Ibero-American Symposium on Project Approaches in Engineering Education

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Welcome to PAEE’2009

The Department of Production and Systems from the School of Engineering and the Research Centre in Education, both of the University of Minho, and the SEFI Curriculum Development Working Group have the pleasure to welcome you at the First Ibero-American Symposium on Project Approaches in Engineering Education.

The demand for engineering professionals is characterised by requirements of deep and solid interdisciplinary technical competences and communication and management skills. Changing Engineering programmes to meet these requirements can be addressed by different learning methodologies. Several institutions of higher education have being addressing these requirements with project approaches to engineering education. A project approach has proven to be effective in making interdisciplinary connections between different subject matters, developing, in parallel, competences of project management, autonomy and communication.

The need for a place to share experiences, encourage more research into the effectiveness of project approaches, have a closer look at the meaning of project approaches for the education of engineers and provide a platform for engineering students to enable them to explain the impact of project approaches on their learning, created a template for the symposium. The programme aims to join teachers, researchers on Engineering Education, deans of Engineering Schools, professionals concerned with Engineering Education and engineering students, to enhance Project Approaches in Engineering Education through workshops and discussion of current practice and research.

The PAEE’2009 Symposium Chair welcomes you in the UNESCO World Heritage and 2012 European Cultural Capital city of Guimarães and hopes you enjoy the First Ibero-American Symposium on Project Approaches in Engineering Education.

Dinis Carvalho

Natascha van Hattum-Janssen

Rui M. Lima

Co-chairs of the PAEE’2009

Welcome from the SEFI Curriculum Development Working Group

The extension of the so called Bologna Process and the building of the European Higher Education Area have contributed to a growing interest in Curriculum Development. This interest is manifested not only among the main actors in the educational community, as teachers, students and those responsible for the management of Universities, but also among many other sectors of the society such as companies, politicians, mass media, and many people in the street.

The Curriculum Development Working Group (CDWG) of the European Society for Engineering Education (SEFI) focuses its activities both on curriculum content and on teaching and learning methods. SEFI CDWG provides a forum for discussing these issues among those directly involved in Higher Education as well as people from companies. The Working Group certainly welcomes any initiatives for doing just that, as this Ibero-American Symposium on Project Approaches in Engineering Education.

Members of CDWG have been involved in the last couple of months in another two meetings on Curriculum Development: First, at the International Symposium on Innovation and Assessment of Engineering Curricula last May, jointly organized by the University of Valladolid and the CDWG, and later, at the Workshop on Active Learning in Engineering Education, in Barcelona last June. Perhaps it is only by chance that these three meetings have been called in the northern part of the Iberian Peninsula. On the other hand, CDWG members play a prominent role in the programme of the SEFI 2009 Annual Conference.

Now, let me do some reflections on the Guimarães Symposium. First, the interest of jumping over the European boundaries and calling colleagues from Ibero-American countries, with which both Spain and Portugal still keep close ties in many fields. Second, the opportunity for not only discussing on project learning but also for being hands- on, working with practical problems and looking for solutions; plenty of time has been allocated for this task in the five workshops appearing in the programme. Finally, I like to outline the possibilities that project- based learning, as one of the active learning approaches, offer in innovative engineering curricula; this meeting is an invitation to discover new possibilities and to find ways for getting better results. It is generally admitted that active learning constitutes the best way to prepare engineering students for life- long learning and many other requirements to which 21st century graduