pensée via une réflexion linéaire qu'on retrouve sur le net. La profusion et la prolifération fait qu'aujourd'hui un apprenant n'éprouve plus le besoin de réfléchir par lui-même et de bâtir son propre raisonnement se laissant envahir par un raisonnement à la carte. Les réseaux sociaux qui connaissent parfaitement nos goûts, nos comportements et nos habitudes via un recueil de données personnelles que les algorithmes peuvent croiser afin de répondre aux demandes d'une manière ciblée et pertinente via des systèmes de recommandations, ne font que cloisonner encore plus nos pensées et nos choix. On nous offre un contenu personnalisé, un contenu qui ne sert qu'à nous cantonner encore plus dans une pensée linéaire, uniforme et homogène. Le besoin d'apprentissage et de découverte personnelle se voit supplanter par le digital qui nous sert et ressert sa « paresse démagogique ».

4. Le Blended learning ou comment dépasser les limites du e-learning

Généralement, on mesure l'engagement des apprenants par le taux d'achèvement des activités. Enrôler un apprenant dans une démarche de pensée critique devient un élément essentiel pour accroître la motivation des apprenants en leur proposant des challenges en vue de les aider à développer leur esprit critique. A l'aune de la pensée critique 2.0, l'apprentissage actif, interactif et social offre aux apprenants l'opportunité d'acquérir une compréhension complète et profonde qui dépasse la capacité de restituer les faits pour en créer et pour partager leur vision du monde.

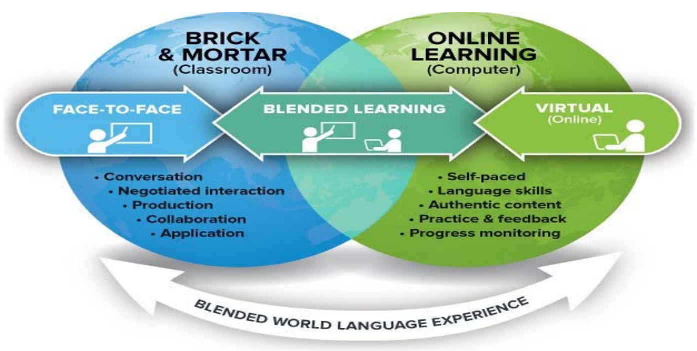


Figure 1: Le blended learning ou la combinaison d'une formation en ligne avec une formation en présentiel

C'est dans cette perspective qu'on se rend compte de la pertinence de la taxonomie de Bloom et de la séparation faite entre les objectifs d'apprentissage de faible densité de cognition, qu'on nomme d'ailleurs « habilités cognitives de bas niveau » ou LOTS appartenant généralement à un e-learning classique où la seule tâche des apprenants est d'assimiler et de comprendre. Par contre, le blended learning permet de sillonner tous les objectifs d'apprentissages proposés par Bloom et essentiellement les « habilités cognitives de haut niveau » ou HOTS. Rappelons juste que le blended learning ou l'apprentissage mixte en français nécessite une formation numérique en présentiel. De ce fait, l'apprenant se voit guider par l'enseignant-coach et peut interagir avec lui et avec ses camarades à tout moment créant par là même une dynamique de groupe nécessaire à nourrir la motivation des apprenants.

Figure 2: Le e-learning face au blended learning

L'apprentissage en utilisant la taxonomie de Bloom a un caractère cognitif, affectif et social et c'est ce qui le rend efficace. Ces activités d'apprentissage qui s'échafaudent, poussent progressivement l'apprenant à une compréhension plus profonde et plus complète du sujet traité. Au début, après avoir visionné une séquence vidéo ou avoir lu un texte, les apprenants prennent conscience de l'existence d'un fait. Ils en viennent à la compréhension après certaines activités, toutefois ce n'est qu'en les appliquant dans un contexte différent - par exemple en discutant sur un forum de leur résultats - qu'ils acquièrent une compréhension plus profonde. Dans le cadre du Cours 1, après confrontation et analyse de leurs résultats sur le forum, ils en viennent à la création d'une base de données collective afin de définir les critères essentiels à l'évaluation de la pertinence d'un site web. In fine, la création d'une réflexion individuelle puis collective, informe sur leur degré de maitrise du sujet.
Pour ainsi dire, la version révisée de la taxonomie permet de mesurer les limites du e-Learning qui se focalisent généralement sur des activités, peu complexes, de premier niveau (définir, ordonner, identifier, répéter…) quand l'objectif est uniquement de leur fournir des connaissances de base ou de se familiariser avec un sujet précis. Pour réussir donc à pousser les apprenants à développer cette compétence devenue primordiale, les activités d'apprentissage doivent idéalement reprendre toutes les étapes de la taxonomie de Bloom.
Les limites du digital learning rehaussent pour ainsi dire un dispositif de blended learning plutôt hybride, qui suggère d'aller plus haut dans la hiérarchie de Bloom permettant aux apprenants de s'essayer aux activités d'application, d'analyse et de création. Les HOTS prennent ainsi tout leur sens. On peut d'ailleurs les répartir en deux niveaux :
D'une part, l'analyse et l'évaluation qui sont intimement liée du point de vue des activités d'apprentissage et des « learning outcomes ». Par contre, la création mérite une catégorie bien à elle parce que les stratégies et les processus qui lui sont propres sont différents des précédents. Somme toute, l'évolution obligatoire des LOTS vers les HOTS peut être remise en question dans certaines activités où l'on peut commencer par le niveau le plus approprié à la zone proximale de développement des apprenants. Nous verrons dans notre tentative d'essaimage pédagogique comment le fait de chercher un article pertinent sur le net afin de prouver sa pertinence nécessite uniquement certaines catégories taxonomiques. Il n'est donc pas nécessaire en amont d'avoir eu un cours détaillé en référencement Web pour réussir l'exercice quand une initiation à la pensée critique peut s'avérer tout aussi efficace.
De plus, lorsque des activités axées sur les LOTS sont transposées au format numérique, elles deviennent des activités appartenant aux HOTS comme l'exemple d'un forum sur Moodle qui serait dans une classe adoptant une pédagogie classique juste une activité de débat ou d'expression orale alors que dans un contexte de blended learning, elle devient une zone de discussion et d'échange qui permet de se remettre en question, de faire son auto-évaluation et de découvrir l'intérêt de son travail. Elle motive les apprenants parce qu'ils se comparent à leurs pairs. Cette activité d'expression orale devient dès lors aussi une activité de production et

de compréhension orale et écrite. Elle peut en simultanée prendre en charge les quatre compétences à développer dans un enseignement de langue (évoquées plus haut). Ainsi, le choix des activités et des ressources numériques doit permettre à l'enseignant de mettre au point un environnement d'apprentissage suffisamment stimulant pour ses apprenants. C'est ainsi que les technologies numériques prennent tout leur sens dans un cadre de Blended learning.

5. Scénarisation d'un cours de langue hybride

Le Cours 1 de Critical thinking a été réalisé sur le système d'apprentissage Moodle, qu'Esprit privilégie depuis quelques années. En effet, ce système permet l'accès aux différents cours sachant que les enseignants d'Esprit et particulièrement d'Esprit School of Business ont périodiquement des formations les encourageant, par la même, à un maniement plus fluide des nombreuses ressources et activités que propose cette plateforme. En d'autres termes, le choix de Moodle se justifie, d'un point de vue pédagogique, par la facilité de création du cours et la réutilisabilité du contenu sous la forme d'un cours structurée en ligne. Elle permet de surcroit d'administrer facilement du contenu aux apprenants en simultanée ou à distance tout en réalisant un suivi personnalisé. Offrant une panoplie d'activités très diversifiées qui ont quasiment les mêmes caractéristiques de nombreux outils digitaux, Moodle encourage nettement à s'initier à l'enseignement digital.
Conscients que l'élaboration d'un programme à l'ère de la « société de réseau» ne peut plus être dissociée de la technologie numérique, on doit dorénavant s'y soumettre : « Nous sommes mis au défi par les raisons socioculturelles d'un programme d'exploration de la notion de «citoyen numérique» et du passage à une expérience éducative cohérente qui prépare les gens à un monde fondamentalement différent de celui d'il ya une dizaine d'années. Pour participer et en tirer parti, les citoyens doivent maîtriser le numérique et posséder les compétences nécessaires pour tirer parti de la société de l'information et y participer. Cela inclut à la fois la capacité d'utiliser de nouveaux outils TIC et la maîtrise des médias pour gérer le flot d'images, de textes et de contenus audiovisuels qui circulent constamment sur les réseaux mondiaux. » (Castells : 2000).
Lors de la scénarisation du cours proposé dans cet article, le premier défi était d'élaborer un cours hybride de langues mettant en avant la pensée critique tout en sauvegardant l'approche communicative qui a comme épine dorsal le travail collaboratif en ligne. Cette tentative de séquençage d'un syllabus hybride avec une diversification des modèles d'apprentissage (classe inversée, cours présentiel avec intégration des activités en ligne etc.) a pour objectif de mettre les étudiants au centre du processus d'apprentissage en leur permettant de partager des expériences différentes avec les enseignants et les pairs. Rappelons tout en passant que ce cours comme tous ceux d'Esprit s'inscrit dans la pédagogie active.
Le second défi était de prendre en compte lors de la conception hybride du syllabus quatre étapes principales conçues et proposées par Bath et Bourke (2010: 7): la planification, la conception-développement des éléments d'apprentissage combinés, la mise en œuvre et la révision-évaluation de la conception. Pour ce faire, un diagramme d'activité, proposé à la figure 3, a été conçu pour suivre les étapes de la conception d'un cours hybride. Nous vous proposons ci-dessous une description des quatre étapes:

5.1 La planification

Cette première étape définit les besoins et attentes du public cible en se basant sur les fiches métiers, les débouchés et les exigences du marché de travail. Vient ensuite la planification du contenu, les ressources d'apprentissage, les activités d'apprentissage et l'évaluation. A ce stade, le contexte du cours comme décrit auparavant nous conduit à considérer la pensée critique comme thème et support principal du syllabus. Le cours a de ce fait été élaboré et dédié à :
Public cible: deux groupes d'étudiants en L3 en Management à Esprit School of Business.
Nombre d'étudiants par classe: 25.
Durée : 3h.
Pré requis: Initiation à la manipulation de la plateforme Moodle et l'exigence du niveau linguistique B2 du CECR.

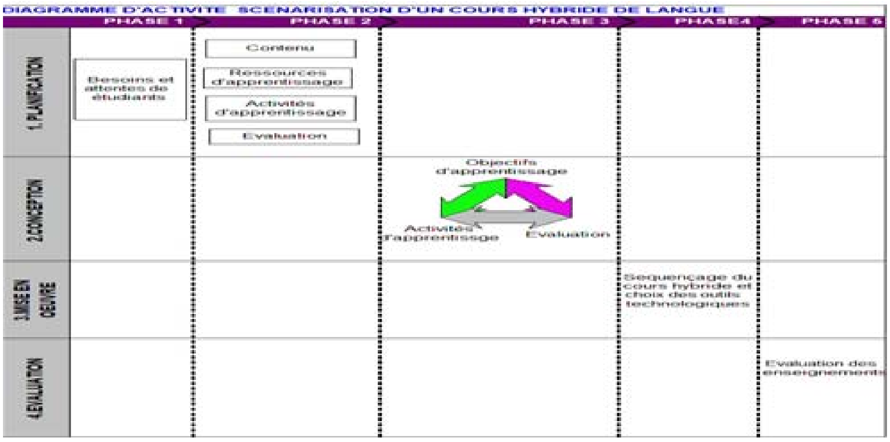
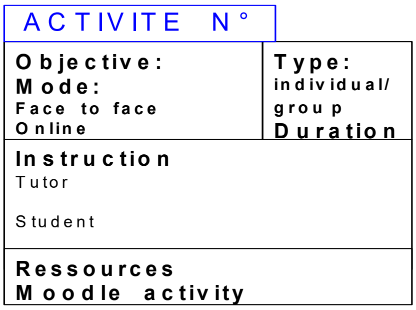


Figure 3: Diagramme d'activité pour la scénarisation d'un cours hybride

5.2 La conception et le développement d'éléments d'apprentissage combinés

Les objectifs d'apprentissage, les activités d'apprentissage et l'évaluation doivent être clairement définis par l'enseignant. L'enseignant conçoit et choisit chaque activité (voir figure 5) en définissant son objectif, son mode d'apprentissage, son type d'activité, et les instructions à respecter pour le tuteur et les étudiants ainsi que les ressources nécessaires et les activités à concevoir sur Moodle.



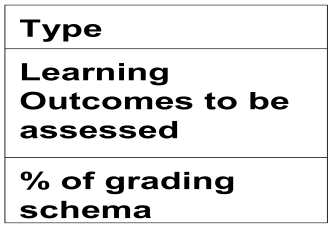


Figure 4: Conception d'une activité

Figure 5 : Conception d'une évaluation d'apprentissage

Par conséquent, les activités d'apprentissage et les évaluations doivent s'aligner aux objectifs d'apprentissage. Comme le mentionne Stein & Graham (2014: 35), ces activités peuvent être effectuées en ligne ou en classe, en fonction de leurs objectifs d'apprentissage spécifiques via des tests réguliers ou des observations des performances des apprenants. La variété et la fréquence de l'évaluation, que nous avons appelée « évaluation ponctuelle », aidera l'enseignant à fournir une notation plus fine et plus fiable. Pour ajouter une authenticité à l'évaluation du cours, des outils en ligne ont été utilisés en mode hybride via des tests à temps réel et des forums de discussion où l'enseignant a eu la possibilité de faire des commentaires sur la pertinence des interventions et l'occasion d'évaluer la participation active des apprenants, toujours de manière ponctuelle. Cela lui a aussi permis de guider leurs travaux d'investigation en les encourageant et en stimulant leur curiosité par des questions critiques et des reformulations de leurs problématiques. Ces maintes interventions ont été, bien évidemment, réalisées lors du Cours 1. A travers ces échanges, l'enseignant a pu détecter certains problèmes linguistiques notamment des lacunes en expressions écrite et orale, qui lui ont permis de planifier, dans les cours suivants, des exercices de consolidation en ligne.

Force est de constater que les recherches liées à la pédagogie active ou encore à la pédagogie dite ouverte a fait couler beaucoup d'encre ces dernières années. Toutefois, la théorie de l'apprentissage constructiviste et celle du online collaborative learning theory, développée par Linda Harasim a attiré notre attention de part sa conception de l'apprentissage en ligne : « La théorie de l'apprentissage collaboratif en ligne, ou OCL, est une forme d'enseignement constructiviste prenant la forme d'un apprentissage en groupe dirigé par un instructeur. Dans OCL, les étudiants sont encouragés à résoudre les problèmes en collaboration par le discours au lieu de mémoriser les réponses correctes. L'enseignant joue un rôle crucial en tant que facilitateur et membre de la communauté de connaissances (Traduction libre). » Cette théorie propose d'abord d'inciter les étudiants à travailler en collaboration pour construire leur propre apprentissage et ensuite d'être individuellement les principaux acteurs de leur formation. Elle favorise un environnement stimulant pour les étudiants, donnant plus d'authenticité aux activités d'apprentissage et plus de valeur à l'engagement des étudiants. Ayant pour base la théorie d'Harasim, nous avons essayé d'adapter les objectifs du cours 1 à la taxonomie digitale étendue de Bloom (voir figure 6) pour convenir à un environnement d'apprentissage hybride. La figure 5 et 6 illustre parfaitement ce propos.

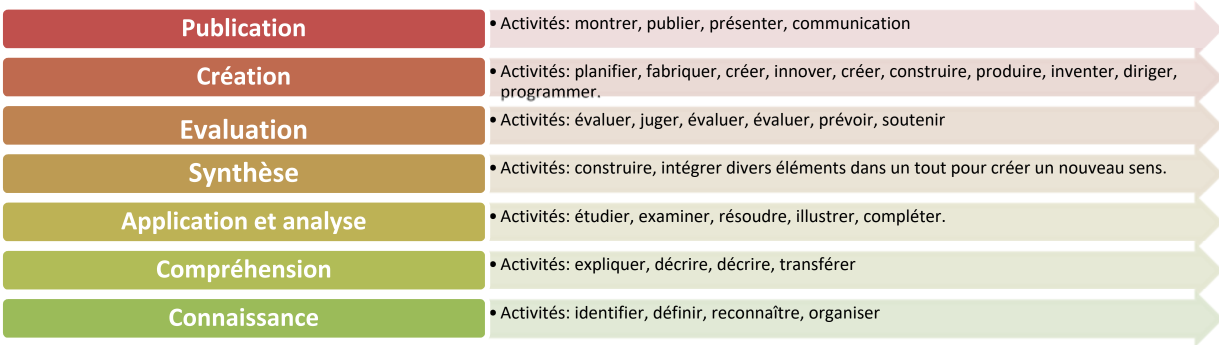


Figure 6: Taxonomie digitale étendue de Bloom selon Fractus Learning

5.3 La mise en œuvre

5.3.1 La scénarisation du syllabus

La mise en œuvre s'est concrétisée par l'élaboration d'un syllabus dans le cours de langue anglaise (module de 21 heures) et qui porte sur le développement de la pensée critique chez les étudiants. Ce dernier est axé sur trois phases :

Une phase d'initiation via le cours 1 expliquée et analysée à la fin de cet article.

Une phase d'approfondissement avec les 2ème et 3ème cours où les étudiants travailleront en classe inversée et en ligne sur la recherche d'arguments et de documentation autour d'une question pour réussir in fine à conduire un débat en présentiel. Ils développeront tout compte fait leur aptitude en expression orale et en rédaction lors de la réalisation d'un essai d'opinion.

Une phase d'application qui consiste à déterminer l'importance de cette compétence en l'appliquant à un projet, durant les quatre séances restantes du module, favorisant bien évidemment comme cadre d'apprentissage l'approche par projet.

5.3.2 La scénarisation d'un cours

Un diagramme d'activité a été conçu comme modèle pour toute scénarisation d'une leçon, comme indiqué, dans la figure 6. Nous avons pris en considération cette démarche dans la scénarisation schématisée (voir Figure 6 et Figure 7) décrivant le Cours 1 dans la phase d'initiation. En effet, après l'identification des savoirs et des compétences à développer tout au long du syllabus, le choix des approches pédagogiques à corréler a été établi. Les activités d'apprentissage ont été séquencées et granulées sur la base du CLAASS qui se consacre à la promotion de l'excellence en enseignement. C'est une planification de cours qui souligne la pratique de l'interactivité de l'enseignement et de l'apprentissage. Elle montre aussi la succession de différentes activités d'apprentissage qui s'alignent avec la taxonomie digital étendue de Bloom.

Ce cours hybride a d'ailleurs privilégié l'utilisation des outils technologiques en présentiel.

Il avait comme objectifs de :

- Développer la compétence de collecte d'informations par les apprenants
- Identifier la pertinence des sources d'information
- Encourager la réflexion critique et l'évaluation des sources web

Et qui se traduisent par les acquis d'apprentissage (learning outcomes) suivants:

- Poster et animer une discussion interne dans un forum en ligne avec les pairs
- Mener un sondage en ligne pour répertorier les sites Web liés au sujet
- Enumérer les sites web trouvés dans des fiches en ligne sur Moodle
- Lier différentes informations pour trouver un site Web fiable de part les références auctoriales
- Construire en collaboration une base de données en ligne des sites web fiables
- Comparer les résultats en utilisant les fiches
- Constituer en collaboration des critères d'évaluation pour définir un site web fiable
- Créer une carte mentale Mind Map en collaboration afin de constituer une matrice de critères

Les étapes du Cours 1 se présentent comme suit :

Activités et tâches	**Ressources Moodle**
Brainstorming sur la question en groupe	Forum
Collecte d'information individuelle sur le net	
Remplissage des fiches en donnant leurs avis sur les caractéristiques notables des sites ou les réponses qu'ils découvrent.	Fiche en ligne
Partage des résultats de recherche en groupe.	Forum
Comparaison en groupe des résultats en répondant aux questions guidées d'approfondissement et sélection de sites pertinents	Forum
Recherche approfondie des sites sélectionnés individuellement	
Elaborer une carte mentale en groupe des critères de sélection	Carte mentale

Ci-dessous donc le modèle de scénarisation du cours 1 de Critical thinking du module d'anglais qui résume les différentes étapes à suivre évoquées plus haut:

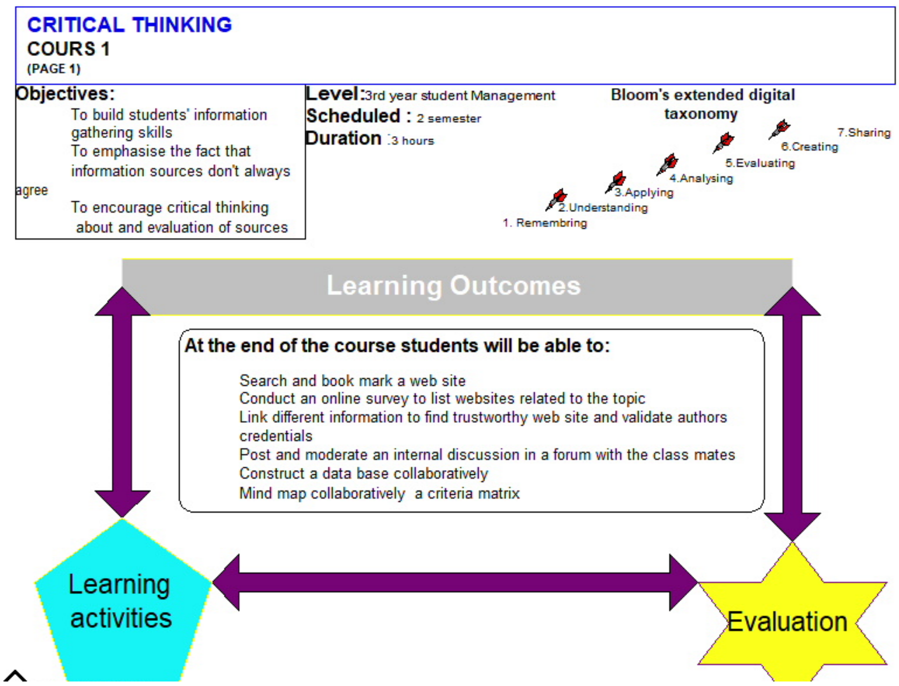


Figure 7: Le schéma du Cours 1 de Critical thinking (continue)

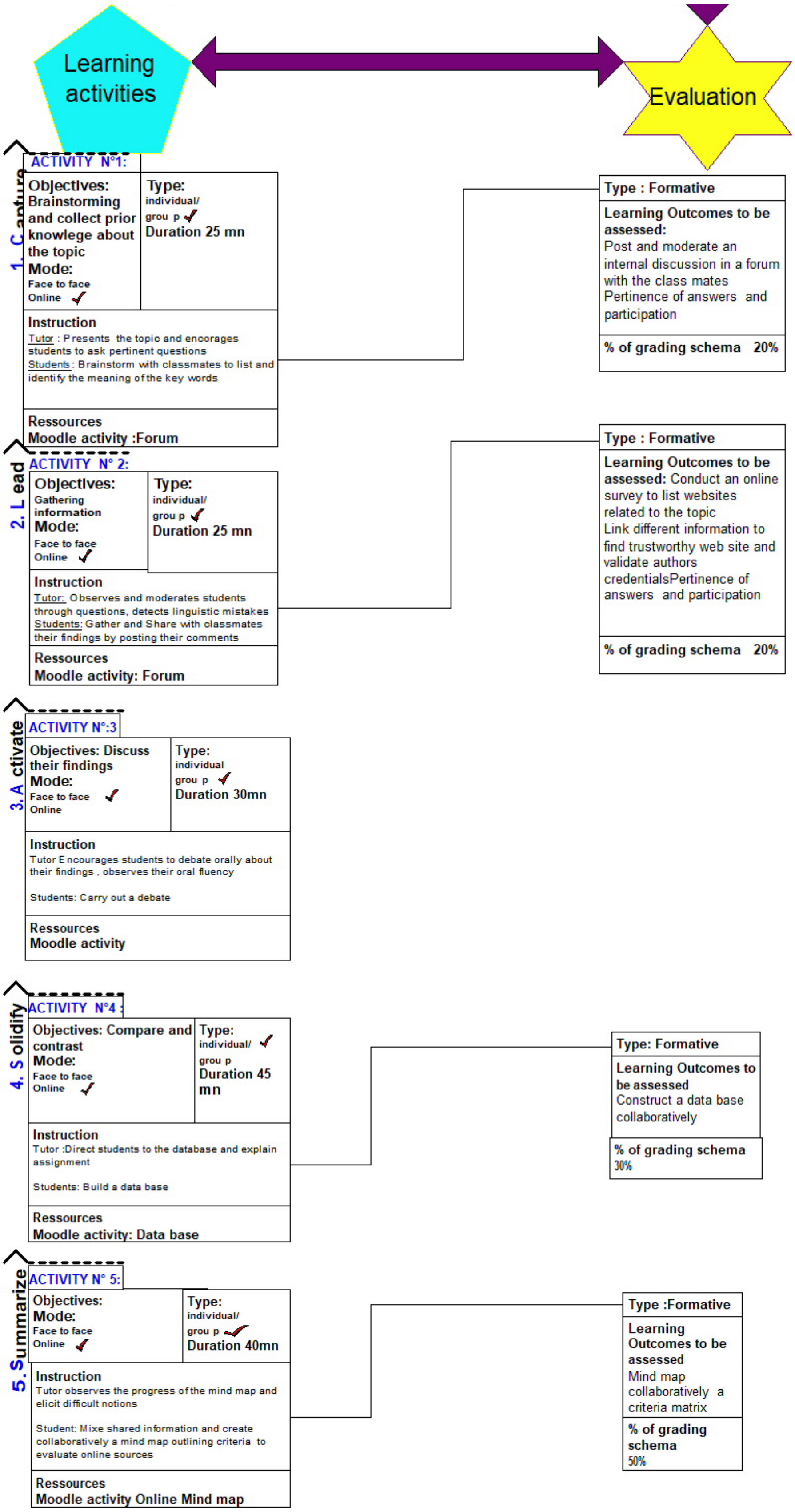


Figure 7: Le schéma du Cours 1 de Critical thinking

5.4 La révision et l'évaluation de la conception

Un formulaire pour évaluer l'enseignement est administré aux étudiants à la fin du syllabus, il est basé sur le feedback des étudiants quant à leur amélioration en compétences linguistiques et communicationnelles ainsi que sur la pertinence du travail en collaboratif au vue de la pensée critique. Ils évalueront de surcroit l'intérêt qu'ils ont porté à la formation hybride.

6 Conclusion

Le vrai challenge de cet article a donc été de mettre ses lunettes de didacticien en vue de réfléchir et de décrire une pratique de la pensée critique qu'il semble souvent difficile d'élaborer et d'écrire. Toute pratique pédagogique à l'ère du digital fait que les contenus disciplinaires et leur processus d'apprentissage influent sur le style d'enseignement. L'enseignement des langues en ligne confronte les enseignants à de nouvelles expériences de modération, d'assiduité virtuelle et d'encadrement. Comme on l'a vu sur la scénarisation du Cours 1, cette intégration du numérique a modifié les pratiques pédagogiques des enseignants et a renouvelé les modes d'apprentissage chez les apprenants. Le blended learning prend le meilleur des différentes approches en les combinant pour maximiser les résultats. La passivité des apprenants se voit supplanter par une réelle implication des apprenants dans la critique à la fois du contenu et de sa transmission. Favorisant une relation plus étroite et interactive entre l'enseignant et l'apprenant, le blended learning favorise l'autonomie des deux parties. Somme toute, les cours de langues semblent être a priori moins concernés par l'acquisition ou la mobilisation d'un « esprit critique » que les DNL. Il s'agit effectivement d'une compétence, d'un processus de pensée qui dépasse le cours de langue en lui-même puisqu'il fait appel à du savoir non linguistique tel que le savoir-faire et le savoir-être puisqu'il ne repose pas seulement sur des objectifs proprement langagiers. Ainsi, aborder des sujets d'actualité autour des cultures qui interagissent avec la langue étudiée implique une multitude de compétences, et ce d'autant plus que les sujets d'actualité demandent aux apprenants de prendre du recul par rapport à l'immédiateté de l'information qui leur parvient. Former les apprenants à un usage beaucoup plus critique du net et par conséquent aux informations qui y sont véhiculées, en les initiant à chaque étape de la réflexion afin de s'assurer de leur assimilation et donc de leur engagement.

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Towards a transformation of the teaching practice: case of the workshop "Ludopédagogie"

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Abstract

The idea of the existence of a relationship between the pedagogical training of university teachers and the quality of the education provided is not new. This work aims to evaluate the efficacy of training targeting university teachers on the theme of "gamification", using the Kirkpatrick model (1994) and focusing on its level three, which is the level of transfer of acquired training. The results of a thematic content analysis showed that the training left positive reactions for participants, it has allowed a learning and a transfer of the practice of the educational game in the classroom.

Keywords: continuing education, teaching practice, transfer, evaluation of training, gamification

Vers une trans(formation) de la pratique enseignante: Cas de l'atelier de formation "La ludopédagogie: de l'animation ludique à la conception de jeux pédagogiques"

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Résumé

L'idée de l'existence de relation entre la formation pédagogique des enseignants universitaires et la qualité de l'enseignement dispensé n'est pas nouvelle. Ce travail vise à évaluer l'efficacité d'une formation ciblant des enseignants universitaires et portant sur le thème de la ludopédagogie en partant du modèle de Kirkpatrick (1994, 2007) et en mettant l'accent sur son niveau trois à savoir le niveau de transfert des acquis de la formation. Les résultats d'une analyse thématique de contenu ont montré que la formation a laissé des réactions positives chez les participants, qu'elle a permis un apprentissage et un transfert de la pratique du jeu pédagogique dans la salle de classe.

Mots clés: formation pédagogique, pratique enseignante, transfert, évaluation de la formation, ludopédagogie.

1 Introduction

De nos jours, notamment avec le mouvement de professionnalisation du métier d'enseignant du supérieur que nous vivons (Colet & Berthiaume, 2009); la question de la formation pédagogique des enseignants universitaires (Berger, 2012 ; Bertrand, 2014 ; McAleese & al., 2013) et de son impact sur la qualité de l'enseignement (OCDE, 2005); prend une place de plus en plus importante. En effet au cours des dernières années, la formation à la pédagogie des enseignants universitaire s'est développée de façon significative dans plusieurs pays ayant misé sur la qualité des enseignements et des apprentissages de qualités pour développer des compétences chez les étudiants (Adouan,2018). S'intéressant à l'impact de la formation pédagogique, une revue de la littérature (Stes et all., 2010) pointe la nécessité de conduire des études qui mesurent les changements dans la pratique quotidienne des enseignants, en plus des changements que ceux-ci peuvent rapporter.

Partant de ces incessants débats ayant trait aux rapports entre la formation pédagogique des enseignants universitaires et la qualité de l'enseignement, l'Association de Promotion de Ressources Pédagogique (APRP), qui gère la Centrale de Ressources Pédagogiques (CRP), s'est fixée parmi ses objectifs, d'offrir des cycles de formation pédagogiques continues aux enseignants universitaires. Les formations dispensées par l'APRP visent à éveiller chez les enseignants, la réflexion sur leurs pratiques et de susciter le changement de celles-ci en adoptant des pratiques innovantes.

L'atelier de formation objet de cette étude porte sur le thème de la ludopédagogie et est intitulé : «la ludopédagogie, de l'animation ludique à la conception de jeux pédagogiques ». L'objectif général de cet atelier est d'initier les participants à la ludopédagogie et de délivrer un contenu global pour l'intégrer dans leurs pratiques aussi bien au niveau de l'animation par le jeu qu'au niveau de la conception de jeux pédagogiques.

Nous cherchons à travers ce travail, à évaluer l'atteinte de l'objectif de l'atelier et de comprendre comment la formation peut favoriser chez les enseignants un changement de leurs pratiques enseignantes?

Pour répondre à cet objectif, nous commençons dans ce papier par situer le problème dans le contexte théorique auquel nous nous référons, pour ensuite préciser la démarche méthodologique adoptée et enfin, finir avec la présentation des résultats de l'étude et la discussion de ces résultats.

2 Problématique de la formation pédagogique des enseignants universitaires

2.1 La formation pédagogique des enseignants

Le sens du terme «formation», ne fait pas unanimité. Il désigne, «tantôt un processus ou un objectif global, tantôt des activités spécifiques» (Legendre, 1993). La formation se fait, en général, en vue de bien exercer une tâche ou un emploi quelconque. Le concept de formation des enseignants est relativement récent, et ce n'est que dans les années soixante que les dictionnaires spécialisés intègrent le sens pédagogique du mot formation (Fabre, 1994).

La notion de formation des enseignants se distingue d'autres concepts proches comme l'instruction, l'enseignement ou l'éducation (Legendre, 1993). En effet, la formation pédagogique implique en plus des connaissances nécessaires «le développement d'habilités et d'attitudes ainsi que l'intégration des savoirs dans la pratique quotidienne de la vie» (Legendre, 1993).

Aujourd'hui, la formation pédagogique des enseignants universitaires s'inscrit dans une logique de développement professionnel et «vient confirmer l'importance de soutenir et de valoriser la fonction enseignante au sein des universités» (Adouan et al., 2018). Ainsi, s'intéressant à la formation continue des enseignants universitaires, ces auteurs la considèrent comme «un ensemble d'actions, de moyens, de méthodes et de rapports planifiés a l'aide desquels les enseignants sont incités à améliorer leurs connaissances, leurs attitudes, leurs compétences nécessaires à la fois pour atteindre les objectifs de l'organisation et ceux qui leurs sont personnels, pour s'adapter à leur environnement et accomplir leurs taches actuelles et futures» (Adouane et al., 2018). De même, Masselter (2004) affirme que la formation continue vise à «aboutir à un changement de la personnalité du formé en exerçant une influence sur ses pratiques professionnelles». La formation continue des enseignants vise par conséquent, à changer leurs attitudes et leurs manières de faire.

Dans ce même ordre d'idées, l'OCDE (1988, p. 11) interprète la formation continue comme la manière dont les enseignants développent leurs connaissances, leurs compétences, leur savoir-faire et leur compréhension du métier d'enseignant tout au long de leur carrière.

Ainsi, nous pouvons avancer que la formation continue des enseignants recouvre un ensemble d'activités qui impliquent un changement ou un accroissement de leurs compétences et de leurs savoirs et dont l'objectif ultime est un changement des pratiques en classe avec une amélioration de l'apprentissage et des performances des apprenants. En s'intégrant dans une approche du perfectionnement professionnel elle permet aux enseignants de devenir des «acteurs réfléchis» dans leur pratique pédagogique (Walshe, 1998) et aurait, dans ce sens, pour fonction de transformer les pratiques pédagogiques des enseignants (Salman, 2014).

2.2 Formation pédagogique et changement de pratique enseignante

«Pratique pédagogique», «pratique enseignante», «méthodes pédagogiques», «modèles pédagogique» ou encore «pratique d'enseignement» sont autant de termes utilisés dans la littérature pour désigner les pratiques professionnelles des enseignants (Duguet et Morlaix, 2012). Ces pratiques des enseignants, sont à l'origine d'un certain nombre de questionnements (Duguet et Morlaix, 2012). Les recherches de Bru (2004) pointent du doigt une «absence de connaissances suffisantes et détaillées» en ce qui concerne les pratiques enseignantes. Clanet (2001) tente de décrire les pratiques des enseignants universitaires, en distinguant les pratiques déclarées des pratiques constatées, et montre qu'il existe une réelle variété des pratiques enseignantes, même si l'exposé oral de l'enseignant durant son intervention domine largement. Il considère la pratique pédagogique comme étant le «fruit d'une interactivité entre des dimensions relevant des situations, des sujets et des processus». De même, Bru (2006) précise que lors qu'elle est qualifiée de pédagogique, la pratique consiste à «mettre en place un certain nombre de conditions cognitives, matérielles, relationnelles, temporelles auxquelles les élèves sont confrontés», Ce dernier prévient que la pratique «ne suit pas toujours un chemin balisé». En effet, dans le cours de la pratique interviennent des évènements imprévus, des émotions des contraintes et des exigences simultanées et parfois contradictoires.

Au-delà de ces problèmes de définitions, les travaux de recherche portant véritablement sur les pratiques d'enseignement à l'université se font rares (Adangnikou, 2008). Cependant différentes études se sont focalisées sur l'impact de la formation continue des enseignants sur leurs pratiques pédagogiques. Ainsi, Cauterman (1999) souligne la relation entre la formation continue et les pratiques pédagogiques des enseignants formés. Il affirme le changement apporté par la formation continue sur les compétences, les attitudes des enseignants et leur pratique pédagogique; «Au lieu de se référer à ce qui est conforme, programmé, prescrit par les instances hiérarchiques supérieures, l'enseignant, à l'issue du stage de formation, prend des initiatives, se donne le droit d'essayer de nouvelles pratiques; il évoque des démarches, des essais et des actions. Il se pose même la question de la pertinence des programmes. Le tout entre, certes, dans la perspective d'une relation pédagogique plus complète» (Cauterman, 1999).

2.3 Le modèle Kirkpatrick (1994, 2007) : niveaux d'impact de la formation pédagogique

Lorsqu'on s'intéresse à la question de l'effet de la formation théorique ou pratique, le modèle fréquemment cité dans la littérature au cours des trente dernières années est celui de Kirkpatrick (1994). Développé dans les années 50, le modèle de Kirkpatrick s'est imposé comme la référence en matière d'évaluation, particulièrement pour les professionnels de la formation continue. Les quatre niveaux d'évaluation, qu'il a intégrés en un modèle, sont encore aujourd'hui tout à fait d'actualité (Blouin, 2000). Il s'agit de l'évaluation des réactions, des apprentissages, du changement comportemental ou transfert des apprentissages et enfin des retombées sur l'organisation.

L'évaluation des réactions cherche à cibler les éléments qui pourraient créer de l'insatisfaction chez les participants et empêcher l'apprentissage. Bret (1998) affirme que l'impression globale de satisfaction ou d'insatisfaction, à la suite d'une formation, restera présente chez le sujet et aura un impact sur son travail et sur ses futures expériences de formation. Le niveau deux porte sur l'évaluation des apprentissages qui est liée à l'atteinte d'objectifs d'apprentissage (Dessaints, 1995). L'amélioration des connaissances, des habiletés et des compétences des participants est appréciée en relation avec l'atteinte des objectifs d'apprentissage (Legendre, 1993). Le troisième niveau apprécie le changement comportemental en terme de transfert des apprentissages et constitue une composante importante pour juger de l'efficacité d'une formation, il vise à évaluer la rétention de l'apprentissage et son intégration concrète en milieu professionnel. Le dernier niveau cherche à mesurer les retombées réelles sur l'organisation à travers une amélioration de la performance au travail se traduisant en un accroissement de l'efficacité de l'organisation.

Le pouvoir de ce modèle et sa diffusion dans différents contextes de formation continue repose sur sa simplicité et sa capacité à aider les gens à réfléchir sur les critères d'évaluation. C'est ainsi que bien que développé dans le contexte de formation continue en entreprise, ce modèle a été transposé au contexte de l'enseignement supérieur pour évaluer l'impact de la mise en place de dispositifs de formation pédagogique (Stes et Van Petegem, 2011).

3 Contexte de l'étude et méthodologie

3.1 Contexte de l'étude

Dans le cadre de sa mission d'appui à la pédagogie universitaire et à l'innovation, l'association de promotion des ressources pédagogiques (APRP) compte parmi ses objectifs la formation et le perfectionnement des connaissances et compétences des enseignants universitaires en nouvelles pratiques de pédagogie universitaire. C'est dans ce contexte, que l'APRP a mis en place un cycle de formation des formateurs (FDF) comportant des ateliers de formation pédagogique au profit des enseignants universitaires. Faisant partie de ce cycle FDF, l'atelier objet de cette étude porte sur le thème de la ludopédagogie et est intitulé : «la ludopédagogie : de l'animation ludique à la conception de jeux pédagogiques ». Lancé en début de l'année 2018, cet atelier a pu être assuré en trois occasions, faisant bénéficier au total 50 enseignants universitaires de différentes spécialités et exerçant dans différents établissements universitaires.

L'objectif général de cet atelier est d'initier les participants à la ludopédagogie et de délivrer un contenu global pour l'intégrer dans leurs formations aussi bien au niveau de l'animation par le jeu qu'au niveau de la conception de jeux pédagogiques. De manière spécifique, les objectifs assignés à cet atelier sont au nombre de quatre ; Découvrir une pédagogie décalée ludoéducative, Expérimenter le jeu comme moyen d'animation en classe, Evaluer le pour et le contre du ludique dans l'approche pédagogique, et Concevoir son propre jeu pédagogique sur mesure.

Afin d'atteindre les objectifs prédéfinis, l'atelier est scénarisé en quatre séquences pédagogiques. Chacune des séquences permet d'atteindre un objectif et chacune a été conçue sous forme d'un jeu pédagogique de sorte que tout le déroulement de l'atelier se fasse dans une logique qui permette aux participants d'expérimenter différents jeux conçus spécialement pour l'atelier.

Dans une première phase, la première séquence à travers une mise en situation sous forme d'un jeu de cartes, invite les participants à jouer et découvrir au cours du jeu des concepts théoriques liés à la ludopédagogie, la deuxième séquence permet de réfléchir et d'analyser les arguments en faveur et les arguments contre la ludopédagogie à travers un jeu de rôle. La troisième permet de conscientiser le mécanisme d'intégration du jeu en classe avec ses trois étapes de préparation, de conception et d'animation à travers un jeu de plateau. Cette trame pédagogique (Alvarez, 2018) est respectée pour chacune des séquences pédagogiques de l'atelier avec une étape de conception et de préparation du jeu en amont de l'atelier, une phase d'introduction et d'animation par le jeu et une phase de conclusion ou de debriefing à la fin qui vise l'ancrage de l'apprentissage et la réflexion sur les possibilités de transfert de ce dernier. La dernière séquence est une phase de transfert permettant la mise en pratique de l'apprentissage par la conception de son propre jeu pédagogique.

3.2 Méthodologie

A travers ce travail, nous cherchons à évaluer l'atteinte de l'objectif général de l'atelier et de comprendre comment la formation peut favoriser un changement des pratiques enseignantes.

Pour réaliser cet objectif nous allons nous référer au modèle de Kirkpatrick (1994), modèle d'évaluation de formation, basé sur quatre niveaux : le niveau réactions, le niveau apprentissages, le niveau comportemental ou transfert des apprentissages et enfin le niveau résultats ou retombées sur l'organisation. Le choix de ce modèle est principalement justifié par son niveau trois dit comportemental et relatif au transfert de l'apprentissage en pratique professionnelle.

La méthodologie utilisée est qualitative; nous cherchons en effet, à évaluer les résultats de l'atelier du point de vue des participants à l'étude (Fortin, 2010). Douze entretiens semi-directifs ont été conduits auprès d'enseignants ayant participé à l'atelier ludopédagogie.

La collecte des données s'est poursuivie jusqu'à la saturation théorique (Glaser et Strauss, 2017). Après transcription, les entretiens ont fait l'objet d'une analyse du contenu qui s'appréhende à un effort d'interprétation se situant entre la rigueur de l'objectivité et la fécondité de la subjectivité (Bardin, 2003).

Dans le cadre de cette étude, et afin de retrouver les thèmes récurrents entre les différents témoignages des enseignants et les contenus qui s'y rattachent, nous avons opté pour l'analyse de contenu thématique. Cette analyse se base sur un découpage du texte selon des unités de sens. Il s'agit de coder le contenu d'un corpus, fragment par fragment (Fallery, Rodhain, F. 2007) et d'associer un code à chaque unité du texte en fonction de son contenu.

Le développement des thèmes peut répondre à deux grandes orientations (Mayring, 2000) : une démarche inductive en partant du corpus pour générer des thèmes, versus une démarche déductive d'application des thèmes identifiés à priori (Deschenaux, 2007). Pour les besoins de cette étude, une démarche mixte est adoptée (Mukamurera, Lacourse, & Couturier, 2006). Notre démarche est à la fois déductive puisque les thèmes sont générés à partir des différents niveaux du modèle de Kirkpatrick (2007) et inductive, puisque les sous thèmes de la grille de codage préétablie, ont émergé des données (Savoie-Zajc, 2000 ; Mukamurera, Lacourse, & Couturier, 2006).

La définition opérationnelle des thèmes et sous-thèmes, le traitement et l'analyse de données ont été effectués en binôme pour rendre le classement thématique plus objectif. Le logiciel NVivo 11 (version de démonstration) a été choisi pour l'analyse thématique.

4 Analyse et discussion des résultats

Dans le cadre de cette étude, les propos de douze enseignants concernant l'impact de l'atelier ludopédagogie ont été analysés; donnant lieu à 324 unités de codage repérées.

Les thèmes de l'analyse sont issus du modèle de Kirkpatrick (2007) et correspondent aux quatre niveaux d'impact de ce modèle à savoir réaction, apprentissage, niveau comportemental et niveau résultat. Les sous-thèmes ont été identifiés à partir du corpus à analyser.

Le tableau 1 présente un aperçu, une brève description des niveaux d'impact considérés dans notre étude ainsi que les sous- thèmes y afférants et des exemples de verbatim pour chaque sous-thème.

Tableau 1– Grille d'analyse de contenu

Thème	Description	Sous thèmes	Exemple de verbatim
Niveau 1 : réaction (Kirkpatrick, 2007)	Ressenti des participants suite à la formation (Kirkpatrick, 2007).	Appréciation positive	« …je ne suis nullement déçue. J'ai apprécié au plus haut degré… »
		Appréciation négative	« Si le nombre des participants est important, il est difficile de s'écouter »
Niveau 2 : apprentissage (Kirkpatrick, 2007)	Changements dans les connaissances (Kirkpatrick, 2007)	Découverte	«j'ai découvert plusieurs types de jeux… »
		Evaluation pour et contre de la ludopédagogie	« Sincèrement, les jeux permettent d'impliquer les étudiants, ils sont plus motivés à suivre… » «..risque en termes de gestion du temps »
	Changements dans les compétences (Kirkpatrick, 2007)	Expérimentation	« plusieurs types de jeux que nous avons essayé pendant l'atelier »
		Acquisition des règles de conception	« La conception des jeux demande des compétences de la part de l'enseignant »
		Réflexivité	«…je me pose plusieurs questions concernant l'intégration des jeux dans mes cours, la méthode d'animation, la conception des jeux adéquats »
	Changements des attitudes (Stes et Van Petegem, 2011)	Adhésion	«… je suis persuadée de la nécessité d'adopter le jeu pour dispenser mes cours »
Niveau 3 : comportemental / transfert (Kirkpatrick, 2007)	Transferts, changements comportementaux dus à la formation (Gillet, 2011)	Posture	« …changement réel de ma manière de donner le cours … »
		Démarche	« … je me suis inspirée du déroulement de l'atelier »
		Intégration du jeu en classe	«.. m'a incité à intégrer les jeux dans un cours où les étudiants expriment une difficulté d'assimilation des concepts »
Niveau 4 : résultat/ retombées (Gillet, 2011)	Impact de la formation en termes de performance (McCain, 2005)	innovation : Conception effective de jeu	« …conception de mon propre jeu »

La répartion des unités de sens en fonction des thèmes prédéfinis est résumée dans le tableau 2. L'analyse de contenu montre que le thème le plus abordé est l'apprentissage correspondant au niveau 2 du modèle, suivi du thème changement comportemental (niveau 3), puis le thème réactions (niveau 1) et enfin le thème retombées (niveau 4).

Tableau 2– Répartition des unités codées (N= 324 en fonction des thèmes.)

	Occurrence	Importance relative par rapport au total des unités codées	Importance relative par rapport au thème
Réaction	**52**	**16,1%**	**100%**
Appréciation positive	50		96,2%
Appréciation négative	2		3,8%
Apprentissage	**200**	**61,7%**	**100%**
Connaissances			
Découverte	14		7%
Evaluation des pour et des contre du jeu	117		58,5%
Compétence			
Expérimentation	14		7%
Acquisition des règles de conception	14		7%
Réflexivité	27		13,5%
Attitude			
Adhésion	14		7%
Comportement (Adoption de la ludopédagogie)	**62**	**19,1%**	**100%**
Posture	5		8,1
Démarche	27		43,5%
Intégration du jeu en classe	30		48,4%
Retombées (Conception effective de jeu)	**10**	**3,1%**	**100%**
Total	**324**	**100%**	**100%**

S'attardant sur la réaction des participants, ce thème est évoqué 52 fois, dont 50 commentaires positifs. Les interviewés trouvent « l'atelier très ludique », et « les jeux bien choisis » ils « ont beaucoup apprécié la méthode de présentation des animatrices, les slides .. ». Cette appréciation positive de l'atelier vient confirmer la satisfaction des participants constatée à chaud. D'après Kirkpatrick (2007), il est parfois accordé peu de crédit à l'évaluation de ce premier niveau de son modèle, pourtant la satisfaction client est essentielle, le mieux étant que les participants gardent une attitude positive envers le programme et les formateurs (Gillet, 2011).

S'intéressant de plus prêt au niveau 2 correspondant au thème apprentissage qui est le thème le plus abordé (61,7% des unités codés) par les interviewés, il s'avère que ces derniers ont atteint les objectifs de la formation. D'abord en termes d'acquisition de nouvelles connaissances puisque certains d'entre eux ont «découvert la ludopédagogie», d'autres plus habitués à la pédagogie active ont pu «différencier certains concepts confus», ils arrivent à évaluer les pour et les contre de la pédagogie par le jeu. Ensuite en termes de développement et d'amélioration des compétences puisqu'ils ont «expérimenté cette pédagogie ludique» et ont «acquis les règles de conception du jeu» et enfin en terme de changement d'attitude puisqu'ils «adhèrent à l'idée d'intégrer le jeu en classe», ils ont même commencé à réfléchir «sur les modalités pratiques» de cette intégration, et sur «la méthode d'animation, la conception des jeux et le nombre adéquat des jeux». Ces résultats confirment que les participants ont acquis un apprentissage au sens de Bourgeois et Nizet (1996) qui précisent qu'il est question «d'apprentissage quand les adultes essaient de changer et/ou d'enrichir leurs connaissances...» Bourgeois et Nizet (1996)

L'évaluation de l'apprentissage (niveau 2) est importante pour deux raisons (Kirkpatrick, 2007). Elle permet de mesurer l'efficacité des formateurs dans la transmission de connaissances et le changement d'attitudes. Cette évaluation permet aux formateurs de savoir quand ils ont réussi ou non un apprentissage, de comparer des méthodes ou des outils pédagogiques et donc par la suite d'améliorer leurs techniques de formation. L'impact positif sur l'apprentissage, nous permet de prédire un changement comportemental au niveau 3 du modèle (Gillet, 2011). En effet selon Kirkpatrick (2007) si la formation n'a pas atteint un ou plusieurs objectifs d'apprentissage, il est impossible qu'il y ait un changement de comportement par la suite.

Le 3ème niveau (Comportements) du modèle de Kirkpatrick se trouve au centre de notre objectif de recherche. Ce niveau comportemental correspond au transfert des acquis. De façon générale, le comportement consiste en l'utilisation, dans le milieu professionnel, des acquis de la formation. Pour Tardif (1999), le transfert présente des particularités qui le distinguent de l'apprentissage, notamment en raison du fait que «il exige un raisonnement analogique entre deux structures, (mémoire à long terme et mémoire à court terme) ce qui n'est pas nécessairement le cas pour l'apprentissage ». c'est cet effet à terme qui se matérialise par deux dimensions : le maintien des compétences acquises après un délais d'une part et leur généralisation d'autre part (Baldwin et Ford., 1988) notamment par l'adoption de la ludopédagogie en classe, que nous visons à travers notre atelier de formation. C'est pour cette raison que ce niveau du modèle est au cœur de notre recherche. Dans notre étude, les données sont collectées après au moins un semestre de la formation afin de laisser le temps aux enseignants d'intégrer la nouvelle pratique.

Ce thème est évoqué dans 19,1% des unités codées. Notre analyse thématique révèle que suite à ce délai, les interviewés adoptent de plus en plus une posture ludique, «par le changement réel de la manière de donner le cours». Ils sont «passé à l'action» en «s'inspirant des jeux de l'atelier» pour entreprendre une démarche «moins sérieuse» ils sont allés jusqu'à intégrer «des jeux dans certaines séquences pédagogiques». Nous constatons ainsi un réel effet de transfert des acquis des participants vers leur pratique professionnelle aussi bien en matière d'animation en adoptant une posture et une démarche plus ludiques, qu'en intégrant le jeu en classe à travers les jeux expérimentés au cours de l'atelier et transposés à leurs propres séquences pédagogiques. Le calcul des occurrences relatives révèle que le sous-thème le plus évoqué par les participants est l'intégration du jeu en classe avec 48,8% des propos codés sous le thème transfert. Ce résultat montre un effet comportemental concret et souligne que le transfert a réellement permis aux participants de tirer profit de la formation, «d'être capables d'exploiter en situation de travail les acquis en effectuant les généralisations, les transpositions, les extrapolations nécessaires» Normand (1991).

Il est important de noter à ce niveau que l'évaluation du transfert, c'est-à-dire des compétences réellement mises en application en milieu professionnel, permet d'évaluer le «degré de continuité entre l'apprentissage dans le contexte de la formation et les comportements en résultant» (Olian *et al.*, 1998). Cependant, il existe un décalage entre les conditions idéales dans lesquelles se déroule la formation et l'environnement dans lequel se trouve le formé une fois dans son milieu de travail. Tessier (2004) considère qu'il y a une déperdition dans le temps, causée tant par des facteurs individuels que par certains autres reliés à l'environnement de travail qui font que le maintien à long terme de ces apprentissages suppose plus qu'une simple activité de formation. Se pose alors la question de "comment arriver à maintenir ou à généraliser les effets favorables des activités de formation" (Dionne, 1995).

Pour ce qui est des retombées de l'atelier appelé également niveau résultat, nous avons classé sous ce thème les propos des enseignants en relation avec la construction effective de jeux personnalisés et ce en se référant à McCain (2005) qui propose parmi les indices permettant de ranger un impact d'une formation au niveau résultat l'innovation et la créativité (développement de nouveaux produits...). La faible occurrence de ce niveau peut être expliquée par le fait que les résultats peuvent mettre un certain temps à se produire Kirkpatrick (2007).

5 Conclusion

Nous visions par ce travail à évaluer l'atteinte de l'objectif général de l'atelier de formation portant sur le thème de la ludopédagogie et de comprendre comment la formation peut favoriser chez les enseignants un changement de leurs pratiques enseignantes.

Pour ce faire nous nous somme basé sur le modèle d'évaluation de la formation de Kirkpatrick (1994). Nous avons utilisé une méthodologie qualitative et nous avons effectué des entretiens avec des enseignants ayant participé à l'atelier ludopédagogie. L'analyse thématique de contenu a montré que notre formation a laissé des réactions positives chez les participants, qu'elle a permis un apprentissage et un transfert de la pratique du jeu pédagogique dans la salle de classe. Néanmoins, nous ne pouvons affirmer, à partir de nos résultats, le changement significatif et durable des pratiques pédagogiques des enseignants ayant participé à la formation et leurs retombées réelles sur l'apprentissage chez les étudiants.

La limite de notre travail est reliée à la limite inhérente au modèle de kirkpatrick utilisé. En effet, ce modèle négligerait l'impact des facteurs contextuels et individuels sur l'efficacité d'une formation permettant ainsi de comprendre les mécanismes favorisant les acquisitions (Bates, 2004). Ceci nous semble d'autant plus important dans le contexte de notre étude, celui de la pédagogie universitaire. Il serait donc intéressant de comprendre et de prendre en considération les facteurs favorisant ou inhibant le transfert des acquis de la formation que ces facteurs soient individuels ou contextuels.

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Scrum4University: Rethinking Scrum as a University Culture for Students, Teachers and Administration

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Abstract

Agile Scrum model, undoubtedly, is one of the potentially viable frameworks, which delineates the processes and practices that help in managing and organizing software development activities. In fact, for software developers, user input on new functionality is essential to determine future iterations and for all work projects, the input of different experts working together towards a common goal is just as important to ensuring positive project development.Designed for multi-faceted projects, this approach facilitates collaborative goal setting, breaks tasks into small manageable chunks over short periods of time (sprints), and encourages communication, accountability, and reflection among team members.That's why, since seven years, at Esprit School of Engineering all project based learning courses include an Agile Scrum approach which was a great success among both students and their instructors. Over the last year, we notice that not only software tutors are interested to be Scrum Master Certificated, but also tutors of non-software or transversal learning and administration staff. This is the main idea of our reflection about how to consider Scrum as a tool for increasing project success with collaborative delivery.In this paper, we explain the basic steps to use Agile Scrum and how to adapt them for any type of project. More exactly, we rethink agility, as a culture change for better efficiency.

Keywords: Scrum; Agile; University; Culture, Cross-Cutting Projects; Project Approaches.

Scrum4University: Repenser Scrum comme Culture d'Université pour les Etudiants, les Enseignants et l'Administration

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Abstract

Le modèle Agile Scrum est sans aucun doute l'un des cadres potentiellement viables, qui délimite les processus et les pratiques permettant de gérer et d'organiser les activités de développement de logiciels. En fait, pour les développeurs de logiciels, la contribution des utilisateurs aux nouvelles fonctionnalités est essentielle pour déterminer les itérations futures et pour tous les projets de travail, la contribution de différents experts travaillant ensemble pour atteindre un objectif commun est tout aussi importante pour assurer un développement positif du projet. Conçue pour des projets à facettes multiples, cette approche facilite la définition d'objectifs en collaboration, divise les tâches en petits morceaux gérables sur de courtes périodes (sprints) et encourage la communication, la responsabilisation et la réflexion entre les membres de l'équipe.C'est pourquoi, depuis sept ans, à Esprit École d'ingénieurs Tunisienne, tous les cours d'apprentissage basés sur des projets incluent une approche Agile Scrum qui a été un franc succès tant pour les étudiants que pour leurs instructeurs. Au cours de la dernière année, nous avons constaté que non seulement les tuteurs en logiciels souhaitaient être Scrum Master Certifiés, mais également les tuteurs de personnel d'apprentissage et d'administration non-logiciel ou transversal.C'est l'idée principale de notre réflexion sur la manière de considérer Scrum comme un outil permettant d'accroître la réussite des projets grâce à la mise en œuvre collaborative.Dans cet article, nous expliquons les étapes de base pour utiliser Agile Scrum et comment les adapter à tout type de projet. Plus précisément, nous repensons l'agilité, en tant que culture, pour une meilleure efficacité.

Keywords: Scrum; Agile; University; Culture, Cross-Cutting Projects; Project Approaches

1 Introduction

Parmi les nombreuses méthodes susceptibles d'améliorer la motivation des étudiants, la pédagogie par projet est souvent citée, depuis plusieurs décennies. Elle est devenue une pratique quotidienne dans les universités et les écoles d'ingénieurs tel que le cas de l'école d'ingénieurs ESPRIT en Tunisie. Pour garantir le bon déroulement de ces projets, il est recommandé d'avoir recours à des méthodes pour faciliter l'organisation et la réalisation de ces projets. Parmi ces méthodes, nous pouvons citer Scrum.

Scrum est une Méthode Agile qui montre une façon de penser et de travailler quelque peu différente des méthodes traditionnelles. Il recense un nombre de valeurs et principes qui nécessitent un bouleversement culturel. Scrum est une méthode Agile très répandue dans les entreprises partout dans le monde. C'est devenu une culture d'entreprise. Des universités n'enseignent pas les Méthodes Agiles telles que Scrum. D'autres se contentent d'un cours magistral.

Or, Scrum est une méthode axée sur la pratique. C'est un modèle d'interactions entre les différents membres d'une équipe, et c'est aussi un ensemble de règles simples et pratiques. D'où la nécessité que les universités s'adaptent et orientent le cours Scrum vers la pratique. Ceci permettra de préparer des diplômés aptes à intégrer des équipes Scrum en entreprises, et à être opérationnels dès les premiers jours en entreprise.

Àfin d'atteindre cet objectif, l'école d'ingénieur Esprit a adapté la façon d'enseigner Scrum. Le résultat était surprenant et a dépassé les attentes. L'objectif était de mieux former les étudiants à la méthode Agile Scrum. Le résultat est Scrum est devenu une culture non pas juste pour les étudiants, mais pour les étudiants les enseignants et même l'administration. C'est devenu une culture d'université.

Dans cet article, nous allons commencer par définir l'agilité et expliquer Scrum. Nous allons, ensuite montrer comment Scrum peut devenir une culture au sein d'une université (Le cas de Esprit). Cette méthode agile peut être utilisée pour organiser le développement des logiciels informatiques, mais aussi pour organiser la réalisation de projets non informatiques (tâches administratives, de comptabilité,…).

Esprit s'est adaptée aux besoins des entreprises, et a commencé à enseigner Scrum depuis des années. Les étudiants ont utilisé cette méthode agile dans les projets intégrés (PI : projets qui intègrent plusieurs langages de développement) et les Projet de fin d'étude (PFE). Les enseignants qui suivent et encadrent les PI et les PFE ne sont pas forcément des enseignants du module SCRUM.

Le département de formation des formateurs de Esprit a proposé des formations Scrum à tous les enseignants pour qu'ils puissent encadrer les PFE et les PI. Les enseignants ont commencé à adopter cette méthode agile dans leurs propres équipes (Unité pédagogique, administration).

Scrum est devenu donc, non seulement une culture d'entreprise, mais aussi une culture d'université.

Nous souhaitons exposer le cas d'Esprit comme modèle qui peut être répandu dans le domaine universitaire ou plus particulièrement des écoles d'ingénieurs.

2 Concepts de Base

Avant d'adapter la méthode Agile Scrum et l'utiliser pour l'école d'ingénieur, nous allons commencer par expliquer les concepts de bases de la méthode Agile Scrum :

2.1 L'Agilité

L'Agilité est un cadre de valeurs et de principes, desquels découlent des pratiques à adopter dans la conduite de projets, les relations humaines, les modes de travail, tout ce qui constitue le quotidien d'une entreprise ou d'une université.

L'Agilité est une réponse à l'accélération de la transformation de notre environnement. Dans un monde en perpétuel mouvement, les processus et les approches définies ne peuvent plus être aussi figées, que ce soit dans les entreprises, dans les institutions ou dans les universités (chacun peut, à titre personnel, adopter une posture agile). L'agilité est donc la capacité à adapter les processus et les modes de fonctionnement pour qu'ils puissent suivre le rythme de l'accélération du monde dans lequel nous vivons.

L'agile Manifesto rédigé en 2001 est l'acte généralisateur des méthodes agiles, pour plus d'informations vous pouvez vous référer à ce lien http://agilemanifesto.org. Il consacre le terme «agile» pour référencer de multiples méthodes existantes, qui ont en commun un certain nombre de valeurs. Voici les quatre valeurs fondamentales que toute méthode agile doit respecter :

- Les individus et leurs intéractions plus que les processus et les outils.
- Un logiciel qui fonctionne plus qu'une documentation exhaustive.
- La collaboration avec les clients plus que la négociation contractuelle.
- L'adaptation au changement plus que le suivi d'un plan.

Pour mettre en pratique les principes de l'agilité nous pouvons avoir recours à plusieurs méthodes Agile, dont:

- Rapid Application Development (1991)
  https://www.productplan.com/glossary/rapid-application-development
- Scrum (1996)
- Extreme Programming (Beck. K & Andres. C, 2005)

Petit à petit Scrum s'est distingué, et est devenu une méthode incontournable en entreprise.

2.2 Scrum

Scrum est un cadre de travail (framework) dans lequel les personnes peuvent aborder des problèmes complexes et adaptatifs tout en livrant de manière efficace et créative des produits de la plus grande valeur possible. Scrum est léger, simple à comprendre mais difficile à maîtriser.

Scrum est un modèle de développement inventé par Jeff Sutherland. Il s'est associé avec Ken Schwaber pour formaliser Scrum en 1995. Ensemble ils ont répandu l'utilisation de Scrum dans de nombreuses sociétés informatiques, et ont contribué à l'élaboration du Manifeste Agile en 2001.

Scrum suit les principes des méthodes agiles, expliqués ci-dessus. Il s'appuie sur trois piliers : Transparence, Inspection, Adaptation. Il met l'accent sur la communication quotidienne entre les membres de chaque équipe (Scrum veut dire Mêlée en Rugby).

Ce modèle Agile Scrum, mis en place en 1995, propose une direction et une planification du projet réévaluées en continu, au rythme des "sprints". C'est un cadre de travail qui permet de tenir la promesse de qualité du produit et de maitrise des délais. Scrum permet de travailler par itérations, d'obtenir une relation client/fournisseur de confiance, de construire l'avancement du projet sur des bases réalistes et de composer avec des priorités changeantes. Elle implique l'auto-organisation des équipes et permet beaucoup plus de réactivité pour s'adapter aux besoins (parfois changeants) du client.

Nous allons décrire brièvement les principes de base de cette méthode Agile Scrum, qui sont décrits en détails dans le guide officiel de Scrum (https://www.scrumguides.org/docs/scrumguide/v2017/2017-Scrum-Guide-US.pdf) et dans (Figure 1):

Une équipe, travaillant sur un projet et utilisant la méthode Scrum, doit avoir trois rôles :

- Le propriétaire du produit« Product Owner »: Il est chargé de maximiser la valeur du travail accompli. Il expose les tâches à faire, les explique et définit les priorités.
- Le Scrum Master: C'est un coach, professeur et guide. Il aide l'équipe et la protège.
- L'équipe « Team » : Les membres réalisent les tâches décrites dans le catalogue du produit « Product Backlog ». Ils sont entre 3 et 9 personnes.

L'équipe Scrum se réunit régulièrement pour favoriser la communication et la résolution des conflits et problèmes. Scrum propose cinq réunions :

- Spring Planning : Pendant cette réunion, l'équipe Scrum détermine ce qui peut être fait pendant l'itération qui démarre, et comment sera effectué le travail. La durée de l'itération est entre deux et quatre semaines.
- Daily Scrum : chaque jour, 15 minutes, l'équipe synchronise ses activités et crée un plan pour les prochaines 24 heures. Chacun répond à trois questions à tour de rôle : qu'est-ce que j'ai fait hier, qu'est-ce que je vais faire aujourd'hui, quelles sont les difficultés que je rencontre ?
- Backlog Refinement : C'est une activité régulière pour mettre à jour le catalogue du produit (ré-estimation de tâches, priorisation,…), pour se préparer aux prochaines itérations (Sprints).
- Sprint Review : Il s'agit de montrer le travail accompli pendant l'itération au « client », et de mettre à jour le catalogue du produit en fonction des remarques.
- Sprint Rétrospective : Cette réunion se tient à la fin de l'itération pour définir ce qui s'est bien passé, ce qui s'est mal passé et un plan d'action pour résoudre ces problèmes et s'améliorer en continue.

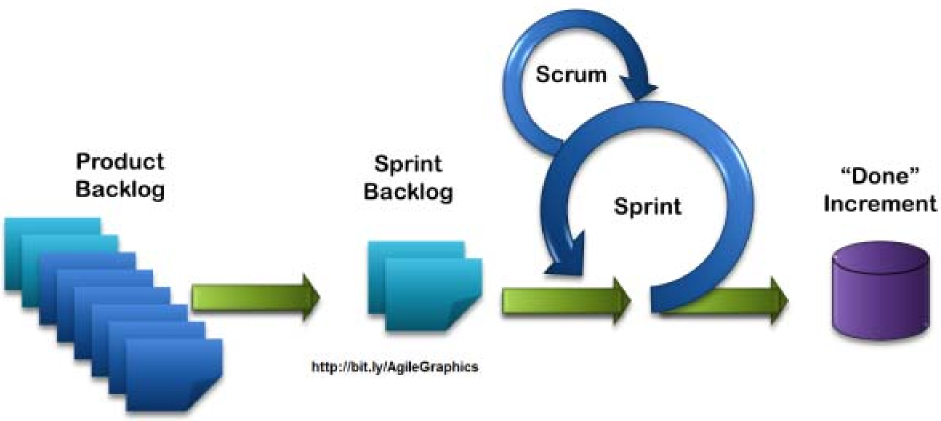

Figure 1. Eléments de base du Framework Scrum (https://www.dataanalysis.com/training/courses/professional-scrum-master-certification).

2.3 Scrum – Culture d'Entreprise

La simplicité du cadre de travail Scrum, son efficacité, et sa mise en avant de l'humain quelque que soit son rôle (client, équipe métier, équipe technique) a permis à Scrum d'être adopté par de plus en plus d'entreprises. Son application a dépassé les équipes techniques (équipes de développement de logiciels informatiques, équipes de support, équipes d'administration de bases de données, web designers…), pour être utilisé par les équipes non techniques (équipe de comptabilité, équipe de marketing, …).

Scrum est devenu une culture d'entreprise. C'est un état d'esprit.

Comment les universités doivent s'adapter et adapter le cours de la méthode Agile Scrum pour que les étudiants soient opérationnels dès leur arrivée dans les entreprises utilisant cette méthode agile ? Et quel impact a eu cette adaptation sur l'université (Etudiants, Enseignants, Administration) ?

3 Solution Proposée

Voici la solution proposée et adoptée par l'école d'ingénieur Esprit pour rendre Scrum une culture d'université, et donc adopté et pratiqué par toute l'université : Etudiants, Enseignants et Administration.

3.1 Scrum – CoursUniversitaireThéorique

Chaque université se doit d'adopter une démarche qui lui permet de rester compétitive et de former des étudiants directement opérationnels à leur sortie de l'école. Pour se faire, une mise à jour des programmes et une introduction de nouveaux modules et cursus est obligatoire. Dans cette démarche Esprit a introduit le cours Agile Scrum.

Les étudiants ont donc les notions de bases de la méthode Agile Scrum avancées précédemment.

Avoir ces notions en cours magistral est une bonne chose, mais ceci ne permet pas forcément à l'étudiant de s'imprégner de cette méthode agile, ni de pouvoir s'immerger facilement dans une entreprise qui pratique Scrum.

La solution trouvée par Esprit et de proposer des Projets Intégrés (PI) tout au long du cursus des étudiants pour leur donner l'occasion d'appliquer la méthode Scrum pendant leur implémentation.

3.2 Scrum – Projets Intégrés Pratiques et Projets de Fin d'Étude

Les Projets Intégrés (PI) sont des projets réalisés par les étudiants tout au long d'un semestre, avec des séances de coaching hebdomadaires dispensées par les enseignants de technologies et outils utilisés lors de ces projets (JavaEE, .NET, Scrum,…). Pour mieux organiser ces projets, nous avons recours à la méthode Agile Scrum. Les entreprises proposent des Projets de fin d'études (PFE) qui suivent souvent la méthode Agile Scrum.

Dans ces deux cas de projets, le cadre de travail Scrum, permet de mieux organiser nos projets et favoriser leur réussite en encourageant la communication entre les membres de l'équipe, et en les guidant tout au long de la réalisation du projet, en offrant des règles à suivre et un cadre de travail simple.

Ces deux types de projets (PI et PFE) permettent aux étudiants de pratiquer Scrum. Mais, ils ont besoin de coachs et des encadrants pour les suivre et les aider tout au long de la réalisation de ces projets. Au début, les enseignants Scrum prenaient en charge ces tâches d'encadrement et de coaching de la partie Scrum du projet.

Ensuite, Esprit a adopté la méthode APP (Apprentissage Par Projet) pour l'ensemble des modules enseignés. Les enseignants Scrum ne suffisaient donc plus à assurer les encadrements des dits projets intégrés.

Toutes les disciplines de la formation à Esprit deviennent concernées par la méthode Scrum de prés ou de loin. En effet, quelque que soit le module appliqué dans le PI (JavaEE, .NET, SOA, Web, …) la méthode utilisée pour organiser le projet est Scrum.

Certes, la méthode Agile Scrum demeure utilisée par les étudiants d'Esprit spécialité TIC. Cependant, les apports de cette méthode nous pousse à envisager de l'appliquer sur les spécialités: Génie Civil et Électromécanique.

4 Résultatet Discussion

Nous allons expliquer comment Scrum est passé d'un cours magistral à une culture d'université. L'école d'ingénieur Esprit peut être considérée comme un modèle dans ce changement culturel.

4.1 Scrum adopté par les Enseignants

Le département de formation des formateurs à Esprit commence donc à former les enseignants à la méthode Agile Scrum, pour qu'ils puissent assurer le suivi des PI et des PFE. C'est devenu un phénomène, presque tous les enseignants demandent à être formé sur la méthode Agile Scrum. Esprit a actuellement plus de 52 enseignants formés et certifiés Scrum Master (www.scrum-institute.org). Quatre sessions de formation certifiantes ont déjà été dispensées :

Tableau 8.Formations Agile Scrum certifiantes.

Formation Certifiante Agile - Scrum		
Date	Nombre	Photo de Fin de Formation
Mars 2019	13	https://www.linkedin.com/feed/update/urn:li:activity:6517849391334768640
Mars 2019	15	https://www.linkedin.com/feed/update/urn:li:activity:6516771721977040896
Décembre 2018	13	https://www.linkedin.com/feed/update/urn:li:activity:6481254859923288064
Juillet 2018	11	https://www.linkedin.com/feed/update/urn:li:activity:6425846672806465536

Cette formation a permis de maîtriser les concepts et les outils de Scrum, savoir rédiger des user stories et faire des estimations, comprendre comment organiser le déroulement d'un Sprint et en faire la revue, savoir comment faire travailler l'analyste métier avec les équipes agiles, maitriser les rôles dans Scrum « SM, PO, Team », et enfin préparer et passer la certification Scrum.

Avec 100% de réussite à l'examen de certification, les participants aux quatre sessions de formation Scrum étaient sérieux, impliqués et très motivés. Ils sont désormais prêts à appliquer les principes de cette méthode avec leurs équipes (White Board, Daily Scrum, Product Backlog, ...). ESPRIT compte continuer à former le corps enseignant, cet été 2019, à la méthode Scrum. Quatre sessions suivront en été 2019.

Les enseignants formés sont devenus plus efficaces lors de l'encadrement et le suivi des projets PI et PFE. Voici quelques témoignages d'enseignants qui ont participé à des formations certifiantesScrum et qui ont appliqué Scrum à ESPRIT ensuite :

Madame Sonia MESBAH – Enseignante Scrum et Génie Logiciel à Esprit : « Vu mon expérience avec Scrum à Esprit, je me permets de passer mon témoignage de plusieurs points de vue:

- Au niveau PIDEV: Au démarrage, l'application de Scrum n'a pas été évidente avec des tuteurs qui ignorent la méthode, mais après plusieurs séances de formation, l'application est devenue plus facile et plus efficace. Néanmoins, il reste toujours quelques difficultés, puisque les étudiants suivent plusieurs cours en parallèle avec le PI.
- En PFE: L'application de Scrum au niveau PFE aide beaucoup les étudiants à avoir l'opportunité de l'appliquer dans un vrai monde professionnel et ils ont eu aussi l'opportunité d'utiliser les outils Scrum (surtout les outils payants), ce qui a rendu l'expérience très enrichissante.
- Entre les profs: L'application de Scrum à Esprit était une occasion pour favoriser la communication entre les différentes équipes (unités pédagogiques) et entre les enseignants de différents modules.

En conclusion, je profite de ce mail pour vous remercier pour votre qualité en tant que formateur Scrum, pour votre générosité et votre modestie. »

Monsieur Karray GARGOURI – Enseignant Java à Esprit : « Un grand merci à M.Mourad HASSINI pour la formation Certifiante Agile Scrum, que j'ai vécue avec lui ainsi qu'avec une bonne équipe d'enseignants de l'école ESPRIT. J'ai beaucoup aimé cette formation, car elle m'a permis de découvrir la méthodologie Agile ainsi que d'expérimenter la méthode Scrum afin de pouvoir réaliser des coachings d'équipe. Cette formation m'a également permis de passer à l'action avec les différents groupes des étudiants (à travers leurs projets PIDEV) et d'intégrer cette activité dans mon quotidien pédagogique. En un mot, l'objectif est atteint et dépassé! »

Madame Thouraya LOUATI – Enseignante JavaEE / Spring à Esprit : « De ma part, j'ai apprécié beaucoup la formation. Elle était très pédagogique et claire. La formation m'aide beaucoup, maintenant, pour les PFE. Ce que je souhaite, vraiment, est d'appliquer SCRUM dans un projet pour se rappeler toujours des petits détails. Merci beaucoup. »

Madame Rihab IDOUDI – Enseignante JavaEE à Esprit : « Personnellement, je trouve que la formation est d'une grande importance pour les enseignants tuteurs afin d'appliquer au mieux la méthode SCRUM dans le cadre de PI et PFE, et d'initier les étudiants au monde professionnel et au travail collaboratif. »

La formation a permis également de favoriser la communication quotidienne et la résolution des conflits et problèmes entre les membres intra et inter UPs .

Un autre phénomène s'est déclenché suite à la formation des enseignants sur Scrum : Il s'agit d'appliquer Scrum au niveau administratif.

4.2 Scrum en cours d'adoption par l'Administration

Des enseignants commencent à avoir l'état d'Esprit Scrum (Communication, Transparence, Adaptation, …) et souhaitent appliquer Scrum au sein même des unités pédagogique (équipes d'enseignants). Donc, Scrum n'est plus utilisé uniquement par les étudiants, mais commence à être adopté et utilisé par les enseignants.

Des membres de l'administration de l'Université (Juridique, Comptabilité, Scolarité…) ont entendu parler de cette méthode Agile Scrum. Ils ont demandé plus de détails aux enseignants Scrum. Maintenant, ils souhaitent être formés à leur tour pour appliquer Scrum dans leurs équipes de Comptabilité, de Ressources Humaines. Des formations sont planifiées cet été 2019. Une fois les règles de bases de Scrum comprises et la certification obtenue, les enseignants déjà certifiés Scrum vont accompagnés ces différentes équipe dans leur marche vers l'agilité et vers Scrum en particulier.

4.3 Scrum– Culture d'Université

On assiste donc, à un début de bouleversement culturel, oùScrum commence peut à petit à devenir une culture de l'Université Esprit.

Tous les étudiants ont un cours Scrum. Ils utilisent Scrum dans leurs Projets Intégrés. Les étudiants en fin d'études utilisent souvent Scrum comme méthode Agile pour leurs projets de fin d'études (PFE). Les enseignants d'autres modules que Scrum, commencent à maitriser Scrum et à suivre des projets qui appliquent cette méthode Agile.

Les enseignants commencent à utiliser Scrum dans leurs échanges quotidiens entre collègues enseignants au sein des unités pédagogiques.

Des membres de l'administration commencent à s'intéresser à Scrum pour l'appliquer dans leurs échanges et pour mieux organiser leurs projets transversaux.

4.4 Généralisation du cas ESPRIT

En voulant bien préparer les étudiants ESPRIT à la vie active, et l'application de la méthode Agile Scrum, l'université ESPRIT a elle-même (corps enseignant et administratif) adopté la méthode Agile Scrum. Voici la démarche à suivre par toute université qui souhaite adopter la culture Agile Scrum :

- Étude de l'existant : A travers des ateliers, recenser l'ensemble des méthodes existantes et utilisées dans l'université.
- Formation : Former les corps enseignants à la méthode agile Scrum pour leur donner les bases de cette méthode.
- Certification : Certifier le corps enseignant donnera plus de crédibilité à l'enseignant quand il donne le cours Scrum ou quand il coach un Projet Intégré. Il est même conseillé de certifier quelques étudiants,

en les choisissant selon des critères d'excellence en leur passant un examen blanc Scrum et choisir les 10 meilleurs par exemple.

- Coaching : Engager quelques coachs Scrum qui vont accompagner les premiers projets intégrés et les premières équipes administratives qui adopterons la méthode agile Scrum.
- Choisir quelques classes et quelques enseignants pour commencer avec eux des Projets Intégrés qui utilisent la méthode agile Scrum pour l'organisation du travail.
- Choisir une équipe administrative pilote pour les accompagner dans leur transformation vers Scrum.
- Logistique : Mettre en place l'ensemble des outils nécessaires pour bien appliquer SCRUM : Tableau blanc, Post-It, cartes de planification poker, espace dégagé pour faire les Daily Scrum, …

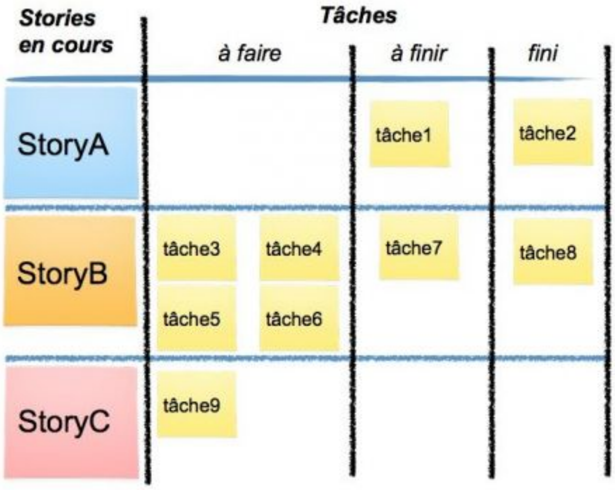

Figure 6. Tableau Blanc (http://www.aubryconseil.com/post/Tableau-a-2-niveaux).

- Adapter la méthode Scrum à l'université, en utilisant tableau blanc virtuel au lieu du tableau blanc physique, vu le nombre d'étudiants et vu que le tableau blanc nécessite un espace dégagé.
- Adapter la méthode Scrum à l'université, en enlevant le Sprint Planning pour les projets non logiciels mais administratifs. Les tâches administratives sont des tâches à planifier et à traiter à leur arrivée, sans attendre la prochaine itération. Sur ce point (suppression de la réunion de planification), nous adoptons la démarche d'une autre méthode agile : Kanban(Matthies, 2018).
- Démocratiser l'utilisation de méthode agile Scrum dans tous les nouveaux Projet Intégrés (PI), et encourager les étudiants en projets de fin d'études (PFE) à faire de même.
- Démocratiser l'utilisation de Scrum par les équipes administratives (Comptabilité, Juridique, Scolarisé), par exemple pour l'organisation des examens, pour la mise en place des emplois de temps chaque semaine, …
- Scrum est un ensemble de règles simples, mais c'est avant tout un état d'esprit (transparence, communication, entraide, adaptation aux changements, …). Donc pour réussir la marche vers l'agilité (Scrum) l'état d'esprit doit être adopté par l'ensemble des enseignants et les étudiants.
- Il est conseillé que la direction (directeur général, directeur général adjoint, directeur d'études, …) soient conscients de l'importance du cadre de travail Scrum et soutiennent les enseignants et l'administration dans cette marche vers l'agilité.

5 Conclusion

Scrum est à l'origine une culture d'entreprise. A vouloir s'adapter au besoin de l'entreprise dans la formation des étudiants, L'université Esprit a découvert la magie de cette méthode agile et commencer à l'adopter. **Scrum est devenu donc, non seulement une culture d'entreprise, mais aussi une culture d'université.**

Pour éviter un rejet de la méthode Agile Scrum, il serait préférable de faire une étude de l'existant dans l'université qui souhaite entamer sa marche vers l'agilité (vers la méthode Agile Scrum). Une fois l'étude de l'existant faite, une feuille de route doit être établie pour les étapes à suivre pour réussir ce bouleversement culturel. Nous conseillons de commencer avec les équipes les plus motivées qui serviront comme modèle pour les autres équipes. Une conduite de changement sera la bienvenue pour accompagner et garantir la réussite de la marche des universités vers l'agilité.

Scrum est un processus empirique et expérimental. Il préconise une inspection régulière, lors de la réunion de rétrospective à la fin de chaque itération, pour s'améliorer continuellement. L'approche de l'intégration de Scrum en université (Scrum4University) pourrait, elle-même, subir ce même processus d'inspection pour réussir la bascule vers l'agilité et Scrum en particulier. Nous pouvons mettre en place des enquêtes pour avoir le retour des enseignants, ainsi que des indicateurs (délai de traitement des tâches avant et après l'adoption de Scrum, Vélocité de l'équipe : La mesure de la quantité de travail terminé par l'équipe lors du précédent Sprint,…). Ces enquêtes et indicateurs nous permettront de calculer l'efficacité, l'efficience et l'acceptabilité réelles de l'approche adoptée dans ce contexte (Scrum4University).

Les méthodes agiles, et Scrum en particulier, mettent en avant l'humain et les interactions entre les différents membres de l'équipe. Pour garantir cette mise en avant de l'humain surtout dans le domaine universitaire, nous pouvons ajouter, en plus de la TODO LIST (Tableau Blanc), une TOBE LIST. Il s'agit d'écrire, pour chaque journée, la façon dont nous souhaitons être.

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PAEE/ALE’2019 SUBMISSIONS FOR THE STUDENTS PAPER AWARD

Submissions accepted for the PAEE/ALE’2019 Students Paper Award in English.

PBL in teaching Project Management: *Mais que Já Civil*

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Abstract

This article presents, in a descriptive way, an experience in the use of the Project Based Learning approach in an undergraduate class in Civil Engineering of the University of Brasilia. The course discussed is "Management of Projects and Multidisciplinary Teams," offered as optional.

The experience reported in this article was carried out in the second semester of 2018, in a class with six students.

In the first third of the course, students were challenged to identify a need perceived by the student body of the Civil Engineering Course, propose a product that would meet this demand, seek sponsorship, produce the proposed product and validate the result with the student body.

To do this, course students needed to use the concepts of market research, requirements gathering, negotiation, collaborative work, and organizing them in the form of a project.

At the end of the project, the students presented an event called "Mais que Já Civil", attending a desire of the student body, and handed to the Academic Center of Civil Engineering - project client - a manual with procedures for repetition of the event.

The post-event evaluation of both the client, the users and coordinators of the civil engineering course demonstrated the mastery acquired by the students of the concepts taught in the discipline.

Keywords: Active Learning; Engineering Education; Project Approaches; Project Management.

1 Introduction

Thinking about the engineering teaching in Brazil, or even in the engineer's formation, it is brought to the surface that the engineer should be capable to generate solutions that are not only correct technically speaking, but also that take into account a cause and effect chain of multiple dimensions. The result is that countless Institutions of Higher Education are modifying their curricula to adapt to the new requirements of the workplace.

It is interesting to note that these new trends indicate in the direction of undergraduate courses with flexible structures, allowing the future professional to have options of areas of knowledge and acting. Permanent articulation with the field of action of the professional, using a psychological basis focused on competence and a pedagogical approach centered on the student. The concern with the valorization of the human being and preservation of the environment integrate the social and political aspects of the professional, allowing the direct articulation with the masters degree and strong connection between theory and practice (National Curricula Guidelines of the Engineering Courses, 2001).

According to the National Education Council (2001), the old concept of curriculum, which can be translated as a curricular framework that formalizes the structure of an undergraduate course, is modified by a more open concept, supported by a set of experiences in the learning process, in which the student participates in the constructive process by developing a coherently integrated curriculum.

Seeking, therefore, to increase the student’s participation in learning, it is seen in the active teaching methodology known as Problem Based Learning (PBL) a solution. In PBL, according to Inoveduc (2018), the goal is to develop critical thinking and problem solving skills in students, emphasizing self-directed learning. The student in this process becomes the protagonist in the active search for information that is needed to solve a problem, while the teacher becomes a guide in the student's work. This fact highlights even more the primary role that the student needs to have, in which his formation depends mainly on himself.

The PBL methodology was used during the course "Management of Projects and Multidisciplinary Teams" of the undergraduate course in Civil Engineering at the University of Brasília (UnB). This article refers to the application of the PBL in the class composed of six students in the second semester of 2018.

In this discipline, students were led to create, manage and execute a project. All the conception of what the project would be, to its management and finally its execution was done by the students of the, being the teacher the supervisor and sponsor of the project.

This project arose from a need identified in the body of students of the Civil Engineering course of University of Brasilia (UnB). The identification was facilitated by the fact that many of the students in the class participated in multiple extension activities of the civil engineering course. Therefore, a greater reach and participation in the project of other undergraduate students was achieved.

In order to provide some of the experience propitiated by extension activities for students and to provide a competence based approach to market necessities, the project was aimed at organizing a one-day event for students of the Civil Engineering course. The theme proposed for this meeting was "Soft Skills Required for the Job Market", with the purpose of satisfying the needs and requirements of the end user, identified through research done together with the undergraduate students.

All the management of the project was carried out according to the book Getting Started in Project Management, by the authors Paula Martin and Karen Tate, of the year of 2001 (ref), besides the PMBOK guide (ref), building a Project Charter (PC), a Project Management Plan (PMP), and executing, monitoring and controlling the project. At the end of the project a manual of planning and execution of the event was prepared for future editions of the event.

Therefore, the purpose of this article is to describe an experience in the use of the PBL approach in a Civil Engineering undergraduate class at the University of Brasilia, reporting how the methodology influenced the application and learning in intra and extra class moments through management of a project created by students to meet needs of the student body.

2 Theoretical Framework

Given the need to place the student as the protagonist and make the learning process dynamic, the PBL methodology is a mechanism to promote such aspirations and to strengthen the understanding and application of knowledge. More than a problem-solving tool, the PBL can be described as, according to Ribeiro (2008): "A methodology of teaching and learning that uses problems - consistent with the future performance of students as professionals and citizens - to initiate, focus and motivate the learning of objective conceptual, procedural and attitudinal knowledge".

It is important to emphasize the relevance of these problems being real or potentially real and involve, explicitly or implicitly, a lot of social and environmental variables intrinsic to the real professional context (Escrivão Filho & Ribeiro, 2009). According to that, in order to reach such propositions, it is good to take some steps to achieve the best development of these methodology.

In this way, a learning cycle is elaborated returned for the understanding, defining, synthesizing and solving the problem in question is developed and always based on teamwork and the complementation of experiences and knowledge. The PBL is then applied through the separation of small groups with the guidance of a tutor. In this approach, the teacher ceases to have a more central role in the teaching-learning process, adopting an external posture (tutor), while the student happens to be the protagonist of this system.

The Project Based Learning can be approached in seven steps (Borochovicius & Tortella, 2014): 1. Clarifying terms and concepts; 2. Problem definition; 3. Problem analysis; 4. Summary; 5. Formulation of learning objectives; 7. Search for information and return.

Despite its wide use in health sciences, specially medicine, the PBL methodology has been adapted to many educational contexts (Ribeiro, 2008) and can therefore be used in the studying of project management and engineering, as is the case described in this article.

Before understanding the concept of project management, it is necessary to understand what is a project. PMBOK Guide define a project as "a temporary effort undertaken to create a unique product, service or result" (PMI, 2018). Temporary effort means that projects have defined beginning and end. A unique product, service or result means projects are created to fulfill objectives through the deliverances and are not replicable.

Tate & Martin (2001), the teaching biography used in the class, define project in a similar way, placing the production of a unique output, the temporary nature, and the lack of predefined job as the three pillars of a project.

Project management is seen therefore as a "set of tools, techniques, and knowledge that, when applied, helps produce better results with the project" (Tate & Martin, 2001). Project management helps individuals and organizations to meet project objectives within the deadlines, while meeting stakeholder expectations. Projects are part of the everyday life of all organizations that evolve over time, and therefore, effective management is considered essential.

The PMBOK Guide states that projects drive organizational change, that is, the goal of a project is to move an organization from the current state to a future state (PMI, 2018), which is seen as most desirable from a strategic perspective of the organization. In the Project Based Learning methodology, in which students execute projects in order to learn the subject, projects focused on the demands of the university can simultaneously stimulate student learning and propitiate improvements in the institution.

Beyond that, PBL methodology application in the studies of project management can, as was the case with the course, foster student participation as a protagonist in teaching while encouraging collaborative work between them. Thus, when faced with a problem, the need to understand it leads to a sharing of past experiences, something that is encouraged in project management, which are richer and more synergistic over time. In this way, the student becomes not only fundamental to the development of the course and the project, but to the team, as a whole. In addition, it gets the students closer to a real market experience, making the problem solving realistic.

3 Methodology

The Project Management and Multidisciplinary Teams course aims to present the student with the basic concepts and tools of project management, with emphasis on the traditional approach, represented by the PMBOK guide. For being considered easy to understand, the studies were initiated by reading the bibliography "Getting Started in Project Management", by Paula Martin and Karen Tate (2001).

The course can be divided into three main stages, being the first one that the teacher used of the first two classes to formulate the course syllabus, using project management techniques and taking into account the student's opinions to decide the evaluation method, among other rules of the discipline. In this stage, the development of the Course Syllabus was used to introduce the concepts of "project", "life cycle", "monitoring and control", "Opening Term" and "Project Management Plan". The second major step was based on the format of the methodology defined by the teacher with the students, where they were responsible for studying the chapter in advance, to ask questions and discuss the subject with the teacher in the classroom, making the classes more dynamic. Finally, in the third stage, in order to put into practice the acquired knowledge, based on the active methodology of teaching, Problem Based Learning (PBL), the group was instigated to identify a lack of knowledge by the student body of Civil Engineering, so that they could design a project focused on filling that gap.

The hands-on stage of the PBL began on October 1st when the students met to define what would be the problem to be worked in the course. The proposal, then, was presented in the next class, October 2, 2018, to the teacher. It was then defined as problems: the lack of a multidisciplinary event offered to the course students and organized by the Academic Center of Civil Engineering (CAENC); the little knowledge of newly enrolled students in the course about the extracurricular activities offered; and low integration among course extension groups. Therefore, to solve these problems, a joint event would be developed where all extension groups should contribute. Presenting this proposal, the teacher requested the development of the Opening Statement (TAP), which was approved on 11/10, the beginning of the project.

Project stakeholders assumed roles as described in the Martin & Tate teaching literature: students acted as the executing team and as managers, for the purpose of learning the subject; CAENC played the role of the customer; the teacher responsible for the discipline was the sponsor, responsible for guiding, providing content and evaluating the quality of project deliverables; the student body as a final consumer; and extension groups as suppliers.

The second meeting of the team, October 15, aimed to define a theme for the event. After several suggestions, the theme chosen was "Softs Skills for the Labour Market", as it talks about the skills that students can develop in extensions and how they contribute to their ability to excel in the labour market. In the following class, the team developed the Project Management Plan, which includes specifications of the stakeholders, the Project Analytical Framework (EAP) and its dictionary, the schedule of activities and budget.

The EAP was divided into three phases: pre-event, event and post-event, so that it would be possible to detail the required activities in the best possible way. The pre-event was composed of all activities related to the preparation of the event, management, fundraising and venue for the event. The Event phase was the detailing of how the event will be executed and the activities that had to be performed on the same day as the event. At last, the post-event phase, which besides counting activities as preparation of the closure report, counts on the production of a second product, particularity of the project as a whole.

According to MARIANO et al. (2017): "An event can be characterized as a single temporary system which, although closed shortly after its completion, usually leaves legacies to be explored, similar to the concept of projects, which is" a temporary effort undertaken to create a product, service or unique result "(PMBOK, 2013, p3)."

That said, the second product of the project was a manual, delivered to the client in order for the event to be performed semi annually by CAENC, and therefore, solving the identified gap in the initial phase of the discipline: the lack of an event that brought together all the extension activities of the course and that is directed to the students. Thus, the project was not only an experiment, but something concrete that provided a change in the academic development of Civil Engineering undergraduates.

Figure 1 shows part of the team working together to plan and execute the project. In the left, students were discussing and organizing the project. In the right, students were building the deliverables schedule of the project. Pictures were taken during classes.

Figure 1. Students working together to plan and execute the project.

4 Results

At the end of the event, a satisfaction survey was sent to the participants. Table 1 shows the participants evaluation about their satisfaction with the event as a whole, separated by course time. Satisfaction evaluation was given as a score from 1 to 5. A score of 1 means "very dissatisfied" and 5 means "very satisfied".

Table 1. Event satisfaction by course time.

Course time	Satisfaction average
Beginning (1st to 3rd semester)	4.67
Middle (4th to 7th semester)	4.56
End (8th semester and above)	4.25
Total average	4.49

The satisfaction assessment of the participants, who are the end users, was considered as high. It is noticeable that the satisfaction decreases as the course time increases, showing that, possibly due to the theme of the event, younger students of the course were better attended.

Other then the satisfaction of the end user, the client's satisfaction was also measured. The score given by the client was the highest (5.0 out of 5.0), showing that, from the perspective of the client and the final user, the project was very satisfactory.

It was also asked to the participants how much would they recommend the event, assigning from 1 to 10. Table 2 shows how much the participants are willing to recommend the event to colleagues.

Table 2. Event recommendation by participants.

Recommendation	Percentage of participants
Strongly recommend (9, 10)	53.8%
Recommend (7, 8)	41.5%
Do not recommend (<= 6)	4.6%

The results from table 2 show the event can be redone successfully, once most participants are willing to recommend the event. One of the client's requirements was that it was possible to repeat the event, with different themes, in the future.

The main objectives of the event were to help students prepare for the job market and show the importance of the extension activities in this preparation, in particular because the event was sponsored by the extensions. Thus, in the satisfaction survey, it was sought to verify if these objectives were fulfilled. It was asked to the participants if they believed the event helped them prepare for the job market, and if the event stimulated them to participate in extension activities, in case they have not already participated. Figure 2 show the results to these questions.

Figure 2. Participants feedbacks.

It is possible to observe, analysing the graphics from figure 2, that the event was able to fulfill the established objectives, auxiliating students to prepare for the job market and showing the importance of the extension activities for such.

At the start of the project management, as soon as the scope was defined, the quality plan was elaborated, in which were established quality criteria for the project deliverables. A project can be considered a success as long as the goals established in the quality plan are hit. Table 3 shows the quality plan, with goals established in the beginning and values hit.

Table 3. Project quality plan, goal vs. hit.

#	Deliverable	Criteria	Goal	Hit
1	Event	Total number of participants	30	69
2	Event	Participants satisfaction feedback average (1 to 5)	4.0 / 5.0	4.5
3	Event	Event delay time in minutes	< 15 min	0 min
4	Manual	Client satisfaction feedback (1 to 5)	5.0 / 5.0	5.0
5	Manual	Grade average assigned by the teacher	SS*	SS*

* SS means "Superior", which is the highest grade in the university.

It is possible to realize, by analyzing the quality plan, that all goals established were hit, demonstrating that the project's objectives were fully accomplished. The success of the project also demonstrates a success for the students, who were capable of applying the concepts of project management learned in class.

Figure 3 shows pictures of the event. In the left, the happening of the event. In the right, picture of the students who organized the event and the speakers.

Figure 3. During the event (left). Organizers and speakers (right).

5 Conclusion

At the end of the project, the main benefit from applying the PBL methodology was the use in practice of fundamental concepts for the management and development of projects and concepts that will be widely used in the market. Succeeding in solutions that not only served the technical part, but also that allowed the students to understand the chain of cause and effect of the multiple dimensions involved in a project.

In addition to the concepts involved in reading the book adopted in the course, students learned and applied concepts such as market research, requirements gathering, negotiation, collaborative work. These definitions were widely studied and used in practice by the students, in order to obtain a product that sought to satisfy the students of the Civil Engineering course at UnB.

It is interesting to note that, in order to solve a demand of the course students, the students sought knowledge that exceeded the subjects syllabus, capacitating in other areas of study, stimulating the results that the PBL methodology hopes to obtain. In this way, students had the opportunity not only to come across a problem and solve it but to concretize their action through a real demand of a client, making the theory and practice relationship much more vivid and stimulating in an academic environment.

In addition, the post-event evaluation of both the client and the users and coordinators of the civil engineering course demonstrated the mastery acquired by the students of the concepts taught in the discipline.

If we look at the discipline as a whole, we realize that the students of the subject had difficulty at the beginning to adapt the methodology of the PBL and ended up having an unsatisfactory result at the beginning, delaying some deliveries. This reflects a lot as the current model of undergraduate engineering courses are arranged, presenting an accumulation of contents and strictly expository classes without dialogue and exchange of knowledge between students and teachers. And at the end of the course, all the students got more than satisfactory result and felt not only valued, but also had an experience that enabled them more than a normal lesson. Until when will the Brazilian system invest in the old model translated as a curriculum? If the PBL methodology was widely used in Brazilian education, what results would we obtain in the formation of the engineering professional?

The meaning in the construction and accomplishment of the event, together with the autonomy given to the students to use their abilities and to be developing throughout the discipline, allied to the impacts that the project brought along with the feeling of connection with the matter, brought the definition of the MAGIC engagement methodology of author Tracy Maylett. And with the engagement in the subject, the students began to worry effectively about the final results of the material, generating products of excellent quality.

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Analysis of Learning Assessment Role Using Active Methodologies in "KAA" Perspective.

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Abstract

This article has in context the proposition of a discipline of Problem-Based Learning (PBL) in which it seeks to achieve soft skills competencies, while technical content is transmitted in the area of product engineering. Through a bibliometric research This analysis seeks to map the studies that encompass the main concepts around the theme: performance evaluation with the use of active methodologies for students from various engineering courses, in particular: computer, software, electrical and mechatronics. The publications analyzed were located through consultations with the database of Scopus journals, being considered as cutting papers published between the years 2007 to 2018. In the classification of the studies, special attention was paid to the performance evaluation process with a focus on the perspective do knowledge, ability and attitudes (KAA). After the definition of the sample, content analysis was performed in 20 articles focusing on the mapping of the evaluation processes of performance in order to identify the most recurrent practices in the evaluative process. The results indicate that the analyzed studies followed the same tendency in their evaluation systems by means of the evaluation method with questionnaires that measure a priori the self-perception of the student when subjected to the active learning dynamics, combined with Application of examinations or tests in order to assess the degree of understanding by means of grades.

Keywords: Active Learning; Evaluating, Problem-Based Learning; Soft Skills.

1 Introduction

The evaluative practices in active education methodologies, especially in engineering, are still elements to be better consolidated. On the one hand, the perception assessments of students and educators are aligned with the conception of education used in these practices. On the other hand, the technical content and the demand for professionals already qualified for immediate use in the market points to more pragmatic tests about the content of technical engineering disciplines.

However, before we deal with the evaluation question, it is paramount that the pedagogical approaches based on expository classes remain dominant in engineering education. This leaves graduates poorly prepared to understand the complexities of the profession (ASEE, 2003). Specifically, the approach based on expository classes emphasizes procedural knowledge and does not have the ability to keep the students' attention, which leads to low frequency rates (Mills & Treagust, 2003). This means that students may not feel motivated to go to classes nor will they be retaining information from classrooms that emphasize memorization and recollection. This is problematic given that the emphasis on memorization rather than application of the knowledge does not provide students with opportunities to see the real use of their learning. Which, in turn, contributes to the high evasion rate verified in the engineering courses? In Brazil, rates reach almost 50% according to the Brazilian Association of Engineering Education (Abenge, 2018).

A report by the American Society for Engineering Education (ASEE, 2009) highlights that to address the growing list of interconnected and complex global problems, it is necessary to train engineers that are capable of dealing with the multifaceted nature of the challenges to be faced in the 21st century. In a recent motion for a resolution on the curricular guidelines for Brazilian engineering courses elaborated by the (i) Enterprise mobilization for Innovation (MEI), (ii) National Confederation of Industry (CNI) and (iii) Abenge entitled "Innovation in Engineering Education: a proposal of national curriculum guidelines for the engineering courses ", it is noted that among the main aspects contained in this document the suggestion that the training in engineering courses changes from training based on content to training based on skills. As this has occurred in courses that have become international reference in other countries. This means that the most important is not just knowing (content) but knowing how to do the task considering attitudes and ethical behaviors. In order to happen, the exchange of traditional classrooms for learning environments, in which contextualized activities are developed based mainly on active learning (Abenge, 2018).

It is believed that the traditional approach of classes does not demand high social skills from students, such as communication, collaboration, personal skills and design skills (Nguyen, 1998). This article does not aim to extend the multiple causes of success or failure in the professional career of engineers. The careers are no longer as predictable as they were in the past, and it is quite likely that an egress today will act in various sectors of the economy, in companies of different sizes and types (Escrivão Filho & Ribeiro, 2009). Thus, it is perceived that engineering students at the "world" level cannot be taught how to deal with the problems of tomorrow and therefore it is imperative to review and direct the undergraduate learning experience in engineering.

Turning to the question of the motivational object performance evaluation of this research, we started with the approach proposed by Bloom (1993), in which evaluation can be characterized in three ways: (i) Diagnostic Evaluation (analytical), (ii) the formative Assessment (parent) and (iii) the summative Evaluation (classificatory). It is possible to observe that the diagnostic evaluation has three objectives: the first is to identify the reality of each student who will participate in the process; the second is to check whether the student presents ability and pre-requisites for the process; the third objective is related to the identification of causes, of recurrent difficulties in learning. Thus, it is possible to review the educational action to remedy the problems.

The formative evaluation is the one that has the function to control and, as such, should be performed throughout the school period. Aiming to verify whether the students are achieving the objectives previously proposed. This function of the evaluation searches, basically, to evaluate whether the student dominates gradually and hierarchically each stage of learning, before advancing to another subsequent stage of teaching-learning. We can also say that it is motivating because it avoids the tensions caused by traditional assessments. It is with the formative evaluation that the student gains knowledge from their errors and successes. Also, the student is encouraged to continue their studies systematically. The formative evaluation allows the professor to detect and identify gaps in the way of teaching, assisting in the reformulation of his didactic work, aiming to improve it. The summative evaluation has as basic function the classification of the students. It is performed at the end of a course or teaching unit to classify students according to their previously established levels of use. Currently, the classification of students is processed according to their income, based on the objectives foreseen. According to Bloom (1983), the summative evaluation "aims to evaluate in a general way the degree to which the broader results have been achieved along and at the end of a course". Through this type of assessment, the students' feedback that is provided informs how much learning was achieved. This is the central objective of the formative evaluation and it lends itself to the comparison of results obtained, also aiming at the attribution of grades. These three functions of the evaluation should be linked or adjusted to ensure the efficiency and effectiveness of the evaluation system and thus having as a result the excellence of the teaching-learning process. Although there is no unanimous agreement on the meaning of "competence," many authors define this as the ability to perform specified tasks effectively (Veraldo, 2017).

To Leme (2012), the competence consists of the following elements: knowledge, ability and attitude, thus defined: (i) knowledge is knowing, (ii) ability is the know-how and (iii) attitude is what leads us to exercise our ability of a given knowledge, because it is the desire to do, an abstract characteristic not observable. Rabaglio (2001), explains that the meanings for the acronym KAA, can be described as: knowledge (K): It concerns knowledge acquired in the course of life, in schools, universities, courses; ability (A): consists of the ability to perform a particular task, physical or mental; attitude (A): Related to behaviors in face of everyday situations and tasks.

According to Reis, Barbalho & Zanetti (2017), engineering education has been the object of studies in search of approaches that provide better results in terms of learning. There are countless publications on the use and analysis of the PBL in consultations in the most diverse databases. The results in general highlight the benefits of using the approach to learning by providing greater absorption of technical content by students and the development of multidisciplinary abilities.

However, this analysis seeks to map a survey of considerations around the theme: performance evaluation with the use of PBL for students coming from various engineering courses. Publications of interest were located through consultations to periodic database "Scopus" and "Web of Science" through the journal for the improvement of higher education personnel being considered as clipping the works published between the years of 2007 and 2018. In the classification of the work, special attention was directed to the performance evaluation process with a focus on the KAA perspective. From this perspective, we want to propose a meeting among the most commonly cited evaluation instruments among the articles analyzed taking into consideration the active methodology PBL as well as the three dimensions of competence based on Durand (2000).

In addition to this introduction, the work has other three parts. Topic 2 presents the extract from the Bibliometric analysis of some researches with the application of the PBL in teaching Engineering. Topic 3 discusses issues related to the evaluation of the four skills in the perspective of the three dimensions of the KAA applied to PBL. Topic 4 brings final considerations to results that came after the development of the research.

2 Bibliometric Analysis

To select the articles, a methodological approach of bibliometric research was adapted to the interests of the research. First, the following filters were directed to the Scopus collection (Elsevier) with the following criteria:

- Topics: Project method in teaching, project-based learning, educational technology, active learning, teaching methods, and problem-based learning resulting in 3,417 articles from 2007 to 2018 when filtered only the following keywords: PBL and Active learning.
- Adjusting the filter to: PBL, active learning OR learning by doing; articles in the Journal Title IEEE transactions on education; peer-reviewed periodicals; centered from 2007 to 2018; cut out sorted by relevance.

From this extraction the 12 articles of the ranking are detailed in table 1.

Table 9. Detailing articles the IEEE Transaction on Education Journal

Title	Authors	Year
A Blended Learning Approach to Course Design and Implementation	Hoic-Bozic, Mornar, & Boticki, 2009.	
Active Methodologies in a Queueing Systems Course for Telecommunication Engineering Studies	García & Hernández, 2010	
Engaging High School and Engineering Students: A Multifaceted Outreach Program Based on a Mechatronics Platform	Habash & Suurtamm, 2010.	
Effective Teaching of the Physical Design of Integrated Circuits Using Educational Tools	Mahfuzul, Sicard, & Dhia, 2010.	
Project-Based Learning and Rubrics in the Teaching of Power Supplies and Photovoltaic Electricity	Martinez, Herrero, & de Pablo, 2011.	
Experiences in the Application of Project-Based Learning in a Switching-Mode Power Supplies Course	Lamar et al, 2012.	
Application of Project-Based Learning (PBL) to the Teaching of Electrical Power Systems Engineering	Hosseinzadeh & Hesamzadeh, 2012.	
A Smart Home Test Bed for Undergraduate Education to Bridge the Curriculum Gap from Traditional Power Systems to Modernized Smart Grids	Hu, Li, & Chen, 2015.	
Analysis of Introducing Active Learning Methodologies in a Basic Computer Architecture Course	Arbelaitz, Martin, & Muguerza, 2015.	
Using PBL to Improve Educational Outcomes and Student Satisfaction in the Teaching of DC/DC and DC/AC Converter	Martinez-Rodrigo et al., 2017.	
A Multidisciplinary PBL Approach for Teaching Industrial Informatics and Robotics in Engineering	Calvo et al., 2018.	
Hybrid Problem-Based Learning in Digital Image Processing: A Case Study	Tan & Shen, 2018.	

The filter was then directed to the collection "Web of Science" with the consecutive caveats:

- Problem-Based Learning (PBL), Active learning, engineering and applied, articles from journals, peer-reviewed journals, concentered between 2007 and 2018; cut out performed by number of citations of each article and relevance.

This search resulted in 49 articles of which the 8 first articles of the ranking detailed in table 2.

Table 2. Articles analyzed from several journals.

Title	Authors	Source
Enabling and KAAracterizing Twenty-First Century Skills in New Product Development Teams	Cobb et al., 2008.	International Journal of Engineering Education
Problem-based learning for design and engineering activities in virtual worlds	Vosinakis & Koutsabasis, 2012.	PRESENCE: Teleoperators And Virtual Environments
Experience applying language processing techniques to develop educational software that allow active learning methodologies by advising students	Castro-Schez et al., 2014.	Elsevier - Journal of Network and Computer Applications
Engineering Students: Enhancing Employability Skills through PBL	Othman, et al., 2017.	IOP Conference Series: Materials Science and Engineering. IOP Publishing,
Problem-based learning of process systems engineering and process integration concepts with metacognitive strategies: The case of P-graphs for polygeneration systems	Promentilla et al.,2017.	Elsevier - Applied Thermal Engineering
Incorporation of Sustainability Concepts into a Civil Engineering Curriculum	Chau, 2007.	Journal of Professional Issues in Engineering Education and Practice
Applying Active Methodologies for Teaching Software Engineering in Computer Engineering	Fonseca & Gómez, 2017.	IEEE Revista Iberoamericana De Tecnologias del Aprendizaje
Incorporating life cycle assessment and ecodesign tools for green chemical engineering: A case study of competences and learning outcomes assessment	Margallo, Dominguez-Ramos, & Aldaco, 2018.	Education for Chemical Engineers

In this context, we conducted a study of the results of each article and its respective performance evaluation approaches after applying the PBL methodology during the teaching learning process in undergraduate and post-graduation courses-graduation level of masters both in engineering, considering the following categories: (i) competences according to Durand (2000): knowledge, ability and attitude (ii) evaluation elements/instruments during the learning process (projects, proof, seminar, questionnaire, etc.) and added as reflection the (iii) classification of the instrument according to Bloom (1993): diagnostic, formative or summative.

3 Competences

The perspective of the KAA or the competency assessment is being used in this work as a dividing line in the evaluative context when proposed by the PBL methodology believing that the active methodologies cannot be applied in the educational scope separately for a regular higher education system. Based on this proposal, the evaluative process of the articles analyzed by this study were classified in Table 3, which includes the evaluation of knowledge, ability and attitude, the elements evaluated and the most commonly evaluation instruments used in the set of articles are separated by the focus given in the type of competence. We identified 10 articles where it is possible to establish that 3 dimensions of the KAA were an agent of concern during the implementation of the performance evaluation (Hoic-Bozic, Mornar, & Boticki, 2009; Martinez, Herrero, & de Pablo, 2011; Lamar et al, 2012; Haje & Hesamzadeh, 2012; Hu, Li, & Chen, 2015; Arbelaitz, Martin, & Muguerza, 2015; Martinez-Rodrigo et al., 2017; Calvo et al., 2018; Cobb et al., 2008; Vosinakis & Koutsabasis, 2012) with a more objective focus on developing the threefold skills, although not all of them leave the three dimensions aligned with their evaluative instruments.

Another 6 articles had a more evaluative approach focused only on the Knowledge (García & Hernández, 2010; Habash & Suurtamm, 2010; Mahfuzul, Sicard, & Dhia, 2010; Othman, et al., 2017; Castro-Schez et al., 2014; Fonseca & Gómez, 2017) although some Ability and Attitudes are cited in their learning objectives. In the same line of approach, two other articles (Promentilla et al.,2017; Chau, 2007) indicate greater targeting in Abilities and Attitudes, that is, when we measured their evaluative instruments, we hoped to find formative and diagnostic assessments rather than simply summative, where written exams are predominant. And last Tan & Shen (2018), they present in their work an approach focused on Knowledge and Ability, not explaining Attitudes in its evaluation. Margallo, Dominguez-Ramos, & Aldaco, 2018 certainly presented a methodology for performance evaluation very close to the strategy we hope to adopt in the context of an active methodology concerned with the 3 aspects of the competence of the KAA.

3.1 Knowledge

According to (Zamyatina et al, 2014), engineering graduates should demonstrate "Knowledge" basic principles related to the engineering of his profession; specialization in development and use of new products and systems, as well as understanding the importance and strategic value of the technological development of society. As already quoted, according to Leme (2012), the "Knowledge" is the know-how. It refers to the study in schools, books, work, and life. Rabaglio (2001), describes the "Knowledge", as the information that accumulates throughout life, through the study. However, in order to obtain the "Knowledge" coming from the study in higher education, the courses generally organize themselves in various disciplines, which together at the end must subsidize the training of professionals for the labor market (technical training). In the articles evaluated, it was observed that the perspective of "Knowledge" had as convergence among the analyzed articles the choice of the most traditional evaluation, for example theoretical exams.

3.2 Abilities

According to Bloom et al (1983), "Ability" is associated with the capability of students to convert and use their knowledge about the discipline. Their knowledge of the world and its life experiences, as well as the techniques used to solve a current problem are interrelated, which makes the competence a set of skills that unites knowledge, abilities and attitudes over a certain area. In view of the concept of "Ability" as know-how (Rudder, 2012), it is understood as technical capacity and knowledge as (Durand, 2000). Teamwork was the ability most cited in the articles evaluated, followed by the ability of oral communication. However, several other abilities could be evaluated within the KAA perspective along with active methodologies as long as the educator manages to make use of other instruments such as a "logbook" containing photos in students ' miniatures so that they can take notes during and after the encounters of a wider range of abilities. Among other abilities, also cited less frequently by the authors, are: written communication, systemic vision, critical analysis, problem solving, independent study and self-regulated work.

3.3 Attitudes

Leme (2012), refers to attitude as being what leads us to exercise our ability of a given knowledge, because it is the desire to do. It is an abstract characteristic, not observable. This means it is related to behaviors in the face of situations and daily tasks, according to Rabaglio (2001). Among the articles evaluated, leadership was the attitude more quoted as an evaluative point, although this dimension did not have a broad coverage for the articles evaluated. However, other terms may have been mentioned. Table 3 details ten articles of the twenty analyzed for this study.

Table 3. Description and classification Assessment instruments and competences

Title	Authors	Competencies: KAA mentioned on paper		Assessment Tool
Incorporating life cycle assessment and ecodesign tools for green chemical engineering: A case study of competences	Margallo, Dominguez-Ramos, & Aldaco, 2018.	Knowledge	Eco-design Environmental Sustainability and Eco-design Relevance of Environmental Issues	1. Portfolio 2. Poster exhibition 3. Competency Acquisition Assessment Questionnaire
		Abilitys	Teamwork, Creativity; And Entrepreneurship	

and learning outcomes assessment		Attitude	Initiative	
Instrument classification: Formative – no examination was foreseen.				
Applying Active Methodologies for Teaching Software Engineering in Computer Engineering	Fonseca & Gómez, 2017.	Knowledge	Software Engineering	1. Software Design 2. Report 3. Presentation
		Abilitys	Team-Work Ability to Synthesize	
		Attitude	Autonomous Work Responsibility	
Instrument classification: Formative – no examination was foreseen.				
Incorporation of Sustainability Concepts into a Civil Engineering Curriculum	Chau, 2007.	Knowledge	Design Project to Civil Engineering	1. Student feedback questionnaire, 2. Peer review, 3. Supervisors' comments 4. Employer surveys.
		Abilitys	Resolução de problemas, Trabalho em equipe multidisciplinar, Comunicação escrita e verbal, Abilitys interpessoais, Gerenciamento de projetos	
		Attitude	Liderança	
Instrument Classification: Formative				
Experience applying language processing techniques to develop educational software that allow active learning methodologies by advising students	Castro-Schez et al., 2014	Knowledge	Language Processor techniques for designing and developing educational software tools	1. Exercises 2. Tool Satisfaction´s Questionnaire
		Abilities	Interpretação Raciocínio	
		Attitude	Not defined	
Instrument Classificatoin: Not specified				
Engineering Students: Enhancing Employability Skills through PBL	Othman, et al., 2017	Knowledge	Not defined	1. PBL Group versus Control Group
		Abilities	Fundamental Skills, Self-Management Skills, Team Work Skills.	
		Attitude	Responsibility Self-motivated Strong leadership qualities Strategic thinking abilities	
Instrument Classification: Not Applicable				
Active Methodologies in a Queueing Systems Course for Telecommunication Engineering Studies	García & Hernández, 2010	Knowledge	Queuing systems	1. Intermediate Examination (TEST) 2. PBL Rating (optional) 3. Questionnaire 4. Final Exam 5. Exercise resolution (problems)
		Ability	Not defined	
		Attitude	Not defined	
Instrument classification: Summative				
Problem-based learning for design and engineering activities in virtual worlds	Vosinakis & Koutsabasis, 2012	Knowledge	Functional and/or Digital prototype	Project (Group) Ability
		Abilities	Working Group Self-directed learning Self-assessment	
		Attitude	Project evaluation Critical Thinking Responsabiblity	
Instrument Classification: summative and formative evaluation				
Enabling and characterizing Twenty-	Cobb et al., 2008		Development of new products; Social entrepreneurship and	1. Satisfaction survey with graduates for

First Century Skills in New Product Development Teams		Knowledge	Socially conscious design projects.	(student leaders who worked with teams having a diverse mix of skills).
		Abilities	Teamwork, Generation and creativity of concepts, Communication abilities, Business abilities, project management	
		Attitude	Ethics; Sense of professionalism, leadership, Dynamism; Agility Resilience and flexibility; effective meetings and scheduling; Setting goals and Work with the mission.	
Instrument Classification: No applicable				
Using PBL to Improve Educational Outcomes and Student Satisfaction in the Teaching of DC/DC and DC/AC Converter	Martinez-Rodrigo et al., 2017	Knowledge	Technical projects, Simulation techniques; Programmatic Content PBL Methodology	1. Report 2. Peer Review, 3. Simulations 4. Project 5. Presentations 6. Theoretical examination, 7. troubleshooting, 8. Student Satisfaction-PBL evaluation[2]
		Abilities	Teamwork Troubleshooting	
		Attitudes	Leadership Initiative Participation	
Instrument classification: Summative				
A Multidisciplinary PBL Approach for Teaching Industrial Informatics and Robotics in Engineering	Calvo et al., 2018	Knowledge	Robotics	1. Classroom activities, 2. Final written examination, 3. Oral presentation and videos. Project Tasks, 4. Student Satisfaction-PBL evaluation, 5. Subtasks with virtual deliveries,
		Abilities	Teamwork	
		Attitudes	Autonomous and Team Proactivity.	
Instrument classification: Summative				
Application of Project-Based Learning (PBL) to the Teaching of Electrical Power Systems Engineering	Hosseinzadeh & Hesamzadeh, 2012	Knowledge	Project Management	1. PBL Online Quiz 2. Portfolio 3. Presentation 4. Written test, 5. Lab Practice Test 6. Self-Assessment, 7. Peer review
		Abilitys	Time Management, Teamwork, Communication abilities	
		Attitudes	Not defined	
Instrument classification: Summative				

4 Conclusion

Soft skills are the competencies of the 21st century recognized by the market working as the differential of the professional future. Among the best known, some already cited in the articles studied, are self-knowledge, communication, proactivity, emotional management, creativity and interpersonal ability. The term KAA, was used in this work for covering both the vision of Hard skill, as in the K for "Knowledge" – Bringing the vision of technical know-how – and softs skills, as in the A for "Abilities" and "Attitude". Thus, enabling a complete and fair view to measure performance having an increasing collection of adjustments for the engineers' formation.

However, we believe that we have gaps not only in a matter of adequacy in how assessment is done, but also in the formation of those who evaluate. These educators are not generally prepared for the evaluation of professional's abilities, although they acknowledge that engineering students need more than the so called

[2] Aplicabilidade da abordagem – PBL, aceitação dos alunos, quando há uma ferramenta AVA avalia-se também a percepção de usabilidade do ambiente VW.

“difficult abilities” to be prepared for their professional future. Perrenoud (2000), worried about this debate on the competences of educators, developed some references on the subject. It proposes a series of specific competencies grouped into families of fundamental competences for educators in the pedagogical process, in order to better perform and develop their actions in the educational field.

The need for an evaluation of learning to be coherent with the epistemological assumptions that guide a curriculum that uses active methodology was determinant for the, timely and somewhat broader, interest in the use of evaluative practices training for the offer of the study product discipline of this article. This evaluation format provides regular and periodic evaluation, throughout the educational process, to obtain data on the progress achieved and thus effecting the timely correction of the distortions observed and fill in the gaps detected.

Among the many lessons learned, perhaps the most important was that the attention that the educator should have when proposing an alignment between the following: The evaluation instrument used as a tool to "measure" the degree of understanding of the student and the defined or expected learning objectives that students reach. That is, many articles are daring to direct their teaching activities to an approach under the application of active methodologies, often with virtual environments, but they forget to establish the exact form in how to track and measure success or failure within the development process.

Thus, we have seen many interesting proposals of engineering education with PBL application, as we seek an alignment in the objective of learning and its assessment instruments, we realized that in the vast majority there were distortions in the definition of evaluation of a purely active performance: where knowledge, abilities and attitudes were being worked out through the active methodologies (in this specific work, PBL) and that evaluation instruments were able to measure their degree of achievement in the teaching-learning process.

Another point worth highlighting in the list of lessons learned is that we have seen that active learning combines with many evaluative instruments. In this regard it drew attention to the expressive number of options used for assessments. As future work, we will use the main skills and attitudes identified as well as good evaluative practices for application in the planning of process and product innovation discipline.

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A New Strategy for Fostering Engineering Students' Entrepreneurial Skills in the School of Entrepreneurs at the University of Brasília

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Abstract

This article presents the school of entrepreneurs at the University of Brasilia and emphasizes its importance in the academic training of students, especially those majoring in engineering. This school is a program within the Technological Development Support Center, which is responsible for the developing the University's innovation policy and disseminating entrepreneurship. We shed light on this school's pedagogy and learning methods, which can qualify students for the professional world. This study discusses the experience of teaching entrepreneurship through the course "Introduction to Business Activity." This course aims to promote and disseminate entrepreneurial culture by developing basic and emerging skills in areas such as entrepreneurship, creativity, and innovation through the creation of new technologies and the emergence of competitive and innovative businesses in the country for undergraduate students' professional preparation. The course's pedagogy proposes a blended learning model with an innovative approach wherein the student's leadership skills are assessed in classroom activities and through distance learning with the use of various tools such as Mobile App, WhatsApp, YouTube, Facebook, and the Moodle platform. We present a descriptive statistical analysis of the sample of students. The results show that 60% of the total students are enrolled in the 15 engineering programs at UnB, evidencing students' growing interest for entrepreneurship, which is not part of all programs. Nevertheless, the courses are offered as an optative and free module course for 1,200 students per year with an average waiting list of 400 students per semester.

Keywords: Entrepreneurial education. Teaching Innovation and Entrepreneurship. University of Brasília.

1 Introduction

In its 57 years of existence, the University of Brasília (UNB) became aware of the possibility of proposing an innovative academic environment and upgrading the curriculum and pedagogy of its academic programs based on the premise of establishing connections among science, research, and development. Thus, the Technological Development Support Center (TDC) was created in 1986. Educators of the Faculty of Technology (FT), especially the Electrical Engineering (ENE) department, responded to a pressing need to recognize the university's importance as an effective space for designing science via the development of basic and applied research. The demand to solve society's problems, particularly those arising from government and companies, has aroused interest to strengthen the triple helix in establishing the necessary dialogue among these agents that are responsible for the development of the country.

A professional's technical training is only partly responsible for their success and development in the labor market. Several other skills and capabilities are needed to remain competitive in today's global context. Transversal, managerial, moral, and creative psychosocial capabilities are essential to the generation of social value and sustaining a competitive advantage (Swiatkiewicz, 2014; Piscopo & Silveira, 2013). Successful professionals and entrepreneurs have skills such as convincing colleagues to invest their personal and organizational resources in business ventures (Hisrich, Peters, & Shepherd, 2014), resilience (Cruz & Moraes, 2013), and coordinating and leading the collective execution of tasks (Nassif, Bastos, & Chaves, 2014). While these skills and capabilities are complex and necessary to create successful ventures, they are not enough. The reality of business is uncertain and turbulent at the international level and still requires the development of owners' capital to train teams and strategic networks, where one learns to lead and be led at the same time (Collinson & Cook, 2006).

Under the supervision of a research professor, Problem-Based Learning (PBL) provides students with the opportunity to solve real problems in society through group projects and the use of modern technology (Martins, 2014). PBL works with the relevant, current issues of society and firms, i.e., real life issues that have yet to be resolved.

In the opinion of Bender (2012), Project-based Learning (PJBL) may be defined using authentic, realistic projects based on a highly motivating and engaging issue, task, or problem to teach students academic content in the context of cooperative efforts to resolve problems. It has currently become an object of great interest from the perspective learning outcomes obtained through its application. Through this methodology, the student can reflect on their ideas, listen to their colleagues, and be heard by them. They can make choices that directly affect the result. Blumenfeld, Soloway, Marx, Krajcik, Guzdial, & Palincsar (1991), states that PJBL should be developed in groups that work together to achieve a common goal, thus suggesting that the outcome of the process can result in realistic products developed autonomously by students.

Team-based Learning (TBL) can be used as a complementary tool to methodologies such as PJBL and PBL (Parmelee, et al, 2012). TBL emerged in the 1970s when Larry Michaelsen presented an educational strategy for classrooms with many students that sought to create opportunities and obtain the benefits of work in small learning groups consisting of five to seven students (Burguess et al. 2014). According to Michaelsen (1998), the teams should be formed to avoid barriers to the group's cohesion. Prior preparation with readings and activities are essential to the process.

In addition to introducing UNB's School of Entrepreneurs, this text aims to discuss the motivation of students who seek more appropriate training in entrepreneurship. We present an analysis of the research we conducted with 1,800 freshmen students in the Introduction to Business Activity (IBA) course on the first day of classes in the last three academic semesters. The results show that 60% of the total students are enrolled in the 15 engineering programs at UNB. Moreover, this study has three other parts. Section two presents the UNB School of Entrepreneurs, and section three discusses the course we examined for this study. Finally, we reveal our conclusions and final considerations.

2 The UNB School of Entrepreneurs

The extension program called Escola Empreend offers undergraduate and extension courses and is an educational environment that favors the relationship among education, research, and extension by using active teaching methodologies to develop entrepreneurial capabilities. The school's goals are to "develop skills in the field of Technological Innovation Management and Entrepreneurship. To execute projects focused on developing entrepreneurial capabilities in the Federal District and other regions. To coordinate extension, specialization, and training courses. To encourage and support young entrepreneurs and university students with professional/entrepreneurial ambitions" (CDT, 2016). Table 1 shows the courses of the UNB School of Entrepreneurs offered every semester to undergraduate students at UNB.

Table 1. Courses Offered by FT and Administered by Empreend/TDC/UNB

Course	Period Offered	Course Type	Number of Students per Course
Introduction to Business Activity	Semester	Blended learning	600
Entrepreneurship and Technological Innovation	Annual	Classroom-based	30
Junior Enterprise 1	Semester	Classroom-based	50
Junior Enterprise 2	Semester	Classroom-based	50
Research in Entrepreneurship and Innovation	Annual	Blended learning	30
Social Technology and Innovation	Semester	Classroom-based	50
Innovation Process and Product Development	Semester	Classroom-based	30

Table 2. Courses Offered by FT and Administered by Empreend/TDC/UNB

Course Name	Description	Methodology	Evaluation
Introduction to Business Activity (IBA)	To promote and disseminate entrepreneurial culture, develop basic and emerging skills in entrepreneurship, creativity, and innovation.	Blended learning with six classroom meetings and nine online meetings using the Moodle platform	Business Plan
Research in Entrepreneurship and Innovation (PEI)	Scientific method. Scientific research. Research project. Literature review. Data analysis. Preparation of scientific articles on entrepreneurship and innovation.	Action-reflection-action in classroom spaces, group dynamics, directed studies, participation in field research, and presentation of results.	Field research and presentation of a scientific article at TDC Business Fair.
Social Technology and Innovation (STI)	Technology, society, and humanity's future. Historical, theoretical, and methodological aspects of social technology. Case studies and qualifications of social technologies in Brazil.	Action Research	Development or qualification of social technologies to resolve social demands in the Federal district and surrounding area.
Innovation Process and Product Development (IPPD)	Position the innovation and product development processes within the design of production systems.	PBL and TBL	Student groups based on the PBL and PJBL methodology.
Junior Enterprise 1 (JE1)	Theoretical and practical knowledge based on three axes – entrepreneurship, innovation, and management.	TBL	Field research
Junior Enterprise 2 (JE 2)	Further theoretical and practical knowledge on topics related to organizational management, enabling student members of the Junior Enterprises to share knowledge.	TBL	Field research
Entrepreneurship and Technological Innovation (ETI)	Add value to the business ideas previously developed in IBA and further the knowledge needed to open a new company.	PjBL	Standard Sebrae (Brazilian Micro and Small Business Support Service) business plan

The point of convergence among them all is the teaching methodology with innovative didactics based on active learning principles, which makes both the educator and the student equally responsible for producing science to solve concrete, real problems. Table 2 presented the courses' descriptions, methodologies, and final evaluation. Every semester, the Emprend offers seven blended learning courses with a practical and theoretical approach to disseminate the culture and knowledge related to entrepreneurship and innovation the purpose is to transform ideas into business and provide academic experience that professionally qualifies the student's training.

3 Success Story: IBA

Introduction to Business Activity (IBA) has a course load of 60 hours per semester with four hours a week. There are no prerequisites, and it is offered to students of all undergraduate majors at the university. The university's system, WEB enrollment, executes course enrollment. IBA has been offered as a blended learning course with six meetings – five of which are held in the TDC building and one held by each group's choice as evidence of the meeting, students are organized into groups of up to five members and they must record a video of up to one minute, upload it to their own YouTube channel, and include the link in an e-mail so that the Distance Education team (EaD) may add the link to the course's playlist. To fulfill the course's 15 mandatory meetings, there are still nine online meetings. The course's content approaches the following topics: Characteristics of the skills and entrepreneurial profile; creativity and innovation; development of ideas; fundamentals for creating a startup; technical design thinking; ideas and opportunities; business models; concept, structure, preparation steps, and business plan model; business strategy; operational plan; SWOT analysis; Canvas Model; concept and importance of marketing for a successful business venture; marketing strategy, competitive advantage, and the marketing compound; sales price strategy; marketing plan within the context of the business plan; financial planning of the business plan; sales price formation; cash flow setup.

3.1 Classroom Dynamics

The first meeting is the inaugural class held in the auditorium of the TDC. There are 6 classes with 100 students, motivational lecture and/or stories from entrepreneurs as opening event, special guests, preferably graduate students from the University, who are aligned with the subject of course and currently innovative entrepreneurs in the city of Brasilia. Still in the first meeting, we present to the students the intention of the course and the importance of student protagonist, the role of the teacher as advisor of the business ideas presented by the working groups. It is suggested that, for the second meeting, students conduct a research about their area of interest in developing a business.

Between the first and second meetings, students fill out an online form with information about their course, period, age, and interest in business. This information enables the division of the class into groups of 25 students, which become part of a WG (work group) for the second meeting. In order to divide the 25-student groups, we used a scrambling technique, in view of the heterogeneity of the classes in relation to the origin of the courses. By this approach, in the end we managed to form groups that were 100% heterogeneous considering areas and courses in some classes.

The second meeting with the duration of one hour for each WG of 25 students, is called the "market of ideas" where the group presents their business ideas. This meeting is held in a special "U" shaped room for the purpose of creating a business meeting ambience. Students present their ideas and they can be "bought" by each other. The result of this meeting is the composition of five groups with five students each that will mold the idea into a business. This new work group will act together until the end of the course.

In the third meeting, groups of 5 students meet in one of the 3 meeting rooms of the TDC entrance hall called: enterprise room, innovate and research. These rooms have an average capacity of 10 people. The dynamic is to let students debate for up to 40 minutes on the proposal of the work, and the teachers listen to the proposals and guide the discussion. This meeting has early scheduling. In the fourth meeting the groups of five are outside the building and the supervision of the teacher of the class. At this stage, they gather to finalize the elaboration of the Canvas model.

In the fifth meeting:

- The groups of 5 students meet for the last time in individual meeting rooms for guidance with teachers responsible for the classes: enterprise, innovate or research. Then, students prepare for the finalization of the business plan and the planning of a presentation on the 6th meeting. The sixth meeting: Along with the business and Innovation Fair of the TDC, the exhibition of 120 projects in poster format is held in sessions divided by classes.
- All works are evaluated by a board of examiners with 3 external guests with expertise in the market. The 20 best placed on the poster exhibition are invited to the pitch session with oral presentation to another board of examiners but now with investors and startup accelerators who may be interested in supporting the continuity of the ideas proposed. It is no longer used as a measure of performance for the course, but as a strategy of visibility and valorization for offering different awards to the tree best placed groups.

Along of the school semester, the groups of work may, whenever they find it necessary, schedule meetings with the course teacher or just schedule the use of meeting rooms for the group. Another differential of the course is that the team of teachers is divided into pairs to meet each class of the six offered every semester. This team is then responsible for mentoring during the classroom meetings as well as the correction and feedback of the work delivered on the AVA platform. Another task team consisting of two professors and two auxiliaries take care of the demands of distance learning beyond the planning of the face-to-face meetings.

3.2 The Learning Methodology

The pedagogical proposal has an innovative approach, approaching education and digital technology, using social network, social media, their own mobile application, evaluation by means of electronic games and their own interactive game room, environment of Virtual Learning (AVA) and instant message exchange application. The following tools are used: Modern tools, applications and concepts such as gamification, agile methods and active methods such as: PJBL (Project Based Learning), PBL (Problem Based Learning) and TBL (Team Based learning).

Concomitantly to the face-to-face meetings there are activities on the Moodle platform with texts, video lessons and online games on their own platform previously developed and used globally, for example, the ITAEWEB[3] game and the interactive games room. They were developed and maintained by the Laboratory of technological innovations for experience environments. We extend collaborative learning to create a conceptual framework that unite TIC tools, enabling the most accurate analysis to estimate educational benefits in order to improve the choice of learning activities. Not only for courses related to entrepreneurship, but also for others that are grouped in this theoretical-practical perspective. WhatsApp groups are used for every 2 classes, totaling 200 students in each so that students can remedy doubts faster since all students come from in person courses and may have trouble in attending a course in the semi-presential model.

One of the success points of the offer of this course has been the opportunity of dynamism in alternating the dynamics of classes as well as the physical structure of the rooms in which we receive the classes for the classroom meetings. The logistics and physical infrastructure of the TDC building located within the UNB contains an auditorium for 100 people, 1 U-shaped room for deliberative council meeting, 1 games room with 2 interactive tables, 3 individual meeting rooms with capacity for 10 people and 1 room with support for videoconferencing with capacity for up to 30 people, entrance hall with capacity for up to 100 people standing has been used in the pilot project as "classroom" to host the 5 meetings of the course of IBA focus specific to this topic to better demonstrate one of the efforts of the Empreend.

3.3 The Learning Assessment Process

The course is divided in 4 modules. Each teaching unit has a set of theoretical and practical activities with products to be delivered that will consolidate the modeling of the business, considering entrepreneurial competencies in learning to work together and to exercise creativity, through practical resolutions of social and economic problems. Within the evaluation criteria students face the following challenges: the delivery of the Canvas business model, the presentation of this model to a qualified team with the possibility of improvements and the improvement of the idea set within a business that can be feasible in the market. Each module will have individual and/or group assessment through the formation of a group of until five students, who will complete part from the projects in the course together.

1. Entrepreneurial skills:
    a. Submit product Proposal/Innovative service (Individual);
    b. Answering the mentorship questionnaire (individual);
    c. Answer the Quiz Module 1 – Google Forms (individual);
    d. Answer the Quiz ITAEWEB Module 2 (individual).
    e. Participation in the second in-person meeting
2. Canvas Model:
    a. Upload from the Canvas template to the virtual Environment (aprender.unb.br) (group);
    b. Participation in the 3rd meeting in person
3. Business proposal:
    a. Submit complete business plan according to the template provided (group);
    b. Resend business plan with corrections if necessary (according to teacher corrections) (group);
    c. Participation in the 4th virtual meeting

[3] www.itae.unb.br

4. Exhibition/presentation of the work at the business Fair of the TDC:
    a. Participation in the exhibition/presentation of the work at the business fair from the TDC (individual);
    b. Participation in an in-person lecture/event that encourages entrepreneurship until the last day of the semester.

3.4 The public of the various engineering courses and the motivation for the discipline

In the first in person meeting of the IBA course students respond an online questionnaire named "Student Profile" in the Google Forms platform. The quiz is linked by the mobile application of the course with important questions to assess the goal of the public that is interested in the school of entrepreneurs. Analyzing the responses of 3 consecutive semesters (2017/2, 2018/1 and 2018/2), we had as input 60% of the academic's registrants from the 15 Engineering courses offered by UNB. Figure 1 highlights the percentage interest in the course by engineering course the 1005 respondents of the engineering courses.

It was found that although the discipline is offered to the entire university community of UNB, most of the students interested are from the engineering courses of the Faculty of Technology of the Darcy Ribeiro campus. This is probably due to the characteristics of the courses of engineering majors, which lead students to think about developing products and services. Another factor may be related to the geographical proximity from FT to Building of the TDC/UNB at the university campus Darcy Ribeiro.

Still, we believe that balancing the supply of discipline among university campuses, because each of them has a reference in their knowledge field. This has been used as a differential for assembling the working groups within the course. The methodology of the course believes that the engineering professionals also need as in all other areas to work in multidisciplinary teams. And the course has enabled this intersection among the most diverse areas of knowledge.

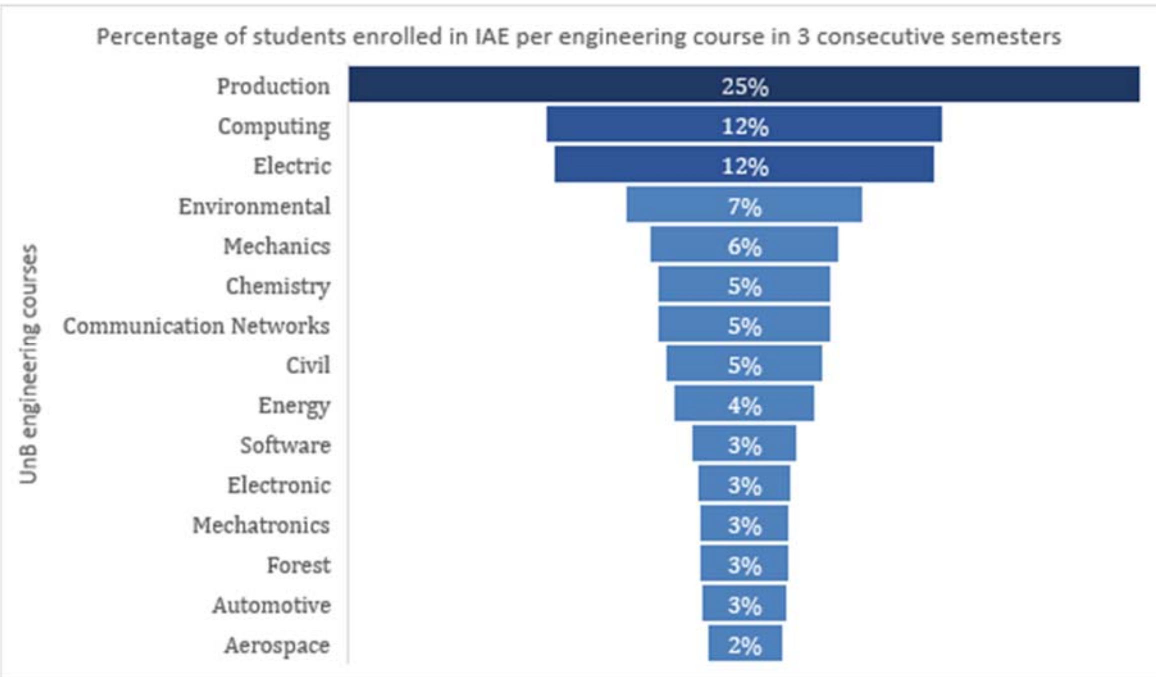

Figure 1. Percentage by engineering course of interest in the discipline - Source: Authors

Figure 2 shows the percentage by type of motivation for the course in view of students interviewed. It is noteworthy that in this sample the discipline is not offered as mandatory discipline, that is, all interested students seek the discipline to compose their curriculums on their own.

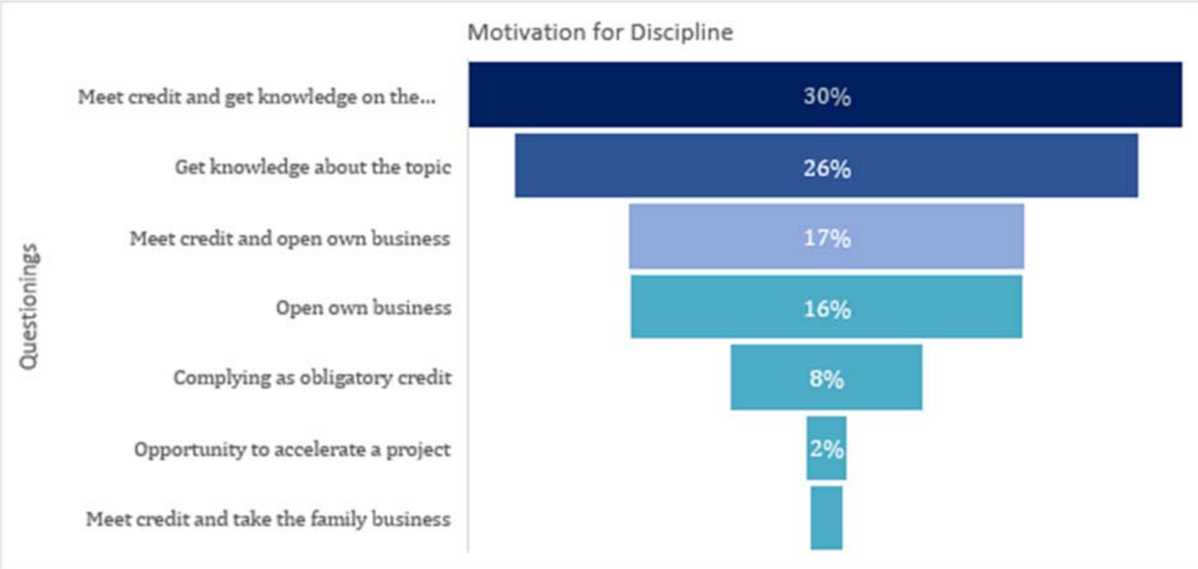

Figure 2. Relation on the motivation type for IBA discipline - Source: Authors

Still in Figure 2, in addition to the first two motivations that suggest the interest in acquiring basic knowledge about the area of course, 56% share this interest. We believe that a possible justification for this high demand, given by the prolonged Brazilian economic crisis with high unemployment rates, entrepreneurship can serve as a professional alternative for an uncertain professional future.

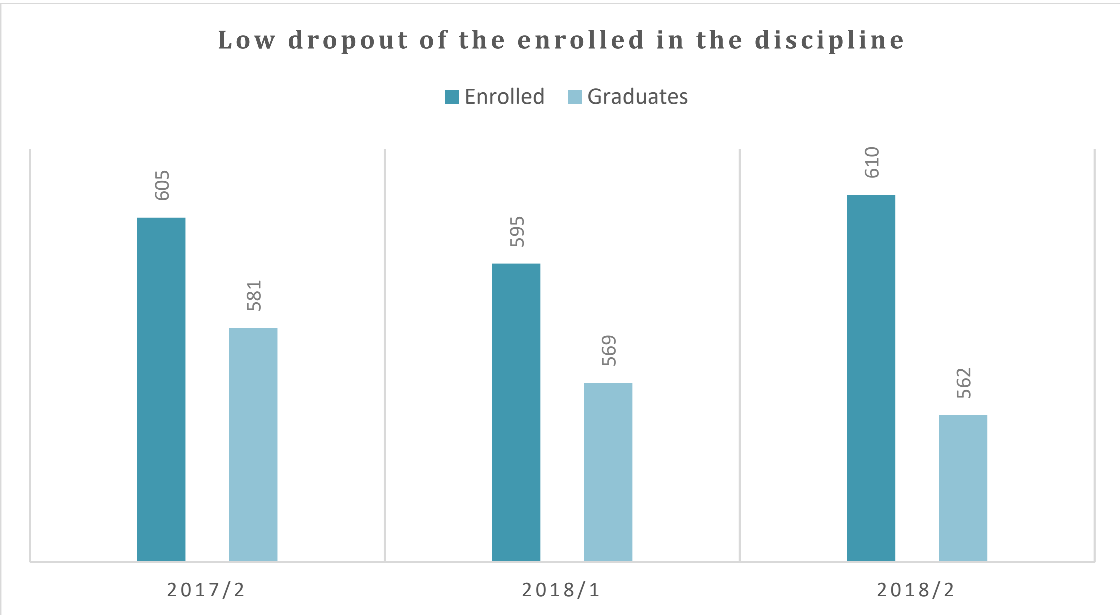

Figure 3. Number of interested in the discipline by semester - Source: Authors

We believe that problem-solving, and learning based on interaction between students are important parts of the process, occupying the longest space of time of the methodology. This set of strategies has contributed to the success of the courses of the Empreend, given the minimum number of evasions in the semester. In the case of IBA, the average utilization of the discipline is 95% as can be demonstrated in Figure 3. Maybe this could explain the average waiting list of 400 students per semester.

4 Conclusion and Future Research

This article presents UNB's School of Entrepreneurs and highlights its importance in the academic training of students, especially engineering students. The school is part of the Technological Development Support Center, which is responsible for developing the university's innovation policy and disseminating entrepreneurship. We draw attention to this school's pedagogy and learning methods, which can qualify students for the professional world. Due to the labor market's new demands, even the most conservative Brazilian educational institutions have shown signs of flexibility regarding their traditional teaching methods. At the same time, the production sector encounters difficulties to recruit skilled workers to work on the frontier of knowledge who have mastered skills and attitudes such as the ability to lead, work in groups, plan and manage strategically, learn independently – the so-called soft skills (Abenge, 2018).

In other words, solid technical training demand is rising, combined with a more humanistic and entrepreneurial formation. At the University of Brasilia, the use of innovative pedagogies with active learning has driven students to think their own business and experience other forms of integration into the world of work. Another aspect is the opportunity to practice entrepreneurial skills by learning to transform ideas into business through the creation of business plans. But the important thing has been learning to work as a team and thinking solutions for the improvement of life in society.

The course contributes to the promotion of the innovation culture and entrepreneurship at UNB and reached, in 2017, the first place among the higher education entrepreneurial institutions of the Midwest, according to the ranking of the Brazilian Confederation of Companies Junior. In addition to achieving the best performance in the region, UNB began to occupy the 8th position in the national classification in 2017. In 2016, the UNB was in the 18th position.

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Serious Game for the Production Engineering Course of the UnB: Student's Trajectory in the Course

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Abstract

The interaction of students with the course seems to influence the motivation of them and the quality of information plays an important role in their engagement. The lack of disclosure about student trajectory in undergraduate courses is a serious problem that can cause frustration, because students expect to receive information about the opportunities offered by the institution so that they can take advantage of the opportunities of academic life (Oliveira et al., 2016). It is essential that higher education courses provide quality information to students so that they can enjoy the benefits from the university without difficulty (Teixeira et al., 2008). In recent years, it has been observed that the use of gamification can favor the increase of the motivation and the engagement of the students in diverse levels of education. It is necessary to motivate the students with the perspective of their professional or academic career, giving them practical possibilities to experience these two paths, using as a means the games and the electronic devices with which they are familiar. The objective of this article is to show a serious game that was developed to the students of the course of Production Engineering of the University of Brasilia that points out the paths that must be traced to obtain the degree of Engineer with the intention of engaging and motivating them . The work design, regarding the objectives, fits the research as exploratory and the strategy used was a case study. The Beta Version of the Game of Production was developed through the application and selection of game techniques of a Gamification Framework. The study showed the feasibility of applying the game in the context of the proposal, having as confirmation the feedbacks collected after the first test with the students.

Keywords: Serious games; Gamification; active learning; engagement; motivation.

Jogo Sério para o curso de Engenharia de Produção da UnB: Trajetória do estudante no Curso

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Resumo

A interação dos alunos com o curso parece ter influência na motivação deles, tendo a qualidade das informações um papel importante no engajamento dos mesmos. A falta de divulgação acerca de informações sobre a trajetória dos alunos nos cursos de graduação constitui um problema grave que pode gerar frustações, pois eles esperam receber informações sobre as oportunidades oferecidas pela instituição para que possam aproveitar as oportunidades da vida acadêmica (Oliveira et al., 2016). É essencial que os cursos de nível superior provem informações de qualidade aos estudantes para que eles possam usufruir corretamente e sem dificuldades dos benefícios que a universidade oferece (Teixeira et al., 2008). Nos últimos anos, a utilização de jogos tem favorecido o aumento da motivação e o engajamento dos alunos em diversos níveis de ensino. Diante disso, é necessário motivar os alunos com a perspectiva da sua carreira profissional ou acadêmica, dando a eles possibilidades práticas para vivenciar esses dois caminhos, utilizando como meio os jogos e os dispositivos eletrônicos com que estão familiarizados. O objetivo deste artigo é mostrar um jogo sério que foi desenvolvido aos estudantes do curso de Engenharia de Produção da Universidade de Brasília que aponta os caminhos que devem ser trilhados para obtenção do grau de Engenheiro, com o intuito de engajá-los e motivá-los. O delineamento do trabalho, quanto aos objetivos, enquadra a pesquisa como exploratória e a estratégia utilizada foi um estudo de caso. A Versão Beta do Game da Produção foi desenvolvida através da aplicação e seleção de técnicas de jogos de um *Framework* de Gamificação. O estudo mostrou a viabilidade da aplicação do jogo no contexto da proposta, tendo como confirmação os *feedbacks* coletados após o primeiro teste com os alunos.

Palavras-chave: Jogos sérios; Gamificação; aprendizagem ativa; engajamento; motivação.

1 Introdução

As instituições de Ensino Superior de forma geral podem sofrer com problemas de comunicação entre os cursos e os alunos, podendo gerar frustações, pois eles esperam receber informações sobre as oportunidades oferecidas pela instituição para que possam aproveitar a vida acadêmica (Oliveira et al., 2016; Teixeira et al., 2008). É essencial que os cursos de nível superior provem informações de qualidade aos estudantes para que eles possam usufruir corretamente e sem dificuldades dos benefícios que a universidade oferece (Teixeira et al., 2008), pois engajamento dos mesmos com o seu curso pode está diretamente ligado com a qualidade das informações recebidas.

Silva Filho et al. (2007) afirmam que as expectativas do aluno em relação à sua formação e a própria integração dele com a instituição constituem, na maioria das vezes, os principais fatores que acabam por desestimulá-lo a priorizar o investimento de tempo ou financeiro para conclusão do curso. Os processos impactam diretamente a formação dos alunos e, a falta de informação clara e objetiva a respeito dos alunos do curso de Engenharia de Produção da UnB, geram prejuízos relacionados a retrabalho, perda de prazos e oportunidades (Magalhães, 2017).

Nos últimos anos, observou-se que a utilização de jogos pode contribuir para aumentar a motivação e o engajamento dos alunos em diversos níveis de ensino. Estudos sobre o uso de técnicas de jogos na Educação Superior mostram resultados significativos para aumentar o interesse em diversas atividades relacionadas à aprendizagem (Freitas et al., 2016; Martins & Fernandes, 2016; Mattos & Bertoni, 2015; Zampa & Mendes, 2017). Os jogos eletrônicos, além de apresentarem conteúdo, promovem a Educação, nos seus diversos âmbitos (Bomfoco & Azevedo, 2012).

Quando os jogos são bem planejados, podem contribuir para o desenvolvimento de competências necessárias aos estudantes, tais como: enfrentar desafios, buscar novas soluções, estimular a argumentação, a organização das ideias, a crítica, a intuição, a criação de estratégias e a aquisição de destrezas cognitivas e motoras necessárias para obterem sucesso no jogo e na vida. (Carvalho, Araújo & Fonseca, 2015; Kessler et al., 2010). Os jogos fornecem oportunidades inovadoras para os alunos contextualizarem informações e estudarem as consequências de suas escolhas (Kanthan & Senger, 2011), pois permitem, através de tentativas, errar e percorrer diversos caminhos em busca do mesmo objetivo, melhorando sua aprendizagem.

Jogar videogames é uma das atividades favoritas dos brasileiros, dado que 82% das pessoas entre 13 a 59 anos fazem uso de pelos menos um *game* em algum dispositivo eletrônico (National Purchase Diary Group, 2015). É muito popular entre os alunos a linguagem dos *games,* visto que as novas gerações brasileiras são nativamente digitais e usam de forma natural esse tipo de entretenimento, além de fazer uso diário de dispositivos eletrônicos para muitas outras tarefas (Deshpande & Huang, 2011).

Nesse cenário, torna-se clara a necessidade de aumentar o engajamento dos alunos no curso de graduação em Engenharia de Produção da UnB. É necessário motivá-los com a perspectiva da sua carreira profissional ou acadêmica, dando a eles possibilidades práticas para vivenciar esses dois caminhos, utilizando para isso as oportunidades adicionais que extrapolam a grade curricular, a saber: atividades complementares, estágio obrigatório e não obrigatório, projetos de pesquisa e Empresa Júnior. Tais oportunidades nem sempre são apresentadas aos alunos de maneira clara e objetiva.

Diante disso, o objetivo deste trabalho é apresentar um jogo sério, desenvolvido em 2018 como parte de um projeto final de conclusão de graduação, que divulga aos estudantes do curso de Engenharia de Produção da Universidade de Brasília os caminhos que devem ser trilhados para obtenção do grau de Engenheiro. O jogo tem como propósito demostrar aos alunos a trajetória que deve ser seguida desde que o momento em que o aluno ingressa no curso e isso pode motivá-los por ter uma visão mais sistêmica.

Este artigo está estruturado em 7 seções, a saber: a seção 2 apresenta conceitos concernentes a Game-Based Learning (GBL), Jogo Sério e Gamificação que dão subsídios para o desenvolvimento do trabalho; na seção 3 é retratada a metodologia utilizada na construção do jogo e na coleta de dados da pesquisa; na seção 4 é apresentado o jogo sério desenvolvido; na seção 5 são apresentados os resultados da avaliação do jogo por parte dos usuários; e, por fim, a seção 6 traz as conclusões.

2 Game-Based Learning (GBL), Jogo Sério e Gamificação

O G*ame-Based Learning* (GBL) é o uso intencional de jogos digitais ou não digitais com o intuito de facilitar o atingimento das metas de aprendizagem no ensino (Wiggins, 2016). Segundo Caponetto, Earp & Ott (2014), os conceitos de aprendizagem baseada em jogos e gamificação são similares, mas suficientemente distintos. O primeiro denota a adoção de jogos para fins educacionais e o segundo, a aplicação de mecanismos de jogos a intervenções educacionais globais.

Entretanto, o método GBL também utiliza técnicas de jogos, como a Gamificação, em suas atividades curriculares (Wiggins, 2016), podendo até mesmo serem utilizados esses dois conceitos de forma intercambiável. Jogos sérios é um tipo de jogo utilizado na abordagem GBL, tendo um caráter de maior obrigatoriedade, cujo propósito é educar ou treinar, diferentemente da Gamificação que está ligada também ao entretenimento (Wiggins, 2016).

Holloway e Kurniawan (2010) definem jogos sérios como um jogo projetado para um propósito primordial que não seja puro entretenimento, por exemplo, educação, embora para ser fiel a ideia de jogos, eles ainda necessitam ser divertidos e envolventes. Os autores dividem o desenvolvimento desse tipo de jogo em 4 fases: Pesquisa, Validação, Desenho e Implementação, sendo a avaliação ou *feedback* um elemento chave para esse processo. Jogos Sérios têm sido utilizado para aprendizagem em diversas áreas: negócios, militar, ciências da computação, matemática e biologia (Subhash & Cudney, 2018).

A utilização de jogos ou parte deles fornece efeitos positivos, mas os efeitos são muito dependentes do contexto em que a gamificação está sendo implementada, bem como dos usuários que a utilizam (Hamari, Koivisto & Sarsa, 2014; Alhammad & Moreno, 2018). Assim, para criação de um bom jogo, torna-se necessário o uso de um framework, juntamente com a análise do público alvo, como base de desenvolvimento da aplicação.

Após 10 anos de pesquisas e estudos sobre gamificação, Chou (2015) observou que todos os jogos são divertidos porque atraem determinadas motivações principais que influenciam os jogadores a fazerem certas atividades. Diante dessas observações, Chou (2015) propôs o *framework* chamado *Octalysis*, que é baseado em 8 motivações principais. Essas motivações principais são chamadas por ele de Core Drives. Para cada um desses Core Drives está mapeada uma gama de técnicas de jogos, totalizando 76 técnicas diferentes. Ao escolher usar um Core Drive é preciso identificar quais técnicas de jogos serão utilizadas para recorrer a ele.

Criar um jogo é muito mais do que simplesmente escolher técnicas de jogos aleatórias. É um ofício que requer muita análise, pensamento, teste e ajuste, além de um bom gerenciamento do projeto. A seção 3 apresenta a metodologia desenvolvida na realização da pesquisa.

3 Metodologia da Pesquisa

A seção 3 apresenta os métodos utilizados na pesquisa e a estruturação da pesquisa para o alcance dos resultados.

5.1 3.1 Método de Pesquisa

Uma pesquisa pode ser classificada de diversas formas. A maneira como está conduzida a obtenção dos dados classifica a pesquisa como estudo de caso, pois a pesquisa está centrada em uma proposta de utilizar técnicas de jogos para motivar os alunos quanto a sua trajetória na sua graduação, no contexto dos alunos do curso de Engenharia de Produção da UnB (Gil, 2008). A abordagem da pesquisa foi qualitativa (Silveira & Córdova, 2009) e as técnicas utilizadas para coleta de dados foram reuniões de validação a cada 15 dias com 2 professores orientadores e 2 alunos do curso e um questionário. A estruturação da pesquisa é descrita na seção 3.2.

5.2 3.2 Estruturação da Pesquisa

Através da classificação do presente estudo no que se refere às diferentes abordagens, se definiu uma estrutura de pesquisa para o alcance dos objetivos propostos. A estrutura está descrita na Figura 1.

Figura 1. Estruturação da pesquisa.

A Etapa Projeto e Desenvolvimento incluiu as atividades de desenho dos possíveis caminhos, de seleção de técnicas de jogos e do desenvolvimento do jogo. Para fazer o desenho dos possíveis caminhos que os alunos podem percorrer durante o curso de graduação em Engenharia de Produção da UnB, foi utilizado o método de Mapa Mental. Para a seleção das técnicas de jogos, foi utilizado o *Framework* Octalysis. Esse *framework* foi escolhido porque é a principal arquitetura utilizada na aplicação de gamificações na Universidade de Brasília, como demonstram os estudos de Freitas et al. (2016) e Nayara, Bela Cruz & de Freitas (2016).

A escolha dos *Core Drives* em cada fase de aplicação e as suas respectivas técnicas de jogos se deu primeiramente por meio da escolha das técnicas viáveis que mais agregariam valor para o público-alvo, partindo da análise das definições e aplicações sugeridas por Chou (2015) dessas técnicas, as limitações do software Unity e a delimitação do tempo para o desenvolvimento do projeto, como também os estudos de caso citados anteriormente de Freitas et al. (2016) e Nayara, Bela Cruz & de Freitas (2016). Em um segundo momento, por meio das ideias geradas pelas reuniões presenciais com a apresentação das definições e exemplos de aplicação de Chou (2015) das 36 técnicas restantes. Os participantes dessas reuniões foram um dos orientadores do projeto e dois alunos do Curso.

A linguagem de programação utilizada para o desenvolvimento do jogo foi o C#, por meio do *software Unity*. As texturas e os ativos retirados da loja oficial do *Unity* e utilizados no jogo podem ser vistos na Tabela 1.

Tabela 1. Ativos e texturas da loja do *Unity* utilizadas no Jogo

Categoria	Nome	Desenvolvedor	Função no jogo	Versão
Textures	*Yughues Free Pavement Materials*	*Nobiax / Yughues*	Textura do mundo	1.0
Characters	*EasyRoads3D Free v3*	*AndaSoft*	Textura dos caminhos	3.1
Textures	*Tiling Material Pack Free*	*Noseams*	Textura paredes	1.0
Textures	*QS Materials Nature - Pack Grass vol.2*	*Quadrante Studio*	Textura do terreno	1.0
Environments	*Modular Fantasy Bridges*	*julien tonsuso*	Pontes	1.0
Essentials	*Unity Samples: UI*	*Unity Technologies*	Menu inicial	1.2.1
Environments	*Medieval Castle Pack Lite*	*Tsunoa Games*	Portal formatura	1.1
Systems	*Pathing Pedestrian System*	*Wired Developments Pty Ltd*	Movimentação dos pedestres	1.0
Characters	*Red Samurai*	*Sou Chen Ki*	Avatar do jogador	1.0
Essentials	*Survival Shooter Tutorial*	*Unity Technologies*	Movimentação e ataque dos monstros	2.6
Characters	*Character Monster 1*	*Solum Night*	Monstro física 1	1.0
Characters	*Necromancer*	*PolyNext*	Professores	1.01
Humanoids	*Goblin*	*PolyNext*	Monstros pequenos fases difíceis	1.1
Humanoids	*The Earthborn Troll*	*Sou Chen Ki*	Monstro Cálculo 1	1.0.3
GUI	*DaD Inventory*	*GoodDay*	Inventário	1.0.0
Dungeon	*Low Poly RPG Item Pack*	*Fi Silva*	Chaves requisitos	1.0
Environments	*Mobile Low Poly Battle Arena / Tower Defense Forest Pack*	*AurynSky*	Moedas créditos	1.1
Characters	*Mini Legion Rock Golem Handpainted*	*Dungeon Mason*	Monstros fáceis	1.0

Na Etapa Demonstração, a Versão Beta do jogo foi disponibilizada em uma loja online de aplicativos e direcionada para teste por um grupo limitado de graduandos e graduados do curso de Engenharia de Produção da Universidade de Brasília, para alunos do ensino médio e do fundamental, e para alunos de outro curso de Ensino Superior da UnB ou de outras universidades. Na Versão Beta foi liberado apenas o primeiro semestre do Curso. O teste teve duração de cinco dias. Durante o período de teste, 43 usuários testaram o jogo em seus celulares.

Na Etapa Avaliação, com o objetivo de avaliar a Versão Beta do Game da Produção e de levantar pontos de melhoria por meio de *feedbacks*, foi elaborado um questionário com 32 perguntas separadas em três tipos: Demográficas, com 8 questões referentes às características sócio demográficas dos respondentes; de Experiência do Usuário, com 22 perguntas sobre a experiência de uso do Game da Produção; e Abertas, formada por 2 perguntas sobre erros e sugestões de melhorias dos testadores do jogo. Toda a estrutura do questionário foi feita com base nos estudos de avaliação de jogos e de gamificações realizados por Klock et al. (2017), Becerra et al. (2017); Kim & Shute (2015) e Mayer et al. (2014)

O questionário foi disponibilizado através de uma ferramenta online e direcionado para todo o grupo de testadores. Eles responderam o questionário entres os dias 28 e 29 de novembro de 2018, tendo sido totalizadas 43 respostas que equivaleu a 100% do número de testadores. Após a aplicação do questionário, foi feita a análise dos f*eedbakcs*. Na seção 4 é apresentado o jogo sério, objeto da presente pesquisa.

4 Game da Produção

O Game da Produção foi construído seguindo a temática RPG em que o jogador controla as ações de um personagem imerso em um mundo repleto de monstros e avatares, pois esse tipo de jogo permite ao jogador escolhas que podem influenciar a sua história, além de ter uma forte interação com o mundo ao qual está inserido, tornando-se o mais adequado ao objetivo da pesquisa. Ao percorrer o mundo o personagem tem a possibilidade de coletar diversos elementos: moedas, chaves, troféus e medalhas. Esses elementos fazem com que o avatar evolua ao longo do jogo. Na Figura 2 é mostrado o menu inicial do jogo.

Figura 2. Menu inicial do Game da Produção.

O avatar representa o aluno da Engenharia de Produção da UnB, as moedas créditos representam os créditos que o aluno tem que conseguir ao longo da graduação, as chaves requisitos representam os pré-requisitos das disciplinas, os troféus representam as aprovações nas disciplinas e as medalhas representam as atividades complementares. Os semestres se tornaram os "estados semestres" e as disciplinas se tornaram as "cabanas disciplinas". Todo o jogo foi pensado para aparelhos móveis, impactando assim toda a sua interface e jogabilidade.

O jogo tem início em um mapa 2D, chamado de Mundo UnB, onde o aluno parte da UnB em direção à Engenharia de Produção. Quando o aluno avança no jogo, ele se depara com diversos caminhos que ele pode percorrer durante a sua graduação e que foram mapeados através do Mapa Mental e, por consequência, de seus diversos cruzamentos. A Figura 3 apresenta alguns desses caminhos e cruzamentos.

Figura 3. Caminhos e cruzamentos do Mundo UnB.

Durante a graduação, o aluno pode cursar disciplinas obrigatórias e optativas, além de outras atividades complementares que agregam valor à sua formação e também permitem obter créditos. Sendo assim, o primeiro cruzamento do jogo é justamente entres esses três tipos de possibilidades apresentadas aos alunos.

Os jogadores podem tomar o caminho que preferirem no Mundo UnB, assim como as conquistas que julgarem necessárias. Precisam conquistar todas as cabanas disciplinas obrigatórias, mas não necessariamente seguir uma ordem. Faz parte do jogo decidir a melhor estratégia de percorrer o Mundo UnB. Dependendo das escolhas, derrotas e vitórias o jogador poderá levar mais tempo para abrir o Portal Formatura. No caminho do estudante na UnB também é assim, ele tem a chance de escolher quais disciplinas e atividades complementares que deseja fazer no semestre e pode se formar com uma quantidade acima do mínimo necessário de créditos, levando, em alguns casos, mais tempo para a formatura.

Ao entrar no estado 1º Semestre, o jogador deixa ter uma visão 2D do mapa e passa a ter uma visão 3D, além de se tornar um avatar do tipo samurai. Esse mundo é composto por outros 50 personagens, que é equivale a quantidade de alunos que entram por semestre no curso de Engenharia de Produção da UnB. O ambiente do jogo é noturno, pois a gradação é destinada a este período. Todo esse ambiente contribui na construção da narrativa da gamificação, dando uma melhor forma ao conteúdo e trazendo um maior significado na interação dos alunos com o jogo. Para facilitar a visualização das conquistas e recompensas, foram introduzidos no jogo três inventários conforme a Figura 4.

Figura 4. Os três inventários do jogo.

O jogo contém três inventários: Itens, Conquistas e Medalhas. O inventário Itens é acessado pelo ícone mochila e nele são armazenadas todas as chaves requisitos, as espadas ou outros objetos que o avatar pode coletar ao longo do jogo. O segundo inventário, chamado de Conquistas, atua como uma estante de troféus e é alimentado após a aprovação e coleta de todos os créditos de uma cabana matéria. Desta forma, o jogador poderá acompanhar quais cabanas disciplinas que ele falta passar ou que já conquistou.

No inventário Medalhas são guardadas as conquistas extras do jogo, como por exemplo, se o aluno participar de algum voluntariado na vida real, ele pode obter uma medalha como recompensa no jogo. O ícone de acesso é formado por medalhas. Pretende-se com isso influenciar o aluno a fazer outras atividades também fora da UnB e que deveriam ser dignas de medalhas, pois compõem uma boa formação profissional e humana. Os troféus das conquistas e as medalhas também influenciam os jogadores a buscarem coletar todos os elementos do jogo até completar a coleção completa do inventário. A aplicação dessa técnica busca influenciar o aluno a aproveitar o maior número de oportunidades que a UnB oferece.

O jogo é dividido em cabanas disciplinas difíceis e fáceis. Para conquistar as cabanas, o jogador tem a ajuda do personagem chamado Professor, que é encontrado ao lado da porta, como mostrado na Figura 5. O jogador recebe uma mensagem motivadora do Professor, ao se aproximar dele. A interação e o auxílio desse personagem são importantes para transmitir a ideia de que um professor, entre outras diversas funções, está na universidade para auxiliar e orientar os alunos. O jogador precisa se aproximar da porta e abri-la para acessar a cabana matéria. Desta forma ele entra em uma batalha como a apresentada na Figura 6.

Figura 5. Entrada da cabana matéria Física1.

Figura 6. Batalha na cabana matéria Física1

Na sequência, o jogador começa a ser perseguido pelo monstro maior da matéria enquanto o Professor ataca os monstros menores para despistar e matá-los. Sem o personagem Professor, seria impossível vencer a batalha. Reforça-se assim a ideia de que o professor na universidade tem a função de atuar como um aliado dos alunos e não como um inimigo. O fundo de cada batalha é adaptado de acordo com o conteúdo das cabanas disciplinas, contribuindo no entendimento de que a batalha está ligada a ação de busca do aluno pelos créditos da matéria específica.

No jogo, os pré-requisitos foram transformados nas chaves requisitos e a posse delas permite o jogador abrir portas no Game da Produção. As chaves requisitos aparecem na porta de forma brilhosa após a coleta de todos os créditos das cabanas disciplinas que são pré-requisitos para conquista de outras. Elas ficam na frente da saída das cabanas disciplinas, de forma que o jogador só pode avançar se pegá-las. O foco do uso dessa técnica é colocar toda a atenção na coleta da chave requisito, pois é um item de extrema importância para o jogo e, consequentemente, para a vida acadêmica do aluno.

A interdependência entre diversas cabanas disciplinas vem do fato de que parte da grade curricular dos alunos da Engenharia de Produção tem disciplinas dependentes de pré-requisitos. Os ditos pré-requisitos são disciplinas anteriores que o aluno deve obter a aprovação antes de matricular em determinadas disciplinas. O sistema de chaves requisitos do jogo ajuda o aluno a entender que há certa sequência nas disciplinas. Não basta o aluno ser aprovado nas disciplinas, é preciso também seguir uma ordem certa para que não ocorra um atraso na sua formatura ou até mesmo um eventual desligamento por tempo extrapolado de permanência na UnB. À medida que o aluno vai jogando, a porcentagem da formatura vai se atualizando.

5 Avaliação do jogo

Com a aplicação do questionário foi possível identificar a experiência dos usuários ao jogar o Game da Produção, que em um contexto geral foi bem aceito pelo grupo de testadores, bem como de erros e sugestões de melhorias. Foi possível medir um alto nível de satisfação com a aplicação criada, mas 69,8% dos jogadores discordaram completamente ou moderadamente quanto às fases do Game da Produção serem fáceis de passar, mostrando assim que o nível de dificuldade da Versão Beta foi elevado.

Quando perguntados se jogariam as novas versões do Game da Produção, 88,4% dos participantes do programa de teste do jogo concordaram de forma completa ou moderada. A maioria maciça mostra assim interesse pelo jogo e um prazer em potencial, principalmente se levarmos em conta que apenas 3 pessoas discordaram em jogar as novas versões. Em relação à aparência visual do jogo, os dados mostraram uma avaliação muito positiva, pois 74,4% das respostas concordaram fortemente ou moderadamente que a aparência visual do Game da Produção é interessante.

Cerca de 83,8% dos testadores concordaram fortemente e moderadamente ao serem questionados sobre se eles indicariam o jogo aos seus amigos que desejam conhecer o Curso. Essa expressiva porcentagem mostra o interesse pela divulgação do Game da Produção, demonstrando, assim, o nível de satisfação alta com o jogo.

Perguntou-se aos testadores da Versão Beta do jogo se eles se sentiram mais motivados a conhecer melhor o curso de Engenharia de Produção após terem jogado o Game da Produção. As respostas para essa pergunta tiveram um empate em porcentagem dos que responderam com neutralidade e dos que concordaram. Essa neutralidade pode também ter sido influenciada pelo fato de ninguém ter conseguido passar do primeiro semestre do jogo, impossibilitando a conhecer um pouco mais sobre o Curso através do mesmo.

Cerca de 86% dos jogadores perceberam que o jogo representa o fluxo curricular de um aluno do curso de Engenharia de Produção da UnB. Essa resposta teve maior pontuação do questionário, chegando esse valor a 4,7. Esses dados confirmam que a principal função do jogo foi atendida. Sem essa identificação, a Gamificação teria sido apenas um jogo como outro qualquer. Essa é a função principal que diferencia o jogo dos demais.

Do total de integrantes do grupo de teste, cerca de 80% concordam de maneira literal ou moderadamente que o jogo é importante para tornar mais claro os caminhos dos alunos no curso de Engenharia de Produção da UnB. Nenhum deles discordou dessa informação. Nenhum deles discordou dessa informação. Fica evidente assim o potencial do jogo para deixar explícito de maneira mais clara as oportunidades do aluno dentro do curso.

6 Conclusão

O estudo teve como objetivo a criação de uma proposta de Gamificação aplicada na trajetória do estudante de Engenharia de Produção da UnB. A revisão de literatura serviu de base para toda a pesquisa, desde o planejamento da Gamificação até o desenvolvimento do jogo e teste. Sem a luz dos conceitos e estudos levantados sobre Gamificação, não seria possível o sucesso dessa pesquisa, visto que eles foram essenciais para a seleção das técnicas de jogos e para o desenvolvimento de ideias de aplicação dos elementos de jogos.

O estudo revelou que é viável a aplicação da Gamificação, tendo como confirmação os feedbacks coletados após a disponibilização da Versão Beta do jogo. Com a aplicação do questionário foi possível identificar a experiência dos usuários ao jogar o Game da Produção, que em um contexto geral foi bem aceito pelo grupo de testadores, bem como de erros e sugestões de melhorias.

Conforme a percepção de cerca de 80% dos usuários do jogo durante o período de teste, o Game da Produção tende a oferecer uma visão melhor de quais disciplinas merecem atenção durante o curso de Engenharia de Produção, sendo esse Jogo Sério importante para tornar mais claro os caminhos ele pode tomar para ter uma melhor fluidez, aproveitando assim as melhores oportunidades. O jogo torna-se o espelho do curso de Engenharia de Produção UnB, abrangendo os itens de maior importância para os alunos.

Tendo em vista a constatação, por meio da avaliação dos usuários, do potencial da proposta de jogo sério desenvolvido no presente estudo e a limitação da pesquisa quanto tempo de desenvolvimento e a amostra pequena de testadores, deixa-se como sugestão de trabalhos futuros as melhorias no jogo, pois não foram aplicadas todas as técnicas de jogos e a aplicação do mesmo em uma amostra maior de testadores. Se os tempos entre os próximos testes forem feitos de forma reduzida, haverá a obtenção de dados do jogo de forma mais recorrente. É necessário também acrescentar os demais caminhos e oportunidades da vida acadêmica no jogo para que ele possa ser cada vez mais dinâmico, adaptando-se às opções de caminhos dos alunos. Pela tentativa e erro, o aluno pode arriscar no jogo o que na vida acadêmica nem sempre é possível, aprendendo assim com as opções.

Por fim, a pesquisa demonstrou que o jogo pode apoiar a divulgação do curso, uma vez que os *feedbacks* dos alunos foram muito positivos e foi demonstrado pelos testadores o interesse em indicar o jogo aos seus amigos que desejam conhecer o curso. Além disso, o jogo pode ser utilizado para divulgar o curso de Engenharia de Produção no Ensino Médio, uma vez que na amostra tiveram-se 4 alunos do Ensino Médio que realizaram o teste e jogaram.

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Teacher role tensions in the transition to project-oriented curriculum

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Abstract

From the first semester of 2018, the Faculty of Engineering of the University of Los Andes, in Colombia, has implemented a course of pedagogical innovation in higher education called the Multidisciplinary Engineering Design Project -MEDP. This course involves teachers and students from the eight engineering programs of the faculty, who have built interdisciplinary teams in order to develop relevant engineering solutions to problems and needs in communities. The MEDP course uses Project Oriented - Problem Based Learning (PO-PBL) and aims not only at generating deep learning in the students but also at becoming a space for faculty professors to develop the necessary competencies to implement courses inspired on Project-Oriented pedagogies progressively in the rest of the faculty. At the beginning of the semester, the Dean's Office sent an invitation to all teachers of the faculty (150) to participate voluntarily in the course, 22 of them voluntarily accepted and gave the researchers the proper consent to use their information from the beginning of the study. The purpose of this study is to identify the tensions that emerge from the engineering professors when they are invited to move from a content-oriented curriculum to a competencies-oriented curriculum such as PO-PBL. We used a qualitative approach for a holistic and in-depth understanding; information was collected using surveys and semi-structured interviews. To systematize we did a triangulation of actors to guarantee the reliability of the study. The results indicate that MEDP`s professors experience various attitudes when implementing the course: from broad receptivity and openness to the pedagogical proposal, to scepticism and rejection even though their participation was based on a voluntary basis. These attitudes point mainly to four transition axes that professors struggle with throughout the course: lectures VS meetings, products VS processes, predesigned problems VS problems identification, and laboratory settings VS real context settings.

Keywords: pedagogical innovation; Engineering Education; teacher role; Project Approaches.

1 Introduction

Los Andes University is a private higher education institution in Colombia that is currently considered the second best university in the country and is ranked 16th in Latin America and the Caribbean (The Ranking Web of World repositories, 2019). In 2012, ABET accredited the programs of the Faculty of Engineering for six years. Since then, some professors adopted a critical position in front of this external certification and debates on the implications for the programs had place.

Additionally, since 2016, the University has begun a process of curricular reflection and progressive implementation of changes and adjustments framed in a university reform process. This reform seeks to support the University in responding more efficiently to the needs of Colombian society in education. In this process, each academic unit has opened a series of discussion spaces on the needs, possibilities, and orientations of curricular change to respond to the general purpose of a more flexible curriculum.

As consequence of these analyses and reflection, faculty professors identified that a content-oriented curriculum, which main teaching activity is the lecture, makes it not possible to achieve the development of some expected competencies declared by ABET, for instance, team-group work or project management. The engineering education literature shows competence-oriented curriculum where students participate in engineering projects as a path to achieve ABET guidelines (Hernandez et al., 2015; Kolmos et al., 2004; Ravn, 2008).

A similar pathway was taken by the program of Biomedical Engineering in 2012 with ABET guidelines in order to involve projects in their curriculum. To the date, this program has a series of courses guided by projects in the first semesters of the career (Hernandez et al., 2018) and a capstone course in engineering design as degree work. Other engineering programs do not have the same line of project-oriented courses, or the projects have developed within more content-oriented courses. Moreover, there are not interdisciplinary courses to establish a joint project.

For this reason, the implementation of a course called the Multidisciplinary Engineering Design Project -MEDP began in the first semester of 2018, under the Project-Oriented Problem Based Learning (PO-PBL) model. This space started as a 16-week undergraduate course with students and professors from the eight engineering programs of the faculty (mechanical, systems and computer, biomedical, civil, environmental, industrial, chemical, electrical and electronic) building interdisciplinary teams to develop engineering solutions to problems and felt needs of a given community and context.

The Faculty of Engineering offers this course directly to students as an initiative to generate processes of educational innovation in the university reform framework, thus it is not associated to an engineering program in particular. The objective of this course is not only to stimulate deep learning processes for students but also to be a learning space for professors of the faculty in which they can develop the necessary skills to implement competence-oriented courses progressively in the rest of the faculty.

To date, the Engineering Faculty has offered the course for the last three (3) academic periods (semesters), in which around 90 students and 20 professors (14% of the teaching faculty staff) have participated voluntarily. This document presents one research exercise carried out throughout the course implementation that answers the following question: what are the tensions that emerge in the engineering professors when invited to move from a content-oriented curriculum to a competencies-oriented one such as PO-PBL?

2 Theoretical Framework

2.1 Content-based curriculum

The content-based curriculum was born at the end of the 19th century with the idea of transmitting to the following generations the most valuable knowledge developed previously as cultural heritage. From there, professors through their specialized speech would be responsible for students' thinking regarding what they read from textbooks that unified this knowledge (Posner, 1992). In this scenario, the teacher is the primary source of information and has the power to teach or transfer what he considers relevant for students to know in the discipline (Martinez, 2014).

From this perspective, the need to cover all topics determines a pedagogical practice characterized by a two or more hour talking teacher in an auditorium or classroom for a lecture where students are passively receiving information with little or no opportunity to participate (Pardo, 2012). Posner (1992) argues that until recently, for educators with this curricular vision, it has become necessary to make explicit the theories about learning, knowledge or motivation that support their position and pedagogical practice. However, content-based curriculum and lecturing is a deeply rooted vision, especially in academic cultures.

2.2 Competence-based curriculum

As an alternative, the competence-based curriculum refers to the development of human being's ability to use a set of knowledge, skills, and attitudes in the intervention of a given context or situation taking into account economic, social and environmental considerations, among others (Pardo, 2012) (Martinez, 2014).

This curricular perspective proposes teaching as a process that aims for students to see, study and participate, in the practical application of knowledge in a particular context since the educational process focuses on student's learning rather than teachers' teaching. Thus, it is not important what is taught but what is learned and, above all, what students are capable of doing with what they have learned (Martinez, 2014).

Consequently, the teacher's purpose is no longer to cover a set of disciplinary concepts in the time traditionally established but to favour learning scenarios for students inside and outside the classroom. This new role does not mean that the teacher has to abandon his purpose of facilitating the understanding of disciplinary content, but rather that his emphasis is on designing learning activities where students must mobilize their resources to face problems and find the most appropriate solutions effectively (Martinez, 2014). In this curricular vision, exchanges between professors concerning their pedagogical doubts and results are fundamental; therefore, the academic discussions on curriculum between them are a central space in the orientation for competences development (Martinez, 2014).

2.3 Educational Innovation

The transition from one curricular vision to another implies processes of educational innovation that, according to Rivas-Navarro (2010), refers to the incorporation of something new in an existing educational system, resulting in the modification of its structure and operations in the achievement of the educational objectives. Innovation is an intentional activity in which the innovative actor deliberately applies and implements new ideas, going beyond merely thinking or talking about the needs for change, in the process of incremental or progressive transformation of some components of the system. The innovative activity aims to benefit the contextual conditions of the situation that intervenes, and it implies a certain degree of unpredictability due to the complex interactions between the actors that participate in it (Bocconi, Kampylis, & Punie, 2013).

2.4 Project Oriented - Problem Based Learning PO-PBL

The Project Oriented - Problem Based Learning is an example of competence-based curriculum. Posner (1992) argues that the PO-PBL curriculum expresses an experimental perspective, as students learn through activities that allow them to use the skills acquired through active personal experience, enabling direct internalizing active learning. Since the interests of the learners are involved, it is also possible to respond to their emotional needs during the learning process.

In practice, the PO-PBL consists of defining a problem in a real context that guides the learning process through the development of a project with particular emphasis on the formulation of questions as part of the process (Hernández, Raven, & Valero, 2015) (Kolmos, Fink, & Krogh, 2004) (Vithal, Christiansen, & Skovsmose, 1995) (Rodriguez-Meza, Kolmos, & Guerra, 2017). The purpose of the PO-PBL, however, is not merely to solve problems but to use them so that students attempt to resolve them, which increases their understanding and knowledge from a multidisciplinary perspective in combining the acquisition of knowledge and the development of skills and abilities unleashed by teamwork, leadership, communication, decision-making, critical thinking, and creativity (Ribas, 2004) (Wood, 2006). Thus, the development of the project has a double purpose: first, final products of learning reified in concrete objects, reports, and presentations; second, the reflective processes that the professors must promote during the meetings.

In opposition to the traditional curricula, where a teacher first exposes the information and then students apply concepts, in PO-PBL students take control of their learning. Therefore, the teacher’s role is to help them to catalyse the experiences (Kolmos, Du, Holgaard, & Jensen, 2008). Consequently, negotiation occurs at individual and collective levels among the members of the class and the teacher (Hernández, Raven, & Valero, 2015) (Hernández, Buitrago, Tocora, & León, 2018) (Raven, 2008). According to (Coffin, 2013) implementing PBL at any level requires changes in learning and teaching methods, and it implies the need for an institution to embark on faculty development. Teacher or staff is one of the significant agents of change who plays a significant role in making the implementation of PBL successful because it requires teachers to acquire educational skills that are different from traditional teaching skills.

This multidisciplinary approach requires a team of teachers to design and implement the course. In the MEDP course, there are two teachers inside this team who take on tasks associated specially with course design, coordination of work contexts and logistics, whereas the hole team of teachers participate as supervisors and advisors of students’ work teams. Additionally, every semester before starting the course dean’s office send an invitation to all teachers in the faculty for them to participate voluntarily as team advisors. In this process, the teaching team meets before, during and after the course to reflect on the execution and to evaluate results.

3 Methodology

Each semester we register the development of the course from a qualitative perspective that allows us to understand the experience from the participant's viewpoint, the context and how events, actions, and meanings give a unique form to the circumstances that emerge in the process (Maxuell, 2005). This study analyses the information collected between January 2018 and January 2019. The participants of the research are 22 professors from the Faculty of Engineering of the University belonging to the eight (8) departments of the Faculty. In particular, the researchers are part of the faculty that accompanies the course development during the semester. This group of professors consists mostly of men between 30 and 60 years old who offer courses in different disciplines in all semesters of the undergraduate and postgraduate faculty programs. They were informed that their participation in the study was voluntary and they signed the required letters of consent.

For the generation, gathering, and systematization of the information, we used an unstructured interview and a questionnaire. The unstructured interview, also called informal conversation interview, relies entirely on the spontaneous generation of questions in a natural conversation within the context of the experience (Turner, 2010). Nonetheless, a limitation of this study raises with the fact that the information gathered through the unstructured interview includes only conversations held with the authors, leaving aside those possibly held among the rest of the teachers' group. On the other hand, we used the questionnaire in its open mode as a strategy to generate anonymous information without face-to-face interaction to alleviate this limitation (Avarez-Gayou, 2009).

In the analysis of the information, we use triangulation as a technique to promote the quality of the interpretation of data. In essence, triangulation is a strategy for comparing sources of information: actors, methods, time and space that, taken together, allow a better understanding of the experience (Flick, 2007). Unlike quantitative research, qualitative studies do not have a specific moment dedicated to data analysis. Parallel to the generation of information, in a dynamic to collect unstructured data, the exercise of analysis gives them an interpretative structure. From this perspective, we wanted to identify the tensions that emerge from engineering professors in the transition from a content-oriented curriculum to a competency-oriented one.

4 Results and Analysis

During the implementation of the MEDP course, the participant professors have experienced different temporary and transitory attitudes concerning the pedagogical and methodological proposal: from broad receptivity, interest, and openness, to scepticism, disdain, and rejection of some components of the course. In this range of attitudes that have emerged in the process of curricular transition, we identified four (4) elements that have generated tension in professors: Lectures VS meetings, product VS process, predesigned problems VS problematization or identification of problems, and laboratory conditions VS conditions of real contexts. These elements, far from being independent of one another, are intimately linked and mutually reinforcing as described as follows.

4.1 Lectures VS meetings

Through MEDP there are some general theoretical sessions that are addressed as workshops such as engineering design, teamwork, and project budget. However, there are no so-called lectures. The other spaces involve professors' meetings with their teams to follow up on the project every two weeks. This substantial difference has generated in the teachers the feeling that in this type of courses, there are no classes and, therefore, there is no rigorous work in the contents of the discipline:

> *"Since in this course we do not do class, the students are not acquiring the necessary tools to work the design in engineering in the contexts" (MEDP teacher, November 2018)*

> *"We should dedicate the first weeks of the course to strengthen in the students the concept of design in engineering so that they can really develop innovative prototypes" (MEDP teacher, mayo de 2018)*

> *"In the meetings with the teams, there is no time to explain the relevant concepts so that they can have better ideas about what can be done in the contexts" (MEDP teacher, September 2018)*

These perceptions might have become visible due to the curricular changes proposed in the pedagogical intervention. In the curriculum focused on content, teachers have the responsibility of presenting the concepts in an orderly manner during the most time in class. Conversely, the meetings are a space for dialogue, and the students must take control of their learning as they heighten the needs that they identify. In this scenario, the student intervenes much more and goes to the teacher autonomously to request advice or guidance, but not as source of information. According to (Coelho, 2014), facilitation in PBL is not merely a matter of sitting there. Instead, it requires proficiency and understanding of concepts behind learning theories, excellent verbal and non-verbal interaction, and abilities to deal with internal struggles such as how long to wait before you interrupt, whether or not to correct an incorrect statement and for how long to allow silence. However, it is possible to ameliorate these concerns by understanding the pedagogical process.

During the two first semesters of implementation, we identified that the course design guides progressively teachers to move from one vision to another: from content oriented to competence oriented. Eventually some professors come to understand that in this curricular approach the acquisition of relevant information by the student is not the entire responsibility of the teacher, but that it becomes an activity of the students as part of their individual and group work for the excellent development of the project and its own learning process. However, other teachers perceive this emptiness permanently and identify it as a failure of the proposal.

Therefore, as a learning space for professors towards different forms of teaching, there appear two challenges in this course: 1. the creation of strategies to favour the understanding of the new place and function of contents; 2. to accompany professors to handle the feeling that they "simply" disappear.

4.2 Products VS processes

During the development of the MEDP course, we observed that most of the orientations of the professors were towards the product, not the process or other abilities. These orientations seem to lead professors to perceive they are wasting time when they devote more time during the evaluation process to make visible students learning instead of explaining the functionality of the product from the corresponding discipline:

> *"Why do we give them so much time for the exhibition of the project? We waste considerable time while every team member presents a part of the project" (MEDP teacher, April de 2018)*
>
> *"If the prototype is functional, it should be able to show it on its own, and it is enough if the best student of the group and explain the prototype" (MEDP teacher, December de 2018)*

In a traditional curricular vision, it is common that teachers use evaluation activities to conclude the course and the presented products are perceived as materializations of the knowledge that students attained according to the disciplinary vision of the teacher. However, the development of competences implies that during the course there are spaces for formative evaluation. In this way, the student gradually leads to improve their performance in the task, which will come to the end of the project with a product. The solution, functional or not, is much more sophisticated than the one generated at the beginning of the course and, above all, the students should be able to give account of the learning that they generated throughout the classes that led them to elaborate their final product.

From the curricular innovation perspective, this tension is the strongest; professors have a marked orientation to the product: if the prototype is not functional or highly developed, the evaluation of the student will be negative. It is still hard for a good part of the faculty to understand the idea that the objective of the course is for the student to learn by doing, learn from his own experience of trial and error. This implies that even the non-functional prototype is a source for students to understand the reasons why it does not work as a part of the learning process and development of reflection skills that form the basis of learning to learn.

4.3 Predesigned problems VS problem identification

As a complement of the previous statement, this category shows the differences in the vision of the problems in these curricular proposals. We decided to present it independently because the understanding of what is a problem is at the heart of the proposed PO-PBL strategy. The MEDP course emphasizes that the problematization – as identifying and defining a problem in concrete context- is part of the competencies that students must develop. For this reason, students face a real context in which they must recognize and identify pressing needs, as well as define to which of them they could contribute better from the articulated work of their disciplines.

In this approach, the problematization is a process that takes time, since the students dedicate themselves to recognize the context, interacting with the relevant actors, identify needs and describe in detail the problem they decide to select for the development of their project. For some professors, this process takes valuable time away from the elaboration of functional and innovative prototypes:

> *"Students begin very late to make prototypes, and they are not really getting to do engineering designs, we should give them more details about the context and the problem from the beginning of the course so that they can use this time in making designs" (MEDP teacher, August 2018)*

> *"While they get to know each other, manage to visit the place, collect quality information and successfully describe a relevant problem, the semester is almost over, and they end up designing that contribute very little to contexts" (MEDP teacher, December 2018)*

Although this is not a generalized view among professors, there is a feeling that during the first half of the course students do not do any engineering. Additionally, some professors struggle with understanding that an engineer in training must also develop the ability to know what s/he is good at and what s/he can contribute to in a given situation. In the MDEP case, the students identify a wide range of problem situations in contexts, but only for some of them, they can propose solutions considering their disciplinary knowledge; this implies additional limitations that influence the proposal of prototypes, and it requires negotiation time between students to make decisions.

These results are again showing the differences between the two curricular models presented in the theoretical referents. While in the content curricula students receive statements of closed problems from which a rapid and correct response is expected (Posner 1992), in the PO-PBL model identifying relevant questions is as important as generating answers (Kolmos et al. 2004).

In this transition, this tension also poses in the first plane an alarm among professors to realize that a student in the last semesters of engineering is taking about ten weeks to identify and decide what and how to contribute to a real situation from his/her training in specific engineering. Within the framework of the curricular reform, this result also provides evidence of the impossibility of developing competencies without students' living an educational experience different from the lectures. In addition, it leads to the reflection made by Hernandez et al. (2015), on the fact that the development of competences in the PO-PBL happens when the students realize projects in a successive and not isolated way, as in the case of MEDP.

4.4 Laboratory settings VS real context settings

For MEDP, the needs identified by the students in the development of the project define the use of laboratories and other types of equipment. In addition, each team has economic resources for the purchase of necessary materials for the prototypes. This is why in no single laboratory students can apply what they are learning. Without trying to simplify the critical role of laboratories in the study of science and engineering, for some teachers, it is illogical to pretend designing outside a laboratory because students may lose control over certain conditions. In a real context, it might be impossible to experiment:

> *"It is challenging to learn from trial and error in engineering design because real contexts are not laboratories; they are real people with real needs" (MEDP teacher, September 2018)*

> *"How can I advise teams to design something if the conditions of real contexts are changing? In six months the situation can change completely and then I have an irrelevant design in the laboratory" (MEDP teacher, April 2018)*

In the content-oriented curriculum, it is common to find that the practice is set apart from the lectures - where the students learn the theory - and their place is usually in the laboratories where the students must repeat a procedure to find the results already formulated previously by the teacher. Again, we identify a different view of the experimentation in the PO-PBL: laboratories should be spaces for the creation of prototypes and the development of tests on them. Here the purpose is not to repeat some results, but to use theoretical and experimental knowledge to propose solutions to the identified problem as they raise (Kolmos et al., 2004 and Hernandez et al., 2015).

Additionally, it is an essential point that teachers and students identify that in real contexts there are ethical elements related to contact with people and communities, which lead to rethinking the more traditional conception of experimentation they have had in the university. This challenge is not addressed directly in the course, and that bears more relevance as part of the curriculum reform.

5 Conclusion

After a year of implementation of the MEDP, accompanied by a rigorous research and systematization exercise, we identify four tensions that emerge from the engineering professors when they are invited to move from a content-oriented curriculum to a competencies-oriented one such as PO-PBL; this is a significant result in the framework of the university reform.

As an initiative to generate processes of educational innovation, to the creators of the course it was always transparent that in this course there are two levels of students: novice engineers who are in the process of disciplinary training, and expert engineers who are responsible for training the novices. Professors as expert engineers knew that they would face challenges; still, they were not fully aware of all the implications of this type of educational innovation. These tensions emerge from the teacher's own learning process in a competence-oriented curriculum, and we conceive them as opportunities to propose concrete and contextualized strategies to support the competence-based curriculum development at the Engineering Faculty of the Universidad de Los Andes in Colombia.

We perceive the following four areas of tension that stand out as challenges and routes to mobilize the curricular transition: First, to broaden the vision of class in which, in addition to the contents, fit the conversations in a type of interaction that allows greater participation of the students. Second, to shift the focus of the educational process so that professors have a holistic view of learning that includes and focuses on the process, rather than on the product. Third, to make professors aware of the importance for students of learning to problematize in changing uncertain situations so that they can create relevant and sustainable engineering designs. Finally, to generate discussions on the distance between theory and practice, and the role of experimentation for the training of new engineers.

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Best practices for *Active Learning*: a literature study using bibliometrics

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Abstract

Engineering is an area of growing changes and goes side by side with technological evolution to offer qualified professionals to the job market. The learning methodologies have changed considerably in recent years, with the aim to adapt to new requirements of the 21st century, and to train professionals with a curriculum that adheres to the demands of the market, necessitating new learning approaches. In order for engineering to be appropriate to a new form of teaching, it is relevant to identify studies on the methodologies of active learning that are being used today. This article aims to highlight the types of active learning that already exists in literature, specifically applied in disciplines related to production engineering. The study was conducted within the context of engineering, in the last 8 years, through a bibliometry, using the Theory of the Approach Analytical Meta Consolidated, and the database used was the Web of Science and Scopus. The result of the research presents a compilation application of methods found in successful cases in universities that use the methodology of active learning, the identification of best practices, tools, techniques adopted and the results achieved. It is hoped that this study will serve as a subsidy for its use in production engineering disciplines, in order to make student learning more effective, autonomous, creative and applicable to the day-to-day problems of engineering.

Keywords: *Active Learning* practices; Engineering; Bibliometry.

Melhores práticas para a aprendizagem ativa: um estudo da literatura usando bibliometria

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Resumo

A engenharia é uma área de crescente mudanças e acompanha a evolução tecnológica para oferecer profissionais qualificados para o mercado de trabalho. As metodologias de aprendizagem têm se modificado bastante nos últimos anos, com o intuito de adequar aos novos requisitos do século XXI, e formar profissionais com currículo aderente às exigências do mercado, necessitando para isso de novas abordagens de aprendizagem. Para que a engenharia esteja adequada a uma nova forma de ensino, torna-se relevante identificar estudos sobre as metodologias de aprendizagens ativas, que vem sendo utilizadas nos dias de hoje. Este artigo tem como objetivo destacar os tipos de aprendizagem ativas existentes na literatura, aplicadas especificamente em disciplinas voltadas à engenharia de produção. O estudo foi realizado dentro do contexto da engenharia, nos últimos 8 anos, por meio de uma bibliometria, utilizando a Teoria do Enfoque Meta-Analítico Consolidado, com as bases de dados *Web of Science* e *Scopus*. O resultado da pesquisa apresenta uma compilação dos métodos de aplicação encontrados nos cases de sucesso em universidades que utilizam a metodologia de aprendizagem ativa, a identificação das melhores práticas, ferramentas, técnicas adotadas e os resultados alcançados. Espera-se que este estudo sirva de subsídios para sua utilização em disciplinas de engenharia de produção, afim de tornar a aprendizagem do aluno mais efetiva, autônoma, criativa e aplicável aos problemas do dia a dia do engenheiro.

Palavras-chave: Práticas de aprendizagem ativa; Engenharia; Bibliometria.

1 Introdução

As mudanças no mercado de trabalho acontecem de forma acelerada, isto posto, as competências necessárias para um engenheiro do século XXI não são as mesmas que as habilidades exigidas no século XX. Entender sobre as qualidades pessoais de cada profissional não era objeto de estudo (Solomon, 2003). Mas com o passar do tempo, a aquisição de conhecimento técnico, com sua subsequente aplicação no contexto de atividades profissionais, tornou-se essencial para o desenvolvimento de competências essenciais de um estudante de engenharia (Monteiro, Reis, Silva & Souza, 2017). O estudo de Soares, Leão, Carvalho, Vasconcelos & Costa (2014), articula que os estudantes são privados da oportunidade de desenvolver suas competências ao longo de seus programas acadêmicos, principalmente por não aplicarem as teorias retidas de forma a associar o conteúdo técnico aos seus campos profissionais.

A necessidade de uma nova metodologia de ensino e aprendizagem vem sendo observada não apenas pelos órgãos nacionais de educação, mas também por professores que percebem a falta de interesse e desmotivação dos alunos durante as aulas tradicionais, de forma que o conhecimento da matéria não se instaura e isso pode ser resolvido pelo uso de novas metodologias de ensino.

A aprendizagem ativa, segundo Menekse, Stump, Krause & Chi (2013), traz novas abordagens instrucionais para ensinar, levar ao conhecimento, que são centradas no aluno, e aborda como envolvê-los de forma mais dinâmica nos processos de aprendizagem. Se baseia na participação, envolvimento e interação dos alunos para criar experiências de aprendizagem mais sólidas.

Assim, o presente estudo tem por objetivo identificar as metodologias de aprendizagem ativa com maiores influências, observando seus métodos para sua efetiva aplicação e os resultados, com foco em engenharia. Avaliou-se a evolução dos estudos sobre este tema nos últimos 8 anos, utilizando-se a Teoria do Enfoque Meta-Analítico Consolidado, que se trata de uma abordagem derivada da meta análise, porém com um objetivo distinto de mapear a literatura, propondo marcos conceituais (Mariano, Cruz & Gaitán, 2011). A seguir, apresenta-se na seção 2 a metodologia da pesquisa e na seção 3 descrevem-se os resultados obtidos através de enfoque meta-analítico. A seção 4 apresenta a conclusão da pesquisa e por fim, na seção 5 as referências deste estudo.

2 Metodologia de pesquisa

A metodologia adotada foi a pesquisa exploratória de abordagem qualitativa, e como estratégia utilizou-se a bibliometria com enfoque meta-analítico. O intuito do enfoque meta-analítico é através de critérios de impacto buscar referências assertivas para a pesquisa científica. Neste trabalho adotou-se o modelo da Teoria do Enfoque Meta Analítico Consolidado - TEMAC (Mariano & Rocha, 2017), que consiste de uma revisão sistemática a partir de bases de dados feita em três etapas: preparação da pesquisa, apresentação dos dados e inter-relação dos dados e detalhamento com um modelo integrador validado por evidências. Apresenta como um tema está sendo abordado dentro da pesquisa, seu histórico, quantidade de publicações, autores, revistas e com quais outros temas tem relação através das palavras chaves. Foi utilizado o software *VOSViewer* para elaboração de mapas de calor, que mostram através das cores quentes para as frias, autores, palavras e artigos que mais foram citados.

3 Resultados

A seguir são apresentados os resultados obtidos utilizando as três etapas do TEMAC.

3.1 Preparação da pesquisa

Na primeira etapa, a preparação, foi levantada através da base de dados *Web of Science* realizada em 5 de janeiro de 2019, resultando inicialmente 7.418 documentos relacionados com o termo *Active Learning,* numa faixa de tempo de 2011 até 2019. Para esse estudo delimitou-se esses resultados dentro das áreas de conhecimento *Education Educational Research, Education Sciencist Research, Engineering industrial* e *Engineering manufacturing*, resultando em 3.308 publicações, considerando conferências e revistas. Também se utilizou da base de dados *Scopus* para uma maior abrangência de informações, obtendo inicialmente 2175 documentos sobre o termo *Active Learning,* de 2011 a 2019. Os filtros das áreas de conhecimento dessas duas bases de dados são diferentes, portanto para se conduzir o estudo com resultados aproximados filtrou-se pela área engenharia e foi feita uma busca de quais revistas/congressos/conferências se referiam a engenharia industrial, engenharia de manufatura, encontrando 463 documentos.

3.2 Apresentação e inter-relação dos dados

Grande parte dos documentos encontrados para o tema foram publicados e apresentados em conferências, simpósios e não apenas em revistas. Por se tratar de uma área de pesquisa que está sendo estudada em diversos âmbitos de conhecimentos, com flexibilidade de aplicação, é comum ter maior índice de aparição em conferências. As conferências que mais publicaram sobre o tema foram a *Inted Proceedings*, com 201 publicações, *Edulearn Proceedings*, com 185 publicações e *ASEE Annual Conference Exposition*, com 178 publicações do total de 3308 publicações (considerando conferências e revistas), tendo outras conferências e revistas abaixo de 120 publicações.

Este estudo tratou de analisar a metodologia ativa pelo âmbito da Engenharia de Produção, porém também foi encontrado o estudo do tema com relevância em outras áreas de conhecimento, como ciência da computação, negócios, gestão, contabilidade e farmácia.

O destaque para o tema está crescendo tendo em vista o seu número de citações (Figura 1a), que chegou a 9892 no total, e também ao crescente número de publicações (Figura 1b), observados na base *Web of Science*.

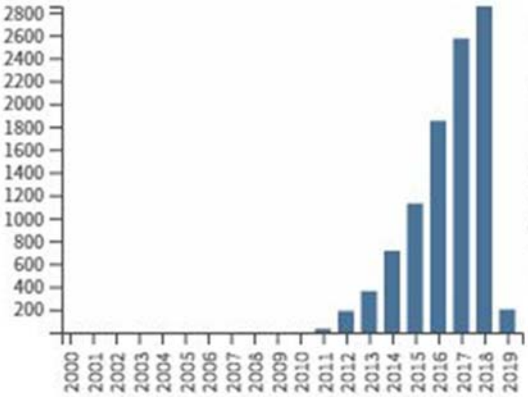

Figura 5a. Evolução das citações

Fonte: Base de dados Web of Science.

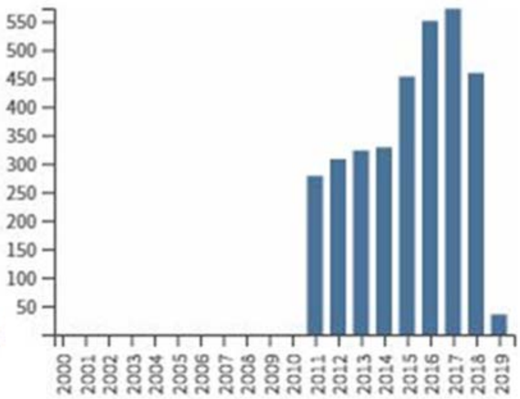

Figura 6b. Evolução das publicações

Fonte: Base de dados Web of Science.

O Estados Unidos é o país que lidera na quantidade de publicações com 1372 no *Web of Science* e 106 no *Scopus*, correspondendo a 41,51% e 22,89% respectivamente. Em segundo lugar no *Web of Science*, aparece a Espanha com 391 publicações, a mesma corresponde ao terceiro lugar na base *Scopus* com 41 publicações, ficando o Brasil em segundo lugar no *Scopus* com 82 publicações. No Brasil, a Universidade de Brasília lidera as publicações com 24 documentos e a Universidade de São Paulo, terceiro lugar, com 12.

O artigo de Mason, Shuman e Cook (2013), foi o mais citado totalizando 208 citações no *Web of Science* - "*Comparing the Effectiveness of an Inverted Classroom to a Traditional Classroom in an Upper- Division Engineering Course*". Foram estudadas as respostas dos estudantes já voltados para a engenharia, diante de uma sala de aula invertida, *Flipped Classroom*, e uma sala de aula tradicional, observando que os estudantes apresentaram desempenho igual ou superior em testes, exames e problemas, porém tiveram uma rápida adaptação e aprendizagem mais satisfatória no formato *Flipped Classroom*. Esse artigo, assim como foi encontrado nos artigos mais citados, seguem a tendência de estudos sobre o método *Flipped Classroom*, aplicado em diversas áreas de conhecimento. Dos 11 artigos mais citados, 6 deles abordam sobre *Flipped Classroom*.

Segundo o *Web of Science,* Mason também foi o autor mais citado, porém não é um dos autores que mais publicaram, sendo Henderson e Shekhar os autores com o maior número de publicações, ambos com 11. Já no *Scopus* o autor que mais publicou foi o Lima, R.M. com 9 publicações e os autores Borrego,M. , Mariano,A.M. e Shekhar, P. com 8 publicações.

O autor Lima,R. M traz em seus estudos compilados de diferentes abordagens de pesquisas e metodologias sobre a Aprendizagem Ativa no âmbito do ensino das engenharias, relacionando-as para trazer formas colaborativas e fomentar os estudos nessa área.

Para entender em quais linhas de pensamentos os artigos estão caminhando, foi utilizado a ferramenta "*Word Cloud*", criado pelo site Tagcrowd.com, para ambas as bases com o intuito de analisar quais são as palavras-chaves que mais aparecem nos artigos. As cinco palavras que mais aparecem são "*learning*", "*education*", "*active*", "*students*" e "*teaching*". Outras palavras que também devemos observar são "*Design*", "*Technology*", "*Engagement*" e "*Flipped*" trazidas pelo *Web of Science e* as palavras "Project", "Project-based" e "Collaborative". O conjunto de palavras encontradas pode ser visualizado pela Figura 2.

Figura 7. Palavras-chave.

Pode-se depreender da Figura 2 que as palavras que estão caminhando junto com o principal foco da pesquisa Aprendizagem Ativa (educação, estudantes, ensino e sala de aula) e suas metodologias, estando voltadas para as áreas de Ciência e Tecnologia.

3.3 Inter-relação dos dados e detalhamento com um modelo integrador validado por evidências

Nesta terceira etapa para identificar a relação entre os artigos obtidos através da base de dados do *Web of Science* e *Scopus* utilizando a palavra-chave "*Active Learning*", foi utilizado o software *VOSViewer* para análise através de mapas de calor. O mapeamento bibliométrico nada mais é do que um arranjo de classificação e visualização (Boyack & Klavans, 2015), que faz a ligação entre os autores.

Foram feitos dois tipos de análises a partir dos mapas de calor, a *Co-citation* e a *Bibliographic Coupling*. A *Co-citation* (Co-citação) verifica pares de artigos que são citados com alguma regularidade em outros estudos (Serra, Ferreira, Almeida & Vanz, 2012). Essa análise aponta as semelhanças entre os estudos, assuntos e grupo de autores. O mapa de calor da *Co-citation* (Figura 3), mostra os grupos de autores que são citados regularmente em trabalhos relacionados ao tema "*Active Learning*".

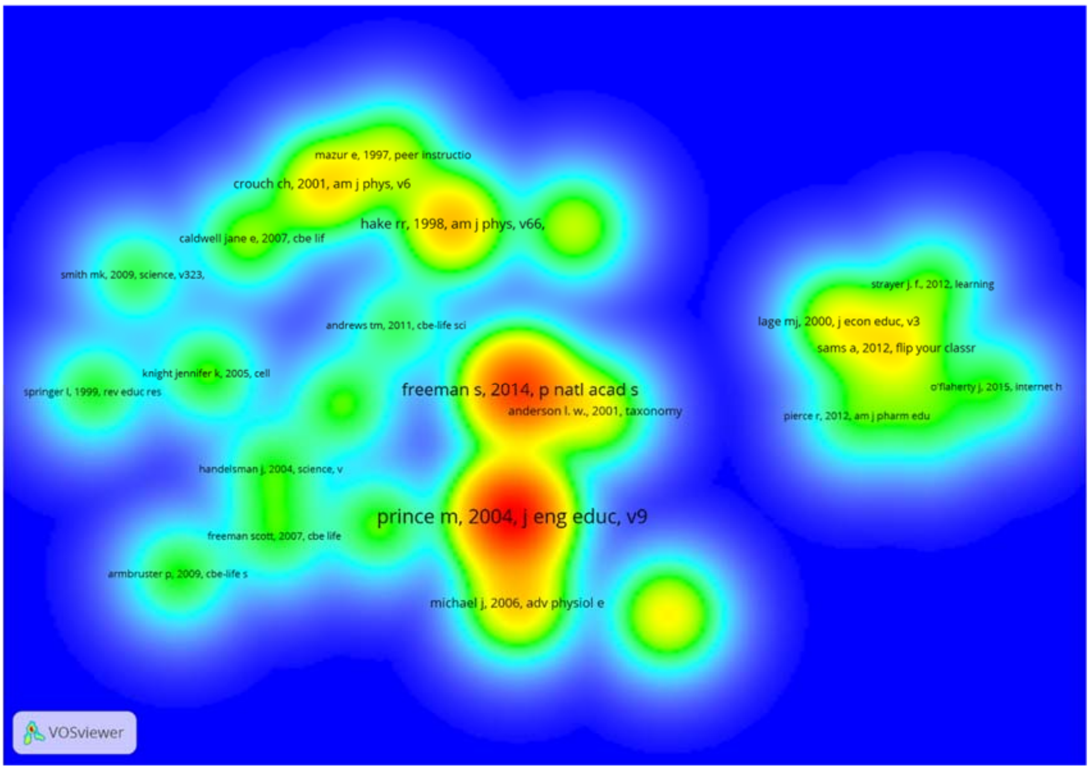

Figura 3. Mapa de calor *Co-citation*.

Em uma pesquisa sobre os trabalhos representados no mapa de calor acima, foi possível relacionar os autores com temas de estudo próximos. Além disso, é possível relacionar os trabalhos dos autores ao tema do trabalho proposto. A partir dos pontos do mapa de calor observa-se três regiões de maior calor, indicando os artigos que mais foram citados. O artigo de Prince (2004) e o de Freeman, Eddy, McDonough, Smith, Okoroafor, Jordt & Wenderoth (2014).

O autor Prince é um dos 10 autores que mais publicaram sobre o tema dentro do lapso temporal analisado, o seu artigo, Prince (2004), "*Does Active Learning work? A review of the research*", traz uma revisão bibliográfica das metodologias *Collaborative learning*, *Cooperative learning* e *Problem-based learning* (PBL) aplicadas a engenharia para examinar criticamente qual seria o elemento central de cada método. Enquanto Prince (2004) estudou o ponto de vista da literatura, Freeman et al. (2014), trouxe o lado experimental, prático em seu artigo "*Active Learning increases student performance in science, engineering, and mathematics*", que faz uma junção de estudos de casos sobre o desempenho observado com a metodologia tradicional versus metodologias ativas, chegando na conclusão da eficiência das metodologias ativas na aprendizagem.

O segundo mapa de calor (Figura 4), está relacionado aos autores que fizeram artigos nos últimos três anos e que citam as mesmas literaturas, de forma que, subentende-se que os autores discorrem de temas relacionados.

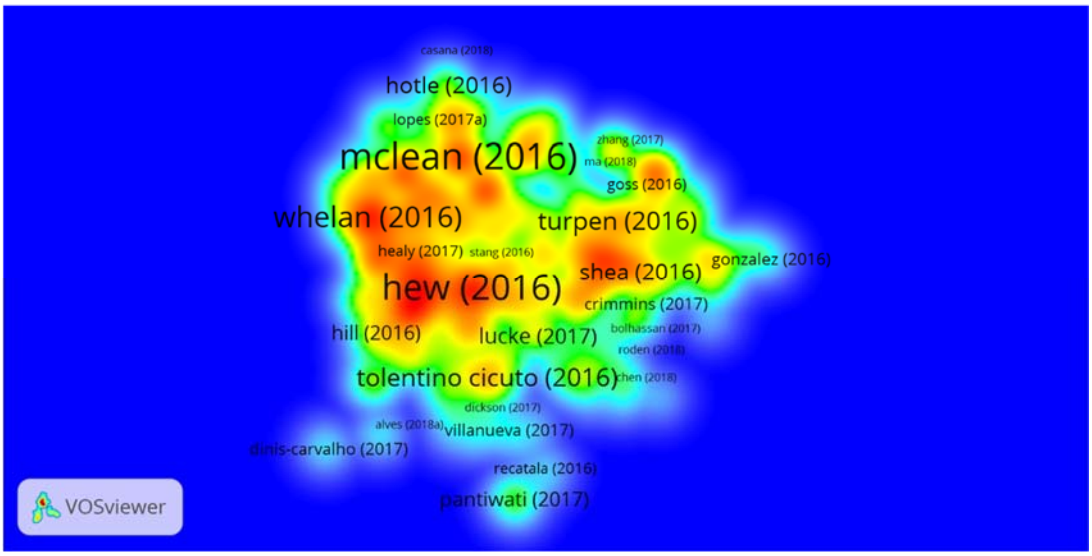

Figura 8. Mapa de calor *Bibliographic Coupling.*

A maior mancha de calor apresentada na Figura 4, relaciona autores que convergem para o mesmo assunto. Nesse caso, alguns dos autores, como Hew (2016), "*Promoting engagement in online courses: What strategies can we learn from three highly rated MOOCS",* apresenta sua pesquisa voltada para uma aprendizagem através de cursos online, discute como causar um envolvimento do aluno e quais fatores os mesmos consideram importantes para o engajamento. Ainda dentro do assunto sobre aprendizagem on-line nas salas de aulas, Mclean, Attardi, Faden & Goldszmid (2016), em "*Flipped classrooms and student learning: not just surface gains*" utilizou a abordagem da sala de aula invertida (*Flipped Classroom*) com métodos da aprendizagem ativa e mostrou que os ganhos podem ser bem mais profundos que apenas na melhora das notas, os alunos da pesquisa, melhoraram seu desempenho na realização das atividades pois criaram suas próprias estratégias de aprendizagem frente aos desafios.

Para uma análise final, após toda a coleta e interpretação das informações dos bancos de dados, relacionou-se, a partir dos artigos mais citados e os mais relevantes, os métodos que eles trazem e seus resultados. O Quadro 1 apresenta esses artigos em ordem do mais citado para o menos citado.

Quadro 10. Autores, artigos e métodos mais relevantes

Autores	**Artigos**	**Métodos**
Mason, Shuman & Cook.	Comparing the Effectiveness of an Inverted Classroom to a Traditional Classroom in an Upper-Division Engineering Course.	Flipped Classroom; Problem-based learning
Baepler, Walker & Driessen	It's not about seat time: Blending, flipping, and efficiency in *Active Learning* classrooms.	Flipped Classroom; Blended Classroom
Rotgans & Schmidt	Situational interest and academic achievement in the active-learning classroom.	Problem-based learning
Gasiewski, Eagan , Garcia, Hurtado & Chang	From Gatekeeping to Engagement: A Multicontextual, Mixed Method Study of Student Academic Engagement in Introductory STEM Courses.	Colaborative Learning; Cooperative Learning; Problem-Based Learning; peer-led team learning
Hwang, Chiu & Chen	A contextual game-based learning approach to improving students' inquiry-based learning performance in social studies courses.	Game-based learning; Inquiry-based learning
Fang	Improving Engineering Students' Technical and Professional Skills Through Project-Based Active and Collaborative Learning.	Collaborative learning; Problem-based learning

Os métodos para aprendizagem ativa que de 2011 até janeiro de 2019 foram identificados como os mais citados foram: (i) *Flipped Classroom*, um método que apareceu com grande relevância na pesquisa e como tendência para os futuros estudos. No seu formato o conteúdo do curso é disseminado fora da sala de aula num formato digital e o tempo presencial da aula é destinado para atividades interativas (Mason, Shuman & Cook, 2013); (ii) Aprendizagem Baseados em Problemas (Problem-Based Learning), um modelo já consolidado que devido aos seus resultados ainda tem bastante representação e consiste na introdução de problemas importantes no início do ciclo de instrução sendo usados para fornecer o contexto para a sala de aula (Prince, 2004), sendo um forte estímulo para o surgimento de sentimentos de interesse (intrínseco) (Rotgans & Schmidt, 2011). Esses métodos podem ser aplicados juntos e também combinados com outros métodos. Na maioria dos casos eles atuam em conjunto com:

- Aprendizagem Combinada (*Blended Classroom*), que é a instrução do conteúdo, que combina o tempo de sala de aula, "*face to face*", com o tempo da instrução on-line (Graham, 2013).
- Aprendizagem Colaborativa *(Colaborative Learning),* que traz um conjunto de estratégias que promove a colaboração entre os alunos em pequenos grupos (dois a cinco alunos), a fim de otimizar a aprendizagem própria e mútua (Johnson & Johnson, 1999).
- Aprendizagem Cooperativa *(Cooperative Learning)*, que implementa estratégias que exigem que os alunos trabalhem juntos (Smith, Stewart, Shields, Hayes-Klosteridis, Robinson & Yuan, 2005), diferindo entre elas a forma de avaliação que segundo Prince (2004), na aprendizagem cooperativa os alunos são avaliados individualmente.

Também se encontrou o método de (iii) Aprendizagem Baseada em Jogos (*Game-based learning*), que adota a forma de simulações em jogos que constroem o conhecimento do estudo (Hwang, Chiu & Chen, 2015). (iv) A Aprendizagem Baseada em Questionamentos (*Inquiry-based learning*), sendo sua estratégia levar o aluno a formular e justificar explicações através de um problema ou tarefa (Hwang, Chiu & Chen, 2015).

Os estudos dos artigos (Quadro 1) ainda não mostram um aumento significante no que se refere as notas das avaliações dos conteúdos realizadas pelos alunos (Baepler, Walker & Driessen, 2014; Mason, Shuman & Cook, 2013), porém o nível de satisfação e engajamento com a forma da aprendizagem aumentou substancialmente (Baepler, Walker & Driessen, 2014; Fang, 2012; Gasiewski, Eagan, Garcia, Hurtado & Chang, 2011; Hwang, Chiu &Chen, 2015; Mason, Shuman & Cook, 2013). Prender a atenção do aluno é fator relativo, pois segundo Rotgans & Schmidt (2011), aumentar o interesse do aluno com o que é novo, é tentador e leva curiosidade para se entender, e depois o interesse volta a diminuir. Dentre os fatores para o aumento do engajamento dos alunos, está o engajamento do próprio professor, que de acordo com Gasiewski, Eagan, Garcia, Hurtado & Chang (2011), o professor precisa ser acessível, ter entusiasmo, humor, trazer o conhecimento de forma criativa, incentivar a coragem, curiosidade e trazer o conteúdo próximo do cotidiano dos alunos.

Para cada método se observou as necessidades para a sua aplicação e as ferramentas que atendem ao que o método propõe (Quadro 2). Em geral, a metodologia de aprendizagem ativa requer espaços físicos que proporcionem mais interação entre os alunos, e que tenham recursos tecnológicos e *onlines,* como infraestrutura básica para sua aplicação. De acordo com os autores (Gasiewski, Eagan, Garcia, Hurtado & Chang, 2011) para que a metodologia de aprendizagem ativa seja mais efetiva, deve ser aplicada em turmas com poucos alunos (menos que 100 alunos).

Quadro 2. Ferramentas e técnicas adotadas pelos métodos de aprendizagem ativa

Métodos	**Ferramentas e técnicas**
Flipped Classroom.	Vídeo aulas de conteúdo, controlar as variáveis demográficas, atividades com pequenos grupos, instrutor apresenta o problema e alunos buscam a solução.
Problem-Based Learning	Grupos de discussão, instruções diretas, problemas reais resolvidos por meio de projetos (Project-Based Learning), estudos de casos.
Cooperative Learning	Design alternativos para as salas de aula, trabalhos em grupo, avaliação individual dos alunos.
Colaborative Learning	Design alternativos para as salas de aula, trabalhos em grupos, avaliação em grupo dos alunos.
Métodos	**Ferramentas e técnicas**

Blended Classroom	Vídeo aula de conteúdo, vídeo aula de atividades, controlar as variáveis demográficas, tecnologias de aprendizagem (computadores, telas interativas), recursos online, design alternativos para as salas de aula, atividades com pequenos grupos.
Game-Based Learning	Sala de aula com poucos alunos, instrução detalhada, tecnologias de aprendizagem (computadores, telas interativas), recursos online, sistema de criação de cenários de jogos.
Inquiry-Based Learning	Sala de aula com poucos alunos, instrução detalhada dos problemas projetados, recursos online.

Depreende-se do Quadro 2 que as ferramentas e técnicas utilizadas para os métodos de aprendizagem se convergem no apoio à aprendizagem ativa, dando espaço a aulas mais interativas, tecnológicas, participativas e mais interessantes, permitindo uma melhor interação dos alunos e consequentemente absorção do conteúdo em questão.

4 Conclusão

Esse estudo compilou os métodos de aplicação das metodologias de aprendizagem ativa dentro dos cursos de engenharia nos últimos 8 anos. A metodologia da pesquisa utilizada foi exploratória, com abordagem qualitativa, e empregou a bibliometria como estratégia, a partir do uso do enfoque meta-analítico consolidado, adaptado ao que se buscava conhecer.

Os resultados identificaram que os métodos de aprendizagem ativa podem serem aplicados sozinhos, mas funcionam melhor quando combinados. O conceito vindo do *Problem Based Learning* serviu como base para os métodos que vieram posteriormente, logo as interações dele com esses métodos é comumente vista. Os estudos dos fatores que levam esses métodos ao engajamento do aluno, direcionam a questões dos espaços físicos, psicológicos, características pessoais, mostrando que a aplicação do método isolado não garante o sucesso almejado, alunos interessados, com mais autonomia e o conhecimento adquirido.

A identificação dos métodos que estão sendo usualmente aplicados serve de referência, no quesito de instrução, uma base para sua aplicação e entendimento do que já se encontrou de resultado no desenvolvimento e aceite dos alunos para que sejam aplicados nos cursos de Engenharia de Produção. São metodologias que incentivam o aluno a se ajudarem e também a buscar o conhecimento de uma forma própria.

A pesquisa permitiu através do Enfoque Meta-Analítico, a identificação das melhores práticas de aprendizagem ativa utilizadas pelas Universidades. Ressalta-se como métodos mais utilizados, o *Flipped Classrroom*, *Problem-Based Learning*, *Cooperative Learning*, *Colaborative Learning*, *Blended Classroom*, *Game-Based Learning*, *Inquiry-Based Learning*. Dentre as ferramentas e técnicas, destacam-se a tecnologia, vídeo aulas, trabalho em equipe, resolução de problemas reais por meio de projetos, cenários de jogos, e atividades baseadas em formatos digitais e interatividade.

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Students’ first-hand experience on the development of competences: solving interdisciplinary industry problems

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Abstract

The Integrated Master in Industrial Engineering and Management is a very challenging degree, mainly because it encompasses so many different scientific areas. It is very common for students to feel a little bit overwhelmed with the amount of competences that need to be developed and put in practice. The University of Minho takes a lead role in terms of creating projects which allow the interaction with companies as well as promote the development of transversal competences. The Integrated Project of the 4th year of Industrial Engineering and Management of the University of Minho is a Project-Based Learning (PBL) strategy sustained by the interaction with industrial companies in an active engineering learning process. Students should be able to accomplish the project’s milestones and assimilate the company’s culture in their weekly visits, during the 5 months of the project. The main objective of the present article is to analyse the student’s visions of the work experience provided by the realization of this project. The methodology is based on the qualitative analysis of a group of students’ narratives related to their visions on the experience. The results show that they perceived the advantages of interdisciplinary learning, development of transversal competences, learning methodologies of team management, and strategies applied in order to deal with the different project’s stakeholders. The main result of this project is the recognition of PBL methodology as an efficient and ingenious form or learning that encourages the students to cope with the requirements and challenges of the actual labour market, while developing technical and transversal engineering competences.

Keywords: Active Learning; Engineering Education; Project-Based Learning; University Business Cooperation

1 Introduction

Active Learning strategies and principles have been promoting Engineering Education through innovative learning environments, which challenges students to reflect and experience learning in engaging and meaningful activities (Bonwell & Eison, 1991; Christie & de Graaff, 2017; Felder & Brent, 2003; Prince, 2004; Prince & Felder, 2006). Active learning can be implemented in several different approaches, e.g. Problem and Project-Based Learning (PBL), Team Based Learning or Flipped class room (Lima, Andersson & Saalman, 2017).

The Industrial Engineering and Management (IEM) area need from its professionals, both technical and transversal competences that should be seriously taken in consideration, not only during their degree, but notably in terms of a long term projection related with the moment in which they will join the labour market (Lima, Mesquita, Rocha, & Rabelo, 2017). Industrial Engineering and Management (IEM) professionals should be prepared to solve interdisciplinary problems, in other words, they must be qualified to manage and frame knowledge from different areas of expertise, such as Costs Managements, Production Systems Organization, Production Planning and Control, among others. These competences applied and related to the technical areas of IEM, are assigned as technical competences. Withal, there still are a very notable type of competences that are transferable and transversal between different professions and functions (CEDEFOP, 2012), who might be known as soft skills, for instance, teamwork, leadership, critical thinking, negotiation and conflict resolution, work ethic, communication skills, self-motivation, responsibility, flexibility, decisiveness, problem-solving, creativity, among others.

A question that should be bring to the table is: Why is Active Learning in Engineering Education so needed and why it might be considered a successful teaching and learning practice? Several authors have been studying this question and found that these learning approaches are particularly effective for students' success (Freeman et al., 2014; Prince, 2004). Moreover, particularly with regard to the Industrial Engineering and Management area of knowledge (Aquere, Dinis-Carvalho, & Lima, 2013; Fernandes, Flores, & Lima, 2010; Fernandes, Mesquita, Flores, & Lima, 2014; Lima, Dinis-Carvalho, Flores, & Hattum-Janssen, 2007; Lima, Dinis-Carvalho, Sousa, Arezes, & Mesquita, 2017) a great emphasis has been put on Project-Based Learning (PBL) as one of the most complete approaches for implement active learning. Considering these approaches this work intends to add a new perspective on the impact on the learning process, from the point of view of students. Thus, the question that the paper tries to answer is: Why students consider that PBL in IEM area of knowledge is so needed and why it might be considered a successful teaching and learning practice?

PBL is a pedagogic approach that allows students to tackle real industrial/business problems while developing commitment in administering the fields of knowledge acquired in several courses, and stimulating students' meaningful competences: making inquiry, creativity, personal and critical reflection, hypothesising. The development of PBL projects in industrial context constitutes an exceptional opportunity for engineering students to develop competences expected by the labour market and usually companies have been very pleased with the results of this type of University-Business Cooperation (UBC). Indeed, according to the perspective of The European Union, "Universities must also provide knowledge and skills geared to the needs of the labour market" (Lima, Carvalho, Sousa, Arezes, & Mesquita, 2017).

Students of the University of Minho have the opportunity to be part of an Institution that is a pioneer in the implementation of practical teaching techniques (Lima, Dinis-Carvalho, Sousa, Alves, et al., 2017)}, implementing it since 2005. The UMinho PBL model was originally inspired in the model of Powell & Weenk (2003), which was introduced by a team of university lecturers after training presented by Professor Powell and promoted by the University of Minho's rectory. Following each semester, teachers always develop a workshop in order to obtain the feedback from the students and teachers involved, which gives important data about the challenges and difficulties registered by the different project's stakeholders and allows the construction of a suggestions system for future improvements (Lima, Carvalho, Flores, & Hattum-Janssen, 2007). The main objective of the project developed in semester seven of the Integrated Master in IEM is offering the opportunity to create a bond between industrial and academic worlds by emphasizing the interaction between companies and students.

The main purpose of this paper is to give a more closely vision of the students' experience while realizing the PBL project during the first academic semester, who took the duration of 5 months, in which the authors of this article integrate a team of IEM students focus in solving the real problems of a company dedicated to the production of textiles for tires. The research methodology was based on a qualitative approach in order to obtain a deeper understand of students' perceptions about university and industry cooperation in PBL's context. Following these line of reasoning, technical solutions developed by students were analysed and a general overview about the process (e.g. challenges, difficulties, improvement suggestions) was realized, considering the perceptions of the students involved. These perceptions were collected with narratives.

This paper is divided in five sections. Following this first section designed as introduction, where was given an theoretical context of the academic context studied and where the main objectives were exposed, the second section refers to the PBL Context and Projects' and Stakeholders' Presentation, the third reveals the technical solutions suggested/implemented by the students, the fourth is related to the Students' Testimony of the Experience and the last one is reserved for conclusions.

2 Description of the PBL approach

In this section a special focus will be given to the description of the specific PBL approach implemented in this program. This description will be focused in the presentation of the general context, followed by the description of main details of the projects proposed by one company to one specific team. Finally, it will be presented the main stakeholders of the project.

2.1 PBL Context

The PBL approach examined in this paper is implemented in the 7th semester of the Integrated Master on Industrial Engineering and Management (IEM) program, and it is formalized in the curriculum through the Integrated Project on Industrial Engineering and Management II course (IPIEM II). It is particularly important to reinforce the necessity to respond to the University's and the company's requirements for the specific projects that will be enlightened in section 2.2 and section 2.3. Thus, during the project, teams of 9 to 11 students try to respond simultaneously to several different stakeholders from the university and the company, dealing with a challenging and enriching learning process. Developing a project like this requires a close cooperation between industrial and higher education organisations. The main phases of the project are: (i) exploration, (ii) analysis and diagnosis of the company's production system and (iii) development of improvement proposals (Figure 7). During the exploration phase, students are assigned to teams and projects in a process influenced by their references about their colleague's performance and by their personal preferences. After that phase, the first visits are made and teams immediately start analysing and subsequently understanding the company production system in a generic way, and ultimately defining the objectives of the project. During the rest of the project, students make the diagnosis of part of the company's production system and propose several improvements to overcome the identified and formulated problems.

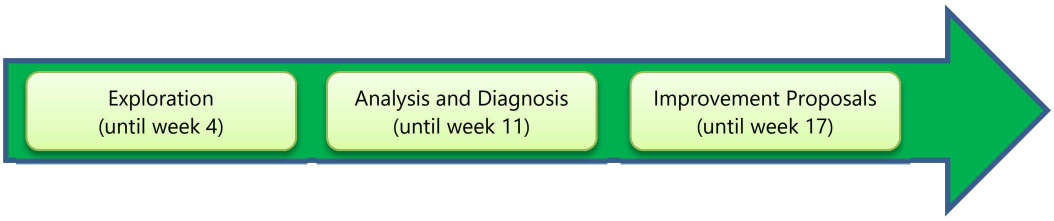


Figure 7. Main phases of the project developed in the IPIEM II course.

In terms of the University's requirements, teachers responsible for the 7th semester require students to make the application of the engineering themes covered by the following courses: (i) Production Systems Organization II (OSP II), (ii) Ergonomic Studies of Workstations (EEPT), (iii) Simulation (SIM), (iv) Production Information Systems (SIP), (v) Production Integrated Management (GIP). These courses and its teachers give support to the teams of students while developing the projects, as illustrated by Figure 8.

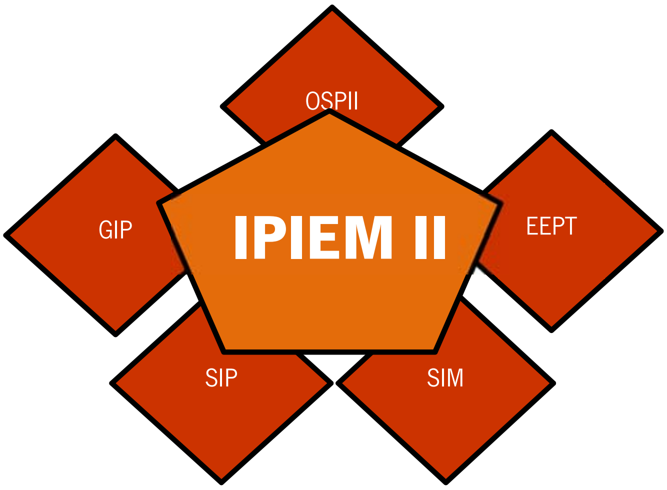


Figure 8. Illustration of the curricular units involved in the IPIEM II.

2.2 Company's Projects

In terms of the company's requirements after some weekly reunions with the engineers responsible for the Department of Industrial Engineering, the team was presented with the following proposal subprojects: (i) Ergonomic Study of the Workstations (ESW), (ii) Implementation of Stock Management Strategies, (iii) Reduction of set-up times, (iv) Overall Equipment Effectiveness (OEE) monitoring and improvement. The mentioned curricular units work as project-supporting courses (Figure 9).

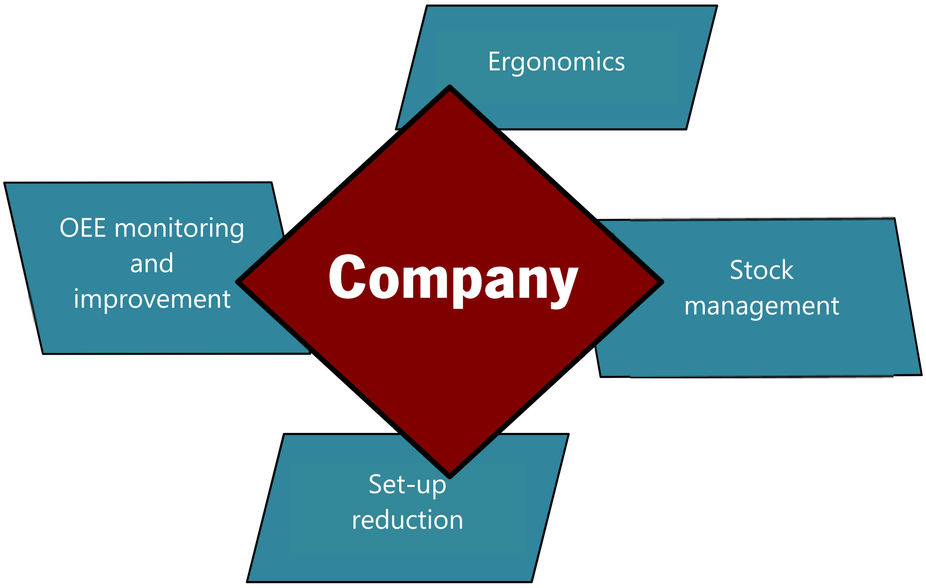


Figure 9. Illustration of the projects proposed by the company.

In order to reduce the number of set-ups the company proposed the Stock Management project to optimize the produced quantities and stock. According to the process, the set-up time could be a barrier on the appliance of the Stock Management project, because of the optimization of produced quantities resulting from the study. To get around this obstacle comes up the Set-up Reduction project, which is related with a new way of working for the operators and the insertion of new tools. To ensure an efficient interaction between operators and the changes caused by the Set-up Reduction project, the company proposed the Ergonomic study of these changes. To evaluate the benefits achieved by all these interrelated projects an OEE indicator was developed and implemented.

2.3 Main Stakeholders

As mentioned in section 2.1, PBL has two main stakeholders: on the one hand, the university teachers, and on the other, the company, which in this case is a company dedicated to the textile production for tires. During the project, the industrial engineer from the company, who provided guidance to the team, emphasised the need for the engineering students' team to cooperate with a group of vocational students, from a pre Higher Education level, in order to develop some industrial prototypes. This prototype could have a huge impact in reducing the set-up time of some of the production machines. This will be discussed in section 3.3. The vocational school selected was FORAVE, a private vocational school, who have been involved in large number of projects developed in company. This school's main objective consists of the preparation of citizens for active life who wish to improve or acquire skills to respond to the requirements of the market in the areas of Production Management, Industrial Maintenance, Electronics and Automation and Quality Control.

2.4 Technical solutions suggested/implemented by students

The technical solutions developed by the students were based in the results of the analysis and diagnosis phase. On account of the broad nature of the developed solutions, these will be introduced in the following sections according to a classification into different categories.

2.4.1 Ergonomic Study of the Workstations

In terms of the subproject related to Ergonomics, after a short period of analysis the students identified a task that caused serious problems to employees at the skeletal muscle level, which were related to the operation of placing rollers in the buffers. This operation was performed by two employees, in which they had to place the rolls, weighing around 110 kg, at different levels of the buffer (Figure 10). This operation has different ergonomic risks, varying from level 1 to level 3, depending on the height. Level 3 of ergonomic risk is a result of the operation, in which the employees raise the arms to a height superior to the height of the shoulder.

In order to solve this problem, the authors resorted to mechanical means (stacker), which raised its rollers up to the level of the desired buffer level, and then it would only be necessary to push the roll from the stacker to the buffer. It was necessary to use the ergonomic evaluation method called REBA (*Rapid Entire Body Assessment*). REBA has been developed to fill a perceived need for a practitioner's field tool, specifically designed to be sensitive to the type of unpredictable working postures found in health care and other service industries (Hignett & McAtamney, 2000). The selected method was used to evaluate the current roll placement process and the proposed process that consists in the use of a stacker as a mean of production aid. The results obtained based on the REBA analysis allowed to conclude that this new proposed method of placing rolls in the buffer allowed to reduce the risk of work-related musculoskeletal disorders in the employees, as well as the reduction of the number of employees needed to perform the task, going from 2 to only 1.

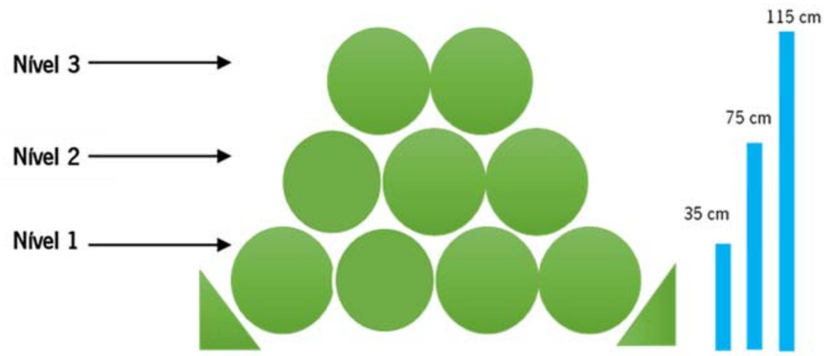


Figure 10. Representation of the stacking of the rolls in the buffer.

2.4.2 Stock Management

The company presented a problem to respond to the variation in demand. Their production is based on forecast, but many times, there is a huge difference between the predicted and the real quantity carried by the client. This problem caused high levels of stopped stock and some stock breaks. The main purpose of this project was to create a new way to manage the production orders based on stock level.

The product studied has a volume of 1.64 m3 and an unpredictable demand. The first analysis on this issue was to understand the actual production strategy in order to get more knowledge about the problem. From this analysis it was possible to get a better knowledge of the demand characteristics of the product. To solve the problem were used a stock management strategy (Casimiro, 2015) to make a new sizing and analyze whether these strategies works and if it's better than the current strategy.

The stock management strategy gives answer to when and how many the companies must produce (Carvalho, 2017). The company provided some data of the history of the demand and production for forty-two weeks of the product under study. The optimum parameters of the stock management strategy were calculated and after that was simulated the application of the model for that period of forty-two weeks and compared to the actual strategy. The simulation results showed that in terms of stock the actual strategy and the level strategy stock levels were almost the same but in terms of production they had a difference that is illustrated by the chart of Figure 11.

According to the charts, the stock level strategy was chosen because it had the best performance. With this strategy the company should produce always 51 rolls when the stock reached 62 rolls. The production would be more leveled and the total production for this period (42 weeks) would be 1785 rolls when the previous is 1733 rolls, from the charts is possible to see that in the current strategy during the 42 weeks there was one in which production was null because the inventory levels were stable and in stock management strategy this happened on seven occasions, which means that the company would be producing more product in a short period of time with the same capacity.

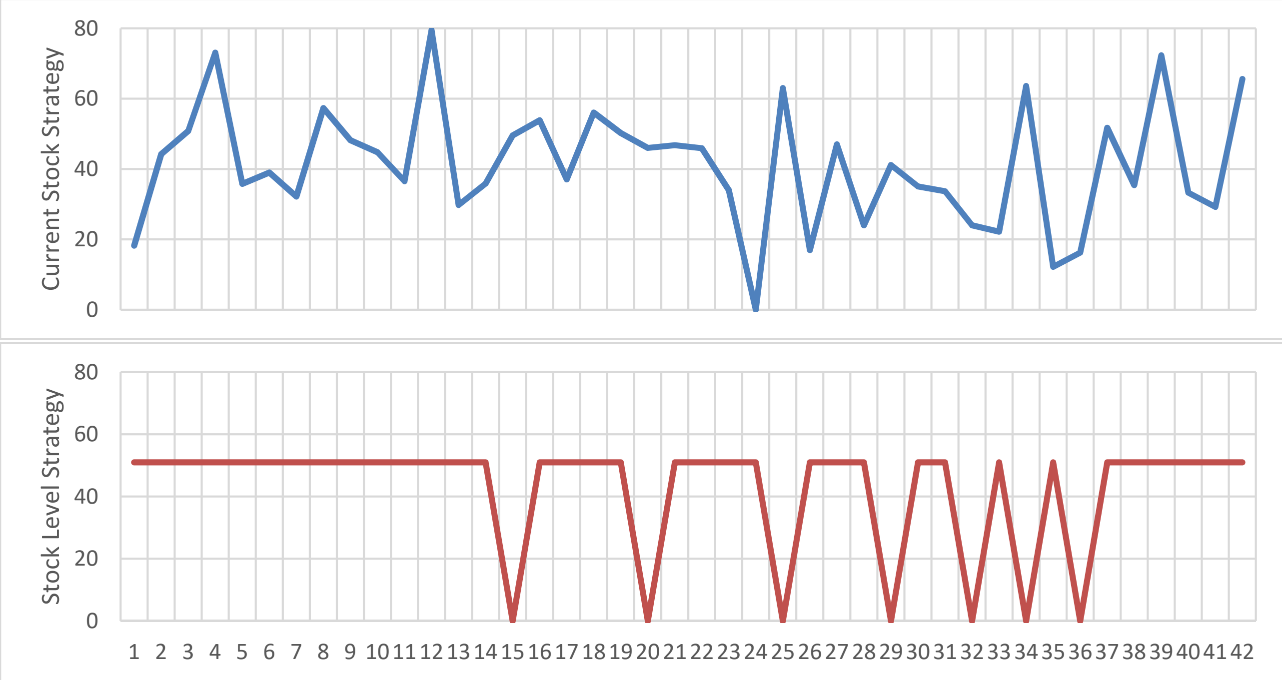
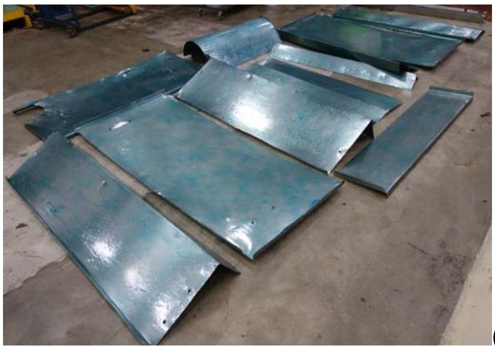
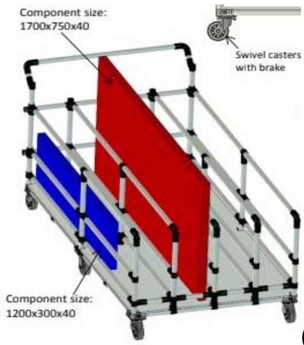


Figure 11. Current production strategy and the proposed production with the stock level strategy.

2.4.3 Reduction of set-up times

Another issue addressed to the team, was the study of the setup time of the Single End machine. As it had an 8-hour Setup time, and when observing its operations, it was verified that it could be reduced if the operation of cleaning of the solutes vat passes from an internal operation (operations made with the machine stopped) to an external operation (operations made with the machine in operation). For this to be possible, it was necessary to replicate the Tub Plate Kit (Figure 12a), to have two kits, as well as the creation of a trolley to store that spare plate kit, (Figure 12b). Both projects were then designed by the team and then delivered to outside companies, being under production. It is expected to achieve a saving of about 3 hours in the setup time of the Single End machine.


(a)


(b)

Figure 12. (a) Illustration of the plates' kit. (b) Illustration of the trolley for the storage of the plates' kit.

2.4.4 Overall Equipment Effectiveness (OEE)

Overall Equipment Effectiveness (OEE) is a performance indicator designed to measure the utilization of critical equipment in three different dimensions, Availability, Performance and Quality (Hansen 2001). OEE is a golden standard for measuring manufacturing productivity. For this specific project it was necessary to create two different files for different machines of the impregnation area. The purpose of these files is to save the respective data of each shift. These files are very interactive and were developed using specific software like VBA and Excel in order to save and apply the appropriate treatment to data. The OEE's values were obtained in tables and graphs.

3 Quality Analysis of the Students' View of the Experience

This section presents a qualitative analysis of the perceptions of five students that were collected using narratives. The narratives were than analysed by two researchers and cross checked with other researcher to overcome some doubts of interpretation.

3.1 Difficulties and challenges faced during the project

During the project the students faced several challenges that let them excited to release everything that they have been learning at university. Those challenges allowed to put the theory in practice and implementing solutions to solve real industrial problems. They see the difficulties as opportunities to grow up as professional of their areas. Working in teams and communication issues were difficulties that tuned in to opportunities to be developed. The following excerpts present evidences for these difficulties and challenges.

> "*The management of human resources within a work team is not always easy and this project has forced us to apply the soft skills or transversal skills that the labour market demands: conflict management, responsibility, communication, leadership ability, motivation, etc. (...) all these competencies have been tested and applied in order to manage the emotional / motivational component of the team*." *Narrative A*.

> *"In addition, since it was an extensive project with multiple elements and entities, it also helped me to improve my soft skills, such as interaction with different people and personalities, communication skills, control of emotions, between others." Narrative D*.

3.2 Developed competences during the project

The BPL environment complements the student's formations, in what could be called the union of the two worlds, the university and companies. This environment allows students to develop several competences or either to improve the ones that they already have. They learn many things from university, what they ask many times is where to apply those knowledges and this environment comes to give an answer to this question. This interaction between students and the company was a big step for students to know which competences the market is expecting from them, as mentioned by these students:

> *"I think this kind of methodology lead us to explore deeply the competences that we have been gathering during the years of formation as well as get to know what is missing in us, in terms of competences that the markets really demand. I had the opportunity to practice and apply concepts that I only had in theories, which proved to me that what we learn at university also add a great value in the real world." Narrative B.*

> *"I was able to understand what the job market expects from an industrial engineer and within those competencies demanded by the market, I also realized which of them I have the most competence." Narrative C.*

3.3 What about the experience?

The PBL experience is a mix of many things, is a mix of bad and good experiences. In general, the students go through many situations, which may either let them excited or frustrated with the project. These emotions depend on many factors, including their own personality. But taking in account the main purpose of the project, which is being in a company improving their learning, as well as applying technical concepts from the academy, it makes them overcome every bad personal experience and focus on the solutions to the companies' problems. Ultimately, this gets them highly motivated when something that they have accomplished is being implemented by the company, which turns to be a very good experience for the students. This experience related issues are evidenced by the following excerpts.

> *"Being in a company once or more times a week was a different dynamic and I felt like I was part of something big, a commitment that made me give the best of myself to achieve a common goal." Narrative B.*

> *"PBL project is, in general, quite positive, that's why I strongly recommend the University to maintain this type of teaching more focused on the practical learning methodologies." Narrative A.*

> *"The PBL was a great academic experience. The link between the reality and the academic side was awesome. I was able to understand what the job market expects from an industrial engineer and within those competencies demanded by the market, I also realized which of them I have the most competence." Narrative C.*

> *"In my opinion, the PBL, in the fourth year of the course until the moment, was the best experience and the best moment of evaluation." Narrative E.*

4 Conclusion

The practice of engineering is permanently urging for updates specially in terms of teaching and learning methodologies. This necessity can be enlightened due to the quick changing needs that business, labour market and society requires from their future professionals. In this way, education in engineering needs to quickly adapt the teaching methodologies in order to train engineers with the correct technical and transversal competences to face a world that constantly creates new necessities, new problems, where different and ingenious solutions are required.

This work presented a contribution for the development of a PBL project in interaction with industries, demonstrating that it is possible to create learning environments embracing real industrial contexts. These hybrid environments with a stimulating atmosphere between the academical and the industrial world, create the opportunity for students to identify and define real industrial problems and develop efficient and practical solutions. Additionally, PBL project were developed in a context of curricular integration with five curricular units, which rewards the students' learning that have the chance to solve problems of a higher level of complexity with the assistance of several teachers with many years of expertise in different knowledge areas. The feedback from professionals of the companies involved is extremely positive, and the students develop a great awareness of the professional applications of the Integrated Master in Industrial Engineering and Management. It is extremely important to sustain that students improve their feeling of being well prepared for the labour market after the experience provided by PBL.

The purpose of this article is to present the solutions students were able to develop in such a PBL setting and additionally, to develop a qualitative analysis of the student's view regarding the experience provided. This perspective was categorised in positive aspects, reflecting about some challenges faced and thinking about improvement suggestions in order to support their brilliant view of the this PBL implementation.

To sum up, reflecting about the student's view it is possible to conclude that PBL reveals to be a huge potential tool as a teaching and learning methodology that only needs to be consistently improved.

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Application of Project Based Learning Approach at process analysis and improvement of a Textile Industry

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Abstract

This study integrates a wider research, here called main research, which central question is: How to apply the Project Based Learning (PBL) in a Production engineering graduation course? The study presents application of the initial model of the PBL approach in Production Engineering, proposed by the main research in a discipline the content group discipline of Synthesis and Integration, which constitutes the backbone and line of training in Production Engineering of the Petropolis Engineering School first graduation course of Fluminense Federal University. The study had as goal research and present solutions related to organizing and management of the industry division department, in charge of divide pieces by batches whom are composed by different shades of fabric, using Process Analysis and Improvement Method. The main result achieved was present a solution collection to improve and organize the division department, taking in consideration the surveyed problems and respective sources.

Keywords: Active Learning; Engineering Education; Project Approaches, Textile Industry.

1 Introduction

Among many innovations in several branches today, teaching methods remain resistant and keeping their traditions. Universities in general and specially engineering courses, still do not allow students to find solutions for experiential issues through dynamic and critical relationship between theory and practice. What is favored in the classrooms is still the transmission of unilateral content, often unrelated to everyday life, which discourages student to remain on the university, generating academic, economic and social losses.

Global economies require constant products, systems and services evolution, and expects collaboration from Universities for technical and scientific advances. Thus, universities and engineering courses need to revise teaching concepts and see education as an union between reflection and action.

The new teaching models known as active methodologies seek to replace memorization processes, unilateral and purely theoretical transmission for self-training and practical application taking into as reference analysis of reality, generating greater responsibility and denoting learning improvement. One of the possible approaches that has gained visibility is Project-Based Learning (PBL), in which students enter the business market within learning process, acquiring knowledge and skills to deal with real world problems. This method emphasizes the students as it integrates knowledge and acting and helps the students to develop critical thinking skills and problem solving.

Therefore, the Fluminense Federal University, located in Petropolis city, started the implantation of this method since its inception in 2015. The institution has agreements with some companies creating a bond between university and business. The university seeks for the student to practice their knowledge acquired in theoretical classes, improving their learning and preparing for professional life from an early age, and they can be inserted in the business environment with some experiences. Companies, on the other hand, acquire academic projects which they could improve their organizational environment.

This study goal is to approach this methodology applied for undergraduate students and the benefits it could provide, through a case of a textile company. The study aimed at presenting solutions related to the organization and management of a company through the methodology and improvement of processes, seeking to improve their productive process.

2 Literature Review

2.1 Project based learning

Project based learning (PBL) is an applicable learning method to undergraduate courses that has as goal centralize students in the learning process introducing real world problems and encourage solving problems using the required tools to present solutions. A reason for the effectiveness of this Method is the student active participation instead of passive contact with information in traditional methods (Rajan, Gopanna & Thomas; 2019).

According to Wiek apud Bascopé, Perasso & Reiss (2019), many skills are acquired by students in PBL application like systemic view, strategics, interpersonal skills. Bascopé, Perasso & Reiss (2019) affirm that this method unites the community where it is applicated. Chang, Kuo & Chang (2018) affirm that PBL is a method which the student applies what he learns from basic and technologic curricula.

Dewey's Active Pedagogy or Pedagogy of Action for example, showed as results learning efficiency through practice, where the student could acquire knowledge during learning process developing physical, emotional and intellectual aspects in real world problem solving (Masson et al., 2012; Souza e Dourado, 2015).

Since then many knowledge areas, exact, biological or technological sciences, has been pursuing to incorporate PBL methodology in their course's contents. To exemplify, may be cited as an example Chemistry Engineering' PET recycling (Rajan et al, 2019), Sustainable Development (Bascopé et al, 2019), Computer Engineering' entrepreneurship (Arias et al, 2018) and Construction Engineering (Muñoz et al, 2016).

At Petropolis Engineering School's Production Engineering course students are exposed to PBL method from 4º semester when they are guided by teachers to solve problems/situations at companies and institutions from petropolitan community, learning about tools that can be used to solve the problems presented. However, before exposing students to real situations, they are given theoretical knowledge through projects developed in course disciplines and have a low-level interaction with real companies, thus preparing for the PBL projects themselves.

2.2 Process analysis and improvement

Process Analysis and Improvement refers to a set of procedures ordered in a system based on facts and data in order to identify and eliminate problems that affect the performance of a process. In another words, it contributes to the planning, structuring, problems solving and continuous improvement of all the processes that are fundamental to the operation of the enterprise according to Palmberg (2009).

According to Krajewski, Ritzman and Malhotra (2009, p. 119) the purpose of the application of this method is "[...] 'know the numbers', understand the process and extract the details. Once a process is really understood, it can be improved."

Between all the existing methodologies, the tool MAMP - Method of Analysis and Improvement of Processes stands out because it has the simplest applicability. The method follows the same principles of MASP - Methodology of Analysis and Problem Solving, but with an advantage: the first step already involves the breakdown of the managerial paradigm, instituting process management as a starting point. Nevertheless, the two methodologies are quite similar.

The fundamental objective of MAMP is to implement a strategy based on measurement and validation of data, focused on process improvement and reduction of variations through the determination of critical indicators and definition of metrics according to Avelino and Correia (2017).

From this knowledge, a model of study conduction was created with all the necessary steps for the application of AMP. The following figure explains each of them.

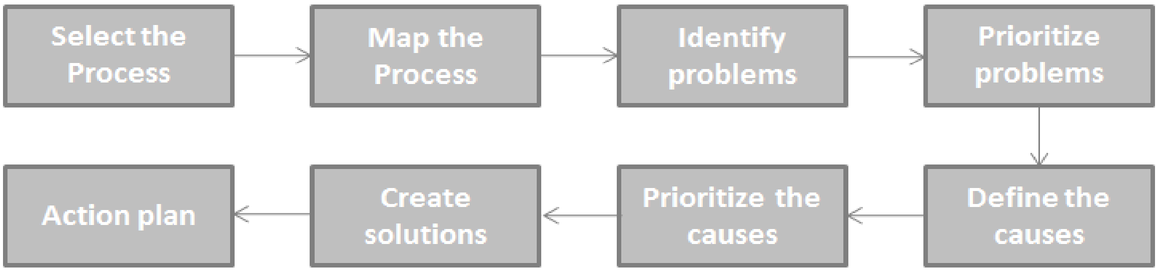

Figure 1. Steps of Process Analysis and Improvement

Source: Adapted from SCARTEZINI, L. M. B. (2009). Process analysis and improvement (p. 40). Goiania.

First, the process to be analyzed is selected and its objectives are defined. It takes into consideration "the needs of internal customers, suppliers, satisfaction surveys with external customers, the products / services offered, as well as the company's strategy" (DOMENICO, 2015, p 21).

After that the process mapping is done with the purpose of identify activities carried out and to show how it is developed. According to Candido, Silva and Zuhlke (2008) the mapping must be done from interviews with stakeholders involved with the process.

The third step is to identify the existing problems with help from the mapping previously elaborated. With this step, it is expected that a certain amount of problems will be raised, which should be selected for their relevance and priority so the solutions efforts can be concentrate on them, finishing not only the third but also the fourth stage of the AMP. According to Campos (2004) "problem" can be defined as the undesired result coming from a process. Prioritization tools and techniques should be used eliminate external interference and avoid prioritizing something that is not relevant to the process.

Fifth step is based on raising hypotheses or theories for main causes of founded problems. At this phase the number of ideas is extremely large and it is necessary to group similar ideas and analyze the inclusion of some ideas in others. Therefore, the sixth step refers to prioritize raised causes.

At seventh step, with all causes defined, corrective actions will be proposed as ways of eliminating problem causes. Besides, implementation plan of proposed improvements can be elaborated, which must respect all the content presented in the study.

3 Methodology

This topic presents the procedures of used methodology, clarifying about the PBL approach. It was divided into subitems, and they were developed to follow the best understanding of the subject matter.

3.1 Search Rank

The research used case study methodology, which constitutes a study knowledge of the theory as it is on practice. It was conducted in order to obtain information in an exploratory way with the bibliographical research, to gather theoretical information of the subject. Also, some interviews with professionals and specialists about the subject were carried out to obtain accurate information and be able to notice the differences brought by theory and its application. The use of documents, articles and other sources of application of the theory studied in practice, were used to prevent and learn from their mistakes and correctness.

3.2 Analysis unit

The research analyzed unit was a textile company located in Petropolis/RJ.

This company has been consolidated at market for 32 years and presents licensing of several Brazilian soccer clubs, offering shirts, coats and other clothes.

The case study was on the division department, which a study of analysis and improvement was proposed in order to provide this department upgrades and organization.

3.3 Data collection procedures

The data were collected through weekly technical visits to the company, where the problem was addressed. The team was able to observe the department and the entire company, making it easier to understand.

Interviews were conducted with the employees on the factory floor and the managers of each department. These interviews were saved for later transcription, and all suggestions were noted.

The company provided documents and spreadsheets related to the management department, which provided important data to be used for the project. In order to facilitate data gathering, it was supported by a focal point, being the bridge between project team and employees/managers.

3.4 Data evaluation and analysis procedures

The collected data analysis was made after the visits in meetings that occurred with project team. Transcriptions of the recordings, documents and spreadsheets were carefully organized and analyzed to make study and comprehension of the matter easier.

3.5 Steps that apply the PBL approach

3.5.1 1st. Step - Definition of the problem and the elaboration of the project opening term

The opening term and problem-situation definition were the initial steps, being the basis of the study to provide essential information and determine the main features of the project. For the execution of these documents, it was necessary to hold meetings between project team, stakeholders, employees and the study sponsor.

This way it was possible to create information about the project using collected and debated data. With the approval of these documents demarcated by the signatures of the sponsor, project manager and the company president, the team started planning the project elaborating the Management Plan.

3.5.2 2nd. Step - Elaboration of the project management plan

The project management plan is the main reference for the project team. It describes how the processes should be executed, controlled, monitored and closed. Thus, it was possible to guide the entire team throughout the project. For this achievement, it was necessary to insert and elaborate Project Canvas, Scope Management, Time Management, Team Management, Communications Management, Stakeholder Management, Risk Management, with Monitoring and Control of Work in the project. For this document, some interviews were conducted with interested peers, in order to obtain some important knowledge; observations were also made during technical visits; research in documentation of similar and historical undertakings of the company and execute meetings between the project team.

3.5.3 3rd. Step - Project execution and control

For the execution stage, the manager will be in charge of coordinating the available resources and delegating the tasks for the members of the team, according to their functions.

This stage of the PBL was carried out with weekly meetings between the project team, the sponsor and the company once a week. These meetings were held at the university campus. The control was performed through monitoring of the Management Plan carried out in the second stage of the PBL methodology.

3.5.4 4th. Step - Project Closure

For this stage of PBL approach, a public presentation was made at the campus. It was open for the managers and partners of the company, employees, students and University teachers, the sponsor and general public. This presentation addressed the study process and solutions proposed by the project team; after that, time for questioning was opened for the public. On the same day, a report was sent to the organization, documenting the process analysis and improvement of the related problem. In addition, a written document was delivered to the sponsor, with technical data of the project execution.

Complementing this step an evaluation of the participating students occurred. This method is carried out with a self-assessment and the fifth step of the PBL approach.

3.5.5 5th. Step - Student Assessment

Self-assessment and Peer Review methods are important for people development. For PBL, this tool allows students to be judged alongside their teammates and provide more detailed information, because they were closer to each other for the entire project.

Peer review is an indicator of future professional performance, being consistent and reliable, providing information that could not be measured by traditional methods. Self-evaluation contributes to the process of continuous learning, as it helps students to identify their strong and weak points.

4 Results

4.1 Problem Situation Analysis

During the productive process of the company, a piece of outfit can pass through several departments, like: cut, division, decoration (stamping, sublimation, embroider), box preparation, sew and stock.

Initially, the clothing fabric is cut and separated in parts according to the decoration. For example, a t-shirt is divided in five parts: back, front, two sleeves and collar, which the front can be designate to embroider process, and the sleeves can be sent to the stamping process. The division department, responsible for stock and distribute all product parts, showed a production deficit, for it was overloaded and unorganized, since it embraces a huge number of parts without a method of organization storage.

Using the method of analysis and improvement of processes, at the first SIPOC tool was used to identify Suppliers, Inputs, Process, Outputs and Costumers of the process subjected and fluxograms as well to analyze and track the productive process. After that, the qualitative and quantitative tools were used, to looking for production constraints inside of the process and the alternatives that perhaps it is the main cause of this situation. For that, aim to get possible and feasible solutions that solve the problems source presented by the company.

4.2 Improvement proposal

After mapping the process of the division department, brought up the problems using the brainstorming toll with the company staff. The problems were grouped using the affinity diagram and prioritized with the relationship diagram. Once the problems are identified and prioritized, its time to find the respective cause using the Ishikawa diagram, as an alternative to figure it out many improvements in this area.

One of the main problems is the difficult to identify the parts and the lack of organization, occasioned due to the limited physical space, absence the correct furniture and the inefficient planning of the boxes, plus the non-attendance of an identification method of the parts. Making harder to identify the lots that need to be unify after decoration and deliver to the next step of the productive process. As a solution, some alternatives have been proposed: create an alternative space and a new methodology to identify the parts in the new physical space.

4.3 Project-based learning and lessons acquired

This kind of contact provided by PBL expands student's knowledge horizon beyond classrooms and purely theoretical knowledge, giving autonomy in the learning process and motivation to continue in the course when exposed to the reality of the professional of production engineering.

Another benefit of the methodology was the need to work in teams, leading the student to deal with different types of people and learn how to deal with interpersonal relationships with colleagues, leaders and people in positions of power in companies and institutions.

The company was also able to acquire new knowledge when approaching the new methodology, such as learning to deal with college students, full of ideas, interests and excitement. In addition, it was understood that the team presented a different and broader view of the company, being able to take a more critical look and point out new improvements, since they were not immersed in the productive process.

5 Conclusion

This study made possible the Analysis of the Production System of the Company, aiming at improvements in activities on the division department. Process Analysis and Improvement tools were used to identify important issue for the project. The data were collected with collaborators from different areas in order to merge with the theory from the literature.

The following solutions were proposed in order to solve the main problems that affect the area: elaboration of an alternative space and creation of a methodology to identify the pieces in the new physical space. Because it is an area with high importance for the operation of the Company, the ideal would be that in addition to the presented solutions, long-term solutions be implemented so that problems be solved more efficiently. For example, the implementation of a piece tracking software along with a storage criterion and / or layout expansion.

In addition, the effectiveness of the active methodology Project Based Learning became evident. Through the practice the students were able to solve an existent problem in the real world, applying tools and the knowledge acquired in the literature. The process added value to the team, which acquired not only the learning but also the ability to deal with real situations within a company.

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Application of the Project Based LearningApproach in Solid Waste Management of a Welding Technology Company

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Abstract

This study integrates a more comprehensive research, called here of greater research, whose central question is: How to apply the Project Based Learning (PBL) approach in a graduate course in production engineering? This paper presents the application of the initial model of the PBL approach in Production Engineering, proposed by the greater research, in one of the modules of the Synthesis and Integration content group that makes up the backbone and conductive line of the Production Engineering training of the first undergraduate course of the School of Engineering of Petrópolis of the Fluminense Federal University (UFF). The purpose of this study was to propose solutions to the solid waste management problems of a welding technology company using process analysis and improvement methodology. The main problems identified were inadequate classification, collection and storage of solid wastes, all due to inadequate procedures, lack of training and incentives to employees. To help eliminate the identifiedproblems, medium to short-term solutions were proposed. In the medium term, it was suggested that the company invest in better employee training. In the short term, the following solutions were proposed: installation of a dome to collect any spatter oil from the machines, installation of a containment basin in the solid waste storage area, creation of a collection center for batteries, electronic waste and creation of a visual signaling system for storage areas.

Keywords: Active Learning; Engineering Education; Project Approaches, Solid waste management.

1 Introduction

The transmission of knowledge, in a globalized world, where quick changes are observed, can be a challenge for academic institutions. The interface between theory and practice is one of the main factors that influence the learning process, so that the student becomes a complete professional and ready for the reality

The active methodologies of teaching are one of the main facilitating tools of this mixture, and Project-Based Learning (PBL) is a technique that has been "emphasizing" in the educational scope of Engineering, in particular, in Production Engineering. According to ABEPRO (2019), production goes beyond the use of scientific and technological knowledge and, thus, Production Engineering is understood as the least technological of Engineering, however it is the most comprehensive and generic area, as it encompasses a greater set of knowledge and skills.

At the Engineering School of Petrópolis, the baccalaureate course in Production Engineering "innovates" when applying the PBL methodology, in partnership with companies from the city of Petrópolis. The discipline of Projects of Production Systems I providesthe undergraduate student with real situations of a company, seeking to answer questions related to the operation of a system of sustainable and cleaner production, through a case study in conjunction with the project demanded by the partner institution.

According to Adissi (2013), development is what does not deplete resources for the future. It is understood as a software of sustainable development, being an environmental protection, an economic stability and a social responsibility (ADISSI, 2013).

Environmental management is a concept fully related to corporate sustainable development because it considers that an organization has a responsibility to identify and manage the negative environmental impacts caused. Solid waste management seeks to integrate business strategies that do not lead to excessive waste disposal, with consequent damage to the environment (ADISSI, 2013).

ABICOR BINZEL® is a German company in the Welding Technology product segment. With its Brazilian headquarters located in Petrópolis, is one of the partners of UFF, and it is always looking for the development of products with high quality, excellence and technology, aiming at the satisfaction of all parties involved in the process, and respecting the principles of sustainability.

This project, demanded by the company, was designed to become the solid waste management system in a more efficient way, approaching even more the ideal resources of sustainable development and allowing more adaptations to new laws or changes in the existing ones .

Thus, the students defined as members of the team of this project carried out this work through the theoretical basis obtained by the literature review and the continuous monitoring through visits to the company. The union of these steps allowed the obtaining and analysis of results, so that improvements related to the demand were proposed.

2 Theoretical Framework

The bibliographic research was organized in order to obtain all the information possible by consulting and citing articles, books and periodicals in physical and digital media related to sustainable and cleaner production systems, and waste management in welding technology companies . These references aided in the selection and organization of search content and search for proposals to solve the problem presented.

2.1 Project Based Learning

Nowadays, when it comes to engineering, the PBL happens to take place in a captivated way, considering that an engineer is expected to solve real and practical problems, which are often very different from those seen in theory.

Project-based learning is about a methodology where the student is the protagonist, and stops learning from the passive and traditional way to begin to learn actively.

During most of the graduation in Production Engineering at UFF - Petrópolis the PBL methodology is present. In all, there are five projects from different areas of Production Engineering. The partnership between the university and local companies allows students to have the opportunity to learn in practice and get to know the professional world more closely.

2.2 Solid waste management

According to Adissi (2013), garbage is considered all that is useless for a given individual. However, what is no longer good for one may be useful to another. When a given object becomes unusable for someone, it is considered a residue.

The Brazilian Law n. 12.305/2010 declares that those who are in a solid or semi-solid state, as well as the gases that are released and release the particularities become unviable in their launch in public sewage or sewage or water, or require for the specific technologies.

According toGomes (2014), care with solid waste is seen as something recent (mid-twentieth century), when it was no longer considered an indicator of consumption and came to be considered a dangerous dimension.

According to Galbiati (2004), the solid waste management model is a system that considers the time of waste generation along with its reuse and/or recycling, to the final treatment and disposal processes. The disposal of industrial waste is the responsibility of the company that generated it.

The classification of solid waste involves the identification of the process or activity that gave rise to them and how dangerous they are. The waste-generating undertaking shall be responsible for the separation of hazardous waste and common waste. After identification and separation, the waste must be placed in suitable containers, so that it can be collected, treated and disposed of in accordance with its characteristics (SIQUEIRA, 2001).

The internal collection is the collection of the trash, at the point of generation of the waste, for the destination of the temporary storage place. While the packaging refers to the placement of the waste in packaging suitable for collection, temporary storage of waste, until the external collection.

External collection consists of moving the waste from the temporary storage site to the transport vehicle. The vehicles used for transport also have certain specifications and authorizations of the competent bodies, including regular surveys, so that there are no problems until the final destination of the waste (SIQUEIRA, 2001).

The Environmentally friendly final destination includes tools such as reuse, recycling, composting, recovery and energy use. Other destinations are accepted by the competent bodies, including the final disposal, observing specific operational standards in order to avoid damages or risks to public health and safety and to minimize adverse environmental impacts.

2.3 Process Analysis and Improvement

Improving the processes of an organization is a critical factor for its success. Whether it is a public or private institution, process improvement must be done in a systematic manner and with the participation of its employees.

Of the several existing methodologies, the PAI methodology - Process Analysis and Improvement is highlighted, as having the simplest application. The PAI is a set of actions developed to improve the activities performed, identifying possible deviations, correcting errors, transforming inputs into products, or services with high added value.

The PAI follows the same principles of MAPS - Methodology Analysis and Problem Solving, which facilitates the use of problem solving tools in organizations in an orderly and logical manner, facilitating the analysis of problems, determination of their causes and elaboration of action plans to eliminate these causes. The advantage of using PAI is that the first step already involves breaking down a managerial paradigm, instituting process management as a starting point. (SCARTEZINI, 2009)

The main goal of improving processes is to add value to the products and services that organizations provide to their customers. With PAI, we seek a set of principles, tools and procedures that provide guidelines for a complete management of activities, focused on meeting the needs of users of the organization's services. The PAI stages involve:

- Mapping of processes;
- Monitoring of processes and their results;
- Identification and prioritization of problems and their causes;
- Corrective, preventive and improvement actions;
- Documentation system and operational procedures.

The use of methodologies and the application of tools known to everyone in the organization, within the same philosophy, allow for greater speed and transparency in internal communications and the consequent speed in decision making.

According to Scartezini (2009) the tools are classified in statistics and not statistics. There are no limits to the number of tools that can be used in the analysis and improvement of processes, but for the effective use of all, knowledge and practice is necessary. However, usually seven are the most commonly used, known as the "seven quality tools" are: Check Sheet, Control Charts, Ishikawa Diagram, Flowchart, Histogram, Pareto Diagram and Dispersion Diagram.

The use of the tools is of great help to the managers, since they make use of data that aid the processes and organizational procedures, in the search of better results. However, ideally, all employees of the company should be aware of quality tools, since it is possible to perfect processes and activities at the level closest to excellence. In addition, when applied properly, tools have the ability to raise the organization's quality levels, improving services and products while increasing the company's competitive capacity.

3 Methodology

With the initial analysis of a Waste Management problem of a welding technology company, a case study was carried out in the partner organization.

The specific objective of this research was to seek proposals to solve the presented problem. Then articles, books and periodicals were consulted on physical and digital media related to sustainable and cleaner production systems, and waste management in welding technology companies, with the aim of later being compared with data collected in the organization.

3.1 Research classification

According to Mello (2012), the classification of the research more usually, can be divided in four ways: nature, objectives, approach and method.

As to its nature, in this case, the applied research was carried out, which is characterized by its interest that the results be applied in the solution of problems.

As to its objectives, in this research, the exploratory research was carried out, involving bibliographical research and interviews.

As for how to approach the problems, a combination of quantitative and qualitative research was used. From the qualitative research, using open questionnaires and observations, it was possible to develop ideas and hypotheses. Already from the quantitative research, through the collection of numerical data, it was possible to quantify the problem through these data and turn them into usable statistics.

As for the method used in the research, it was the case study since it involves the deep study for a detailed knowledge. According to Voss, Tsikriktsis and Frohlich (2002), there are many challenges in the case study because it is time-consuming, requires skilled researchers and has to be very careful in generalization, but the results have a strong impact and can lead to new perceptions . Yin (2003) defines three types of case study, which vary according to the objectives: exploratory, explanatory and descriptive.

3.2 Unit of analysis

The unit of analysis was Binzel do Brasil Industrial, located in the neighborhood of Itaipava, Petrópolis.

3.3 Data collection procedures

For data collection, the three principles of Yin (2003) were used, where the first principle is to use several sources of evidence, the second principle is the creation of a case study database and the third principle is to maintain the evidence chain.

In this case, the interview instrument was first used, which functioned as a key point, based on primordial concepts for a better analysis. Observation was another important technique, which made it possible to more closely identify the processes and characteristics of the company. The documentary part of the work was done through interpretations of the information and documents made available by the company.

3.4 Data evaluation and analysis procedures

After analyzing the problem situation and making the bibliographic research, the accumulated content of the research was compared with what actually occurs. In this way, analyzes of documents and information were carried out, so that solutions could be studied and discussed.

3.5 Steps in applying the PBL approach

Mapping of the waste management process was done and the project team sought basis, from a literature review, to identify key opportunities for improvement. In addition, meetings were held with coordinators and employees to gain more knowledge of the company's production flow. The PMBOK Guide (2017) was also used as a basis for the project itself.

3.5.1 1st Step - Definition of the problem situation and elaboration of the project opening term

The problem situation is a fundamental part of the project and seeks to answer the following questions: "What is the problem to be studied?", "Why is the problem relevant?" and "What are the expected results?".

In the project the problem situation turned around inefficient management of the internal flow and waste disposal generated by the company's production sector.

The project opening term is a document developed to authorize the project, it contains the justifications, objectives, benefits, stakeholders and project schedule.

3.5.2 2nd Step - Elaboration of the project management plan

According to the PMBOK Guide (2017), developing the project management plan is the process of documenting the actions needed to define, prepare, integrate, and coordinate all auxiliar plans.

A project management plan was developed to ensure that it would include all the necessary work, as well as to control, monitor and close the project. Part of the plan was management of the scope, time, risks, communications, stakeholders and staff.

Scope is the process of developing a detailed description of the project, containing requirements, timeline, cost and feasibility information, quality, risk and acquisitions.

The product of this project was the Diagnosis with proposals and recommendations to make the Waste Management System more efficient and sustainable. composed of the following by-products:

- Mapping the Sustainable Production System;
- Mapping of the waste management process;
- Analysis of the waste management process;
- Analysis of the final destination of the waste;
- Proposals for improvements in the Waste Management System and sustainable management;
- Training and procedures recommendations for employee awareness;
- Creation of informative panels on sustainable management;

It is noteworthy that the Project Canvas tool that allowed sketching the project template.

3.5.3 3rd Step - Project execution and control

The project was monitored and controlled mainly by the manager, who evaluated the performance as a whole, through control points during the timetable, focusing on the quality of the tasks of each stage of the project. Corrective actions were used to avoid delays or inadequacies, and change control helped to maintain the project during its execution.

Following the activity list, the production system mapping was carried out, through data collection of the company by meetings with coordinators of PPC and Logistics. Next, the waste management process was mapped to obtain a better specific knowledge. Finally, an analysis was made of all the waste produced by the administration sector, cafeteria and the machining and assembly sectors, and verified the final destination of all waste generated.

3.5.4 4th Step - Project Closure

The closing of the project took place in a public presentation, where all the interested parties of the project were present. In the presentation were submitted the proposals for improvements and informative panels on sustainable management for the company, and the research report to the tutor tutor.

3.5.5 5th Step - Student Assessment

The evaluation was carried out according to the progress of the project, deliveries were counting notes for the final result, each member with its function demanded by the project manager. And in the end, an individual assessment of each member of the group, made by the responsible tutor.

4 Results

After the analysis of the problem situation, researches were first carried out in order to understand more about the subject, and then mapping tools were used to arrive at a feasible improvement proposal. It is worth mentioning that for a more in-depth study on the subject, it was necessary to conduct interviews with collaborators, observations and access to company documents, to have a comparative with the bibliographic research.

4.1 Analysis of the problem situation

In this case study, the process selection for the process improvement analysis was made by the company's own demand, once it is a project, its justification was properly the problem situation presented.

4.1.1 Mappings - The current solid waste management system

The study on management began with the elaboration of the *SIPOC Diagram*, which gave the idea of the company as a whole. The extension of SIPOC to a "Sustainable SIPOC", containing solid waste flow, came from the idea of the relationship that the waste has with the processing and the location that this waste falls into the system, as outputs.

Based on Adissi (2013), a second mapping was carried out, regarding the direct and indirect residues of the production, and management waste from the administrative and catering sectors..

Direct residues can be divided between waste from the Machining and Assembly sectors. Containing in the first, metals and machining oil mixed with filings, in addition to filings and tips. And the second, metals such as scraps, mixed and pure copper, plastic waste and rubber.

In indirect waste are the waste generated by the assembly, ie waste wood, cloth and water contaminated with oil and packaging waste, in the case of plastic, paper and cardboard, wood (coils) and gas cylinders.

Management waste includes batteries, electronics, paper and cardboard, plastic, organic waste and metals.

4.1.2 Identification of problems

The brainstorming that along with the observation, made possible the identification of the problems, from the analysis of the mappings of the studied processes.

The identified problems were: lack of classification; lack of discrimination of source of origin; inadequate collection of plastic with rubber; inadequate collection of plastic with paper and cardboard; improper collection of other inorganic wastes with organics from the administration; inadequate storage of used oil and contaminated water; lack of definition of the transitional packaging area; improper disposal of contaminated materials with oil; improper disposal of batteries, batteries and electronics; and unidentified waste of administration waste.

4.1.3 Grouping and prioritizing problems

The grouping of problems was carried out so that later common root causes, with problems of the same family, were found.

Through the Affinity Matrix, most of the problems were grouped according to their degree of similarity, creating five large families of problems, being: incomplete identification; inadequate recall; improper storage; improper disposal and; destination. It is also worth noting that the problems of excess paper used were not grouped.

From the grouping of certain problems in families, the Relationship Diagram was designed to identify which problems would be most impacted and which ones would be more impacting.

4.1.4 Survey and prioritization of causes

The causes were raised through the Ishikawa Diagram, which facilitated the identification of root causes. It is important to point out that the Ishikawa Diagram was made for families of more shocking problems (inadequate identification and inadequate recollection). The family of problems of inadequate storage was also considered, since it was understood to cause impact of disposal problems and subsequent disposal.

In general and summarized, for the different groups, the following causes were found: lack of investment request; lack of procedures; lack of training; lack of incentive; inappropriate disposal science; lack of awareness and; lack of knowledge.

4.2 Proposal for improvement

The improvement proposals were basically divided into solutions understood as short-term solutions and long-term solutions. In addition, Information panels related to the knowledge and awareness problems encountered were proposed and, in this case, made up.

4.2.1 General solutions for families of problems - Long term

Analyzing the Ishikawa Diagram,it was realized that by solving the root cause problems, several derived problems would already be solved. Thus, the root causes to be treated are: lack of procedure, lack of training, lack of incentive and lack of knowledge.

Cleaning officials must follow certain procedure and due training. This procedure must be done by a waste manager, and it should be specified what types of waste the company generates the most, such as collection, separation, storage and disposal, as well as the importance of using equipment collection.

It was understood that to encourage employees, it is necessary to empower and value them.

The lack of knowledge can be solved through environmental education through informative lectures and posters by the company on the characteristics and risks of each type of waste, so that employees know the importance of the process for the company, community and environment

4.2.2 Solutions specific to certain problems - Short term

From the situations presented in each family, some sets of specific solutions were proposed that aim at reaching the root causes.

- Installation of a dome near the exit of parts of the CNC lathes, in order to avoid the splash of oil coming from the machine;
- Installation of a containment basin capable of supporting at least 10% of the contents stored on it, or the construction of a collection drain around the area ;
- Creation of an electronic waste collection center in the company;
- Creation of informative panels, strategically spread by the factory, creation of procedures and training to employees and the creation of a visual system for the signaling of the packaging and storage areas for each type of waste.
- Following the INEA, three selective collection containers, "Recyclable", "Non-Recyclable" and "Compostable", should be installed in the administration and refectory.
- Discard oil contaminated materials from the same companies that remove the oil and contaminated water.
- Implementation of a Workflow tool that reduces the excess paper generated and automates the process of documentation, authorization, general communication and production order, for example.

4.2.3 Proposed panels

In addition to the set of proposed solutions and recommendations, it is proposed and printed panels composed of a classification table and discrimination of the company's source of waste origin, in order to better understand and display the employees and customers, another with the new Sustainable Production System, and a new one with the new look-flow chart of the company, which allows the knowledge of the sources of waste within the production.

5 Conclusion

With this case study it was possible to conclude that a project-based learning discipline can be very faithful to the proposal, while the students are immersed in a business reality. The day-to-day of a manufacturing becomes something closer to the academic environment.

It was also verified that the planning of a project is essential for its subsequent execution. Planning tools, when well-known and well-applied, are the basis for the work to be done and are directed towards the expected results.

In addition, with this research it was possible to understand a little more about the sustainable and cleaner production systems and the trends that these have been suffering with the technological evolution.

It was also noted the difficulty in integrating business management to sustainable development and its three pillars, in order to manage, for example, solid waste in a welding technology company. The lack of knowledge, awareness, procedure and training for employees are, in many cases, root causes of greater problems when related to the environmental management of productive units.

It is concluded that the concern with sustainability principles and adjustments to environmental nonconformities are important factors for achieving development without exhausting resources for the future.

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Explaining the acceptance and use of YouTube as an online learning platform: A study through structural equations

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Abstract

The expansion of technologies has favored new forms of learning, such as distance learning. Distance education in Brazil increased substantially, especially the so-called free courses. The number of students in free courses almost triples the number of formal courses. Understanding the reasons that free course platforms have many stakeholders is important in understanding student behavior on online platforms. To analyze the factors that explain the adoption of these platforms we have studied the acceptance and use of YouTube as a platform for free courses through the Unified Theory of Acceptance and Use of Technology model. Thus, the objective of this study is to understand the use of the YouTube platform for learning free courses. In order to reach this study, an exploratory study was carried out using a questionnaire with 51 respondents, and the results were analyzed through modeling of structural equations. The results reached a value of 74.5% in the explanation of the model, and the most important factors were Habit (29.8%) and Expectation of Income (27.8%).

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

Explicando a aceitação e uso do YouTube como plataforma de aprendizagem on-line: Um estudo por meio das equações estruturais

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Abstract

A expansão das tecnologias favoreceu novas formas de aprendizagem, como o ensino a distância. A educação a distância no Brasil aumentou substancialmente, principalmente os cursos chamados livres. O número de alunos dos cursos livres quase triplica o número de cursos formais. Compreender os motivos que as plataformas de cursos livres tenham muitos interessados é importante para compreender o comportamento do estudante em plataformas online. Para fazer a análise dos fatores que explicam a adoção destas plataformas se estudou o a aceitação e uso do YouTube como plataforma de cursos livres por meio do modelo da Teoria Unificada de Aceitação e Uso de Tecnologia. Assim, o objetivo deste estudo é compreender o uso da plataforma YouTube para aprendizagem de cursos livres. Para alcançar este estudo foi realizado um estudo exploratório por meio de questionário com 51 respondentes, e os resultados foram analisados via modelagem de equações estruturais. Os resultados alcançaram o valor de 74,5% na explicação do modelo, sendo que os fatores mais importantes foram Hábito (29,8%) e Expectativa de Rendimento (27,8%).

Keywords: Cursos livres. Fatores de Uso e Aceitação do Youtube, Aprendizagem por meio da Tecnologia

1 Introdução

Compreender o complexo panorama do ensino é um desafio. Mello, Monteiro, & Mariano (2018), explicam que o incremento e uso contínuo da tecnologia, a necessidade de práticas para engajar os alunos e a inclusão social são tema cotidianos em sala de aula. Este desafio se maximiza quando o país é o Brasil, com dimensões continentais e um desnível acentuado de renda e acesso a serviço público de qualidade nas regiões.

Com uma tentativa de ampliar o alcance da educação no Brasil, o governo brasileiro estabeleceu via Decreto nº 5.800, de 8 de junho de 2006, o sistema de ensino a distância (EaD), chamado de Sistema Universidade Aberta do Brasil (UAB), com a finalidade de expandir e interiorizar a oferta de cursos e programas de educação superior no País, através da modalidade a distância (Brasil, 2006).

Em poucos anos o EaD teve uma expansão muito grande, chegando a 4.570 cursos 100% EaD, com um crescimento de 528.320 matriculados em graduação EaD em 2009 para 1.320.025 em 2017 (Brasil, 2017).

Adicionalmente a expansão dos cursos EaD no Brasil, pode-se perceber um aumento exponencial do número de cursos livres não coorporativos. Atualmente são 16.557 cursos livres não corporativos (aqueles não regulamentados por órgão educacional) e com um crescimento de 755.194 em 2010 para 3.839.958 em 2017(Brasil, 2017).

Assim, com o avanço da tecnologia, os cursos on-line livres (CoL), passaram a se tornar um dos principais veículos da aprendizagem informal diminuindo o que Pereira, Fillol, & Moura (2019), chamaram de brecha tecnológica, cultural e educativa entre a vida do jovem fora e dentro da sala de aula. Compreender os aspectos que levam um estudante escolher uma plataforma ou outra no momento de realizar sua formação é importante para conhecer os fatores de engajamento deste estudante, uma vez que ao conhecer os motivos de sua livre escolha de uma plataforma para aprendizagem informal, como *YouTube*, podem revelar estratégias para serem adotadas nas plataformas formais como o *moodle*.

Assim, o problema desta pesquisa é: quais fatores levam os estudantes a adotar uma plataforma de aprendizagem de cursos livres?

Por se tratar de um país com muitas diferenças econômicas, foi escolhida uma plataforma que oferece cursos online de maneira gratuita como o YouTube, pois a probabilidade de encontrar entrevistados que tivesse usufruído da mesma seria alta. Espera-se que com a resposta deste problema, outras plataformas de ensino informais e formais se tornem mais atrativas aos estudantes.

Deste modo, o objetivo desta pesquisa é compreender o uso da plataforma YouTube para aprendizagem de cursos livres. Este trabalho estrutura-se com um referencial teórico, seguido da metodologia, resultados e análises e finalmente as considerações finais.

2 Revisão da literatura

O YouTube é uma plataforma global para compartilhamento de vídeos, lançada em 2005, com mais de 1,9 bilhões de usuários/mês, com uso diversificado, desde videoclipes de músicas até videoaulas (9 em cada 10 pessoas utilizam a plataforma para estudar) (YouTube, 2018). Atualmente, a própria plataforma possui um canal para compartilhar conteúdos sobre educação, que é o canal Youtube Edu.

Embora seja uma plataforma que oferece um grande número de possibilidades, Klobas, Mcgill, Moghavvemi, & Paramanathan (2018a), alertam em seu estudo sobre o uso compulsivo observado em estudantes da Malásia, mas explicam que se o uso da plataforma é feito para informação e aprendizado este perigo diminui substancialmente.

Esse compartilhamento de conteúdo faz do YouTube uma plataforma diferente das outras redes sociais, pois em YouTube o engajamento do usuário está centrado no compartilhamento de conteúdo, enquanto em outras redes sociais, está centrado nas interações sociais(Klobas, Mcgill, Moghavvemi, & Paramanathan, 2018b).

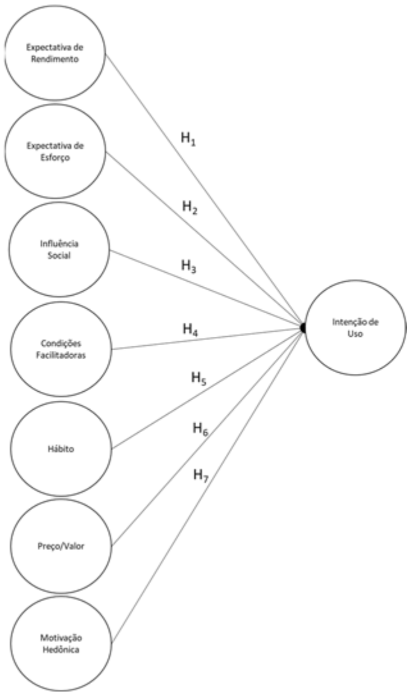
Compreender o motivo de uso e aceitação do YouTube para aprendizagem, é conhecer um pouco mais sobre engajamento do aluno para CoL. Embora existam diversos modelos para aferir a aceitação e uso de uma determinada tecnologia o modelo de UTAUT 2 (Teoria Unificada de Aceitação e Uso de Tecnologia), se tornou bastante consolidado na literatura (Mariano & Diaz, 2017).

O modelo de equações estruturais UTAUT 2 foi desenvolvido a partir do estudo de Venkatesh, Morris, Davis, & Davis (2003), que elaboraram um modelo unificado (UTAUT 1) que abrangia os elementos de oito modelos que trabalham com a aceitação da tecnologia. Em 2012, Venkatesh, Thong, & Xu (2012), ampliaram o modelo para preferências de consumo lançando o UTAUT 2.

O modelo UTAUT2 utilizado na presente pesquisa é baseado no modelo adaptado do UTAUT2 proposto por Ramírez-Corrêa, Mariano, Alfaro, & Rodrigues (2015), que possui 8 variáveis, onde 7 antecedem a variável "Intenção de uso". A seguir são apresentadas e definidas essas 7 variáveis conforme definição de Venkatesh et al. (2003).

1. Expectativa de rendimento: grau em que uma pessoa crê que o sistema ajudará a alcançar ganhos no desempenho;
2. Expectativa de esforço: grau de facilidade relacionado com a utilização do sistema;
3. Influência social: grau que uma pessoa percebe que outras pessoas acreditam que ela deva usar o sistema ou a tecnologia;
4. Condições facilitadoras: grau em que uma pessoa crê que existe uma infraestrutura para suportar a utilização do sistema;
5. Hábito: o que as pessoas realizam de forma automatizada;
6. Preço e valor: é uma razão que as pessoas têm a tendência de arcar com uma nova tecnologia;
7. Motivação hedonista: é considerado como prazer advindo do uso da tecnologia.

Assim, esta pesquisa apresenta as seguintes hipóteses:



- H_1- A Expectativa de rendimento influência a intenção de uso
- H_2- A Expectativa de esforço influência a intenção de uso
- H_3- A Influência social incide sobre a intenção de uso
- H_4- As Condições Facilitadoras influenciam a intenção de uso
- H_5- O Hábito influência a intenção de uso
- H_6- O Preço/Valor influência a intenção de uso
- H_7- A Motivação Hedônica influência a intenção de uso

O modelo foi desenhado e calculado, obedecendo todas as etapas de confiabilidade e validade. Os resultados foram apresentados no capítulo 4.

3 Método

Esta pesquisa foi do tipo exploratória com abordagem quantitativa por meio da Equações estruturais via variância. O Local de estudo foi Brasília e o objeto de estudos foram estudantes da Universidade de Brasília que utilizam a Plataforma YouTube como meio de aprendizagem para cursos livres. O instrumento de coleta de dados foi o questionário validado de Ramírez-Corrêa, et al. (2015), contendo um total de 26 perguntas com opções de respostas definidas conforme itens da escala Likert de 7 pontos variando entre discordo totalmente, discordo, discordo moderadamente, neutro, concordo moderadamente, concordo e concordo totalmente.

O instrumento de coleta de dados foi um questionário on-line aplicado por meio do *Google Forms*, entre os dias 15/11/2018 e 02/12/2018 e validado via software SmartPLS. Foram alcançadas 100 respostas, porém apenas 51 puderam ser utilizadas por estarem devidamente complementadas. Assim a amostra foi de conveniência. Para o calcular o modelo de equações estruturais via variança (PLS-SEM) foi utilizado o programa SmartPLS . A escolha do método PLS-SEM se deu devido o caráter exploratório da pesquisa. Foi cálculado utilizando o PLS consistente e todas as variáveis reflexivas.

4 Resultados e Análises

Seguindo o que recomenda Chin, (2013); Hair, Risher, Sarstedt, & Ringle, (2018); Joseph F. Hair, Hult, Ringle, & Sarstedt, (2014), foram realizadas as etapas de valoração global, de medida e confiabilidade e validade do modelo, assegurando que o modelo é confiável e válido. O modelo calculado aparece na figura 1.

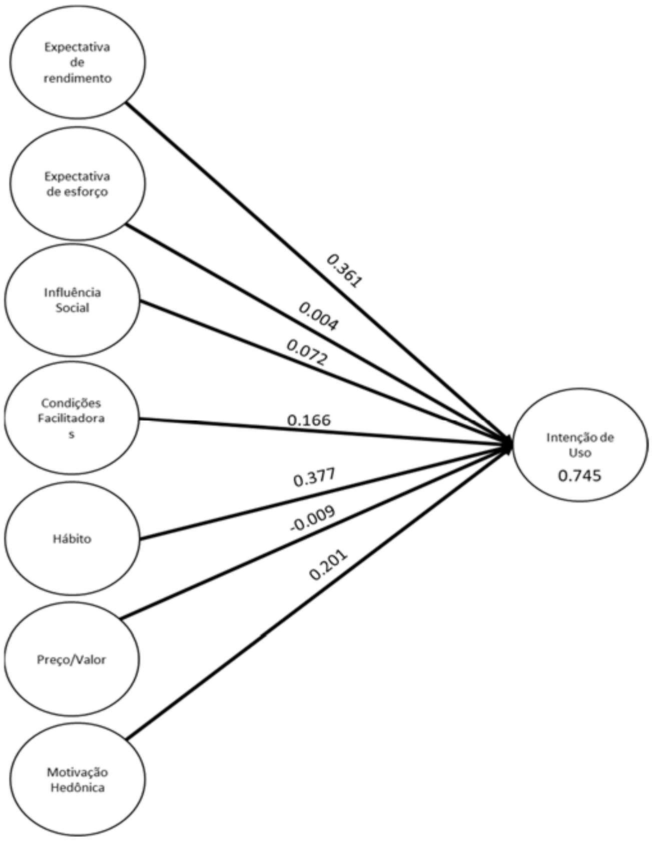


Figura 1. Modelo calculado. Fonte: Própria

Foram utilizas as premissas de Ramírez-Corrêa, Mariano & Salazar (2014), para avaliação do modelo via equações estruturais, dividindo em 3 etapas a valoração do modelo estrutural a. Valoração do Signo e Magnitude, b. Valoração da Decomposição da Variância e c. Valoração do Coeficiente de Determinação.

Segundo Ramírez-Corrêa, Mariano & Salazar (2014) para realizar a Valoração do Signo e Magnitude e que as hipóteses sejam confirmadas ou não, deve-se observar os valores do Beta (Path do caminho), que devem ser maiores que 0,2 (diretamente relacionada) ou menores que -0,2 (inversamente relacionada) Chin (2013). Como as hipóteses não estabeleceram o signo da influência como positiva ou negativa, observa-se apenas a magnitude da influência. Pode-se observar que o hábito, expectativa de rendimento e Motivação Hedônica foram suportadas nesta pesquisa (hipóteses 1, 5 e 7), ratificando o estudo de Hew, Lee, Ooi, & Wei, (2015), que encontrou resultados similares pesquisando a adoção de aplicativos na Malásia em uma amostra de 288 indivíduos. Para a decomposição da Variância procedeu-se via multiplicação dos pesos dos betas e as correlações das variáveis latentes, conforme Hair, et al (2018). Pode-se perceber que as variáveis que mais exercem influência sobre a intenção de uso são hábito, expectativa de rendimento e Motivação Hedônica, representando 29,8%, 27,8% e 11,3% de influência respectivamente.

Finalmente a valoração do coeficiente de determinação. Hair, et al. (2014) explica que coeficientes de determinação $R2>0,25$, são considerados fracos, $R2>0,50$, são considerados moderado e $R2>0,75$, substanciais. Pode-se observar na Figura 1, a intenção de uso do YouTube para aprendizagem com cursos livres por indivíduos foi explicada em 74,5% pelas variáveis condições facilitadoras; expectativa de esforço; expectativa de rendimento; hábito; influência social; preço e valor; intenção de uso e motivação hedonista, sendo considerada um modelo que explica com satisfação a intenção de uso. Assim, pode-se perceber que a intenção de uso da plataforma YouTube para cursos livre é influenciada de maneira mais forte pelo hábito. O Fomento do hábito pode realizado de diversas maneiras. Diaz (2017) explica que uma maneira de incentivar o hábito é por meio de promoções e preços baixos. O fato de o YouTube ser uma plataforma que conta com uma grande variedade de conteúdos gratuitos favorece para ser uma das plataformas mais utilizadas. Algumas plataformas pagas como *Udemy* ou *Data Science Academy* são exemplos de plataformas de cursos livres pagas que oferecem alguns cursos grátis para criar o hábito ao estudante. No caso do YouTube, o fato de ter uma plataforma com amplo conteúdo pode também ter ajudado no aumento do hábito, uma vez que o uso da plataforma ocorre para o entretenimento. A expectativa de rendimento aparece como a segunda variável mais influente. Para aumentar a expectativa de rendimento a plataforma pode deixar claro os benefícios dos cursos e possíveis desfechos para o profissional que assista. No caso do YouTube, grande parte dos vídeos de cursos livres são gravados por pessoas que o jovem se identifica, admira ou confia devido uma referência anterior. Finalmente a Motivação Hedônica, que é o uso da plataforma fomentando o prazer pessoal. Neste caso a plataforma pode usar de gamificação ou mesmo oferecer algum benefício extra, livros entre outros.

Em um ambiente Universitário pode-se melhorar o uso de uma plataforma de aprendizagem on-line, criando-se o hábito do aluno mediante disponibilidade de todo material via plataforma on-line, fazendo o uso da plataforma uma atividade cotidiana. O mesmo sobre o rendimento, garantindo material extra apenas pela plataforma, beneficiando o aluno que usa a plataforma on-line a ter acesso a estes materiais especiais. E finalmente a motivação hedônica que pode ser ampliada com o papel do professor mais ativo, utilizando algumas ferramentas mais lúdicas para passar a mesma informação, afastando-se a visão do *moodle* como um depósito de arquivos.

5 Considerações finais

O objetivo geral deste estudo foi compreender o uso da plataforma YouTube para aprendizagem de cursos livres. Foi descoberto que o Hábito, a Expectativa de rendimento e a Motivação Hedônica influenciam a intenção de uso 29,8%, 27,8% e 11,3%, respectivamente. O modelo foi explicado por todas as variáveis em 74,5%, demonstrando sua efetividade conforme a literatura. Os resultados colaboram para que outras plataformas para cursos informais ou formais possam melhorar sua adesão e participação. O problema da pesquisa foi respondido. Para a agenda futura sugere-se que esta pesquisa seja aplicada a outras plataformas online de cursos formais e informais.

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Application of the Project Based LearningApproach in Solid Waste Management of a Welding Technology Company

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Abstract

This study integrates a more comprehensive research, called here of greater research, whose central question is: How to apply the Project Based Learning (PBL) approach in a graduate course in production engineering? This paper presents the application of the initial model of the PBL approach in Production Engineering, proposed by the greater research, in one of the modules of the Synthesis and Integration content group that makes up the backbone and conductive line of the Production Engineering training of the first undergraduate course of the School of Engineering of Petrópolis of the Fluminense Federal University (UFF). The purpose of this study was to propose solutions to the solid waste management problems of a welding technology company using process analysis and improvement methodology. The main problems identified were inadequate classification, collection and storage of solid wastes, all due to inadequate procedures, lack of training and incentives to employees. To help eliminate the identifiedproblems, medium to short-term solutions were proposed. In the medium term, it was suggested that the company invest in better employee training. In the short term, the following solutions were proposed: installation of a dome to collect any spatter oil from the machines, installation of a containment basin in the solid waste storage area, creation of a collection center for batteries, electronic waste and creation of a visual signaling system for storage areas.

Keywords: Active Learning; Engineering Education; Project Approaches, Solid waste management.

Aplicação da Abordagem Project Based Learning na Gestão de Resíduos Sólidos de uma empresa de Tecnologia de Soldagem

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Resumo

Esse estudo integra uma pesquisa mais abrangente, chamada aqui de pesquisa maior, cuja a questão central é: Como aplicar a abordagem Project Based Learning (PBL) em um curso de graduação de engenharia de produção? O estudo apresenta a aplicação do modelo inicial da abordagem PBL em Engenharia de Produção, proposto pela pesquisa maior, numa das disciplinas do grupo de conteúdos Síntese e Integração que compõe a espinha dorsal e linha condutora da formação em Engenharia de Produção do primeiro curso de graduação da Escola de Engenharia de Petrópolis da Universidade Federal Fluminense (UFF). O estudo teve como objetivo propor soluções para os problemas de gestão de resíduos sólidos de uma empresa de tecnologia de soldagem, utilizando metodologia de análise e melhoria de processos. Os principais problemas identificados foram a classificação, recolhimento e armazenamento inadequados dos resíduos sólidos, sendo suas causas-raiz: procedimentos inadequados, falta de treinamentos e incentivos aos colaboradores. Para ajudar a eliminar os problemas identificados foram propostas soluções de médio a curto prazo. A médio prazo foi sugerido que a empresa invista no treinamento dos colaboradores, focando na solução dos problemas identificados. A curto prazo foram propostas as seguintes soluções: instalação de uma cúpula para recolhimento de óleo respingado das máquinas, instalação de uma bacia de contenção na área de armazenamento de resíduos sólidos, criação de um centro de recolhimento de pilhas, baterias e resíduos eletrônicos, criação de um sistema visual para sinalização das áreas de armazenamento.

Palavras-chave: Aprendizagem ativa; Engenharia da educação; Abordagem de projetos; Gestão de resíduos sólidos.

1 Introdução

A transmissão de conhecimento, em um mundo globalizado, onde rápidas mudanças são constatadas, pode ser um desafio para instituições de ensino acadêmico. A interface entre a teoria e a prática é um dos principais fatores que influenciam no processo de aprendizado para que o aluno torne-se um profissional completo e pronto para o "mundo real".

As metodologias ativas de ensino, são uma das principais ferramentas facilitadoras desta mescla, sendo a Aprendizagem Baseada em Projetos (PBL) uma técnica que vêm se destacando no âmbito educacional da Engenharia, em específico, da Engenharia de Produção. Segundo a ABEPRO (2019), a produção vai além da utilização de conhecimento científico e tecnológico e assim, a Engenharia de Produção é compreendida como a menos tecnológica das Engenharias, ao passo que é a mais abrangente e genérica, sendo a que engloba um conjunto maior de conhecimentos e habilidades.

Na Escola de Engenharia de Petrópolis, o curso de bacharelado em Engenharia de Produção inova ao aplicar a metodologia PBL, em parceria com empresas da cidade de Petrópolis. A disciplina de Projetos de Sistemas de Produção I possibilita o primeiro contato do aluno da graduação com situações reais de uma empresa, buscando responder questões relacionadas ao funcionamento de um sistema de produção sustentável e mais limpo, por meio de um estudo de caso em conjunto com a demanda do projeto requerida pela instituição parceira.

Segundo Adissi (2013), o desenvolvimento sustentável é o desenvolvimento que não esgota os recursos para o futuro. Entende-se como desenvolvimento sustentável corporativo o gerenciamento de negócios, levando em conta os três âmbitos envolvidos pelo desenvolvimento sustentável, sendo eles: a proteção ambiental, a estabilidade econômica e a responsabilidade social (ADISSI, 2013).

A gestão ambiental é um conceito totalmente relacionado ao desenvolvimento sustentável corporativo, pois considera que uma organização tem a responsabilidade de identificar e gerir os impactos ambientais negativos causados. A gestão de resíduos sólidos busca integrar estratégias de negócio que não levem ao descarte excessivo de resíduos, com consequentes danos ao meio ambiente (ADISSI, 2013).

A ABICOR BINZEL® é uma empresa alemã do segmento de produtos de Tecnologia para Soldagem. Com sede brasileira localizada em Petrópolis, é uma das parceiras da UFF, e está sempre em busca do desenvolvimento de produtos com alta qualidade, excelência e tecnologia, visando a satisfação de todas as partes envolvidas no processo, e respeitando os princípios de sustentabilidade.

Este projeto, demandado pela empresa, teve como intuito tornar o sistema de gestão de resíduos sólidos da mesma mais eficiente, aproximando-se ainda mais dos princípios ideais do desenvolvimento sustentável e possibilitando, entre outros benefícios, maior adaptabilidade perante novas legislações ou mudanças nas existentes.

Assim, os alunos definidos como membros da equipe deste projeto, realizaram este trabalho por meio do embasamento teórico obtido pela revisão de literatura e do acompanhamento contínuo através de visitas a empresa. A união destes passos permitiu o alcance e análises de resultados, para que melhorias relacionadas à demanda fossem propostas.

2 Referencial Teórico

A pesquisa bibliográfica foi organizada de forma a obtenção de todas as informações possíveis através de consultas e citações de artigos, livros e periódicos em mídias física e digital relacionados a sistemas de produção sustentáveis e mais limpos, e gestão de resíduos em empresas de tecnologia de soldagem. Essas referências auxiliaram na seleção e organização do conteúdo da pesquisa e na busca por propostas para solucionar o problema apresentado.

2.1 Aprendizagem baseada em Projetos

Atualmente, quando se fala em engenharia, o PBL passa a ter lugar cativado, tendo em vista que se espera de um engenheiro soluções para problemas reais e práticos, que são por muitas vezes bem diferentes dos vistos na teoria.

A aprendizagem baseada em projetos se trata de uma metodologia onde o aluno é o protagonista, e deixa de aprender da forma passiva e tradicional para passar a aprender ativamente.

Durante a maior parte da graduação em Engenharia de Produção na UFF - Petrópolis a metodologia PBL está presente. Ao todo são cinco projetos, de diferentes áreas da Engenharia de Produção. A parceria entre a universidade e empresas locais permite que os alunos tenham a oportunidade de aprender na prática e conhecer mais de perto o mundo profissional.

2.2 Gestão de Resíduos Sólidos

Segundo Adissi (2013), lixo é considerado tudo que é inservível para determinado indivíduo. Contudo, o que não serve mais para um, pode ser útil para outro. Quando determinado objeto torna-se inservível para alguém, este é considerado um resíduo.

A Lei brasileira n. 12.305/2010 diz que os resíduos sólidos são aqueles em estado sólido ou semissólido, bem como gases contidos em recipientes e líquidos cujas particularidades tornem inviável o seu lançamento em rede pública de esgoto ou esgotos ou corpos d'água, ou exijam para isso soluções técnicas específicas ou tecnologicamente de difícil disponibilidade.

Para Gomes (2014), o cuidado com os resíduos sólidos é visto como algo recente (meados do século XX), quando deixou de ser considerado como um indicador de consumo e passou a ser considerada uma dimensão perigosa.

De acordo com Galbiati (2004) o modelo de gestão de resíduos sólidos é um sistema que considera o momento da geração dos resíduos junto com seu reaproveitamento e/ou reciclagem, até os processos de tratamento e destinação final. A destinação dos resíduos industriais é de responsabilidade da empresa que gerou.

A classificação de resíduos sólidos envolve a identificação do processo ou atividade que lhes deu origem e quanto sua periculosidade. A empresa geradora dos resíduos deve ser responsável pela separação entre resíduos perigosos e resíduos comuns. Após a identificação e a sua separação, os resíduos devem ser colocados em recipientes adequados, para que se possa ter a sua coleta, tratamento e destinação final, de acordo com suas características (SIQUEIRA, 2001).

A coleta interna é o recolhimento do lixo da lixeira, no ponto gerador do resíduo, para a destinação do local de armazenagem temporário. Enquanto que o acondicionamento refere-se a colocação do resíduo em embalagens adequadas para coleta, até que seja feita a coleta externa.

A coleta externa consiste na movimentação do resíduo do local de armazenagem temporário até o veículo transportador. Os veículos utilizados para o transporte também dispõem de certas especificações e autorizações dos órgãos competentes, inclusive com vistorias regulares, para que não haja problemas até a destinação final dos resíduos (SIQUEIRA, 2001).

A destinação final ambientalmente inclui ferramentas como, por exemplo, a reutilização, a reciclagem, a compostagem, a recuperação e o aproveitamento energético. Outras destinações são admitidas pelos órgãos competentes, entre elas a disposição final, observando normas operacionais específicas de modo a evitar danos ou riscos à saúde pública e à segurança e a minimizar os impactos ambientais adversos.

2.3 Análise e Melhoria de Processos

Melhorar os processos de uma organização é um fator crítico para o seu sucesso. Seja uma instituição pública ou privada, a melhoria de processos deve ser realizada de forma sistematizada e com a participação de seus colaboradores.

Das diversas metodologias existentes, destaca-se a metodologia AMP – Análise e Melhoria de Processos, como tendo a aplicação mais simples. A AMP é um conjunto de ações desenvolvidas para aprimorar as atividades executadas, identificando possíveis desvios, corrigindo erros, transformando insumos em produtos, ou serviços com alto valor agregado.

A AMP segue os mesmos princípios da MASP - Metodologia Análise e Solução de Problemas, que propicia a utilização das ferramentas de solução de problemas nas organizações de forma ordenada e lógica, facilitando a análise de problemas, determinação de suas causas e elaboração de planos de ação para eliminação dessas causas. A vantagem da utilização da AMP é que o primeiro passo já envolve a quebra de um paradigma gerencial, instituindo o gerenciamento de processos como ponto de partida. (SCARTEZINI,2009)

O grande objetivo de realizar a melhoria de processos é agregar valor aos produtos e aos serviços que as organizações prestam aos seus clientes. Com a AMP, busca-se um conjunto de princípios, ferramentas e procedimentos que fornecem diretrizes para um completo gerenciamento das atividades, com foco no atendimento das necessidades dos usuários dos serviços da organização. As etapas da AMP envolvem:

- Mapeamento dos processos;
- Monitoramento dos processos e de seus resultados;
- Identificação e priorização de problemas e suas causas;
- Ações corretivas, preventivas e de melhoria;
- Sistema de documentação e procedimentos operacionais.

A utilização de metodologias e aplicação de ferramentas conhecidas de todos na organização, dentro da mesma filosofia, permitem uma maior rapidez e transparência nas comunicações internas e a consequente agilização na tomada de decisões.

De acordo com Scartezini (2009) as ferramentas são classificadas em estatísticas e não estatísticas. Não há limites para a quantidade de ferramentas que podem ser utilizadas na análise e melhoria de processos, porém, é necessário conhecimento e prática eficazes. Entretanto, usualmente sete são as mais utilizadas, conhecidas como "as sete ferramentas da qualidade" são Folha de verificação, Cartas de controle, Diagrama de Ishikawa, Fluxograma, Histograma, Diagrama de Pareto e Diagrama de Dispersão.

O uso das ferramentas é de grande ajuda para os gestores, uma vez que fazem uso de dados que auxiliam os processos e procedimentos organizacionais, na busca de resultados melhores. Entretanto, o ideal é que todos os colaboradores da empresa tenham conhecimento das ferramentas da qualidade, uma vez que é possível aperfeiçoar os processos e atividades ao nível mais próximo da excelência. As ferramentas, possuem a capacidade de elevar os níveis de qualidade da organização, melhorando serviços e produtos ao mesmo tempo em que aumenta a capacidade competitiva da empresa.

3 Metodologia

Com a análise inicial de um problema de gestão de resíduos de uma empresa de tecnologia de soldagem, foi realizado o estudo de caso na organização parceira.

O objetivo específico desta pesquisa foi buscar propostas para solucionar o problema apresentado. Então foram consultados artigos, livros e periódicos em mídias física e digital relacionados a sistemas de produção sustentáveis e mais limpos, e gestão de resíduos em empresas de tecnologia de soldagem, com o intuito de posteriormente ser comparado com dados coletados na organização.

3.1 Classificação da pesquisa

De acordo com Mello (2012), a classificação da pesquisa mais usualmente, pode ser dividida de quatro maneiras: natureza, objetivos, abordagem e método.

Quanto a sua natureza, neste caso, foi realizada a pesquisa aplicada, que se caracteriza por seu interesse que os resultados sejam aplicados na solução de problemas.

Quanto aos seus objetivos, nesta pesquisa, foi realizada a pesquisa exploratória, envolvendo pesquisa bibliográfica e entrevistas.

Quanto a forma de abordar os problemas, foi utilizada uma combinação das pesquisas quantitativas e qualitativas. A partir da pesquisa qualitativa, utilizando questionários abertos e observações, foi possível desenvolver ideias e hipóteses. Já a partir da pesquisa quantitativa, através da coleta de dados numéricos, foi possível quantificar o problema por meio destes.

Quanto ao método utilizado na pesquisa, foi o estudo de caso, uma vez que envolve o estudo profundo a fim de um detalhado conhecimento. De acordo com Voss, Tsikriktsis e Frohlich (2002), existem muitos desafios no estudo de caso, pois consome muito tempo, necessita de pesquisadores habilidosos e tem que ter muito cuidado na generalização, porém os resultados têm forte impacto e podem levar a novas percepções. Yin (2003) define três tipos de estudo de caso, que variam de acordo com os objetivos: exploratório, explanatório e descritivo.

3.2 Unidade de análise

A unidade de análise explorada foi a Binzel do Brasil Industrial, localizada no bairro Itaipava, Petrópolis.

3.3 Procedimentos de coleta de dados

Para a coleta de dados foram utilizados os três princípios de Yin (2003), onde o primeiro princípio é utilizar várias fontes de evidências, o segundo princípio é a criação de um banco de dados para o estudo de caso e o terceiro princípio é manter o encadeamento das evidências.

Neste caso, primeiramente foi utilizado o instrumento da entrevista, que funcionou como ponto chave, baseando-se em conceitos primordiais para uma melhor análise. A observação foi outra técnica importante, que tornou possível uma identificação de forma mais minuciosa dos processos e características da empresa. A parte documental do trabalho foi feita através de interpretações das informações e documentos disponibilizados pela empresa.

3.4 Procedimentos de avaliação e análise dos dados

Após analisada a situação-problema e feita a pesquisa bibliográfica, comparou-se o conteúdo acumulado da pesquisa com o que de fato ocorre. Desta forma, foram realizadas análises de documentos e informações, para então serem estudados e discutidos meios de soluções.

3.5 Etapas da aplicação da abordagem PBL

Foi feito o mapeamento do processo de gestão de resíduos e a equipe do projeto buscou embasamento, a partir da revisão bibliográfica, para identificar principais oportunidades de melhoria. Além disso, foram realizadas reuniões com coordenadores e colaboradores, para adquirir mais conhecimento do fluxo da produção da empresa. Foi utilizado também, o Guia PMBOK (2017), como base para o gerenciamento projeto.

3.5.1 1ª. Etapa – Definição da situação-problema e elaboração do termo de abertura do projeto

A situação problema é parte fundamental do projeto e busca responder às seguintes questões: "Qual é o problema a ser estudado?", "Por que o problema é relevante?" e "Quais os resultados esperados?".

No projeto a situação-problema girou em torno da gestão ineficiente do fluxo interno e descarte de resíduos gerados pelo setor de produção da empresa.

O termo de abertura do projeto foi um documento desenvolvido para que o projeto fosse autorizado, contendo as: justificativas, objetivos, benefícios, partes interessadas e cronograma do projeto.

3.5.2 2ª. Etapa – Elaboração do plano de gerenciamento do projeto

Segundo o Guia PMBOK (2017), desenvolver o plano de gerenciamento de projeto é o processo de documentação das ações necessárias para definir, preparar, integrar e coordenar todos os planos auxiliares.

Fizeram parte do plano elaborado, o gerenciamento do escopo, do tempo, dos riscos, das comunicações, das partes interessadas e da equipe.

O escopo é o processo de desenvolvimento de uma descrição detalhada do projeto, contendo informações de requisitos, cronograma, custo e viabilidade, qualidade, riscos e aquisições.

O produto deste projeto foi o *Diagnóstico com propostas e recomendações para tornar o Sistema de Gestão de Resíduos mais eficiente e sustentável*. composto pelos seguintes subprodutos:

- Mapeamento do Sistema de Produção Sustentável;
- Mapeamento do processo de gestão de resíduos;
- Análise do processo de gestão de resíduos;
- Análise do destino final dos resíduos;
- Propostas de melhorias no Sistema de Gestão de Resíduos e de gestão sustentável;
- Recomendações de procedimentos e treinamentos para conscientização dos colaboradores;
- Criação de painéis informativos sobre gestão sustentável;

Vale ressaltar que a ferramenta *Project Canvas* que permitiu esboçar o modelo do projeto.

3.5.3 3ª. Etapa – Execução e controle do projeto

O projeto foi monitorado e controlado majoritariamente pelo gerente, que avaliou o desempenho como um todo, por meio de pontos de controle durante o cronograma, prezando pela qualidade das tarefas de cada etapa do projeto. Ações corretivas foram utilizadas para evitar atraso ou inadequação e o controle de mudanças ajudou a fazer a manutenção do projeto durante sua execução.

Seguindo a lista de atividade, foi realizado o mapeamento do sistema de produção, através do levantamento de dados da empresa a partir de reuniões com coordenadores de PCP e Logística. Em seguida, foi feito o mapeamento do processo de gestão de resíduos para obter um maior conhecimento específico. Por fim, foi feita uma análise de todos os resíduos produzidos pelo setor de administração, refeitório e dos setores de usinagem e montagem, e verificado o destino final de todos os resíduos gerados.

3.5.4 4ª. Etapa – Encerramento do projeto

O encerramento do projeto se deu em uma apresentação pública, onde estavam presentes todas as partes interessadas do projeto. Na apresentação foram entregues as propostas de melhorias e os painéis informativos sobre a gestão sustentável da empresa, e o relatório de pesquisa ao professor tutor.

3.5.5 5ª. Etapa – Avaliação dos alunos

A avaliação foi realizada conforme o andamento do projeto, entregas foram contabilizando notas para o resultado final, cada membro com sua função demandada pelo gerente do projeto. E no final, uma avaliação individual de cada membro do grupo, feita pelo tutor responsável.

4 Resultados

Após a análise da situação-problema foram realizadas primeiramente pesquisas com o intuito de entender mais sobre o tema, e então foram utilizadas ferramentas de mapeamento, para poder chegar à uma proposta de melhoria viável. Vale ressaltar que para um estudo mais aprofundado sobre o assunto, foi necessário realizar entrevistas com os colaboradores, observações e acesso à documentos da empresa, para ter um comparativo com a pesquisa bibliográfica.

4.1 Análise da situação-problema

Neste estudo de caso, a seleção do processo para a análise de melhoria de processo foi feita pela própria demanda da empresa, uma vez que é um projeto, sua justificativa foi propriamente a situação problema apresentada.

4.1.1 Mapeamentos - O sistema de gestão de resíduos sólidos atual

O estudo sobre a gestão teve início com a elaboração do *Diagrama SIPOC*, que deu a ideia da empresa como um todo. A extensão do *SIPOC* para um *"SIPOC* Sustentável", contendo o fluxo dos resíduos sólidos, permitiu entender a relação que os resíduos têm com o sistema e como estes saem do mesmo.

Baseado em Adissi (2013), foi realizado um segundo mapeamento, relativo aos classificados como resíduos diretos e indiretos da produção, e resíduos da administração, provenientes dos setores administrativos e refeitório.

Os resíduos diretos podem ser divididos entre resíduos gerados nos setores de Usinagem e Montagem. Contendo no primeiro, metais e óleo de usinagem misturado com limalha, além de limalha e pontas. E o segundo, metais como sucatas, mistos e cobre puro, resíduos de plástico e borracha.

Nos resíduos indiretos estão os resíduos gerados pela montagem, ou seja, resíduos de madeira, pano e água contaminada com óleo e resíduos de embalagem, no caso plástico, papel e papelão, madeira (bobinas) e cilindros de gás.

Dentre os resíduos da administração estão pilhas, baterias, eletrônicos, papel e papelão, plástico, resíduos orgânicos e metais.

4.1.2 Identificação dos problemas

O *brainstorming*, junto com a observação, tornou possível a identificação dos problemas, a partir da análise dos mapeamentos dos processos estudados.

Os problemas identificados foram: falta de classificação; falta de discriminação da fonte de origem; recolhimento inadequado de plástico com borracha; recolhimento inadequado de plástico com papel e papelão; recolhimento inadequado de demais resíduos inorgânicos com orgânicos da administração;

armazenamento inadequado de óleo utilizado e água contaminada; falta de definição da área de acondicionamento transitório; descarte inadequado de materiais contaminados com óleo; descarte inadequado de pilhas, baterias e eletrônicos; e destinação não identificada de resíduos da administração.

4.1.3 Agrupamento e priorização dos problemas

O agrupamento dos problemas foi realizado para que posteriormente as causas raízes em comum, com problemas de mesma família, fossem encontradas.

Através da Matriz de Afinidade, a maioria dos problemas foi agrupada de acordo com seu grau de similaridade, criando-se cinco grandes famílias de problemas, sendo elas: identificação incompleta; recolhimento inadequado; armazenamento inadequado; descarte inadequado e; destinação inadequada. Vale ressaltar também que os problemas de excesso de papel utilizado não foram agrupados.

A partir do agrupamento de determinados problemas em famílias, o Diagrama de Relações foi elaborado para que se identificassem quais problemas seriam mais impactados e quais seriam mais impactantes.

4.1.4 Levantamento e priorização das causas

As causas foram levantadas por meio do Diagrama de Ishikawa. É importante salientar que o Diagrama de Ishikawa foi feito para as famílias de problemas mais impactantes (Identificação inadequada e recolhimento inadequado). A família de problemas do armazenamento inadequado também foi considerada, pois se entendeu que era causador de problemas de descarte e posterior de destinação.

De forma geral e resumida, para os diferentes grupos, foram encontradas as seguintes causas: falta de solicitação de investimento; falta de procedimentos; falta de treinamentos; falta de incentivo; ciência do descarte inadequado; falta de conscientização e; falta de conhecimento.

4.2 Proposta de melhoria

As propostas de melhorias foram divididas basicamente em soluções entendidas como de curto prazo e de longo prazo. Além disso, foram propostos e, neste caso, confeccionados e impressos, painéis informativos relacionados aos problemas de identificação, conhecimento e conscientização encontrados.

4.2.1 Soluções gerais para as famílias de problemas - Longo prazo

Analisando o Diagrama de Ishikawa, percebeu-se que solucionando os problemas das causas-raíz, vários problemas derivados já seriam solucionados. Deste modo, as causas a serem tratadas foram: falta de procedimento, falta de treinamento, falta de incentivo e falta de conhecimento.

Os funcionários responsáveis pela limpeza devem seguir certo procedimento e devido treinamento. Este procedimento deve ser feito por um responsável da gestão de resíduos, e nele devem estar especificados quais os tipos de resíduos a empresa mais gera, como deve ser o recolhimento, sua separação, armazenagem e descarte, além de alertar a importância do uso de equipamentos de segurança no recolhimento.

Entendeu-se que para incentivar os colaboradores, é necessário capacitá-los e valorizá-los.

A falta de conhecimento pode ser resolvida a partir da educação ambiental através de palestras informativas e cartazes pela empresa, sobre a característica e risco de cada tipo de resíduo, a fim de que os colaboradores conheçam a importância do processo, para a empresa, comunidade e meio ambiente.

4.2.2 Soluções específicas para determinados problemas - Curto prazo

A partir das situações apresentadas em cada família foram propostos alguns conjuntos de soluções específicas que visam atingir determinadas causas. Estas soluções são compostas por:

- Instalação de uma cúpula nas proximidades da saída de peças dos tornos CNC, a fim de evitar o respingo de óleo proveniente da máquina;
- Instalação de uma bacia de contenção capaz de suportar no mínimo 10% do conteúdo armazenado sobre ela, ou a construção de um ralo de coleta em volta da área;
- Criação de um centro de recolhimento de resíduos eletrônicos na empresa;

- Criação de painéis informativos, estrategicamente espalhados pela fábrica, criação de procedimentos e treinamentos aos colaboradores e a criação de um sistema visual para a sinalização das áreas de acondicionamento e armazenamento que cada tipo de resíduo deverá sanar.
- Seguindo o INEA, na administração e refeitório deverão ser instalados três recipientes de coleta seletiva, "Reciclável" "Não Reciclável" e "Compostável".
- Descartar os materiais contaminados com óleo através das mesmas empresas que retiram o óleo e a água contaminada.
- Implementação de uma ferramenta de *Workflow* que diminua o excesso de papel gerado e automatize o processo de documentação, autorização, comunicação geral e ordem de produção, por exemplo.

4.2.3 Painéis propostos

Além de todo o conjunto de soluções e recomendações propostas, foram propostos e elaborados painéis compostos por uma tabela de classificação e discriminação da fonte de origem dos resíduos da empresa, a fim de melhor entendimento e visualização aos colaboradores e clientes, outro com o novo Sistema de Produção Sustentável, e um último com o novo aspecto-fluxograma da empresa, que permite o conhecimento das fontes geradoras de resíduos dentro da produção.

5 Conclusão

Com este estudo de caso foi possível concluir que uma disciplina de Aprendizado Baseado em Projetos consegue ser bem fiel à proposta, ao passo que os alunos são imersos em uma realidade empresarial. O dia-a-dia de uma manufatura torna-se algo mais próximo do ambiente acadêmico.

Foi verificado também que o planejamento de um projeto é essencial para sua posterior execução. Ferramentas de planejamento quando conhecidas e bem aplicadas embasam o trabalho a ser feito e encaminham em direção aos resultados esperados.

Além disso, com esta pesquisa foi possível compreender um pouco mais sobre os sistemas de produção sustentáveis e mais limpos e as tendências que estes vêm sofrendo com a evolução tecnológica.

Constatou-se a dificuldade em integrar o gerenciamento de negócios ao desenvolvimento sustentável e seus três pilares, no sentido de gerir, por exemplo, resíduos sólidos em uma empresa de tecnologia de soldagem. A falta de conhecimento, de conscientização, de procedimento e de treinamento para os colaboradores são, em muitos casos, causas-raiz de problemáticas maiores quando relacionadas à gestão ambiental de unidades produtivas.

Conclui-se, que a preocupação com os princípios da sustentabilidade e ajustes perante a não conformidades empresariais no âmbito ambiental são fatores importantes para que se atinja o desenvolvimento sem esgotar recursos para o futuro.

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The application of quality management practices in Superior Education Institutions: a systematic literature review

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Abstract

The educational process assessment is fundamental to identifying gaps between the student's expectation of quality and the actual service quality, in order to coordinate actions and achieve a better service quality level. The academy has made efforts to propose adaptable models to assess and improve quality in different Higher Education Institutions (HEI). This article's objective is to identify, in the scientific literature, the best quality assessment practices applied to HEI. In order to do so, it used a bibliometric method with the intent to organize the findings in the Web of Science database. The bibliometrics method utilized was the TCMAF – Theory of the Consolidated Meta-analysis Focus (Mariano e Rocha, 2017), a meta-analytic approach that follows the rules of bibliometrics, with the definition of key words, the time period of the research and the knowledge areas. Then where found 215 documents about the theme "Quality Management on Higher Education" that were organized by year of publication, authors that most published, institutions and countries with more publications and the most recurrent themes in the publications. This study used a qualitative, integrative and systematic review approach to organize the authors ideas in an integrative model of quality management practices applied in HEI. The study contribution was the analysis of the quality management practices in the HEIs, presented through a comparative board highlighting the research methods, the techniques used and the key results achieved by the main authors followed by a suggestion of managerial practices that stimulates a proactive attitude of the HEI with focus on process approach on quality, self-assessment models and program and projects planning to improve the observed quality of its services and product by the interested parts and contributors.

Key-Words: Quality Management Practices; Higher Educations Institutions; Theory of the Consolidated Meta-analysis Focus

A aplicação de práticas de gestão da qualidade em Instituições de Ensino Superior: uma revisão sistemática da literatura

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Resumo

A avaliação do Ensino é fundamental para identificar *gap´s* entre a qualidade esperada pelos discentes e a aplicada de fato, a fim de direcionar ações no sentido de atingir um melhor nível de qualidade deste serviço. A academia tem dispendido esforços para propor modelos de avaliação e de melhoria da qualidade adaptáveis para diversas Instituições de Ensino Superior (IES). Este artigo tem como objetivo identificar na literatura científica as melhores práticas de qualidade aplicadas às IES. Para isso, utilizou o método de bibliometria, com o intuito de organizar os resultados encontrados nos bancos de dados *Web of Science* e *Scopus*. A bibliometria foi realizada por meio da Teoria do Enfoque Meta-Analítico Consolidado (Mariano e Rocha, 2017), seguindo as leis bibliométricas, com a definição das palavras-chave, período temporal de pesquisa e áreas de conhecimento. A partir disso, foram encontrados 215 documentos sobre o tema "Gestão da Qualidade no Ensino Superior" que foram organizados por ano de publicação, autores que mais publicaram, instituições e locais com mais publicações e os termos mais recorrentes nas publicações. Este estudo utilizou abordagens de revisão qualitativas, integrativas e sistemáticas para organizar as ideias dos autores destes temas em um modelo integrador de práticas de gestão da qualidade aplicadas em IES. A contribuição do estudo foi a análise das práticas de qualidade aplicadas às IES, apresentada por meio de um quadro comparativo, ressaltando os métodos de pesquisa, as técnicas utilizadas e os resultados alcançados pelos principais autores, e a sugestão de práticas gerenciais que estimulem uma abordagem proativa das IES, com foco na gestão da qualidade baseada em processos, modelos de autoavaliação e planejamento de projetos e programas que visem melhorar a qualidade observada de seus serviços e produtos para as partes interessadas e colaboradores.

Palavras-chave: Práticas de Gestão da Qualidade; Instituições de Ensino Superior; Teoria do Enfoque Meta Analítico Consolidado.

1 Introdução

A qualidade do processo educacional em instituições de Educação Superior (IES) é dinâmico e por isso, deve estar atento às necessidades de mercado e da sociedade, aos novos perfis de estudantes e tecnologias disruptivas. As primeiras iniciativas de aplicação da qualidade para identificar pontos falhos, pontos fortes e propostas de melhorias na Educação Superior no Brasil, datam do fim da década de 80 e década de 90, que se consolidam com o Programa de Avaliação Institucional das Universidades Brasileiras – PAIUB. Neste período foram utilizados diversos instrumentos de medição para avaliar a qualidade dos cursos em Instituições de Ensino Superior, mas eles se mostraram insuficientes ou complexos demais para estabelecer um padrão avaliativo para todas as IES de um país continental como o Brasil e com diferentes níveis de maturidade para cada região (Sobrinho, 2010).

Em 2004, por meio da Lei nº10.861, foi instituído o Sistema Nacional de Avaliação da Educação Superior (SINAES), com o intuito de garantir a padronização entre as políticas nacionais de educação e a administração de cada instituição e seus resultados esperados (BRASIL, 2004). A Legislação institui que "a avaliação realizada pelo SINAES constituirá referencial básico para os processos de regulação e supervisão da Educação Superior, a fim de promover a melhoria de sua qualidade" (BRASIL, 2006) e contempla ferramentas de avaliação de desempenho conforme diretrizes e objetivos estabelecidos pelo governo brasileiro.

No Brasil os parâmetros de avaliação para a qualidade dos cursos de Educação Superior e das IES são discutidos e estabelecidos pela Comissão Nacional de Avaliação do Ensino Superior (CONAES), do Ministério da Educação (MEC), e o Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira (INEP) é responsável por planejar, executar, controlar e gerar relatórios acerca da avaliação de desempenho atual dos cursos de graduação de todas IES do país (BRASIL, 2004). A avaliação do desempenho da IES deve ser insumo para a gestão da qualidade na instituição e deve gerar análises de causa raiz e estabelecimento de planos de ação para aumento do desempenho observado, visando a manutenção do serviço educacional da instituição.

A avaliação do INEP contempla três eixos no processo de Educação Superior, são eles: o Estudante, a Instituição e o Curso. Para verificar o desempenho dos estudantes, é aplicada uma avaliação, conhecida como Exame Nacional do Desempenho dos Estudantes (ENADE). Quanto ao eixo da Instituição, é aplicada o Instrumento de Avaliação Institucional Externa (IAIE), que avalia as questões referentes à infraestrutura da IES. Com relação ao Curso, é utilizado como ferramenta o Instrumento de Avaliação do Curso de Graduação (IACG). As avaliações de Curso e de Instituição têm etapas bem definidas com análise preliminar da instituição e do curso, avaliação *in loco* e as considerações finais da avaliação com formação de conceitos geral e específicos. Os conceitos específicos são divididos em dimensões no caso do IACG do curso de graduação, sendo elas organização didático pedagógica, corpo docente e infraestrutura. Quanto ao IAIE da instituição, os eixos são planejamento e avaliação institucional, desenvolvimento institucional, políticas acadêmicas, políticas de gestão e infraestrutura institucional (INEP, 2017).

Uma Instituição Federal de Educação Superior (IFES) entrega valor à sociedade por meio de uma ampla carteira de serviços e produtos realizados em menores células organizacionais e cada uma delas possui indicadores a serem avaliados e controlados periodicamente para garantir uma melhoria contínua.

O objetivo geral deste artigo é realizar uma revisão sistemática da literatura sobre a aplicação da Gestão da Qualidade em Instituições de Ensino Superior (IES), a fim de verificar quais são as práticas adotadas para uma avaliação da qualidade dos serviços em instituições de Ensino, e propor um modelo que possa ser aplicado às Instituições de Ensino Superior (IES).

A seção 2 apresenta a metodologia adotada na condução do trabalho.

2 Metodologia da Pesquisa

Esta pesquisa realizou um estudo exploratório sobre a Gestão da Qualidade aplicada às instituições de Ensino Superior com abordagem qualitativa, e utilizou uma revisão sistemática da literatura, por meio de um enfoque meta-analítico, a partir da abordagem da Teoria do Enfoque Meta Analítico Consolidado (TEMAC) de Mariano e Rocha (2017). O TEMAC foi dividido em três etapas: a preparação da pesquisa; a apresentação e interrelação dos dados; e o detalhamento por meio de um modelo integrador.

Foram consideradas para consulta da revisão sistemática as bases de dados *Web of Science, e* Google Acadêmico. *A base de dados Web of Science* é considerada uma das mais completas em trabalhos acadêmicos, com ampla linha de tempo para publicações e ótimo sistema de indexação dos mesmos (Mariano e Rocha 2017), trabalhando com fator de impacto e *h-index* .

Na etapa da preparação da pesquisa foi necessário definir as palavras chaves, o espaço temporal e quais áreas de conhecimento seriam investigadas. O tema de pesquisa foi o "processo de planejamento, garantia e avaliação da qualidade do serviço de Ensino Superior". As palavras chaves foram "*university*" e "*quality management*", com um filtro temporal de 2000 até 2018 e com pesquisa restrita às publicações em engenharias mecânica, industrial, de manufatura e em administração empresarial.

Na segunda etapa do TEMAC, utilizando a plataforma *Web of Science*, foram obtidos os dados das revistas mais relevantes na área, revistas que mais publicam sobre o tema, evolução do tema nos últimos 18 anos, documentos mais citados, autores que mais publicaram e mais citados, países e universidades com mais publicações, agências que mais financiaram pesquisa, as áreas que mais publicam e a frequência de utilização de palavras-chaves. A apresentação e a interrelação dos dados é mostrada nas seções 3.2.

Para a conclusão da análise bibliométrica foi necessária a utilização do *software* gratuito *VosViewer* 1.6.5 (*http://www.vosviewer.com/)*, para criar grupos (*clusters*) de relacionamento entre os resultados encontrados na segunda etapa. Também foi realizada a leitura dos principais artigos identificados na segunda etapa e analisadas as cocitações dos resultados indexados da pesquisa para o entendimento das fontes de informação no assunto e sua rede de conexões com outros artigos relevantes.

Foram considerados também os dados provenientes de leis e instrumentos normativos do governo que discutem a avaliação da qualidade de instituições de Ensino Superior no Brasil.

Por fim, a partir dos resultados encontrados, foi proposto um modelo integrador com o objetivo de mostrar as melhores práticas de avaliação de qualidade voltadas à área de Educação.

A seção 3 exibe os resultados encontrados da revisão sistemática da literatura, tomando como base o método TEMAC.

3 Revisão Sistemática da Literatura

3.1. Etapa de preparação da pesquisa

A primeira etapa foi a preparação da pesquisa, ao qual foram pesquisados os termos "*University*" e "*Quality Management*", através da plataforma *Web Of Science,* delimitando as áreas de Engenharia de Produção, Engenharia Mecânica e de Administração Empresarial, no período de 2000 a 2018. A busca retornou 215 documentos relevantes.

3.2. Apresentação e interrelação dos dados

No levantamento bibliométrico foi observado que o documento mais relevante e mais antigo do filtro de pesquisa foi "*Quality Management applied for higher education*" (*Mergen et, al,* 2000) e ele propõe um modelo de três eixos (*Design*, Conformidade e Performance) para avaliar e identificar pontos de melhoria em instituições de Ensino Superior com a justificativa que até aquele ano não havia nenhum modelo padrão de gestão da qualidade em instituições de Ensino e isto gerou dificuldades na implementação dos princípios de Gestão da Qualidade, especialmente nas atividades fim da universidades (estrutura curricular, pesquisa, gestão da rotina e ensino). Esta busca por um modelo comum de Gestão da Qualidade se repetiu ao longo destes 18 anos como visto em um artigo, do ano de 2017, chamado *"Enhancing the Quality of Services and Reputation Level in Technical Engineering Higher Education"*, (*Dumitriu,* 2017) onde ele propõe uma adaptação da casa da qualidade do *QFD - Quality Function Development* para identificar as necessidades base da Gestão da Qualidade nas universidades, e faz citação ao artigo de *Mergen, E. et al* (2000), como autores que já apontavam a falta de modelos para melhoria contínua em universidades.

A Figura 1 extraída da plataforma *Web of Science* ilustra os artigos que combinam as palavras chave "Gestão da Qualidade" e "Universidade", no período de 2000 a 2018, representando o aumento no número de publicações no tema de Gestão da Qualidade nas instituições de Ensino.

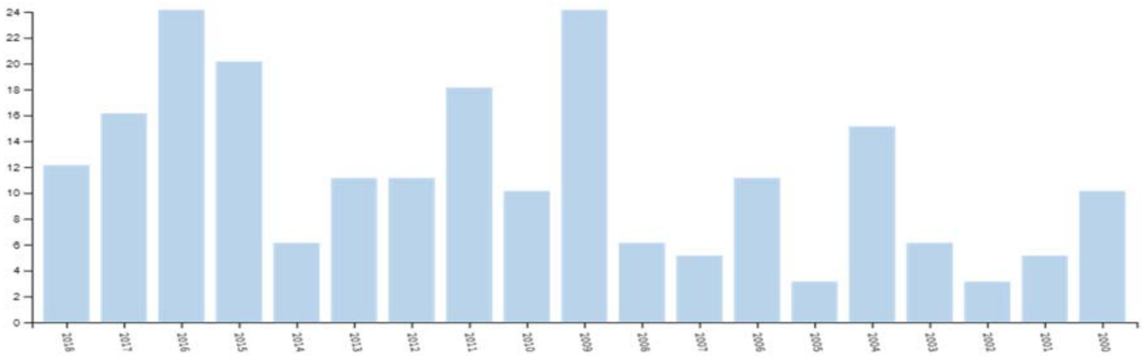

Figura 1 - Evolução de publicações ano a ano (Fonte: Web of Science, 2018)

Dos artigos identificados, o *"Relationships between the EFQM model criteria: a study in Spanish universities"* (*Calvo-mora,* 2005*)* foi o segundo mais citado entre os 215 documentos levantados. Ele faz uma análise multivariada da compatibilidade do modelo de excelência da fundação Europeia de Gestão da Qualidade

(EFQM) com objetivos de melhoria da qualidade e busca da excelência no serviço de IES, e conclui que é um modelo adequado. No artigo ele analisa temporalmente a Gestão da Qualidade nas IES espanholas que em 1995 tiveram suas primeiras avaliações da qualidade, contemporâneo ao início do Programa de Avaliação Institucional das Universidades Brasileiras - PAIUB que também foi o primeiro programa integrador da avaliação da qualidade em IES do Brasil. O modelo proposto para IES neste artigo de *Calvo-mora* é um *framework* de nove critérios para avaliação de serviço, estes critérios são inspirados nos conceitos de Qualidade Total (TQM - *Total quality management*) e são eles: liderança, pessoas, política e estratégia, cadeia de suprimento e parcerias, processos internos, resultados com pessoas, resultados com clientes, resultados com a sociedade e estabelecimento de KPI - *Key Perfomance Indicators*.

Ainda no levantamento bibliométrico revela-se o autor que mais publicou artigos neste tema, *Rusu, Costache* com quatro publicações. Ele revisou as mudanças no sistema de Gestão da Qualidade de IES na Romênia e identificou os fatores mais críticos para a garantia da qualidade, conduzido por questionários aplicados aos reitores das dez maiores Universidades do país. Rusu em seu artigo mais recente, "*From Quality Management to Managing Quality*", chamou a atenção na atuação do gestor de qualidade da Universidade para a realização de suas atividades sempre com respaldo científico, com baixo custo e análise do impacto na performance do serviço prestado. Este autor também evidenciou a importância da avaliação da qualidade sob a perspectiva de diversos atores do processo, ele escreveu: "Os gestores de universidades ganham uma nova atividade: Ser receptivos com as necessidades de clientes, usuários e sociedade" (*RUSU*, 2016, pg. 293, tradução do autor).

3.3. Detalhamento, modelo integrador e validação por evidências

Com base nos metadados obtidos da plataforma *Web Of Science,* através da ferramenta *VOSViewer* foi possível identificar o fator de cocitações e a relação entre os pares dos artigos que são citados com alguma regularidade, representado através de um mapa de calor, conforme apresentado na Figura 2, a partir dos 215 artigos encontrados. Posteriormente, foram revisados os autores presentes neste mapa e feita uma análise de proximidade dos temas para detalhamento da literatura do trabalho e proposta de um modelo integrador.

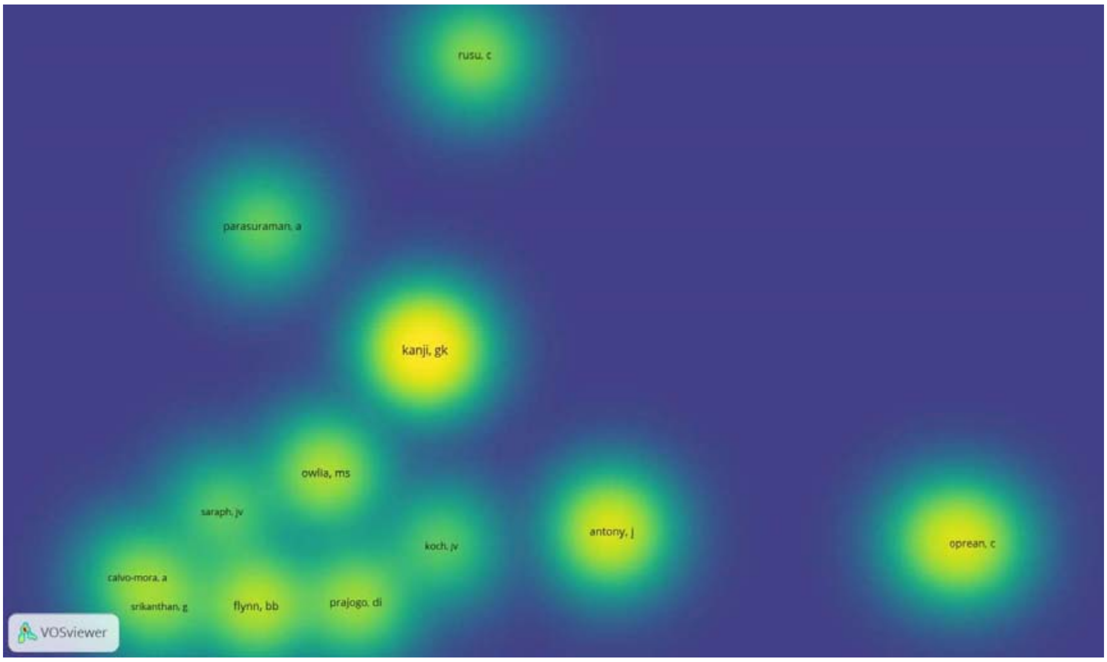

Figura 2 - Mapa de calor de cocitações (Fonte: Elaborado pelos autores, com o software *VOS Viewer*)

Dada a proximidade entre os clusters de citação na Figura 2, é importante apresentar as ideias dos autores Kanji e Parasuraman, apesar de suas publicações não serem especificamente sobre o tema "Qualidade em IES", eles são os mais citados como referência em Gestão da Qualidade para os autores que exploraram esta área de conhecimento no contexto de IES. A citação que conecta os diversos autores nesta pesquisa bibliográfica é a de Kanji, com sua publicação sobre os princípios da Qualidade Total (TQM) e como ela mudou o cenário competitivo global nas indústrias. Em seu artigo "*Total Quality Management: the second industrial revolution*", Kanji afirma que a qualidade é erroneamente associada às despesas em um processo, mas atualmente sabe-se que processos com alto custo podem ter baixo valor agregado ao cliente e processos de baixo custo podem ter um valor agregado maior aos olhos do cliente, logo a percepção do cliente deve ser o foco principal da Gestão da Qualidade e deve permear todo fluxo de valor da organização, buscando a integração de toda organização e baixos custos, e não somente em processos de apoio com a inspeção do produto (*Kanji*, 1990). Kanji faz um revisão dos 14 princípios da Gestão da Qualidade Total, suas ferramentas essenciais e quais etapas críticas para implementação desta metodologia, sendo elas Identificação e preparação do projeto de implementação, compreensão e compromisso da alta gestão com a qualidade total, estabelecimento de um processo horizontal para a melhoria contínua e o desenvolvimento de novas iniciativas com informações do primeiro ciclo do projeto de qualidade (baseado na metodologia PDCA - *plan, do, check and act*).

Outro autor relevante e com influência nas publicações foi Parasuraman, que desenvolveu uma ferramenta que analisa quantitativamente os *gap's* entre o valor enxergado e o esperado por clientes de serviços. Esta ferramenta foi chamada de SERVQUAL e até hoje é utilizada por organizações em diversos setores devido à sua natureza generalista. Esta abordagem generalista na qualidade de serviços é necessária, pois segundo Parasuraman (1988), "serviço é um construto abstrato e elusivo por conta de três características únicas: intangibilidade, heterogeneidade e inseparabilidade de produção e consumo."

Com base nas ferramentas de gestão da Qualidade Total revisadas por Kanji e na importância da percepção do cliente sobre o *design* do serviço, as outras publicações relevantes levantadas buscam integrar estes compromissos com a qualidade e identificação do "caminho do cliente" para perceber a qualidade nos ambientes universitários e nos processos de negócio e de apoio que o sustentam. Nas publicações de Calvo-mora, Leal e Roldán observa-se a proposta de adaptar modelos de Gestão da Qualidade advindos do setor industrial para o ambiente interno e externo de IES. No artigo *Relationships between the EFQM model criteria: a study in Spanish universities* (2005), estes autores realizam uma mudança nos viabilizadores dos resultados obtidos pelos processos de liderança, políticas e governança, processos finalísticos e análise de valor para o cliente, tradicionalmente do Modelo de Excelência em Gestão (MEG) da Fundação Europeia para Gestão da Qualidade (EFQM), para se adequarem às principais pessoas impactadas pelo ecossistema de instituições de Ensino Superior. Estes viabilizadores de resultado são definidos como gestão de pessoas; parcerias e recursos; resultados estudantis, de pessoas e para a sociedade. Neste documento os autores utilizaram um questionário, em Escala *Likert* 1-7, direcionado aos processos e seu relacionamento com os viabilizadores de resultados adaptados do modelo EFQM. Como resultado de pesquisa, confirmaram as hipóteses (por análise de R-quadrático) de que há uma relação lógica entre os viabilizadores de resultados do modelo em que a liderança e o comprometimento da alta gestão têm maior impacto sobre os viabilizadores de resultados por meio da institucionalização de políticas e estratégicas para a Gestão da Qualidade e dos recursos escassos à disposição da faculdade. Este é um primeiro passo para qualquer projeto de implementação da gestão da qualidade na administração universitária, pois sem estratégias definidas *top-down* e com bom fluxo de comunicação entre os envolvidos, não é possível a medição de sucesso do projeto.

Os autores conseguiram demonstrar a relação entre a garantia da eficiência administrativa e de ensino com a obtenção de resultados de pesquisa e produtos para a sociedade. Além das contribuições dadas pelos autores citados, previamente é importante comentar também a revisão sistemática do tema, realizada por Maria J. Manatos, Cláudia S. Sarrico e Maria J. Rosa em 2015, que aponta uma tendência em busca da internalização da Gestão da Qualidade nas políticas e sistemas de gestão das IES. No texto, os autores citam os três níveis onde deve haver integração de práticas da Gestão da Qualidade das IES: nível de processo; de organização e de princípios da qualidade, e por sua vez cada nível possui critérios e desmembramentos diferentes. Com relação ao nível de processo, possui os critérios de ensino e aprendizado, pesquisa e acesso à educação, processos de apoio e serviço à comunidade. Quanto ao nível de organização, contempla critérios para um programa, unidade e instituição; e para o nível de princípios da qualidade (inspirados na norma ISO 9000:2015) deve-se avaliar critérios como foco no cliente, liderança, envolvimento das pessoas, abordagem por processos, visão sistêmica, melhoria contínua, tomada de decisão apoiada em fatos e dados, e relação ganha-ganha.

A revisão sistemática indicou que, quanto ao nível de processos, as pesquisas publicadas neste tema têm mais foco em ensino e aprendizado. Já no nível de organização, essas aplicações de ferramentas da qualidade são realizadas a nível institucional. No tocante aos princípios da qualidade, o ponto mais enfatizado e priorizado é o foco no cliente. Este estudo corrobora com as propostas de implantação de ferramentas de Gestão da Qualidade nos processos de autoavaliação do ensino e aprendizado de um curso de Ensino Superior (os estudantes e seus conhecimentos ao sair da universidade) e com a identificação de necessidades socioeconômicas do ambiente onde a instituição está situada, que é o foco no cliente. Foi elaborado um resumo com os principais conceitos apresentados por cada um destes autores mais relevantes no levantamento bibliométrico, que pode ser visualizado no Quadro 1.

Quadro 1: Artigos e autores mais citados (Fonte: elaborado pelos autores, 2019)

Artigos	**Autores**	**Método**	**Técnicas utilizadas**	**Resultados alcançados**
Total quality management: the second industrial revolution	Kanji, G. K.	Estudo de caso qualitativo aplicado	Observação	O propósito do autor é descrever os conceitos de qualidade propostos por Deming, expondo os princípios do TQM, sua implementação e as principais ferramentas utilizadas na estratégia de produção, dentre elas a análise de fluxo de valor, poka yoke, gestão visual, controle estatístico de processos e just in time. Kanji aponta que o custo de qualidade total é menor que o custo de oportunidade de não se adaptar.
Servqual: A multiple-item scale for measuring consumer perception of service quality	Parasuraman, A.	Pesquisa exploratória quantitativa	Aplicação de surveys	Este texto analisa os parâmetros determinantes na venda de serviços, deste modo, os autores por meio de pesquisas exploratórias feita em shoppings com centenas de clientes e com etapas de execução, avaliação de resultado e refinamento da pesquisa desenvolveram uma escala avaliativa de qualidade comparando as funções esperadas com as funções percebidas pelos clientes de serviços, esta escala foi chamada de SERVQUAL. Este artigo não cita diretamente o tema de qualidade em IES mas apresenta uma ferramenta para a avaliação do serviço prestado pelas IES.
From Quality Management to Managing Quality	Rusu, C.	Pesquisa teórica qualitativa	Observação	O objetivo do trabalho é influenciar a alta gestão de IES para a cultura da qualidade e propor um processo de tomada da decisão administrativa para os métodos de ensino, produção científica e projetos de extensão, baseado em necessidades globais socioeconômicas e com ações corretivas anuais para melhoria de conceitos; currículo; infra-estrutura; avaliações e corpo docente.
Relationships between the EFQM model criteria: a study in Spanish universities	Calvo-mora, A., Leal, A., Roldán, J. L.	Estudo de caso qualitativo aplicado	Questionários e regressão linear com mínimo quadrático	O artigo procura adaptar algum método de gestão da qualidade para os gestores de IES. O modelo escolhido para estudo foi o modelo de excelência em gestão da EFQM (mudando os viabilizadores de resultados para gestão de pessoas, parcerias e recursos, resultados estudantis, resultados de pessoas e resultados para a sociedade) e a atribuição de valores de importância para as dimensões deste modelo selecionado.
The integration of quality management in higher education institutions: a systematic literature review	Manatos, M., Sarrico, C., Rosa, M.	Revisão sistemática da literatura	Pesquisa bibliométrica	Os autores fizeram um resumo de pesquisas sobre a gestão da qualidade na Educação por meio de revisão sistemática da literatura e apresentaram as tendências futuras e definição das principais linhas de pesquisa em gestão da qualidade da educação: Integração das ferramentas de Gestão da Qualidade com a administração geral de IES.
Quality management applied to higher education	Mergen, E., Grant, D., & Widrick, S. M.	Estudo de caso qualitativo aplicado	Observação	Os autores elaboraram um modelo para operacionalizar atividades universitárias com base na descrição de qualidade do design, conformidade e performance dos seus serviços. Ao fim do artigo um modelo de gestão administrativa é sugerido como base para processos de reestruturações curriculares e avaliação do ensino e pesquisa.

Com base no resultado da pesquisa sobre as práticas de qualidade adotadas em instituições de Ensino, a Figura 3 destaca as práticas utilizadas pelos autores que contribuíram com os estudos.

Figura 3 - Práticas de Gestão de Qualidade adotadas pelas IES (Elaborado pelos autores, 2019)

A partir das práticas identificadas pelos artigos e autores mais citados, que mostraram pesquisas relevantes, foi proposto um desenho de um modelo integrador para a avaliação da Qualidade na Educação. Este modelo propõe a adoção de uma cultura pró ativa de gestão da IES com processos de autoavaliação da qualidade percebida pelas principais partes interessadas, representadas pela sociedade e pelos atores internos da instituição, sob diferentes dimensões do processo educacional (pesquisa e inovação, ensino e aprendizado). O modelo apresenta também o desenvolvimento de planos de ação para melhorar os níveis observados pela autoavaliação e *rankeamentos* externos. Para nortear o nível de qualidade e a qualidade observada para os serviços, sugere-se a aplicação de ferramentas de análise de percepção, como o SERVQUAL, e métodos de engenharia de serviço e de produtos com base no levantamento de necessidades, como a elaboração do QFD para definir os produtos oriundos de processos de ensino e aprendizado, pesquisa e acesso à educação, processos administrativos e de apoio e serviço prestados à comunidade, como pode ser visto na Figura 4.

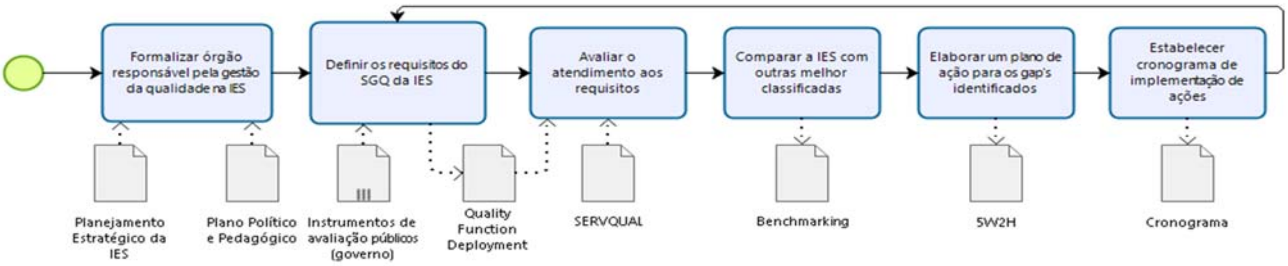

Figura 4 - Modelo Integrador (Elaborado pelos autores, 2019)

O modelo integrador ilustrado na Figura 4 tem como objetivo apresentar o processo de Sistema de Gestão da Qualidade que contempla as práticas propostas nas IES, utilizando o QFD para definir requisitos do SGQ que serão insumos para adaptação do SERVQUAL na avaliação da IES, de acordo com as pesquisas realizadas na revisão sistemática da literatura. Espera-se que as IES possam gerenciar o processo do Sistema de Gestão da Qualidade, por meio do ciclo PDCA, monitorando a implementação das ações. Vale ressaltar que a provisão de recursos é fundamental para que o modelo funcione na prática, recursos esses que devem ser empregados na capacitação de docentes e disponibilização de infraestrutura adequada.

4 Conclusão

A qualidade dos serviços oferecidos pelas instituições educacionais no Brasil é responsabilidade do Ministério da Educação (MEC). O SINAES estabelece e regula as normas, com o propósito de garantir a padronização para a definição das políticas nacionais de educação. O INEP por sua vez, é responsável por avaliar o desempenho dos cursos de graduação, apontando as lacunas existentes. Existem indicadores de qualidade para avaliar os eixos da Educação que se referem ao Estudante, à Instituição e ao Curso. No Brasil, é necessário seguir as orientações do MEC para se tornar um curso de referência.

Foi realizado um levantamento bibliométrico sobre a aplicação da Gestão da Qualidade em instituições de Ensino Superior e identificou-se, por meio dos estudos mais relevantes as práticas utilizadas na avaliação do nível de qualidade das IES. Segundo a literatura, as práticas de qualidade mais adotadas fora do Brasil são a adoção de TQM e suas técnicas; a aplicação de ServQual para identificar as percepções dos atores, a adoção do Modelo de Excelência em Gestão (EFQM) e a Gestão por Processos. A partir das análises, propôs-se um modelo integrador para que possa ser utilizado por instituições de Ensino, com o objetivo de garantir a qualidade dos serviços oferecidos à sociedade.

Ainda sobre as práticas mais utilizadas para avaliação da qualidade nas IES, os resultados indicaram a utilização de questionários para levantamento de requisitos da qualidade nas perspectivas de atores internos, sociedade impactada pela IES e dos alunos, a aderência à modelos sólidos de mercado e indústrias para excelência em gestão e qualidade total e a comparação de avaliações de qualidade entre IES por meio da realização de *benchmarkings*.

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Education in Engineering: Application of Active Learning in the Context of Population Aging

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Abstract

In recent years active learning practices have been increasingly applied in the classroom, directed to the various stages of teaching. In this sense, the young person is the core of the directions for applying this methodology. However, the advent of the demographic transition has made the world more and more aged. The society that previously did not provide a social place for its elders today needs to redirect efforts by developing educational practices that increasingly contemplate the participation of these individuals. In this sense, this article aims to map the discussions about applied active learning, in the educational educational context, for the elderly. This study is of the bibliographic type, exploratory in nature and quantitative approach through TEMAC, in the WOS and Scopus databases. The results revealed that the active learning applied to the elderly in engineering does not exist since the focus is still on solutions of problems of this group, by the students of engineering, especially for students of biomechanics, with the proposal to improve mechanical prostheses and similar.

Keywords: Active learning, Education, Population Aging, Elderly.

Educação na Engenharia: Aplicação da Aprendizagem Ativa no contexto do envelhecimento populacional

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Resumo

Nos últimos anos as práticas de aprendizagem ativa têm sido cada vez mais aplicadas em sala de aula, direcionadas para as várias etapas de ensino. Nesse sentido, têm-se o jovem como cerne dos direcionamentos para aplicação dessa metodologia. Contudo, o advento da transição demográfica, tornou o mundo cada vez mais envelhecido. A sociedade que antes não previa um lugar social para seus idosos, hoje, precisa redirecionar esforços elaborando práticas educativas que contemplem cada vez mais a participação desses indivíduos. Nesse sentido, esse artigo tem como objetivo mapear as discussões sobre aprendizagem ativa aplicada, no contexto educacional de engenharia, para os idosos. Este estudo é do tipo bibliográfico, de caráter exploratório e abordagem quantitativa por meio do TEMAC, nas bases *WOS* e *Scopus*. Os resultados revelaram que a aprendizagem ativa aplicada para os idosos na engenharia não existe uma vez que o foco ainda está voltado para soluções de problemas desse grupo, pelos estudantes de engenharia, sobretudo para os alunos de biomecânica, com a proposta de aprimorar próteses mecânicas e similares.

Palavras-chave: Aprendizagem ativa, Educação, Envelhecimento Populacional, Idoso.

1 Introdução

De acordo com a Organização Mundial da Saúde - OMS, até o ano de 2025 o Brasil, em transição demográfica, será o sexto do mundo em número de pessoas idosas e, pela PNAD (2017), o país já conta com 30,2 milhões de indivíduos idosos. Miranda, Mendes & Silva (2016) observaram por exemplo que, em 2010, existiam 39 idosos para cada grupo de 100 jovens e, em 2040, estimaram um número três vezes maior: 153 idosos para cada 100 jovens. Desse modo, o contexto político, econômico e social do envelhecimento passa a ser de interesse dos pesquisadores no intuito de pensar subsídios de transformação social mediante essa nova condição dos cidadãos.

As oportunidades educacionais tornam-se uma opção libertadora para os idosos, já que oferecerem a convivência de uma mesma geração, abrem a possibilidade de atuação em comunidade e melhoram a qualidade de vida desses indivíduos. Numa perspectiva societária, a escolaridade tem implicações importantes nas formas de viver a longevidade na medida em que impacta a qualidade de vida, autonomia, participação social e condições de saúde da pessoa idosa (Elo, 2009; Percac-Lima, Grant, Green, Ashburner, Gamba, Oo & Atlas, 2009).

Já as práticas de aprendizagem ativa têm sido cada vez mais aplicadas em sala de aula, direcionadas para as várias etapas de ensino focando, contudo, no jovem como cerne dos direcionamentos para aplicação dessa prática. É sabido que esse tipo de metodologia funciona adequadamente para os jovens, contribuindo na construção de competências e habilidades visto que "exigem pesquisar, avaliar situações, pontos de vista diferentes, fazer escolhas, assumir alguns riscos, aprender pela descoberta, caminhar do simples para o complexo" (Morán, 2015, p. 18).

Nesse cenário, surge a pergunta que orienta esse trabalho: A aprendizagem ativa está sendo aplicada, no contexto educacional da engenharia, para os idosos?

Este trabalho contribui na ampliação dos estudos da temática relacionando-a ao campo do envelhecimento populacional, promovendo não só oportunidade para pesquisas futuras, mas também fomentando a discussão atual entre os estudiosos das políticas públicas educacionais no Brasil.

Assim, este artigo tem como objetivo mapear as discussões sobre aprendizagem ativa aplicada, no contexto educacional de engenharia, para os idosos a partir das bases de dados *Web of Science* e Scopus.

Por se tratar de revisão da literatura, esta pesquisa apresenta o método, a revisão e os resultados, de uma só vez já que a revisão é o resultado perseguido. Na sequencia é apresentado as discussões dos resultados, as considerações finais e as referências do trabalho.

2 Método

Trata-se de uma pesquisa de natureza exploratória com abordagem quantitativa. Foi proposto uma revisão de literatura do tipo pesquisa bibliométrica, através do Enfoque Metaanalítico Consolidado – TEMAC de Mariano & Rocha (2017). O TEMAC é composto por três etapas: preparação da pesquisa, apresentação e interrelação dos dados, detalhamento e validação por evidências.

Por sua qualidade e nível de informações disponíveis essa pesquisa utilizou as bases de dados *Web Of Science (WOS) e Scopus* para a análise bibliométrica. A coleta de dados se deu entre 15/03/2019 e 20/04/2019. O objeto de estudo analisado foram os idosos no contexto da aprendizagem ativa na engenharia.

A busca inicial foi realizada em duas etapas. Na primeira etapa buscou-se em ambas as bases de dados as palavras-chaves "*active learning*" AND *education*, sendo apenas o primeiro termo com aspas. O resultado total encontrado foi 1164 registros. Nessa etapa buscou-se identificar o cenário global da aprendizagem ativa no contexto educacional da Engenharia. Na segunda etapa, incluiu-se o termo "*elderly*", com o intuito de trazer o contexto do idoso no cenário já mapeado. Contudo a busca na plataforma *WOS* não reportou nenhum artigo e, na *Scopus*, foram exibidos apenas 4 artigos com essa palavra como filtro.

As próprias plataformas serviram como instrumento de coleta de dados, visto que possuem métodos sistematizados de exportação de arquivos de dados. Para gerar os mapas de calor de *co-citation* e *coupling*, foi realizada a junção dos resultados das duas bases pesquisadas. Para realizar essa análise foi utilizado o software *VosWiewer*.

3 Revisão e Resultados

3.1 Preparação da Pesquisa

Em ambas as bases foi realizada uma busca pelas palavras-chaves "active learning" AND education sendo apenas o primeiro termo com aspas. Como resultado da *WOS*, foram reportados 3.730 artigos e 7.203 artigos da *Scopus*. Refinou-se os filtros da busca somente para a área de engenharia, no espaço temporal de 5 anos (2015 a 2019). O resultado para *WOS* foi de 237 artigos e para a *Scopus* 927. Quando se filtrou os resultados pela palavra "elderly" encontrou-se zero artigos na *WOS* e quatro na *Scopus*. Os detalhes serão explicados na interrelação dos dados.

3.2 Apresentação e interrelação dos dados

O artigo mais antigo exibido na plataforma *WOS* foi "*Sustainable Construction Education Using Problem-Based Learning and Service Learning Pedagogies*" dos autores, El-adaway, Pierrakos , Truax (2015), publicado em janeiro de 2015, que fala sobre a incorporação de conceitos de desenvolvimento sustentável na educação em engenharia por meio da aprendizagem ativa com o objetivo de que engenheiros possam projetar, construir e operar os sistemas de infraestrutura. As metodologias ativas utilizadas foram, a aprendizagem baseada em problemas (PBL), aprendizagem de serviço (SL), estratégia de gerenciamento de curso, bem como as filosofias educacionais e de aprendizagem.

Já na *Scopus* o artigo mais antigo foi "*Tablet PCs and slate devices can improve active learning classroom experiences*" dos autores Tront & Prey (2015), discutem que o uso de Tablet PCs e um esforço nominal, os professores conseguiram aumentar e enriquecer a interação aluno-professor, resultando em maior compreensão e retenção de informações dos estudantes quando as sessões em sala de aula são interativas, em vez de palestras passivas mais tradicionais.

Do total dos 237 documentos reportados, *WOS* 156 são artigos e 81 *Proceedings Paper*. Já na *Scopus* 645 são *Conference Paper*, 246 *Article*, 12 *Book Chapter* e 24 outras publicações. Sobre os idiomas publicados, têm-se o inglês, o espanhol, o português e o japonês em ambas as bases pesquisadas. Na *WOS*, os três países que mais publicam são: Estados Unidos, Espanha e Japão. Já na *Scopus*, aparecem Estados Unidos, Brasil e Portugal nas três primeiras colocações.

As palavras-chave foram analisadas de forma agregada nas duas bases. Conforme a figura, têm-se uma nuvem de palavras onde os termos *education, engineering, learnig, active* sobressaem-se. Esse resultado é esperado quando confronta-se as os termos de busca, confirmando a sistematização do processo. O resultado inovador aparece nas palavras acessórias como *artificial, computer, intelligence, programming, project, teaching, systems, technology* que podem apontar que os caminhos da aprendizagem ativa na área de engenharia estão fortemente relacionados com o desenvolvimento e a aplicação tecnológica.

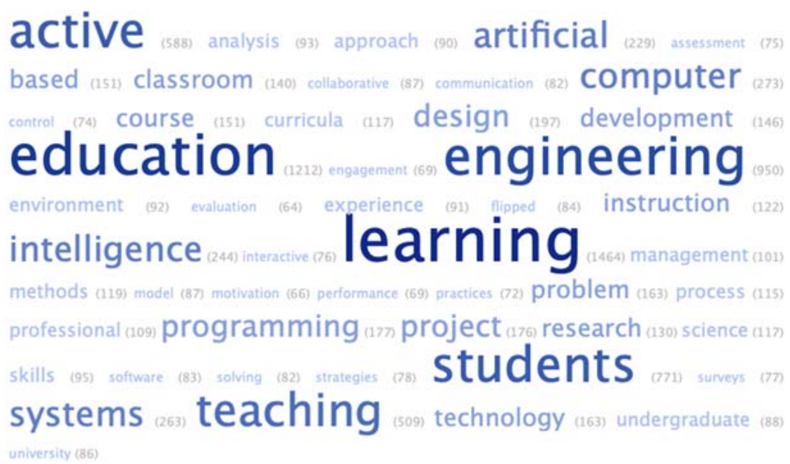

Figura 1 – Nuvem de palavras-chave dos artigos reportados. Fonte: tagcrowd.com

Finalmente, quando se filtra os resultados da busca "*active learning*" e "*education*" com o termo "*elderly*", tem-se apenas quatro artigos, em ambas as bases, que estão apresentados no quadro abaixo. Conforme pode-se observar, o idoso não é contemplado nesse contexto de aprendizagem ativa na educação em engenharia. Os resultados encontrados mostram que o idoso, quando é citado, faz parte do contexto de aprendizagem do estudante e, não o ator envolvido na aprendizagem ativa.

Quadro 1 – Resultado do termo "*elderly*" na pesquisa de aprendizagem ativa na educação em engenharia

Título	Autores	Ano	Pesquisa
Bad to the Bone: Multifaceted Enrichment of Open-Ended Biomechanics Class Projects	Kuxhaus, L., Troy, K.L.	2018	A mentalidade empreendedora (EML) é uma estrutura que o corpo docente pode usar para enriquecer projetos de cursos promover tanto a mentalidade empreendedora quanto a proficiência técnica em estudantes de graduação em engenharia. Nos projetos, implementados em EML em diferentes instituições com dados demográficos estudantis semelhantes, os alunos tiveram um bom desempenho e desfrutaram da natureza "real" dos projetos, apesar de suas frustrações com a natureza aberta das questões colocadas.
Elements of Technology Enabled/Enhanced	Hassan, N.F.B., Puteh,	2018	A Tecnologia Ativada / Aprimorada Aprendizagem Ativa (TEAL), combina conteúdo educacional de um palestrante, simulação e experiências do aluno usando ferramentas tecnológicas para fornecer

Título	Autores	Ano	Pesquisa
Active Learning (TEAL) to Enhance Quality and Employability of Bachelor's Students	S.B., Muhamad Sanusi, A.B.		uma rica experiência de aprendizado colaborativo para os alunos. Garante o desenvolvimento aprimorado do conhecimento e das habilidades do aluno, a fim de produzir trabalhadores qualificados e com habilidades adequadas de empregabilidade. Os resultados mostram que elementos do TEAL ajudariam as instituições a promoverem os estudantes a se envolverem na aprendizagem ativa.
Designing a table-top tangible user interface system for higher education	De Raffaele, C., Buhagiar, G., Smith, S., Gemikonakli, O.	2017	A capacidade das Interfaces de usuário tangíveis (TUI) de envolver e intrigar os alunos em pedagogias de aprendizagem ativa comprovada no ensino superior. Os resultados obtidos ilustram um aprimoramento significativo da experiência do aluno durante a utilização de tal tecnologia e descrevem quantitativamente a potencialização do design para transmitir conceitos complexos no ensino superior.
A case study of interprofessional collaboration between engineering and health sciences students at Penn State DuBois	Waryoba, D.R., Demi, L., Fatula, A.	2016	Estudo de caso de projetos de design colaborativo entre alunos do primeiro ano de engenharia (ENG) e do segundo ano de Assistente de Terapia Ocupacional (OTA). Concepção e fabricação de dispositivos de assistência para pessoas idosas e / ou deficientes. A colaboração também os ajudou a apreciar o conhecimento que as pessoas trazem de outras profissões que introduz novas ideias para a equipe, respeitando os pensamentos e as ideias dos outros.

Fonte: Autor

3.3 Detalhamento e validação por evidências

A último passo do TEMAC realiza a análise das principais contribuições e abordagens das bases selecionadas (*Scopus* e *WOS*) por meio de *coupling*, e *co-citation* que demonstram respectivamente as frentes de pesquisa e as principais abordagens sobre aprendizagem ativa na educação em engenharia. Foi utilizado o software *VOSviewer* para criar o mapa de calor apresentado na Figura 2 e 3, respectivamente.

Para a análise do *co-citation*, as bases foram agregadas utilizando o algoritmo scop2wos. O resultado apresenta zonas de calor que representam um conjunto de autores com teorias e abordagens similares e que são citados juntos em relação a temática pesquisada (Ramos-Rodrígue & Ruíz-Navarro, 2004). A figura 1 exibe quatro clusters.

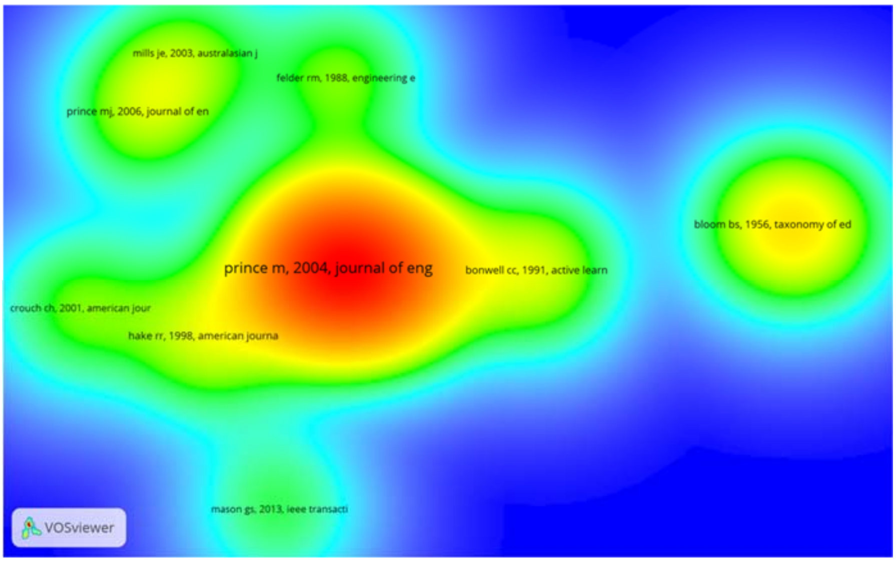

Figura 2 – Co-citation

Fonte: VOSviewer

O primeiro cluster formado está a direita e dedica-se inteiramente ao assunto da educação em si. Trata-se da referência a Bloom (1956) em seu artigo "*Taxonomy of educational objectives*" focado nas habilidades que devem ser desenvolvidas nos alunos a medida que progridem seus conhecimentos. De acordo com o autor ele deve passar basicamente pelas etapas de conhecimento, compreensão, aplicação, análise, síntese e avaliação.

O segundo cluster é formado por 4 autores e, é neste cluster que está o cerne das discussões visto a zona mais avermelhada do mapa. O autor mais antigo é Hake (1998) com o artigo "*Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses*" que verificou que o engajamento interativo dos alunos se mostrou com melhores resultados que os métodos tradicionais.

Bonwell, & Eison (1991) aparecem com o artigo "*Active Learning: Creating Excitement in the Classroom*" uma monografia que examina a natureza da aprendizagem ativa no nível superior, a pesquisa empírica sobre o uso desta metodologia e os obstáculos mais comuns em relação ao corpo docente e discente para implementar técnicas ativas de aprendizado.

O artigo "*Peer instruction: Ten years of experience and results*" de Crouch, & Mazur (2001) atesta o aumento do domínio em cálculo e álgebra para não-residentes a partir da aplicação do Peer Instruction (PI) nos cursos introdutórios de física. E, finalmente, Prince, M. (2004) com o artigo "*Does active learning work? A review of the research*" que realiza uma revisão da aprendizagem ativa e como ela trabalha, que aparece como destaque do mapa como o autor mais citado nas buscas.

No terceiro *cluster* estão localizados os autores Prince & Felder (2006), Mills & Treagust (2003) e Felder & Silverman (1988). Todos discutindo o ensino dedutivo e indutivo direcionado para os cursos de engenharia.

No último *cluster*, está Mason, Shuman, & Cook (2013) que, no artigo "*Comparing the effectiveness of an inverted classroom to a traditional classroom in an upper-division engineering course*", trazem resultados de uma sala de aula invertida com um método que pode liberar o tempo de aula para atividades centradas no aluno.

O segundo mapa de calor, representa os principais *fronts* de pesquisa, revelando quais autores tendem a permanecer importantes (Figura 3).

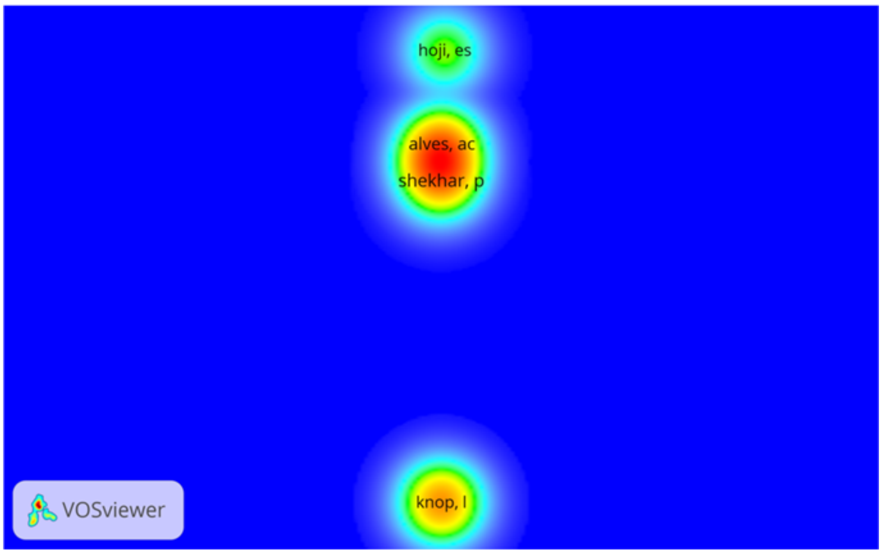

Figura 3 – Coupling

Fonte: VOSviewer

Na figura 3 o mapa indica os autores mais citados como Alves, e Shekhar que escrevem sobre experiências em tutoria, percepções em PBL e aprendizado baseado em projetos de programas de engenharias elétrica, civil e gestão industrial. Em amarelo, está Knop, como o segundo cluster relevante. Ele possui artigos direcionados para aprendizagem ativa de alunos do ensino médio focado na educação STEM, acrônimo usado para designar quatro áreas do conhecimento: Ciências, Tecnologia, Engenharia e Matemática. Finalmente, no terceiro cluster, Hoji, que escreveu artigos que relatam sobre estratégias colaborativas de ensino e aprendizagem combinando comunicação de dados e redes de computadores.

4 Discussão dos Resultados

Os resultados da aprendizagem ativa na educação, focada na área de engenharia foram bastante positivos, apontando que este assunto já vem sendo discutido pelo menos há duas décadas na área.

Contudo, a ausência da palavra "*elderly*" na busca dos resultados, na base *WOS* e o *report* de apenas 4 artigos na base *Scopus*, sem colocarem o idoso como ator envolvido no trabalho da metodologia ativa, refletem o ageísmo presente na sociedade. Na perspectiva do ageísmo, o conceito de idoso é baseado na estereotipagem e discriminação contra as pessoas que são etiquetadas como "velhas", assim como o racismo e o sexismo se realizam em função da cor da pele e do gênero (Butler,1975; WHO, 2018).

Desse modo, é necessário pensar na presença das pessoas idosas e propor medidas educacionais que possam ensiná-los a serem mais ativos e integrados na sociedade. Está ao alcance de todos manifestar-se nos ambientes sociais, culturais e econômicos, alterando a imagem, mitos e distorções presentes no contexto do envelhecimento e combatendo o ageísmo atual (Butler,1989). O contexto educacional é um desses pontos a serem observados e devem priorizar as premissas do envelhecimento ativo com qualidade de vida (Salmazo-Silva & De Lima, 2012).

A educação para justiça social passa pela justiça cognitiva (De Sousa Santos, 2016) e isso implica acesso de pessoas de todas as idades à educação, que deve estar contemplada nos planos e políticas brasileiros para construção de projetos pedagógicos emancipantes e transformadores, tomando-se como parâmetro uma sociedade que necessita envelhecer ativa e criticamente.

Com o envelhecimento da população em escala mundial, faz-se necessário incluir os idosos no contexto da aprendizagem ativa em todos as áreas à medida em que esse indivíduo passará mais tempo compondo o tecido social e precisará estar em constante aprimoramento educacional para manter-se saudável, ativo, autônomo e com boa qualidade de vida.

5 Considerações Finais

Como resposta ao problema de pesquisa: A aprendizagem ativa está sendo aplicada, no contexto educacional de engenharia, para os idosos? Têm-se os resultados bibliométricos deste estudo que revelaram que a aprendizagem ativa aplicada para os idosos na engenharia não existe uma vez que o foco ainda está voltado para soluções de problemas dos idosos, pelos estudantes de engenharia, sobretudo para os alunos de biomecânica, com a proposta de aprimorar próteses e similares para o grupo. Deste modo o objetivo da pesquisa de mapear as discussões sobre aprendizagem ativa aplicada, no contexto educacional de engenharia, para os idosos foi alcançado revelando que não existem publicações na área. Como futuras pesquisas aconselha-se realizar um mapeamento dos idosos presentes nos cursos de Engenharia no Ensino Superior no Brasil para compreender o cenário atual, marcado pelo envelhecimento populacional.

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Project based learning: Civil Engineering Student's feedback (case study)

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Abstract

Project based learning is a challenging task, requiring expertise in the topic to be taught our learning is enhanced when the teacher is highly effective. As Students our learning is optimal when we are engaged in the learning process. The development of engineering school is critical for the future of the profession. School should be expected to gain pedagogical training through Projects based learning and as civil engineering students we want to talk about our Project based learning experience and the best example is the "urban planning and sustainable development" project. We will present a feedback as a first year of the Civil Engineering of the Private School of engineering and technologies (ESPRIT) students. We were able to participate throughout the first semester of the 2018-19 academic year in project that included workshops, tutorials, site visits, courses and in-situ work. The "Urban planning and Sustainable Development" project, which was part of an "Architecture and Urbanism" teaching unit, aims to bring together the different modules around a common project in order to allow students to grasp the complexity of engineering practice by understanding it in its entirety, to concretise and assimilate the different knowledge and know-how to acquire the targeted skills, as well as working on the aspect of being-well-being through different situations and modes of evaluation. Still in the framework of project-based learning, which adheres to the concept of active pedagogy deployed with the objective of targeting the skills required, the recourse to feedback to talk about the experience is necessary. The reflection around this participation and the commitment of the students accentuate the wish to make of us active actors and co-constructors in the process of learning. While offering us the opportunity to take a look at the approach developed, the methods used, the productions produced, the role and level of involvement of the actors concerned, as well as the means used. Our work traces the progress of the project "Urban Planning and Sustainable Development" from our point of view as students, we will present the pedagogy deployed in this project in our vision as students, we will discuss the innovative contributions of this project in terms of training and also on a personal and interpersonal level, we will also invoke the obstacles that we had to overtake. We will finally bring a critical look on the subject and propose the points that can be improved in this approach.

Keywords: Active pedagogy, student's feedback, project based learning, integrated projects, engineering education, skills.

1 Introduction

This paper describes our experience as students in the project based learning approach. Being aware about the importance of the operationalization in the training of engineers, in this context several questions arise:

What are the skills expected of the civil engineer? How will the expected skills be developed in the courses? What processes of build up with the actors (teachers, students)? What is active learning? What are its advantages and disadvantages? What is the impact on this approach on students?

The purpose of this paper is to provide student's answers and points of view practitioners in these issues, in the specific context of higher education. It will focus on reflection. The objective is to give a feedback of the pedagogy adopted in the project "Urban planning and Sustainable Development", to underline both the potential difficulties and its contributions.

According to Rogiers a competence is "the possibility for an individual to mobilize an integrated set of resources in order to solve a situation-problem that belongs to a family of situations "(Roegiers, 2000), and in a more specific way, for an engineering school we can use the definition of the competence of Guy Le Boterf, that leads to the following wording which details the ability to act effectively (Le Boterf 1999). It will be recognized that a person knows how to act competently if she can combine and mobilize a set of relevant resources (knowledge, know-how, qualities, etc.) in order to achieve in a particular context professional activities according to certain methods of exercise to produce results (services, products), meeting certain performance criteria to a recipient.

The specification of the context of the evaluation is important for the recognition by the entourage of the action carried out with competence. The expression of the competence can be done in the school or in a professional environment.

Civil engineering is at the forefront of the development of the world in general and in particular a country. The world population has doubled in the last two decades, in the face of this demographic explosion the area of civil engineering must ensure socio-cultural satisfaction of the population in terms of buildings (buildings), displacement (roads), energy (dam), etc.

The choice of the civil engineering leads us to be actors of this process of development and thus engineer, architect, etc., are in the forefront for the construction of new city and infrastructure by ensuring the future needs of the populations.

As an engineering school the “école Supérieure Privée d’Ingénierie et de Technologies” ESPRIT uses an active pedagogy placing the student at the center of the learning process. The goal of this school is to train directly operational engineers and the slogan of the school allows to guess directly this vision "se former autrement" which means “to get formed in a different way”. The figure 1 shows the components of pedagogy deployed in ESPRIT.

Figure 13: Active pedagogy learning situations adopted in ESPRIT

2 Project-Based Learning Approach

The manner in which civil engineering is taught must change. That change is necessitated by different causes like globalization, sustainability requirements, emerging technology, and increased complexity with the corresponding need to identify, define, and solve problems of traditional disciplines. As always within the civil engineering profession, change must be accomplished mindful of the profession’s primary concern for protecting public safety, health, and welfare.

As part of the training process the project based learning approach is used in order to make improve the teaching methods.

2.1 The general definition of PBL

Project-based learning (PBL) is a comprehensive approach to classroom teaching and learning that is designed to engage students in investigation of authentic problems, it is a model that organizes learning around projects.

According to the definitions found in PBL handbooks for teachers, projects are complex tasks, based on challenging questions, that involve students in design, problem-solving, decision making, or investigative activities; give students the opportunity to work relatively autonomously over extended periods of time; and culminate in realistic products or presentations (Jones, Rasmussen, & Moffitt, 1997; Thomas, Mergendoller, & Michaelson, 1999). According to other defining features found in the literature include authentic content, authentic assessment, teacher facilitation but not direction, explicit educational goals, (Moursund, 1999), cooperative learning, reflection, and incorporation of adult skills (Diehl, Grobe, Lopez, & Cabral, 1999).

2.2 PBL according to us as students

Project-based learning is a teaching method used by some teachers in order to group students to better study modules with learning outcomes in common or aiming for the same skills.

This method groups together several modules by placing the focus on the learner and introduces an interactive dynamic in teaching. Students have the opportunity to build their own knowledge and are placed in problem solving situations, so they make unexpected discoveries. The individual takes a central place because competence is seen as a "combinatorial knowledge" (Le Boterf 1999), and the individual is "builder of his skills" (Le Boterf 1999).

More simply formulated, the teacher becomes a guide and a counselor when students make decisions for the realization of the project.

The renewed interest for this pedagogy is based on the possibilities it offers in the acquisition of skills.

2.2.1 What are the PBL impacts on students?

Project-based pedagogy develops several student skills such as self-confidence, responsibility, and the argumentation that leads students to justify and make choices; the spirit of initiative, organization, and oral expression allow him to express his ideas in public.

This pedagogy also develops the ability of mutual listening, the spirit of mutual aid, the solidarity and other's opinion respect.

In most cases, project-based learning can be done in four steps: first we start by defining the project clearly, second we organize and plan the work process, in the third position comes the realization of the project and finally its evaluation.

The way in which these steps are carried out is not often respected since it depends on the teacher in question who has several factors to manage, such as the duration of the project, the learning tools at his disposal and sometimes the number of students.

2.2.2 What is the teacher's role?

The teacher is also at the heart of the learning process.

He coordinates the work and provides the student with what he needs in carrying out the project, more precisely, it takes into account the needs and interests of students; explicitly defines the skills to be attained, plans and organizes the various phases leading to the realization of the project,

He must coordinate the tasks performed to help students and guide and encourage them.

2.3 PBL in the Civil Engineering training at ESPRIT

As a first year students we participated throughout the first semester of the 2018-19 academic year in project that included workshops, tutorials, site visits, courses and in-situ work.

That was for us the opportunity to know the concept of PBL with the "Urban planning and Sustainable Development" project, which was part of an "Architecture and Urbanism" teaching unit.

We could through this project of concretising and assimilating the different knowledge and know-how to acquire the targeted skills, as well as working on personal and interpersonal skills through different situations and assessment methods.

3 “Urban planning and Sustainable Development” project

A complete engineer must have other skills than technical, he works as a team, manages groups, takes into account human factors and above all be able to inspire others.

We chose to work on the project UPSD (Urban Planning and Sustainable Development) a project that lasted almost a semester, in which we learned about the technical aspect, it was a prerequisite for the other modules and led us to achieve it by acquiring the expected learning outcomes.

3.1 Project description

The initial idea of this project was the willingness of teachers to break with theoretical and abstract projects. For this, they proposed that we work on the rehabilitation of an existing building, to do this they suggested the building of ESPRIT as a study corpus.

Subsequently, it was up to us to choose the space to work on (cafeteria, classroom, amphitheatre ...). From the start, we were involved in the decision making.

We had to work in groups, during the formation of groups, teachers strongly recommended us to form heterogeneous groups composed of Tunisian and African sub saharan students.

So, for one semester, it was up to us to propose a new sustainable layout for the selected site. Initially, each group completed a diagnostic report of the selected areas. An exercise that familiarized us with the techniques of in-situ work (taking measurements, drawing sketches, doing surveys, interviews ...) which are basic techniques for an engineer.

From that moment, each course session becomes a correction and supervision one. To better accompany us and distribute the tasks within the groups, we were called to fill in weekly specifications which explains the involvement of each member of the group. One of the methods of monitoring for teachers is as shown in Table 2 to define WHO does WHAT, WHEN and HOW?

Table 1: The WHO does WHAT WHEN and HOW description

Who	What	When	How
Persons in charge of the task	The description of task	The time allocated in this task and the deadline	The way it will be done

The project was not limited to lectures or coaching sessions. To better optimize the process, we also visited construction sites, in order to discover the professional environment and learn about companies and the practical life of civil engineers.

One of the highlights during this project was the workshop settled to understand the techniques of producing mock-up. Students from the ENAU (National School of Architecture and Urbanism) in 3rd and 4th year animated a workshop on the techniques of producing a mock-up. The figure 2 shows the students in action during the workshop.

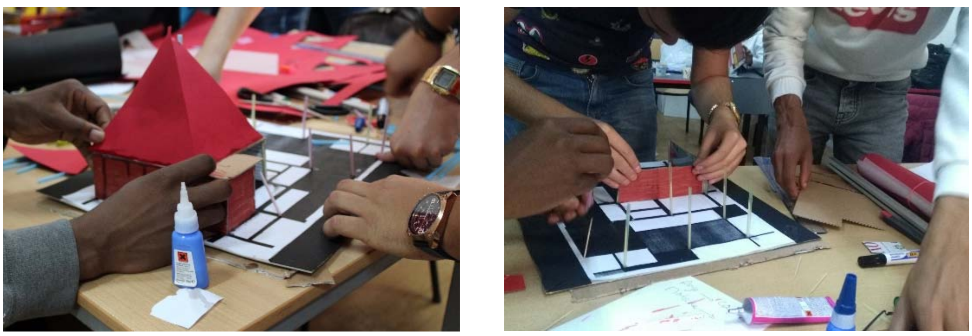

Figure 14: Students producing mock-ups

The alternation between practical and theoretical aspects in the project was a climax. Thus, at any time when a need for a knowledge or a theoretical concept is required, teachers do not hesitate to make it according to the pedagogical means that seems most appropriate.

In addition to technical knowledge and group work methods, oral presentation techniques are one of the objectives of the "Urban planning and Sustainable Development" project. In every session, the groups had to present orally and with adequate tools the progress of their work.

The investigations, the verbal exchanges, the emission of hypotheses, the observations, the explanations, the arguments, the documentary researches and the experiments are always done on two levels: at the level of the group first, then at the level of the class, with possible feedback.

This alternation between individual and collective work allows the gradual construction of scientific knowledge by students.

3.2 Matching learning outcomes and Learning situations

The link between competence and situation is vital. Competence is defined in particular with reference to the situation it makes it possible to master. Although it is conceivable that competence is 'transversal' (in making it possible to master several situations), in contrast, there is no sense in discussing competence without referring to at least one situation that the said competence makes it possible to master because otherwise it would suggest that the individual with the competence could master any situation. In this sense, Le Boterf (1994) uses such phrases as 'competence put into action' and 'situational competence'.

The table 1 illustrates the learning situations adapted to each learning outcome.

Table 2: Match between learning outcomes and learning situations

	Produce mock-up	Real case Study	Understand the notion of spatial quality (comfort and atmosphere).	Elaborate plans with annotations, quotations and mass properties with materials
Theoretical course				x
Tutorials		x	x	
Group Workshops	x	x	x	
Visits				x
PBL	x	x		x

4 Feedback and criticism

Our first year in ESPRIT was marked by this Project Based learning approach at both scientific and academic acknowledges level, it also allowed us to develop our skills, our teamwork abilities and our way of interacting within our school and revealed many advantages:

- As first-year students, we had an interesting experience. As presented by the teachers at the beginning of the year, the objective of the module is to make us discover the engineering profession in Civil Engineering field, to introduce us to different missions and tasks and simulate the different conditions of collaborative work with other stakeholders of the profession.
- At this stage, we can attest our satisfaction for attending the objectives fixed in the beginning of the module through an adapted process.

- Indeed, one of the assets of this active pedagogy is to gather students and teachers around a common project, allowing a better understanding of teamwork. The transmission of knowledge between teacher-students or student-students is done in a more fluid and direct way.
- Throughout our academic curriculum, we studied theoretical courses without knowing how to make the link between the applications of the formulas, methodological approaches. We were glad to discover this module associating practice to theory, based on concrete projects where the theoretical notions are used when the need arises. Thus, all the courses were at the service of the project, allowing us to make a direct link between theory and practice.
- We found that the method adopted has a considerable impact on the level of learning and the quality of reception of information, the diversity of these pedagogical methods was at the base of acquisition of learning outcomes.
- In the classical teaching methods, students are essentially passive receivers, so by enhancing the layout of the class into a participative one, we moved to a more flexible and interactive workshop space configuration, allowing us to simulate the working conditions of the an operational engineer within his office. Teachers become coaches or supervisors who supervise and guide us during the different phases of the project. This availability and proximity to teachers allowed us to improve our abilities.
- The autonomy that we had throughout the project, allowed us to put ourselves in various situations and develop our sense of curiosity to solve the difficulties.
- The error is a learning engine. During some sessions, as students during this project we were allowed to experiment and make mistakes. We were aware that the error is not a fault, it is necessary, it is inherent to the learning process. It is about moving from a common thinking to a scientific thinking. It is a permanent intellectual gymnastics that should be done to rectify one's natural point of view based on everyday experience.

However, like any new method, some points need to get improved in order to optimize the effectiveness of the result of the experiment for students and teachers:

- Time was a handicap in the realization of our project, or even in teacher's monitoring and supervision.
- The important number of students made decision-making within a group difficult and sometimes impossible.
- The divergence of opinions, the problems within the groups, the allocated time for the project "Urban planning and Sustainable Development» slowed down our progress and affected our productivity.
- The assessment by peers; a technique that we have appreciated and tested once during a formative assessment was not reproduced and generalized in all the reports as well as in the final evaluation.

5 Conclusion

This paper has attempted to answer several questions: how does the teaching method impacts the acquisition of competence? What's the role of students and teachers in learning process? How the PBL affects the students learning? After a review and analysis of the available work, it emerges that the developing teaching methods is always beneficial for optimal learning.

How to help students without solving problems in their place and teach them that a problem can have multiple solutions? Scientific education is not learning by heart facts, knowing phenomena and their interpretation, it is also understanding how scientific knowledge has been established.

Critical thinking requires constant questioning. Students must learn to ask the relevant questions and always think of proposing answers.

The transition from a traditional question to an operational one requires work of reformulation and reflection. This work requires a search for information, by researching the available means leading to the correct answer. It is necessary to learn to think in a scientific way, to learn not to be content with dogmatic answers but to search for the logical response.

It is not surprising that this type of project takes a more important place in our training process which, by vocation, wish to offer a professional training linked to standards of competence and bathed in a performance culture. The thoughtful development of the skills of our engineers is a strategic issue.

The skills that we learned to deploy were experimented along the project and even when writing this article we had to experiment again teamwork, we had to manage our differences of opinion and find a middle ground to reach a result we would as a team agree on.

We are aware that as students the relevance of our judgment could be mistaken by our lack of experience. Our goal is to share our experience in this module in total transparency hoping that it would be beneficial in the process of continuous improvement.

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The responsibility of the engineer in the field of sustainable development and environmental protect: the project "Sustainable Construction and Environment" as example

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Abstract

This paper presents our learning experience as part of the project "Sustainable Construction and Environment" based on an active and collective learning perspective. The Learning situation experience was originally in three respects: the teaching materials provided, the learning activities adopted and the nature of the rendering requested. The prevention of natural resources and the protection of the environment also require awareness raising. To be able to act actively, the civil engineer needs in a first place, to be informed about the environmental impact of construction activities. On the other hand, it must propose valid and sustainable solutions to combat this negative impact. At this level, our project consists in its first part, to produce audio-visual media for a campaign to raise awareness of the negative impacts of civil engineering activities on the environment. As for the second part, we were called upon to launch advertising campaigns for sustainable products and techniques for constructions. The project "sustainable construction and environment" involved us in real production situations which gave us the opportunity to integrate in a practical way our theoretical knowledge and develop others

Keywords: Project approaches; sustainable construction; environmental protection.

1 Introduction

Active pedagogy is an experiential learning method based on the learner's involvement in situations that allow him not only to apply his skills but also to develop them. Project-based learning is one of the approaches to active pedagogy. It is about directing learners to sources of information in order to have the necessary tools to carry out a project. The teacher no longer intervenes to introduce the subject to the students but to create situations that encourage learning. (Benoit Raucent, Elie Milgron, Bernard Bourret, Anne Hernandez, Christophe Romando, 2001). The project can be a concrete realization (a model, software...) or simply an oral or written presentation.

This pedagogical approach is increasingly adopted in education in general and in engineering education in particular. (Philippe Padula, Michel Larini, Perrine Martin, 2016). In this context, our school, the private higher school of engineering and technology ESPRIT, offers us a study plan in which project learning occupies a considerable volume. Among these projects, the sustainable construction and environment project subject of this article.

In this paper, we present the project, then we will cite the learning outcomes of this work and we will end by defending the innovative aspect of this project.

2 Project presentation

Certainly, an engineer is a designer, an innovator and a creator. But is the role of the engineer limited to technical aspects of the cost of societal needs? The industrial and economic production system threatens its sustainability through over-exploitation of natural resources and harmful impact on the environment. In this respect, the engineer, as a main contributor to this system, must be aware of this danger that threatens humanity. (Karel F. Mulder, 2009).

Therefore, the introduction of the concepts of sustainable development and environmental protection in the curriculum of engineering training is crucial. Training programmes must integrate an awareness-raising strategy that is often essential to identify the problem and raise collective awareness. Second, future engineers must be encouraged to adopt sustainable and environmentally responsible production processes.

In this context, the "sustainable construction and environment project" is included, in the third semester of our civil engineering training at the private engineering and technology university. In its general context, the project is based on a problem-solution approach; in fact it raises two major environmental problems related to the field of civil engineering: construction site waste and hazardous materials used in civil engineering; secondly it proposes possible solutions by presenting the targets of the high environmental quality site charter and ecological materials. (Figure 1)

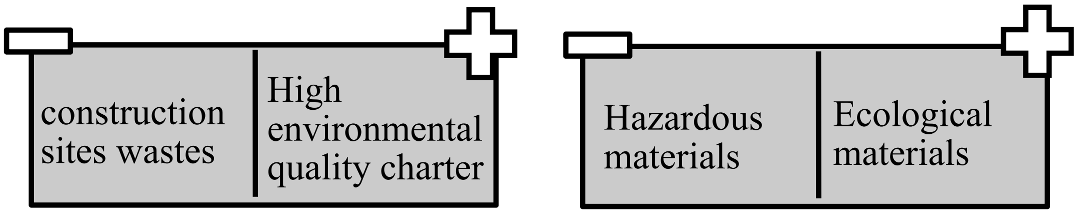

Figure 15. Problem- solution approach.

This project consists in producing audio-visual supports covering the following subjects: construction waste, waste recycling techniques, demolition waste re-use, ecological materials, etc. The supports produced can be brochures, flyers, reports, interviews, etc...

3 Learning activities

The pedagogical approach adopted by our tutor throughout this project is based on innovates and originals learning situations. The learning sequence is based on five pedagogical activities divided into five phases: the discovery phase, the divergent phase, the convergence phase, the production phase and finally the publication phase. (Figure 2)

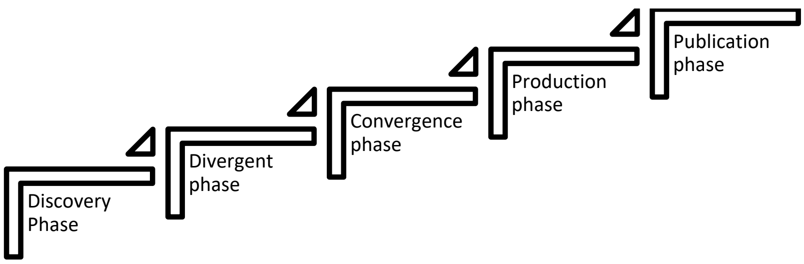

Figure 2. Learning sequence components.

3.1 Discovery phase

The discovery phase is a triggering phase; it is a setting in a general framework. This phase aims to stimulate our curiosity and highlight the subject matter, with triggers. A trigger can be a video, a number, a picture or simply a question. Following this trigger a discussion takes place to broaden around the subject provoked. This fundamental and introductory phase is the basis for our work. At the end of this phase, subjects of the audio-visual supports as well as the related themes are defined.

3.2 Divergent phase

The divergence phase is a brainstorming activity where ideas are gathered to have the widest possible search.

At the beginning of this phase we divide into small groups of three students each, in fact for the rest of the project the work will be in groups. We had access to an original educational support such as guides, articles, technical sheets of industrial products..... The aim of this activity was to use the documentation provided to extract some information related to the subject and to propose an appropriate content for our document. The major challenge of this step was to extract as much information as possible in a limited time.

3.3 Convergence phase

The convergence phase is an activity of presentation and discussion. We present the work developed in the divergent phase to our colleagues and discuss the content. Our colleagues expose their critics and we try to defend our choices. For each passage following the intergroup discussions, we note the relevant ideas that we agree on until we converge on the themes to be treated in the rending. Finally, a common content is defined to be developed in the final renderings.

3.4 Production phase

The production phase consists of two sections: the work on the rendering and the preparation of the publication phase animation. First, we started with the bibliographic research and the collection of data necessary for the elaboration of our rendering as requested by our tutor. Therefore, we started by reviewing the documents for an in-depth reading, then we tried to have other information sources. We have consulted experts (to conduct interviews). And we have moved to institutions and companies active in the fields of our research. Then we passed to the design phase: the recording of interviews and reports, the making of videos and the creation of posters, while thinking about the way in which we will present our renderings to the public. To do this, we are interested in creating some animation tools for our presentations. And we prepared the scenario for the release of our publication.

3.5 Publication phase

The publication phase is a deployment phase in which we have tried to present the results of our work in a clear and relevant way. Our tutor asked us to present the work in a very original way by making us imagine a whole scenario. Some of us have chosen to play the role of environmental experts to lead awareness campaigns, others have worn the hat of sales representatives to demonstrate environmentally friendly materials, and others have presented themselves as contractors in the waste treatment sector to present solutions for the re-use and recycling of construction and demolition waste. Other colleagues simply kept within the academic framework and presented their own point of view as future actors in the field of civil engineering. To enrich our publications and attract the attention of our listeners, we animated our presentations with games and quizzes (figure3) to better involve our colleagues and help them to memorize information.

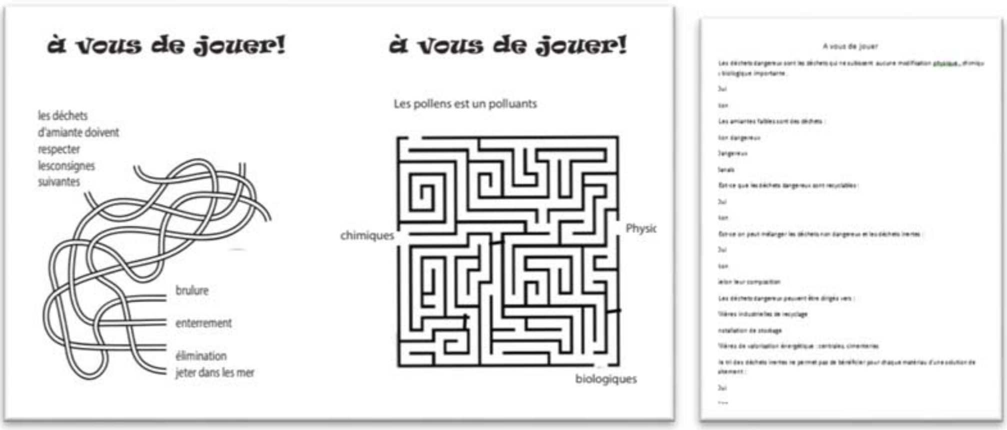

Figure 3. Examples of quizzes and games.

4 Learning outcomes

The "sustainable construction and environment project" is a project with an increasing pace, from the simplest to the most complex. It covers the learning outcomes at different scales. By projecting the steps of our project on the bloom taxonomy scale we notice that the learning activities defined above cover the different levels of the bloom classification (Nguyen and Blais, 2007). We started the project with simple recognition and understanding activities until we reached the end of the project to accomplish design and creation tasks. (Figure 4)

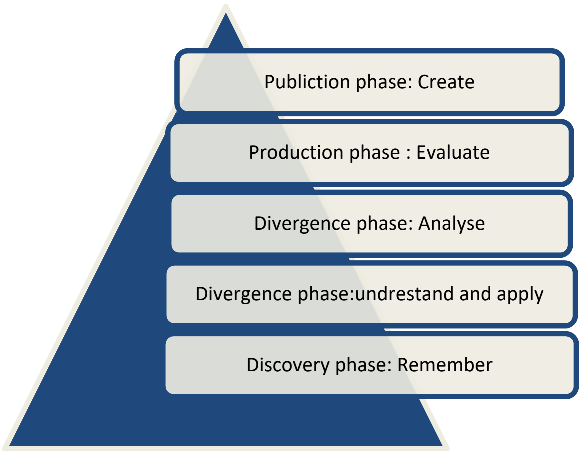

Figure 4. Learning outcomes according to the bloom scale.

This pedagogical experience was an opportunity to apply acquired skills and develop others. At the end of this project we have acquired knowledge, know-how and interpersonal skills.

Table summarizes these achievements.

Table 11. Achievements.

knowledges	know-how	Interpersonal skills
*To identify the types of construction waste * To identify techniques for waste re-use * To recognize green building techniques	*To propose sustainable solutions * To collect information in a focused way *T Edit documents and supports	*Conducting interviews *To defend an achievement or a point of view * To criticize an achievement or a point of view * To manage work in a team * To contact experts and professionals

5 The innovative aspect of the project

The sustainable construction and environment project was introduced to us by adopting an innovative pedagogy on three levels. The nature of supports, the production activities and the returns requested.

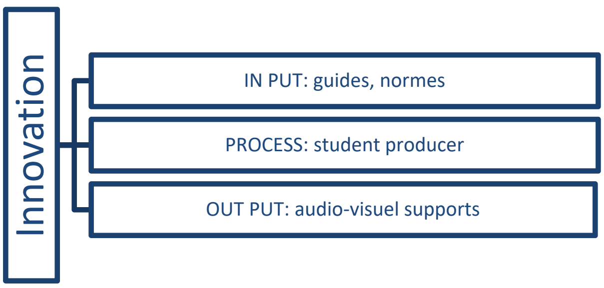

Figure 5. Innovative aspect of the project.

5.1 Innovative input:

The supporting documents provided by our teacher for this project were quite original. In fact, to have a starting point we had access to guides for organizing work camps, statistical studies and websites. The volume of these documents was limited but rich in information. On the other hand, the support was easy to consult given the clarity of its content and the quality of its writing. (Figure 6)

Figure 6. Examples of educational supports.

5.2 Innovative methodology of the work:

The pedagogical experience of the sustainable construction and environment project was original, innovative and motivating. Our tutor has adopted a teaching method based on active learning activities. We have moved from the classic positioning of the student in the pedagogical act as a simple speaker to a real actor and producer.

5.3 Innovative output:

In the majority of projects the rendering is a written document or a classic presentation which is not the case for the "sustainable construction and environment" project for which our tutor asked us to create audio-visual supports. The originality of this rendering has involved us more in the project. The hours of rendering preparations were a real moment of fulfilment, imagination and creativity.

On the other hand, it is a real publishable product; the fact of signing audio-visual productions with our own names was very motivating. We were really interesting in production, unlike the classic rendering of projects which are generally stressful and boring.

6 Conclusion

The sustainable construction and environment project is a pioneering project on both the pedagogical and technical levels. The pedagogical sequence is based on motivating and oriented activities. The content introduces essential concepts for engineering training.

The project has helped us to develop our engineering skills. We have deployed a field of knowledge that allows us to imagine, design and produce high-quality renderings.

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Concrete formulation for 3D printing

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Abstract

The 3D printing is an innovative technology that is increasingly present in all sectors, in particular in the sector of the BCE (building and civil engineering works). Fast evolution of this technological innovation puts the needy engineer to adapt itself and to get acquainted to these technologies. Is in this frame joins the inter-department project which has for objective the construction of a 3D concrete printer. It is the multidisciplinary project which implies many specialties of engineering insure by the departments of the school: computer science, electro mechanic and civil engineering. The development of this work has been entrusted to us, as students of the 4th year civil engineering, and This in the framework of an integrated project requiring joint efforts and group work. It is a matter of determining the proportions of the `concrete' mixture to be printed. This work focuses on two essential points: First, the pedagogical component covering three main axes: the multidisciplinary one that gave us the opportunity to open up to other specialties. The application of the skills acquired during our training by the results of experimental tests on fresh and hardened concrete. Scientific research to know the characteristics and properties of the concrete to be extruded presented for us a new engineering training link. Second ,Technical component of determining the formula of a concrete suitable for 3d printing technology using materials available on the local market and even recyclable materials and testing it from the point of view of workability, flowability, and resistance.

Keywords: Concret; 3d printing; Flowability

1 Introduction

Designing and creating innovative, effective solutions is an essential skill in the training of an engineer, This is why our school is always a pioneer in creating innovative projects while involving the student in their achievements. This method of active learning is being used more and more in our engineering training at the private Higher School of Engineering and Technology. In fact, this pedagogy places the student at the centre of the training process and involves him in problem solving, based on different teaching approaches such as the project approach, which is based on a systematic process of knowledge acquisition and transfer (Proulous, J. 2004) or the problem-based approach that is based on the investment of a student or group of students in a worrying situation that presents a certain level of difficulty (Legendre,R.2000).

The active pedagogical formulas are well integrated into our university process in various forms such as integrated projects, an example of which will be the subject of this paper, where we will first deal with its general framework by then we will explain the different stages of its development and we will end by explaining its impact in two parts pedagogical and technical

2 General framework

In the field of civil engineering 3D printing develops several strengths. Technological advantages, since this process offers architects a great freedom, giving the possibility to print buildings with new geometric shape. This technological innovation in the field of constructions has already in the application phase by several global companies including the Chinese company "WINSUN" as well as the French company "XTreee" (C. Gosselin, and all. 2016).

However, this technology is still absent in Tunisia. It is in this context that integrates the project of our school which aims at the design and manufacture of a 3D printer of concrete which for objective construction of the bearing elements.

Considering the multidisciplinary aspect of this project, it was launched as an interdepartmental project that encompasses all departments including our Department of civil engineering, the Department of electromechanical and the Department of informatics.

This multidisciplinary aspect of the project allows the decompartmentalization of disciplines and specialties and the intervention of each to solve a problem or ensure a project task which leads to say that any discipline retains its autonomy and contributes by optimize efforts and results. Figure 1 illustrates the distribution of stains according to the skills offered by each discipline

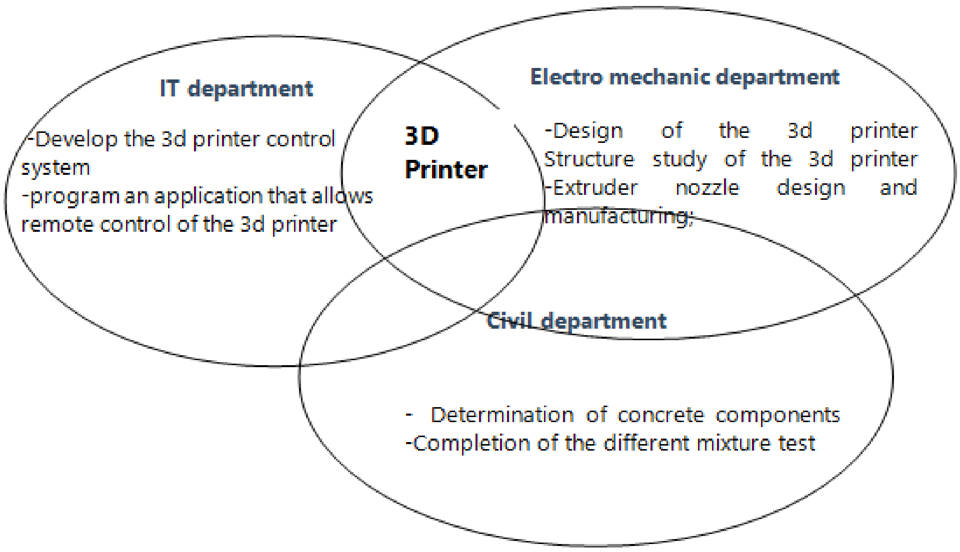

Figure 16. Departmental distribution of stains

To realize this project and to develop it, it has been shelled in several sub-projects according to the specialty called integrated projects.

The concept of the integrated project involves the deployment of various skills acquired in different modules throughout the engineering training process; it requires using certain skills which aim to complete it. What is the case with our project subject of this article that we were entrusted to us the students of the fourth year civil engineering as part of the teaching unit "project structure and work"

The purpose of our project is to determine the different constituents, a concrete for 3D printing.

We also need to determine the exact proportions of the material in question so we will evaluate their physical and mechanical characteristics.

This mixture must be made up of materials available on the local market and even recyclable materials

3 Working methodology

To realize this project in four phases, we respect and realize either in group or in an individual way. The first is the brainstorming phase, the second is the project planning, the third bibliographic research and we end with the phase of the experimental study and the exploitation of the results.

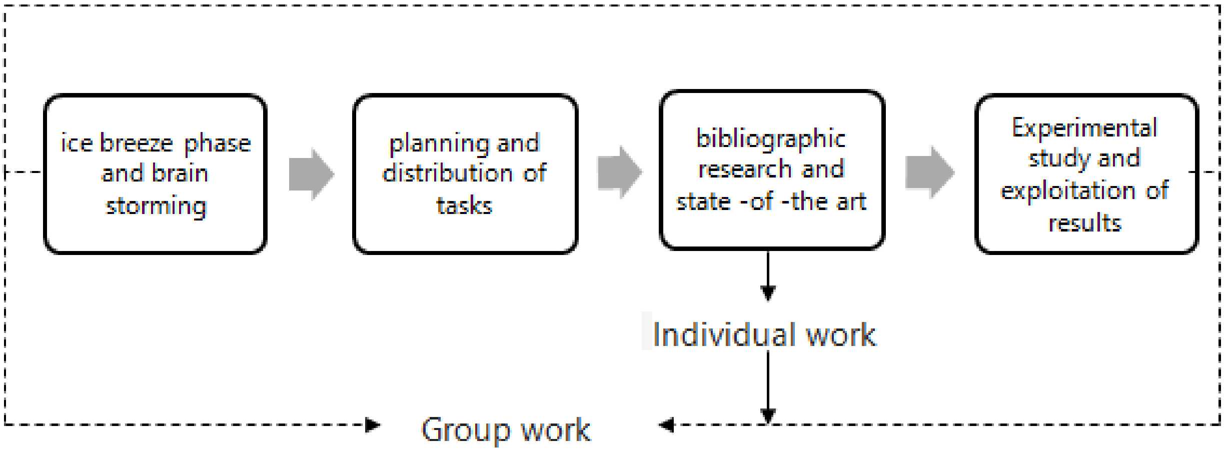

Figure 2. The different phases of the project

3.1 Brain -storming

According to (A. F Osborn), brain storming is a technique that allows an individual group to find a solution for a specific problem based on the ideas of these members. This is a method that we applied in the first coaching sessions.

We were gathered by our tutor first to get acquainted since our team was composed of students of heterogeneous classes, second to Exchange on the subject and to understand the purpose and method of evaluation from a workbook issued by our teacher

3.2 Planning and distribution of stains

According to the World Organization for Standardization "A project is a single process consisting of a set of coordinated and controlled activities, with start and end dates, undertaken with the aim of achieving a goal that meets specific requirements, including time, cost and resource constraints "(iso10006.2003).

As a result, our study began with the planning of our project and the implementation of an action plan. This phase was carried out by applying the different skills and knowledge acquired throughout the project management module. In fact it consists in dissecting the overall project in sub-stains then in elaborating a detailed planning of the different stages of the project run by setting the duration , start and end date of each sub-task while respecting the duration of the integrated project which is six months. Then we have set a coordinator who will take care of the scheduling of the meetings of our team and we dispatch the tasks to ensure the smooth progress of our work.

3.3 Bibliographical research and State of the art

3D printing technology is classified as a scientific innovation especially in the field of construction and the components and natures of the materials used in this technology are still a research topic whose results are not accessible enough. This is why a thorough research phase is needed. Following the request of our tutor this step was carried out in an individual way to expand the collection of information each on its side to assimilate the theoretical part by the different members of the group. This phase has been divided into two parts: the first consists of the bibliographical research and the consultation of the scientific reviews published in this subject (C. Gosselin, and all .2016), (Balletti, M. and all .2017). And the second is to make a finding on additive products existing on the local market taking into consideration the cost factor.

3.4 Experimental testing and exploitation of results

Once the constituents of the concrete fixed and validated by our tutor. We have begun the phase of experimental studies on mixing in the materials laboratory of our school. In fact, the printing process followed in this project is based on the FDM technique "Fused Deposition Modeling" (Prashanth, S.N.and All, 2017) in this sense the material is deposited layer by layer through an extruder head. These processes require the presence of two contradictory characteristics of the concrete. The first is its workability: the mixture must have a fluid consistency so that it can be extruded and the second its self-bearing capacity in the fresh state, ie it must bear the burden of the subjacent layers as soon as it is printed. Due to the complexity of the problem we have to multiply the tests, each time changing the proportions of the adjuvants to reach satisfactory results. After the completion of the experimental study, we proceeded to the synthesis and reviews, the results found and we began the preparation of the requested rendering which was in the form of a report and a presentation.

4 Pedagogical and technical impact

The innovative criterion of our project as well as the adopted pedagogy allowed us to develop our knowledge, our know-how and our knowledge to be. Figure3 illustrates the different pedagogical and technical advantages of our project.

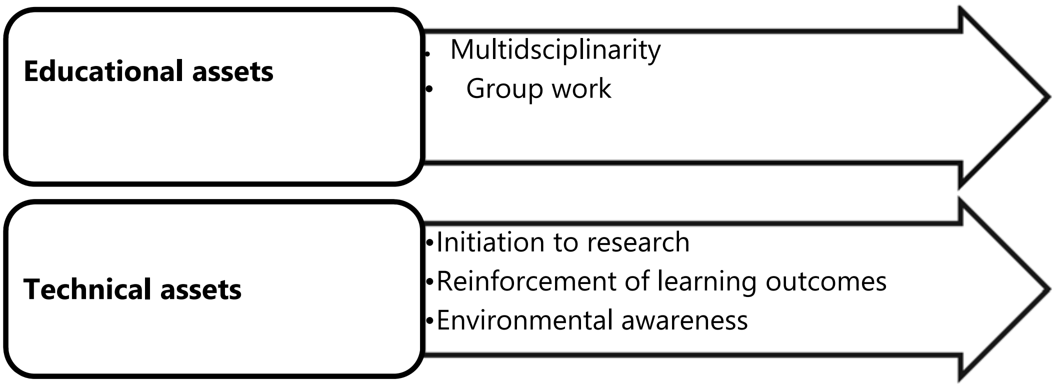

Figure 3 the pedagogical and technical impact of the project

4.1 Multidisciplinary

During the design phase we have taken into consideration several technical constraints that depend on other specialties as an example the granulometry of aggregates used in the subject mixture of our research.

In fact, unlike ordinary or conventional concrete, which must be cast, 3D printing is based on the injection of concrete through an extruder nozzle. This nozzle has a diameter that must be taken into account when formulating the mixture. This is why we contacted the group of the electromechanical department responsible for the construction of the nozzle to fix the maximum diameter of the grains and which of the order of 2cm.

The multidisciplinary aspect of this project gave us the opportunity to open up to other disciplines and presented us with an opportunity to strengthen the links between the departments and students of our school for a better result of knowledge production.

4.2 Group work

This integrated project presents an important opportunity for exchange and accumulation of knowledge and skills . It presented an opportunity to learn how to work as a team and how to accept differences. Group work has also allowed us to develop our skills and competencies through collaboration and cooperation between team members.

Within our group we have combined our efforts and shared the tasks especially those tests to achieve better results and respond to factors time.

4.3 Strengthening learning outcomes

Through the project of concrete formulation for a 3d printer we could use our knowledge acquired during the various modules throughout our curriculum. And the need for these prerequisites appears from the first step of the project, during its planning which was done through the software wbs (Critical Tools WBS 2016) studied and mastered during the project management module. This project also presented an opportunity to apply and deepen our knowledge in the field of materials and this by carrying out the different tests on the fresh and hardened concrete such as the test of setting time to determine the setting time of the cement paste, the test of workability to evaluate the fluidity of the mixture and also the compression test to test the concrete resistance at 28 days.

4.4 Initiation to research

Doing research is a first experience for us, future engineers in civil engineering.

Under the guidance of our tutor we have to consult documents relating to our problem to collect the necessary information to make our project succeed. However, we have faced the scarcity of work on this topic since it is a new field of investigation in the world. This first step in the field of research we learned to glean information, sort the necessary, rebuild them for the investment of our project.

Nevertheless we have noticed that some constituents of the concrete used for the printing used in the world as examples are the smoked of silicas (Saric-Coric.M and all.2003) are either expensive or rare in Tunisia that is why we have contacted several suppliers and we looked for substituent that can develop the same results.

4.5 Environmental awareness

Any industrial activity can have a devastating impact on the environment that is why it is imperative that the enterprise implement practices to prevent adverse effects of their activities on the environment, specificity of our project responds to this purpose by recycling waste. Indeed we have used the waste of quarry of limestone as essential component of our concrete. This material is a fine powder produced during the crushing and sifting of limestone rock. This fact has an economic impact since it will reduce the cost of our product by using wasted waste.

5 Conclusion

In this paper we have exhibited our fourth year project of civil engineering cycle and which aims to formulate concrete for a 3D printer and its impact on our training. Indeed this opportunity allowed us to put into practice all the knowledge acquired along four years of training.

It was also a good alternative to the initiation of research especially in an innovative field allowing us to follow the technical and technological developments that are taking part in the world and thus to standardize with the training outside of our country. It is a very rewarding opportunity because it has allowed us to deco centralizes our specialty and to open ourselves to other specialties inherent in our own or even foreign but of a great contribution for the realization of our project.

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Study and integration of sensors for the monitoring of the concrete extrusion process

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Abstract

These last years, the expansion of 3D printing building has increased remarkably. And some parts of the 3D printer used are still evolving, such as the flume to inject the concrete, the structure used and even the optimisation of the software used to control the 3D printer. Therefore, this work consists essentially of monitoring the process of the concrete extrusion from its injection through the extruder until its ejection from the flume. The work will face three major phases, the first one is the concrete extruder study and design, the second, consist of the production of the extruder and implementing sensors, and finally the tests and validation. The main output of this work will be a classification of the different concrete composition depending on the way it is extruded from the flume. Other criteria will be fixed through this work to help identify the suitable concrete mixture to use with the produced concrete extruder.

Keywords: 3D Printer; Classification; Concrete; Extrusion.

1 Introduction

3D Concrete printing has known an important expansion since it enhances the construction field on several levels by minimizing the duration, the cost and the use of labour of the construction process compared to the traditional method. This innovative technique provides also a higher flexibility in building complicated structural shapes that aren't feasible conventionally and delivers a higher improvement in the safety and the environmental impact of the 3D printed structure.

Because of its enormous benefits, many companies have been experimenting with different methods and technologies of 3D concrete printing. The Chinese company, WinSun, has recently demonstrated its mastery in 3D printing after printing 10 houses in under 24 hours, with each house costing a mere 5000$ thanks to their largest 3D printer in the world that uses sand and a chemical binding agent to create a stone-like material. Nowadays, and after the success of this experience, many companies are working to resolve the various design and operational constraints of 3D concrete printing, which are of vital importance for future development of this construction technique. In the other hand, other companies are trying to improve some parts of the 3D printer such as the flume to inject the concrete, the structure used and even the optimisation of the software used to control the 3D printer (ZEI, 2015).

This paper focuses on monitoring the process of the concrete extrusion from its injection through the extruder until its ejection. The main output of this work will be a classification of the different concrete composition depending on the way it is extruded from the flume. It also studies the design and the implementation of the sensors in the extruder. The outcomes of this research and its applications to real-life construction practices target the need for improved automation in civil engineering projects, the need for efficiency in resource management and a rapid and less expensive construction method.

2 Materials: Concrete selection

In France, only autoclave-hardened cellular concrete complies with NF EN-441-7. However, another type of concrete exists and is silencing all criticism. Approved in the United States and in several European countries (Germany, United Kingdom...), honeycomb concrete – or cellular concrete – is inspired by the structure of human bone tissue. It consists of a ground and aerated mixture of limestone and polished slate that forms a soft mineral foam. Once hardened and dried, this concrete results a homogeneous sausage, thanks to the mineral network of calcium silicates, a large proportion of air and gas. This gives it its cellular structure visible to the naked eye.

This concrete, much lighter than conventional concrete, also has excellent sound and thermal insulation properties: a 40 cm thick cellular concrete wall (without insulation, coating or membranes) thus has a coefficient of thermal resistance R of 4.68 m^2K/W, higher than that of a brick or cinder block wall, accompanied by 10 cm of glass wool. On the noise side, a 24 cm wall of cellular concrete provides an average noise attenuation of 40 dB, which is about 5 dB better than traditional walls in other materials, while being a lightweight, non-flammable and sturdy material. There is also another interesting type of concrete: The Ultra-High-Performance Fibber-Reinforced Concretes are one the best cementitious materials with exceptional performances. They are characterized by a compressive and tensile strength over respectively 150 MPa and 6 MPa at 28 days. These concretes have exceptional mechanical and durability properties compared to concrete ordinary. However, these concretes have a fragile behaviour as well in compression that in traction.

In this project we chose the Reactive Powder Concrete (RPC) which is a cement matrix material with an outstanding mechanical performance and durability [2], It is a cementitious system based on Portland cement, silica fume and fine elements, containing a large dosage of superplasticizer and characterized by a very low water / cement ratio (W / C). It also owns a greater homogeneity due to the replacement of traditional aggregates by very fine sand whose particle sizes do not exceed 600 µm.

Table 12. Selection Parameters for RPC components.

Property of RPC	Description	Recommended Values	Types of failure eliminated
Reduction in aggregation size	Coarse aggregates are replaced by fine sand, with a reduction in the size of the coarsest aggregate by a factor of about 50.	Maximum size of fine sand is 600 µm	Mechanical, Chemical & Thermo-mechanical
Enhanced mechanical properties	Improved mechanical properties of the paste by the addition of silica fume	Young's modulus values in 50 GPa – 75 Gpa range	Disturbance of the mechanical stress field.
Reduction in aggregate to matrix ratio	Limitation of sand content	Volume of the paste is at least 20% greater than the voids index of non-compacted sand.	By any external source (e.g., formwork).

This cocktail of constituents with physicochemical and granulometric with several properties makes it possible to obtain a particularly dense skeleton on a very wide range of rheological behaviour, from very viscous to very fluid. The formulation of OPIs, usually based on optimization of the arrangement granularity and minimization of inter-particle porosity, however, remains a complex process due to the high sensitivity of the properties of the mixture to even a small variation in the dosage of these constituents. Another major obstacle to the use of these materials is their high cost compared to high-grade concretes or very high performance.

The use of industrial processes to both guarantee the respect of the composition of the mixture throughout the production chain and to ensure high production rates could be an important lever for development of

OPIs. From this point of view, extrusion seems to respond to such requirements. Extrusion is a mechanical process of applied industrial manufacture the shaping of many products (metals, plastics, materials composites, clays, foods, ...). In the field of cementitious materials, this technique could be a promising avenue with high productivity, particularly suitable to produce A prefabricated elements at very high mechanical performance.

In this context, this study is devoted to the development of RPC Extrusions (RPCE), in the perspective of the manufacture of tubular elements suitable for chemically aggressive environments. To this end, different OPIs have been prepared with varying amounts of superplasticizer, silica in crushed quartz to obtain extrudable mixtures. Parallel to their microstructural analysis by X-ray diffraction and electron microscopy at scanning (Courtial et al., 2011), the materials were characterized in the fresh state (extrudability), at young age (hydration kinetics, chemical and endogenous shrinkage in free and prevented conditions), and in the longer term (mechanical resistance, porosity and durability) (MOUNANGA et al., 2011).

3 Mechanics: Extruder Design

The design of the appropriate machine that would function as a 3D printer for the concrete mix is critical to the project success. Several criteria had to be taken into consideration during the design, as the machine had to account for both the fresh and the printed properties of the concrete previously discussed. The machine is basically composed of three main components: the concrete tank and pumping mechanism, the printing nozzle, and the motion control system. The concrete starts its journey at the tank and is manually pumped to reach the nozzle, which is responsible for pouring it. The machine is designed to move on a tri-axial plane (x y-z) in order to print a 3- dimensional element.

the selected concept is an extruder with a square orifice, two non-adjustable rectangular side trowels (one on each side) and a screw mechanism to create the flow of concrete

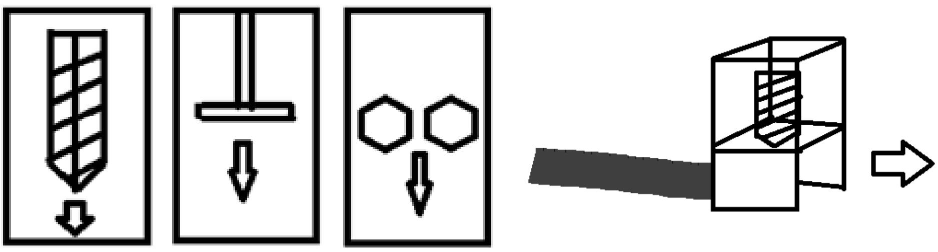

Figure 1. Selected concept (left); Possible flow creating mechanisms (right).

Another critical element that has a high impact on the extruded concrete properties is the nozzle. The nozzle diameter has a direct relationship with the concrete mix properties, specifically its flowability. As the diameter size decreases, the flowability of the mix should be increased to account for it and vice versa. In addition, the nozzle has two trowels, a side and top trowel, which lag it.

The side trowel on the outer side functions to straighten the concrete being poured as the nozzle passes by. The top trowel serves to straighten the upper surface of the concrete layer to ensure maximum buildability. Before designing the nozzle, different opening diameters ranging from 1 cm to 2 cm can be chosen. The optimal diameter for the nozzle is 2 cm. A diameter greater than 2 cm caused buildability problems as the layer couldn't hold itself while a smaller diameter presented segregation problems of the concrete components(LARS,2015).

The body of the extruder decomposes from two cylinders. the first will include the Archimedes screw and the second will ensure the arrival of concrete. the two cylinders will be welded together at an angle of forty-five degrees. This assembly will be made of stainless steel to resist to a potential corrosion due to concrete humidity.

The Archimedes screw is the part who is responsible for the concrete transport from the hopper to the nozzle. It has the same diameter of the inner wall of the corp. The worm screw mixes the concrete and it has a relationship with the concrete mix viscosity and flowability with acting on the speed of rotation.

The components and its materials that are needed for the extruder are

- Electric motor- of the shelf component
- Hose- flexible material to perform bending motion
- Auger- metal for robustness
- Pipe with top- and bottom lid- hard plastic for cheapness
- Side trowels- hard plastic or metal for robustness
- Coupling- metal for robustness
- Attachment to robot- hard plastic or metal
- Threads, nuts, set screws and regular screws

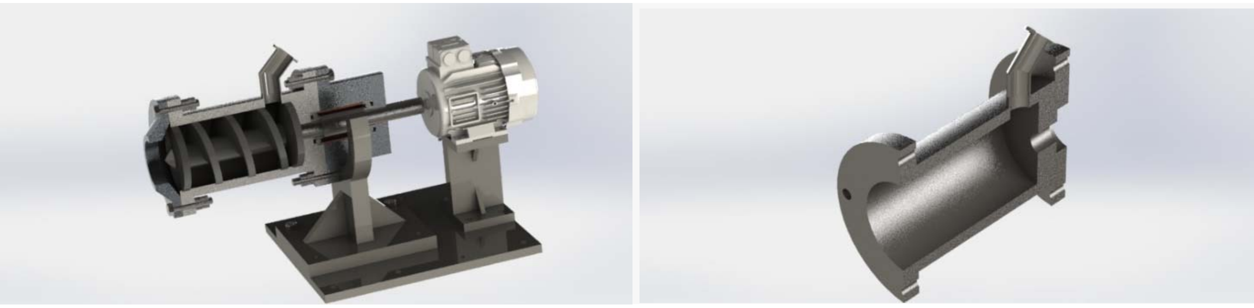

Figure 2. Extruder design (left); Corp and filling system design (right).

4 Process: Thermal Monitoring

Under fluctuating curing temperatures, setting of concrete occurs earlier at higher temperatures and later at lower temperatures (WADE, 2010). This means that the process of extrusion should be done at precise temperature to obtain the best conditions of setting. The monitoring of the process is then essential for a better setting, and this through sensor placed on the extruder. The goal of placing sensor on the nozzle allows us to know if the concrete mixture is extruded at good conditions, to avoid any fluctuations in the setting time and the characteristic of the dried concrete.

The use of sensors to monitor the process can only allows us to control the conditions of the extrusion, by this we could add some actuators able to minimise the temperature of the whole extruder by isolating it or ventilation to minimise the temperature, or by heating it to raise the temperature depending on what we need.

The next figure fig.3 shows where the sensor should be placed to detect the temperature of the concrete extruded.

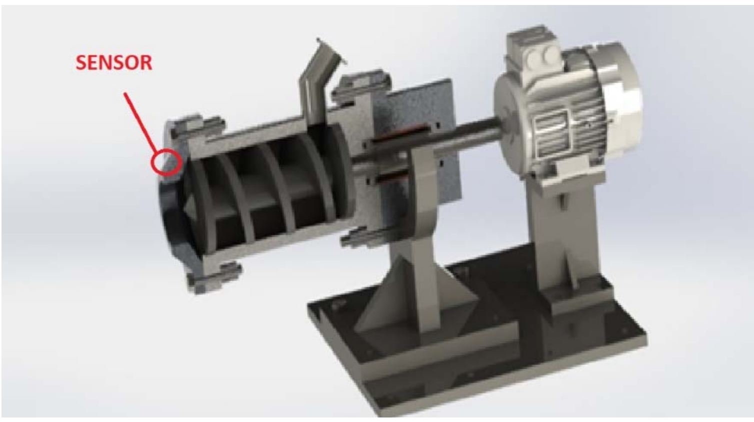

Figure3. sensor position on the extruder.

5 Conclusion

This document is an overview of the concept we are building in our school. The calculation of the dimension of our extruder will allow us to make test in real condition to verify our expectation. The innovation in this project lies in the fact that we'll be able to control the extrusion rate of flow and its temperature during the printing process. This will make us able also to control the time of setting of the concrete and its final specifications depending on the structure we are printing.

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"Daltons" innovative solution for Color blindness

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Abstract

Color blindness is a condition where there is a difficulty in distinguishing colors. We present in this paper an innovative solution that assists people with color blindness to see colors correctly via iOS and Android application. Starting with the authentic Ishihara color test, similar to the test used by the ophthalmologists, to diagnose this disorder. Using the results found we apply an appropriate color filter on the camera rendering of the smartphone. This solution is an efficient and cost-effective way to show the true colors to the colour-blind people. This application is tested on different patients with different types of color blindness and the obtained results show the efficiency of our solution in dealing with the problem in hands.

Keywords: Color blindness, mobile application, camera filter, image processing.

1 Introduction

Human color vision is based on the response of three different classes of photoreceptors, called cones, located in the retina. Each class of cones is sensitive to photons of different wavelengths: long-wavelength (L), middle wavelength (M), and short-wavelength (S) regions of the visible spectrum. Color blindness, also called color vision deficiency CVD generally caused by either a complete lack of one of the three classes of cone pigments or the modification of one of them. The former is called dichromacy and the latter is called anomalous trichromacy. The dichromacies are distinguished in protanopia, deuteranopia and tritanopia according to the missing class of cones [1].

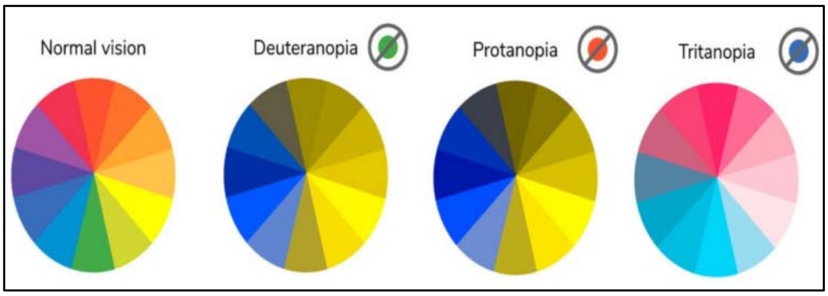

Figure 17: Simulation of three types of color blindness

CVD is the inability to distinguish between certain colors, such as blue and yellow or red and green. This disorder affects approximately 1 in 12 men (8%) and 1 in 200 women in the world and it's caused by a genetic condition, inherited from the mother.

Most treatment strategies for genetic disorders do not alter the underlying genetic mutation. Therefore the purpose of this paper is to present a solution that enhance color vision though a mobile application that offers detection of this anomaly and correct the colors using the smartphone's camera.

2 State of the art

2.1 Working towards treatment

The idea of finding a cure for color blindness was a theoretical dream, beyond the existing medical abilities. Curing a genetic disorder require gene therapy, repairing the damaged chromosome. However few years ago a study co-authored by Jay Neitz at the University of Washington [2] succeeded in injecting cells into squirrel monkeys. The results were auspicious that eventually lead clinical trials that are going on now.

2.2 Related work on color blindness correction

- Color Enhancer for Chrome browser

Color Enhancer is a chrome extension that adjusts properties of colors. It's like applying filters used by mobile camera. The adjustments enhance the colors. [3].

The limitation of this existing solution is the restriction to web usage.

- Color Correcting Lenses

The lenses have optical filters, which eliminate certain wavelengths of lights. This gives more accurate ratio of light entering the eye.

Color-corrective lenses don't work for everyone with red-green color blindness. Also it's expensive and available only in North America. [4]

3 Solution Architecture

In this section we present the detailed project architecture, and the different features in the application.

3.1 Big Picture

The solution consists of creating a mobile application for color blind people to enhance color vision through the phone's camera.

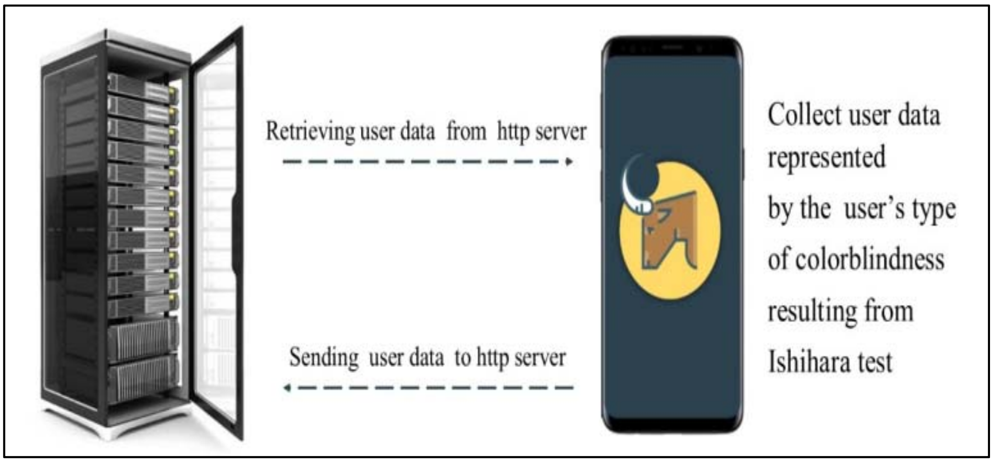

Figure 18: Global solution architecture

The user takes a colorblindness test and his results will be saved in server, then the camera retrieve the data from the server to apply to the correct filter for each user.

3.2 User Scenario

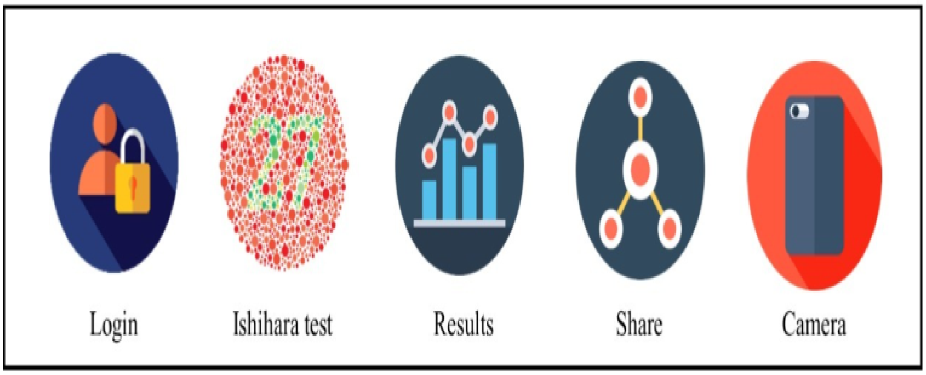

Figure 19: Feature of the application

After logging, the user fills a form to gather information about color blindness and make statistics for research purposes.

Color blindness detection requires certain tests to take to detect the anomaly and the type of color blindness. Therefore, we provided a Test section in the application.

We implemented two tests, Ishihara test [4], and the most used test to detect red-green color blindness. The test is formed of number of colored plates of which contains a circle of dots appearing randomized in color and size. Within the pattern are dots which form a number or shape clearly visible to those with normal color vision, and invisible, or difficult to see. The second test is tritan color blindness test that detect blue-yellow color deficiency, consists of number of plates with colored C shape and the user has to identify the empty space. These tests are fit for everyone to take starting from the age three.

After finishing the test, the user gets immediate result, specifying the type of color vision anomaly and brief explanation, with share on social media feature that gives the ability to share results with the user's closed ones or share it to spread awareness of this disorder that can be hard to detect, or even more, like emailing it to his ophthalmologist.

Depending on the results obtained we apply a filter on the camera rendering that correct and enhance colors. The Application contains three main filters, one for each type of color blindness. we applied a color correction algorithm named LMS Daltonization [6] that corrects the red, green and blue color vision for the colorblind. Daltonization is technique for adjusting colors in an image for improving the color perception by a colorblind viewer. starting with Converting RGB image to LMS color space and simulate the different types of color blindness after that converting simulated image from LMS to RGB and make the difference between the original and simulated image the next step in this algorithm is to Shift colors towards visible spectrum by multiplying by error matrices and Add shifted colors to original image to enhance color vision.

There are two modes for camera rendering, normal mode where the user is able to see corrected colors through the phone's screen in portrait mode.

The second mode, a VR mode, where there is split screen containing two filtered camera views. it gives the option to use the application with VR cardboard, offering a better and more realistic experience to the colorblind.

4 Test and Results

The mobile application Daltons was presented to ten color blind subjects, to test the accuracy of color correction filters and get feedback. We received encouragements from people who tried the application and suggestions different features that serve their needs as color blind.

4.1 Screenshots and Prototype

In this section, we present some screenshots of the mobile application.

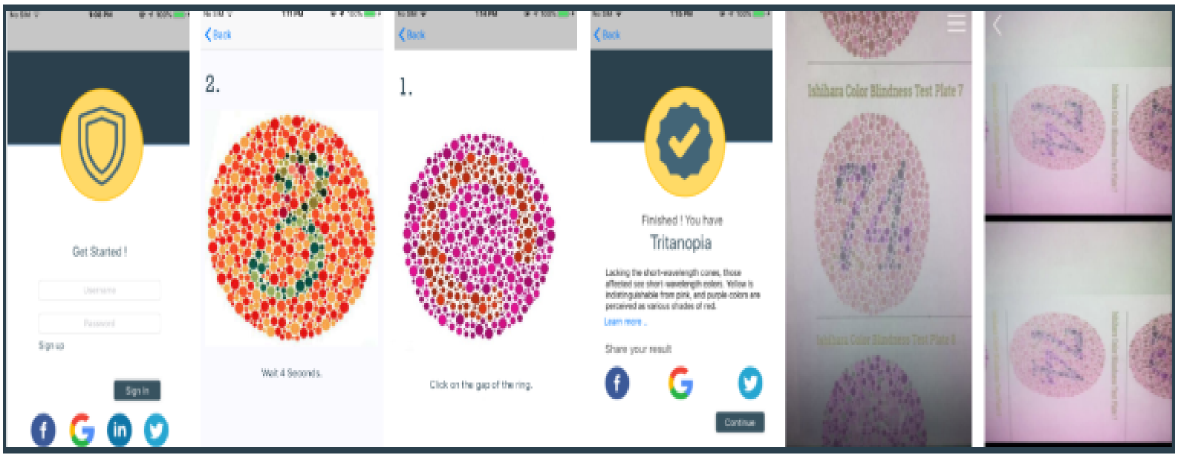

Figure 20: Screenshots from "Daltons"

4.2 Feedback and data analysis

The results of colorblindness test with and without using "Daltons".

Table 1 presents the collected data from the case studies on ten color subjects:

Table 1 - Case studies

id	sexe	age	Test results	
			Without using "Daltons"	With using "Daltons"
1	M	5	Protanopia	Protanopia
2	F	20	Protanopia	Normal
3	M	15	Deuteranopia	Normal
4	M	34	Protanopia	Normal
5	F	55	Deuteranopia	Deuteranopia
6	M	60	Tritanopia	Normal
7	M	22	Deuteranopia	Normal
8	F	47	Tritanopia	Normal
9	M	18	Tritanopia	Normal
10	M	11	Tritanopia	Tritanopia

The studies reported very positive results, most of the subject succeeded retaking color blindness test.

For the impressed colorblind who tested the application, they admire the precision of detecting color blindness and the good quality of camera with the color correction, giving them the chance to enjoy the world with its actual colors, especially with VR mode that gave more realistic experience.

The application did not help some subjects who have extreme kinds of color blindness that may need different correction algorithms to be applied.

Looking forward to enhance to correction to cover more sub types of color blindness and offer new services that make the user's experience more efficient and helpful.

The limitation of this study is the difficulty of finding subjects to test the application, since it's not very common disorder. And that explain the limited number of subjects in the studies.

Overly, we find the obtained results as promising. The mobile application on android and iOS is able to help its uses r detect and solve the problem of color blindness.

5 Conclusion

In this paper we presented a mobile application as a solution to permit color blind people see the color as they are and be able to use it on daily bases.

Emerging mobile-based technologies can have an influence to the eye-care market implicitly. It helps in creating innovative communication channels with clinicians, while also providing a lay person with self-testing methods in the palm of his hands.

Self-testing applications may be useful for anyone living in low-resource areas. Mobile technologies also provide a framework for the digital connectivity of ophthalmic diagnostic devices for eye-care professionals, supporting streamlining diagnostic processes, and offering immediate solution.

6 Acknowledgment

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PAEE/ALE'2019 Hands-on and Workshops Submissions

Submissions accepted for the PAEE/ALE'2019 hands-on and workshop sessions, characterized by being high interactive sessions in which participants and session organizers share their experiences and have common opportunities do develop competences to apply in their own practice.

Impulse response and transfer function. Touch them to understand them

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Abstract

Signal processing related topics are the basis of telecommunication engineering and other TIC related degrees. Even though signal-processing theory is not extremely complex, profound understanding it is not easy. The methods used to optimize sound reinforcement systems are a direct field of application of these concepts, with a clear visual feedback.

Working with a simple setup, composed by an audio interface, a microphone and a loudspeaker, allows us to see and use impulse response and transfer function, to understand how they change when the setup changes, and to correlate these changes with theory. The proposal is mainly based on demonstrating how to work with this setup and let attendants to work with it.

Connecting these experiences with large-scale sound systems, as seen in music festivals, makes these topics very appealing to young students

Keywords: Student engagement in learning, Signal processing, Sound reinforcement systems optimization, Impulse response, Transfer function

1 Introduction

I.T. related engineering degrees, especially those with courses about communication or electronic circuits in their syllabus, like telecommunication, computer science or electrical engineering, use some common signal processing concepts that can be considered to be the basic pillars of more advanced concepts used in digital systems analysis. A profound understanding of these concepts is crucial as they will appear repeatedly along the degree. Even though going deep inside these concepts is not a goal of this proposal, an overall description is going to be presented to let the reader have an idea about them and their complexity (or lack of complexity) and to put the activity into context.

Many of the systems studied can be considered to be LTI (linear and time-invariant). The behaviour of such systems can be fully characterized by its *impulse response* (IR) $h(t)$. The I. R. is the output from a LTI system when its input is an impulse signal $\delta(t)$. Figure 1 shows an example of IR from a LTI system.

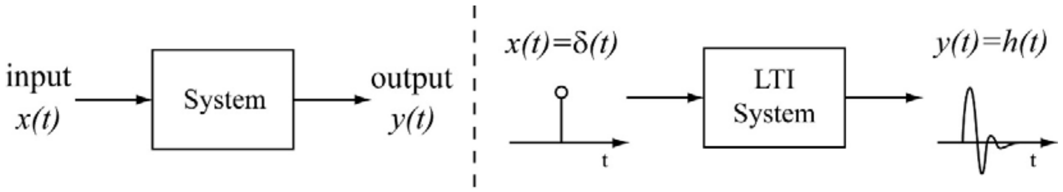

Figure 1. General system representation (left). LTI system impulse response (right).

Once the IR is known, it is possible to calculate the response $y(t)$ of the system to any input signal $x(t)$ by means of what is known as the convolution function between the input and the IR.

$$y(t) = \int_{-\infty}^{+\infty} h(\tau)x(t-\tau)d\tau = x(t) * h(t)$$

The main drawback of IR is that, as the system becomes more complex, the calculus complexity increases exponentially, making it quite difficult to obtain. Luckily, if we change from time to frequency domain, the convolution function becomes a multiplication, so the involved maths become easier. Moving the IR from time to frequency domain is done by means of the *Fourier Transform* ($\mathcal{F}$), and the result is called the *Transfer Function* (TF) of the system $H(f)$.

$$H(f) \triangleq \mathcal{F}[h(t)] = \int_{-\infty}^{+\infty} h(t)e^{-j2\pi ft}dt$$

So, knowing the TF of the system under study and the frequency domain information of the input signal, it is possible to know the output of the system using just a multiplication. As Fourier Transform leads to complex numbers, the expressions to be used to get TF and its amplitude and phase are:

$$Y(f) = H(f) \cdot X(f)$$

$$|Y(f)| = |H(f)| \cdot |X(f)|$$

$$\arg Y(f) = argH(f) + argX(f)$$

Although these set of expression are not too complicated, they are not intuitive and, taking into account that these are fundamental concepts in signal processing, if students present lack of solid mathematical background, they can become a huge obstacle. To deal with this situation, connecting these concepts with real life engineering tasks, as appealing to students as large sound reinforcement systems (figure 2) is a very useful tool to engage students and to make IR and TF become interesting and understandable concepts.

Figure 2. Live event sound system (left) and processing and analysis elements (right).

Connecting large-scale sound systems used in music festivals with signal processing concepts has been proved to engage students with ease. At the University of Alicante, in a course called Advanced Audio Visual Systems, we have been using sound reinforcement systems analysis as a way to improve the degree of understanding of IR and TF with Telecommunication Engineering students. Some details of the project (in Spanish) can be found in Romá (2016).

2 Activities

The session will start with a *conventional* approach to the IR and TF concepts by means of their definitions. A good reference for that is the Communication Systems book by Bruce Carlson in any of its editions, as it is commonly used as one of the main references in engineering degrees.

In the second part of the session, the simplest implementation of the set-up for analysing sound systems will be presented (figure 3) and we will be able to obtain real IR and TF data. Some experiments will be conducted to show some basic properties of IR and TF, trying to understand the amount of information that can be obtained from the phase display of the TF. To have an idea of the full potential of sound reinforcement systems analysis as a signal processing field of application, McCarthy (2016) can be an interesting reference.

We will share some examples about how we use these techniques with our students and the kind of systems we work with and will present some free tools to implement similar systems.

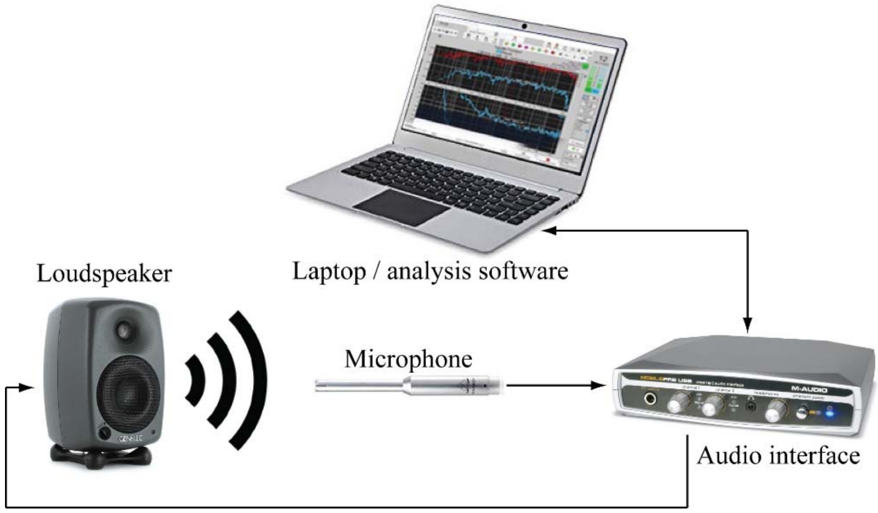

Figure 3. Basic set-up for obtaining I. R: and T. F. of a loudspeaker.

Those attendants having their own laptops, will be able to directly try some experiments after installing open source software (OSM - Open Sound Meter, https://psmokotnin.github.io/osm/). Besides, some instructions will be facilitated about how to generate test signals providing the required system responses using an open source audio editing software (https://www.audacityteam.org/download/).

3 Expected results

One of the main expected outcomes of the session will be to understand how loudspeaker measurement can be an easy way to understand the concepts of IR and TF. In the process we will obtain several real IR's and TF's (figure 4) and will try to correlate this information with theory. Attendants will also learn how to set-up similar systems under low budget conditions, even for free with open source and simulation tools.

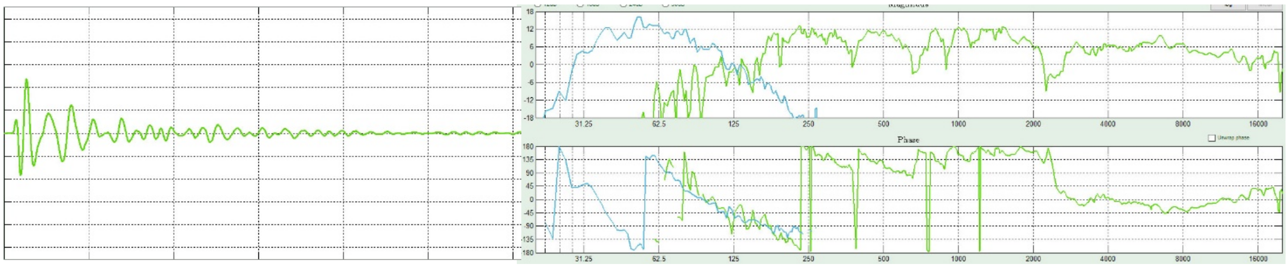

Figure 4. Real IR (left) and TF (right).

I will also try to get feedback from session attendants in order to improve the way in which I'm using these tools, and to look for other disciplines in which they can be used.

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Teaching Portfolio Workshop

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Abstract

The Swedish Government has commissioned The Swedish Higher Education Authority (Swedish government press release, Swedish Higher Education Authority) to carry out a follow-up of pedagogical development work at Swedish universities. The mission is to provide a national overview and to contribute to knowledge about higher education institutions' work with pedagogical development. The Authority is asking all universities for input regarding what the Authority should prioritize in its mission regarding university education development work. Most universities in Sweden have prepared instructions for writing a teaching portfolio. Chalmers University of Technology has used guidelines since many years (Chalmers Guidelines for pedagogical portfolio). The aims are to promote pedagogical development and to be used at promotion and employment processes (Chalmers Guidelines for pedagogical portfolio, Chalmers vision of pedagogical competence, Larsson & Olsson, 2015). At the *Teaching Portfolio Workshop* Chalmers' guidelines for writing a pedagogical portfolio (Chalmers Guidelines for pedagogical portfolio) will be presented and discussed with the participants. Participants will, through active participation and learning in groups discuss and start to write the section - which is often regarded as the most important part of the Teaching portfolio - which has the subheading "Your pedagogical activities: approach, reflection and development". Finally, the seminar is summarized with the participants' contributions from group work. Examples from completed portfolios are shown and followed by joint discussion and opportunity to ask questions.

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

1 Introduction

The Swedish Government has commissioned The Swedish Higher Education Authority (Swedish government press release, Swedish Higher Education Authority) to carry out a follow-up of pedagogical development work at Swedish universities. The mission is to provide a national overview and to contribute to knowledge about higher education institutions' work with pedagogical development. The Authority is asking all universities for input regarding what the Authority should prioritize in its mission regarding university education development work.

The Association of Swedish Higher Education Institutions (The Association of Swedish Higher Education Institutions) recommends that all teachers write a teaching portfolio, showing the teacher's pedagogical experience and pedagogical competence including teaching skills. Internationally, educational development and teaching excellence in higher education have been highlighted for more than thirty years (Gunn Fisk, 2014, Report to European Commission).

Most universities in Sweden have prepared instructions for writing a teaching portfolio. Chalmers has used guidelines since many years (Chalmers Guidelines for pedagogical portfolio). The aims are to promote pedagogical development and to be used at promotion and employment processes (Chalmers Guidelines for pedagogical portfolio, Chalmers vision of pedagogical competence, Larsson & Olsson, 2015). Chalmers University of Technology and the University of Gothenburg offer in cooperation a seminar series on how to write a teaching portfolio. The Chalmers University of Technology has developed guidelines for writing a teaching portfolio (Chalmers Guidelines for pedagogical portfolio). In the teaching portfolio, teachers´ are encouraged to document their pedagogical practices and experiences and to reflect upon concrete examples of their teaching, supervision and other pedagogical tasks using the didactic questions: what, how, and why. The teachers need to show and motivate their pedagogical choices, their planning, their justification of pedagogical approach, their implementation and the results and analysis of their pedagogical work.

Development and assessment of competences are today an obvious part of all activities at university level, thus also for teaching and learning activities. Teacher's pedagogical competences and teaching skills are crucial for high quality teaching and student learning. High quality teaching requires innovation, motivation and creativity. This will not happen without the enthusiasm of skilled teachers who deliver it.

Academics are rational actors, and in the main, they will allocate time to tasks that are rewarded. Thus acknowledgement and rewarding are necessary to promote university pedagogical development.

Universities need to acknowledge and reward quality teaching and pedagogical development. The best way to this to be done is transparently and visible across the institution. It is recommended that engaged teachers are allowed and encouraged to share their enthusiasm, internally within the institution and externally through publishing, and presenting at conferences.

Institutions are recommended to try to build coalitions, communities of practice, of teachers willing to put effort on pedagogical development. This may build up a positive reputation for teaching skills and successful courses in order to attract more teachers willing to contribute to quality teaching and invest in pedagogical development. Thus, make sure that institutional support is in place and build a positive reputation for successful teaching and pedagogical development.

Annual personal review processes and opportunities for advancement and promotion are of course important encouraging factors.

Active learning is often applied in Engineering Education and when practicing active learning the role and pedagogical skills of the teacher is fundamental.

This *Teaching portfolio workshop* is most explicitly associated with the symposium theme "Development and assessment of competences", but is also related to several of the other symposium themes.

2 Activities

The workshop will start with a short introduction to teaching portfolio and workshop material. At the *Teaching Portfolio Workshop* Chalmers' guidelines for writing a teaching portfolio (Chalmers Guidelines for pedagogical portfolio) will be presented, used and discussed with the participants.

At the Teaching portfolio workshop active learning will be practiced. The participants will interact in mutual exchange of experiences and knowledge, in reflections and discussion regarding the workshop topic. The participants will collaborate in groups, discuss and start to write the teaching portfolio part which has the title "Your pedagogical activities: approach, reflection and development". This part is by educational experts considered as one of the most interesting parts when assessing a teacher's teaching portfolio and pedagogical skills.

Finally, the workshop will be summarized with the participants' contributions from group work and discussion input from the participants. Examples from completed portfolios will be shown and followed by joint review, discussion and opportunity to ask questions.

3 Expected results

Main expected outcome of the workshop is that the participants should get a picture of what can be included in a teaching portfolio to document and show their pedagogical competence, including teaching skills. The workshop will provide opportunity for the participants to start to reflect on how teaching and other pedagogical tasks can be carried out in order to support student learning and how pedagogical development at university can be promoted. The workshop will also address how a teacher´s pedagogical competence and teaching skills can be documented, reflected upon and shown in a teaching portfolio.

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Assessing group and individual work in a collaborative project

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Abstract

Assigning collaborative and group work in tertiary education is considered as a learning method necessary to acquire a set of competences. It allows students to be rewarded for their knowledge and help ensure them gain real world skills they can immediately use in a work environment. As part of tutors' overall monitoring and evaluating process, they are asked to award grades to individuals as well as to the group. It is a hard task especially when learning outcomes set to the project assigned encompass knowledge, attitude, and skills. The evaluation process should be upgraded, modified and redesigned for each project. In addition, the most accurate way to determine a person's competences at something is to assess them using their knowledge and skills in an on-the project situation. The tutor cannot be omnipresent in all different steps of the project neither to observe individual contribution nor the group alchemy. As a consequence diligent students can be profoundly demotivated by group projects if they feel that their own success is dependent on team members who don't do their share. Well designed assessment has numerous benefits aside from the obvious one of providing a measure of students' progress as it can be a means to engage students with their learning. Ideally then, we should aim to support active learning rather than assessment of learning to ensure that the assessment process is an integral part of students' education. So, it is very important to think about making assessment criteria and grading scheme clear. This workshop aims to explore what are critical to be considered for a structured assessment tool, discuss assessment methodologies to evaluate competencies and finally tailor collaboratively a toolkit to help tutors find the balance of knowledge, attitudes and skills in their evaluation process.

Keywords: Active Learning; Assessment, Engineering Education, Group work.

1 Introduction

Through collaborative and group work, members develop their cognitive abilities accenting transferable skills along with the subject knowledge. As teachers, designing assessment rubrics to evaluate the group output of the project can be easy therefore the assessment of the learning and contribution by individual students are not known and cannot be assessed. It will be frustrating for evaluators especially when it is known that the most effective evaluation is that which encourages and rewards effective teaching practices on the basis of student learning outcomes (Doherty & al., 2002; Shapiro & Levine, 1999). The technique of outcomes assessment is the best way to measure student learning and efficiency of teaching methods.

Before designing a project-based course, teachers and tutors need to identify the learning outcomes based on the three taxonomies of Bloom: knowledge-based, skills-based and affective goals. A series of activities and assignments aligning them with different evaluation formats are created.

This workshop aims to discuss what are critical to be considered for a structured assessment tool, reflect upon assessment methodologies to evaluate competencies and finally tailor collaboratively a toolkit to help tutors find the balance of knowledge, attitudes and skills in their evaluation process.

This workshop is meant to help teachers understand and take into account different items to shape or design evaluation rubrics for their students regarding their projects.

2 Activities

The workshop is tailored to lead participants to take into account different items while shaping or designing evaluation rubrics for their students regarding their projects to generate customised ones.

The workshop is divided into 4 parts:

1. The launch of the project:
    a. The ice break activities and group formation: Groups will be formed by having participants choose their favourite dish from a deck of cards representing common international and ethnic snack foods. Each dish picture represents an assessment aspect to be dug deeper during the workshop.
    b. Entry event and driving question design: After watching a short video participants in groups will brainstorm to identify the problem/aspect to be treated, then guided by a given creative map template, they will define the driving question. Participants will receive a role to be played.
2. Investigation and reflexion
    a. Within their groups, participants start their sustained inquiry about the crafted driving question and set their voice and choice.
3. Critique and feedback
    a. A gallery walk will be organised and teams will be directed to different stations to ask questions and discuss their findings.
4. Final Presentation:
    a. Groups synthesise their findings and fill in a criteria matrix using Google docs for collaborative work.

Active learning will be practiced during the workshop where all participants will experience the collaborative work to present at the end their chosen final product which will be a grid encompassing all criteria they need as teachers to assess group work in their mutual classes.

3 Expected results

The main workshop output is a criteria matrix to help tutors to generate their own tailored evaluation grid to assess group and individual contribution within a project (Fox,M.A & Hackerman,N, 2003). A toolkit to help tutors find the balance of knowledge, attitudes and skills in their evaluation process.

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Moodle and peer assessment for better learning

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Abstract

The workshop will be divided into three parts. In the first part, the main use cases of peer assessment will be explored, with a presentation of the pedagogical advantages, the key factors of success as well as the risks related to this activity. In the second part, the participants will use a workshop already created under Moodle but from the point of view of a learner: they will first submit a simple assignment, then correct three submissions of other participants. In the third part, participants will set up a workshop activity under Moodle, in order to put into practice, the best practices and tips seen in the first part. At the end of the session, participants will be able to set up a Peer Assessment process using Moodle Workshop online activity and have an understanding what good practices to use to make this activity a formative one for students.

Keywords: Peer Assessment; Active Learning; Workshop; Moodle.

1 Introduction

Peer assessment is defined by Topping as: « Peer assessment is an arrangement for learners to consider and specify the level, value, or quality of a product or performance of other equal-status learners » (Topping K. , 2009).

The peer assessment method has many advantages and it allows teacher to transform the assessment into a real pedagogical activity. (Bouzidi & Jaillet, 2007)

On the other hand, teachers should be aware about some risks of the peer assessment activity. For example, Kim and Ryu pointed this risk of PA: « cognitive gap between students can affect the success of this practice; good students do not accept to be evaluated by weak students » (Kim & Ryu, 2013). To avoid this risk of acceptance the activity should be anonymous and supervised by teachers.

Bouzidi and Jaillet demonstrated that Peer Assessment can be trusted if there are at least four evaluation and if referring to exact science field (Bouzidi & Jaillet, 2009).

Hsu pointed another risk of Peer Assessment (PA): “Weak students need a clearly established grid to be able to take advantages of peer assessment” (Hsu, 2016). That’s why a well-prepared grid to assess students work by their colleagues is important.

2 Activities

The workshop will be divided into 4 parts. Table 13 resume the lesson plan. The number of participants can be between 16 and 24 persons. Participants should come with their laptop to be able to participate effectively.

The first practice activity will be under ESPRIT Moodle website: https://www.esprit-moodle.com. The website will be available in English and French. During this first practice part, participants will use a workshop already created under Moodle but from the point of view of a learner: they will first submit a simple assignment, then correct three submissions of other participants.

In the second practice activity, participants can use their Moodle websites or continue with ESPRIT Moodle. At the end, participants will set up a workshop activity under Moodle.

Table 13. Lesson plan proposed for the workshop

Activity name	Technics	Duration	Necessary logistics
Peer Assessment theory and typologies	Presentation	15 min	Data projector
Understanding Peer assessment using Moodle workshop activity	Practice activity	30 min	PC et connexion internet
Using Moodle workshop	Practice activity	30 min	PC and internet connexion
Closing	Discussion	15 min	

As we can see in the Table , Gielen has resumed the different criteria's of a PA activity (Gielen, 2007). Participants will be able to understand and choose what to apply from most of them in a Moodle workshop activity.

Table 14. Gielen(2007) typology of peer assessment

Cluster (van den Berg, Admiral, & Pilot, 2006b)	**Variable**	**Range of Variation**
Cluster I **The function of PA as an assessment instrument**	Curriculum area/subject	All
	Objectives	Of staff and/or students? Time saving or cognitive/affective gains?
	Focus	Quantitative/summative or qualitative/formative or both?
	Product/Output	Tests/marks/grades or writing or oral presentations or other skilled behaviors?
	Relation to staff assessment	Substitutional or supplementary?
	Official weight	Contributing to assess the final official grade or not?
Cluster II **Interaction between peers**	Directionality	One-way, reciprocal, mutual?
	Privacy	Anonymous/confidential/public?
	Contact	Distance or face to face?
Cluster III **Composition and feedback group**	Year	Same or cross year of study?
	Ability	Same or cross ability?
	Constellation Assessors	Individuals or pairs or groups?
	Constellation Assessed	Individuals or pairs or groups?
	Place	In/out of class?
	Time	Class time/free time/informally?
Cluster IV **Requirement & award**	Requirement	Compulsory or voluntary for assessors/ees?
	Reward	Course credits or other incentives or reinforcement for participants

Finally, animators will give more feedback about their experience and there will be an open discussion with all participants.

All the materials will be shared with participants.

3 Expected results

At the end of this workshop, participants will be able to understand the fundamentals of Peer Assessment in general, how it works using Moodle Workshop online activity from student's perspective and how a teacher can setup this activity online under Moodle. Participants will also understand some Peer Assessment risks and how they can avoid them.

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"What I hope students will remember for my course in ten years?"

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Abstract

According to the literature, active learning in engineering education has been challenging teachers to think and to do differently. Teachers expect to create a meaningful experience in the classroom, motivating and inspiring their students. For that reason, communication is one of the most important competences in teaching practice. This workshop aiming at using a "communication toolbox" to create unforgettable experiences in the classroom. Three questions will be developed during the workshop: 1) "We teach who we are?" – participants will think about their teaching identity; 2) "Can we be a remarkable teacher?" – communication techniques will be put into practice in different classrooms situations; 3) – "What I hope students will remember for my course in ten years?" – participants will be challenged to develop an action plan to make the difference in their teaching practice.

Keywords: Engineering Education; Teacher Practice; Communication.

1 Introdução

Active learning is all about meaningful experiences (Bonwell & Eison, 1991; Prince, 2004; Prince & Felder, 2006; Christie & de Graaff, 2017). This purpose includes why, what and how students learn, but also "with whom" students learn. For that reason, teachers are the masterpiece of the teaching and learning process. First of all, they must be able to create meaningful learning experiences that encouraged and inspired students to the learning process.

Engineering Education research has been discussing how to improve teaching practice in many different ways, challenging teachers to think and to do differently (Lima, de Graaff, Mesquita & Aquere 2018; Lima & Mesquita, 2018). Nevertheless, engineering teachers typically are not prepared for teaching practice, in terms of how to plan a course, how to engage students, how to asses them, amongst other issues. Being an expert in the field it is not enough to teach engineering. According to the literature, communication is a key-competence in teaching practice (Tigelaar, Dolmans, Wolfhagen, & Van der Vleuten, 2004; Zabalza, 2009). For Goldberg and Somerville (2014), communication is the main principle in the relation between teacher and student and, for that reason, implies to listen, ask questions, give feedback and encourage to try new possibilities.

Thus, this workshop aiming at using a "communication toolbox" to create unforgettable experiences in the classroom.

2 Activities

This workshop is organized in three parts, in order to create opportunities to reflect and work on the impact of the communication in students' engagement in the classroom. With this in mind, the workshop focusing on three main questions:

1) "We teach who we are?"

During this first activity, the participants will think about their teaching identity, based on the idea that the way we communicate is related with who we are.

2) "Can we be a remarkable teacher?"

Then, a “communication toolbox” will be explored with the participants. This toolbox includes different techniques (e.g. backtracking) in order to teachers put into practice in different classrooms situations.

3) – “What I hope students will remember for my course in ten years?”

Finally, the participants will be challenged to develop an action plan to make the difference in their teaching practice.

The workshop will close with some sum-up ideas and also collecting feedback from the participants, in order to improve further editions.

3 Expected Results

At the end of the workshops is expected that the participants are able to present an action plan, in which teachers will put into practice, at least one, communication technique provided by the toolbox. The main purpose is to support teachers in the way they communicate in the classroom, turning the teaching and learning process an unforgettable experience.

4 Additional Information

Maximum number of participants: 30

Duration: 90 minutes

Resources: Video projector and Sound Column

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Competencies driven by Lean Education: system-thinking, sustainability and ethics

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Abstract

Lean Education (LE) derives from Lean Thinking, a paradigm that emerged in the industry and nowadays was spread to all industries and services, including the education services, not only as a way to improve these services but, more important, as a pedagogical platform to innovate the learners curricula and better prepare them to professional world. With Fourth Industrial Revolution, also known as Industry 4.0, Lean Thinking principles are more needed than ever in order to train people so they know how to serve better "clients" but in a "lean way", i.e., delivering the product, just using the resources needed to produce it, respecting people and the environment. To achieve this, it is fundamental to know the whole and not just a part, having system-thinking competencies. Lean Education is a need in all professionals, from the line operator to the top management administrators because lean solutions must be found in all activities people do. Advocating Lean consumption is also part of this training. This is why teaching Lean is so important, teaching and learning Lean should call for both content and competency mastery. In order to acquire these competencies, Lean Thinking cannot be successfully taught by traditional expositive methods. Based on Toyota Education Model and Training within Industry (TWI) origins, students need "learning by doing" approaches such as project-based, serious games, hands-on among others to internalize such principles into an industrial environment. In the workshop proposed, participants will have the opportunity to discuss the current professionals' needs and competencies in teams. Each team will discuss some topics such as weaknesses of current problem solving strategies (Content vs competencies, Holistic vs compartmentalized, passive vs active learning methodologies, link to industry,…); Lean Engineering concept, principles, tools and system-thinking, ethics and sustainability competencies. Then, some scenarios of professional competencies needed for future will be discussed.

Keywords: Lean education; Competencies; Fourth industrial revolution; active learning methodologies

1 Introduction

Lean Thinking principles were developed by Womack and Jones (1996) to serve as a guide for companies interested in implementing Lean Production (J. P. Womack, Jones, & Roos, 1990). Lean Production System was the name given by Krafcik (1988) to Toyota Production System (TPS). According to this author, TPS superb others automotive industrials by innovating in the work organization, they took minds and hands philosophy of the craftsmen era, merged it with work standardization and assembly of Ford system and added the glue of teamwork. With this, they managed all their operators as a team members, all capable of developing industrial engineers tasks, dismissing in this way the role of the management staff exclusive of this category till TPS.

TPS was also a different system from the very-known mass production system because Toyota was "doing more with less" where "less" means less human effort, less space, less equipment, less stocks, less product development time, i.e., less of everything - based on exactly what the client wants. Producing or consuming more resources than needed in an activity and that the client was not willing to pay is considered waste by Ohno (1988) and this kind of activity should be recognized and, therefore, must be reduced or eliminated. This urgent need came from the constraints that Japan was suffering after the World War II. These adverse conditions demanded a system-thinking solution, not just a local optimized solution. Furthermore, it demanded a socio-technical system where the human is the system centre, not only a cog in the mechanism. At the same time, they designed a "respect-for-human" system (Sugimori, Kusunoki, Cho, & Uchikawa, 1977), by respecting their fragile condition and deploying their strongest strength: their creativity potential. Respect, greater responsibility and authority are demanded on this system which calls for an ethics behaviour.

Nowadays, the epoch is different, but this urgent need continues. Due to the climate changes and challenges that humans face, TPS key concepts described are more important than ever, in order to achieve sustainable development and assure the future needs of the next generations (Brundtland, 1987). Sustainability issues were also a concern since the very beginning of TPS as the overproduction was considered the worst waste (Ohno, 1988). Eliminating this, all the other wastes are reduced, including the inventories that are linked to higher rates of economic growth (Sanidas & Shin, 2017). Furthermore, Lean Engineering is recognized by their potential to achieve global development (Alves, Kahlen, Flumerfelt, & Siriban-Manalang, 2019).

Lean Thinking principles are universally applied to different sectors, from operations to education (Alves, Kahlen, Flumerfelt, & Siriban-Manalang, 2014; Alves, Flumerfelt, & Kahlen, 2017; Amaro, Alves, & Sousa, 2019; Danese, Manfè, & Romano, 2018; Flumerfelt, Kahlen, Alves, & Siriban-Manalang, 2015), being currently assumed as a philosophy and a "way of life". Lean Education is a need in all professionals, from the line operator to the top management administrators because lean solutions (Womack & Jones, 2005) must be found in all activities people do. Even in an Fourth Industrial Revolution ongoing where Industry 4.0 topic (Kagermann, Wahister, & Helbig, 2013) is always in the day agenda, Lean principles are more needed than ever in order to train people so they know that clients must be served but in a "lean way", i.e., delivering the product, just using the resources needed to produce it. Advocating Lean consumption should be also part of this training. Contributions of Lean Thinking principles on Industry 4.0 implementation are possible at different levels (Brito, Ramos, Carneiro, & Gonçalves, 2019).

Bearing in mind the facts presented, teaching Lean is vital. Nevertheless, Lean learning calls for both content and competency mastery (Flumerfelt et al., 2015) and should not be just "taught". Lean Thinking principles are not an easy subject because learning is expedited through practice. Thus, Lean Thinking cannot be successfully taught by traditional expositive methods. Based on Lean Engineering learning origins, engineering students need "learning by doing" approaches to internalize such principles into an industrial environment (Alves, Moreira, Leão, & Flumerfelt, 2017). Such practices, in or outside of classrooms, are necessary for professional engineering career success, as well as for other professionals from other field (e.g. managers, designers, physicians, nurses, etc.) (Alves, Leao, Maia, & Amaro, 2016; Flumerfelt, Alves, Leão, & Wade, 2016). This is how Toyota develop their human resources, by having them applying *Genchi Genbutsu* (onsite, hands-on experience) even today (Toyota Motor Corporation, 2018, p. 37).

Even now, with Lean Engineering learning integrated into engineering curriculum in many universities (Alves et al., 2017), there is still resistance to accept it as a different management content for engineering curriculum. Normally, the arguments that Lean is "common sense" or "Lean Engineering is classical Industrial Engineering application" are evoked. It is true that, sometimes, Lean Engineering does apply common sense approaches, but most of the time, it is very counterintuitive, implying a new and active discipline to be effective. Fortunately, many researchers and professionals do understand this discrepancy and have described their ideas, impressions and how they introduce Lean Engineering into curriculum design in several papers in scientific journals, international conferences, and thesis, among others. Some of these works are reported in Alves et al. (2017).

Today, it is of general knowledge and highly recommended by many reports, that in order for engineering students to be successful in their future professions they need to be skilful both in the engineering contents and competency mastery. Lean Engineering Education promotes and facilitates this mastery by a "learning by doing" approach, based on teaching and learning tools. This workshop will call for the active participation of the participants that will search such tools and will map the Lean Thinking principles "pulled" by each tool.

The workshop facilitators intend to put participants discussing such questions based on their knowledge and their own experiences. The answers given by the participants are important to move towards professional competencies. Workshop participants are expected to increase their knowledge about LE.

2 Activities

The session starts with an "Ice-breaker" activity, then interdisciplinary teams formation will take place. A maximum of 23-25 participants can be accommodated. The participants will be divided in four teams, according the themes discussed, each one with five to six members. Each team will discuss some topics such as weaknesses of current problem solving strategies (Content vs competencies, Holistic vs compartmentalized, passive vs active learning methodologies, link to industry, Industry 4.0, Education 3.0,…), Lean Education concept, principles, tools and system-thinking, ethics and sustainability competencies. Then some scenarios will be provided to participants to discuss professional competencies needed for industry. It is intended to introduce the taxonomy 3H (Flumerfelt et al., 2015) to the participants. The workshop will end with a workshop assessment.

3 Expected results

After the workshop session, the participants will understand why is so important to learn and teach Lean Education, the fundamental principles/concepts inherent to Lean Thinking principles and effective tools to teach/learn lean in their classes. The point of the scenarios, planning steps and discussion is to point out the critical need for Lean Education to closely align with the essentials of engineering practice of the future. The future of engineering professional practice in 2030 cannot be fully understood since no one knows the future. But, by creating and examining viable scenarios of the future as the basis for planning for engineering education, and more generally, education, a position is created that asks for decision making by educators to improve pedagogy, curriculum, instruction and assessment.

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La ludopédagogie: comment animer un cours par les jeux pédagogiques

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Résumé

L'atelier de formation intitulé "La ludopédagogie: comment animer un cours par les jeux pédagogiques?" s'inscrit dans un cycle de formation proposé par l'association de promotion des ressources pédagogiques et la centrale de ressources pédagogique (l'APRP-CRP) sous le thème « LA PEDAGOGIE UNIVERSITAIRE AUTREMENT », destiné aux enseignants universitaires et ayant pour objectif de faire découvrir des nouveaux outils et d'initier les participants aux nouvelles méthodes pédagogiques. Cet atelier porte sur le thème de la ludopédagogie et cible les enseignants universitaires et formateurs de différentes disciplines.

Mots clés: Pédagogie active, Ludopédagogie, jeux pédagogiques, travail de groupe, pratique pédagogique

1 Introduction

Aujourd'hui, les pédagogies qui s'appuient sur l'emploi de jeux apparaissent comme une issue de remplacement aux pratiques traditionnelles. En effet les jeux sont susceptibles de solliciter la motivation des étudiants et de leur permettre de développer des connaissances dans le cadre de situations d'apprentissage complexes, et dans un sens, plus authentiques (Sanchez et al. 2011).
L'apprentissage par les jeux pédagogiques s'inscrit dans la grande famille des pédagogies actives et suscite aujourd'hui de plus en plus d'intérêt en milieu éducatif. C'est ainsi que plusieurs études scientifiques sur la pédagogie ludique en tant que telle, et tout au long de la vie, sont en plein essor (Engels, 2015).

Les trois conceptrices de l'atelier sont dotées d'une expérience de plusieurs années dans l'adoption de la pédagogie active dans leurs pratiques professionnelles au sein d'instituts supérieurs des études technologiques et sont actuellement focalisées sur le thème de la ludopédagogie et particulièrement des jeux pédagogiques aussi bien sur le plan de sa pratique en classe que sur le plan de recherche scientifique montrant son intérêt dans l'amélioration de l'apprentissage. C'est dans ce sens que dans un objectif de diffusion de la pédagogie du jeu en classe dans le milieu universitaire que cet atelier de formation cible les enseignants universitaires, les formateurs et les conseillers pédagogiques.
Portant sur une durée de 4 heures, l'atelier a pour objectif ultime de faire vivre aux enseignants participants de nouvelles expériences pédagogiques constructives, qu'ils pourront reproduire avec leurs étudiants. Les objectifs spécifiques sont au nombre de quatre ;

- Découvrir une pédagogie décalée, ludoéducative
- Expérimenter le jeu pédagogique comme moyen d'animation en classe
- Évaluer les avantages et les limites du ludique dans l'approche pédagogique
- Approcher les étapes de conception d'un jeu pédagogique

2 Activités

La ludopédagogie offre, dans l'éventail des pédagogies actives, une source privilégiée pour engager les participants, particulièrement par l'immersion dans un contexte pratique et concret. Elle est fondée sur l'idée d'utiliser le jeu comme méthode pédagogique (Alvarez, 2018). Adopter l'approche ludique permet de créer un contexte favorable à l'apprentissage pour les enseignants et les apprenants. C'est ainsi que cet atelier de formation comporte différentes activités alternant théorie et pratique.

Partant de la conviction qu'il est nécessaire que l'enseignant ou le formateur soit lui-même impliqué et motivé pour l'adoption de la pédagogie par le jeu pour pouvoir l'implémenter, nous avons choisi de concevoir l'atelier dans une ambiance ludique autour du jeu. En effet, tout au long de l'atelier, le participant expérimentera différents jeux pédagogiques afin de s'acquérir des concepts théoriques liés à la ludopédagogie, apprendre à adopter une posture ludique dans l'animation d'un cours par les jeux pédagogiques, et comprendre le mécanisme de l'intégration du jeu pédagogique en classe.
Ces objectifs seront atteint en suivant la scénarisation présentée dans le tableau 1.

Tableau1: Scénarisation pédagogique de l'atelier

Activité	Techniques utilisées	Output	Durée
Prise de contact Présentation des objectifs de l'atelier	Brise glace par un jeu de dés (story cubes)	Ambiance détendue Objectifs explicités	30 mn
Séquence 1 : Expérience	Mise en situation via un jeu de cartes conçu pour l'atelier. Travail de groupe.	Découverte des concepts théoriques de la ludopédagogie à travers le jeu	60 mn
Séquence 2 : Analyse/Réflexion	Jeu de rôle Travail de groupe Débat	Identification et discussion des avantages et limites de la ludopédagogie.	40mn
Séquence 3 : Généralisation	Présentation du mécanisme du jeu par un jeu de plateau conçu pour l'atelier. Travail de groupe.	Conscientiser chez les participants le mécanisme d'intégration du jeu à leurs pratiques d'enseignement	60 mn
Séquence 4 : Transfert	Travail de groupe. Restitution et discussion plénière.	Adopter une approche réflexive par rapport aux habitudes antérieures Amener les participants à mettre en pratique l'apprentissage en proposant un jeu adapté aux besoins d'un objectif pédagogique bien défini.	40mn
Evaluation	Mind map	Evaluation	10mn

3 Résultats attendus

Au delà de la découverte, nous visons à travers cet atelier à porter un nouveau regard sur sa pratique enseignante et d'y apporter un changement via la mise en place de la ludopédagogie dans les cours et activités d'apprentissage. Une étude d'impact sera lancée ultérieurement auprès des participants pour évaluer cet impact escompté.

Aujourd'hui, le jeu, qu'il soit numérique ou physique, s'invite dans les salles de cours en tant que méthode pédagogique innovante sous la forme, par exemple, de jeux de rôle (Sanchez et *al.*, 2015), de jeux collaboratifs de co-construction (Lépinard, 2018) ou encore d*escape games* (Guigon et al., 2017). L'atelier de formation en ludopédagogie est, nous l'espérons, un premier pas ouvrant des perspectives vers un développement de ces dispositifs pédagogiques.

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The "Empty Square" Activity

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Abstract

This hands-on session will propose an activity called "The empty square". The main objective of this hands-on session is to provide an environment conducive to the development of teamwork skills, as well as promoting moments of reflection on the importance of teamwork for engineering students and for an engineer's professional development. It will be offered in English and may have up to 30 participants.

Keywords: Teamwork skills; Engineering Education; Active Learning.

1 Introduction

The great engineering challenges of the twenty-first century are complex and multidisciplinary in nature. Engineers engaged in addressing problems of societal concern that have economic impact will necessarily be members of multidisciplinary teams. Teamwork is identified as one of the most important abilities sought by employers of engineers (Passow, 2012; Smith, 2007).

Seat, Parsons & Poppen (2001) brought that there is no secret that the quality of interpersonal, communication, and teaming skills in engineering graduates—termed *performance skills*—is of concern to both industry employers and engineering educators. These skills include communication abilities, interpersonal interaction, conflict mediation, team performance, understanding of technical culture, and sensitivity toward diverse populations due to race, ethnicity, gender, and socio-economic standing.

Salas, Sims & Burke (2005) proposed eight teamwork components that would allow the team to have guaranteed success: shared mental models, closed-loop communication, and mutual trust, team leadership, mutual performance monitoring, backup behavior, adaptability, and team orientation.

Students normally work in groups and they need to learn how to work in teams. Students need to believe that great teams work together to accomplish great results. When proposing a teamwork task or project, instructors should explain to their students the real importance of working in teams and which competences can be developed through teamwork. Instructors can also give some important reasons of why they chose to plan a teamwork task for their students, explaining how important is to have a collaborative culture in their future workplace. Instructors can list that teamwork fosters creativity and learning, improves idea generation, boosts productivity, allows the workload sharing, helps the development of strong work ethic and team spirit, improves communication skills, makes work more fun, among others.

2 Activities

The activities in this workshop are:

(i) Getting to know each other.
(ii) Dividing the participants in teams and sub-teams.
(iii) Developing the Empty Square Activity:
Part 1: Execution sub-teams get out of the room and steering sub-teams work on the instruction manual;
Part 2*:* Steering sub-teams get out of the room and execution sub-teams work on the solution of the puzzle according to the instruction manual.
(iv) Reflecting on the results obtained by the different teams.

3 Expected results

By the end of this hands-on session, we expect that the participants can recognize that teamwork can improve creativity and learning, communication skills, self-respect and respect for each other, among other skills that are important for academic and professional life.

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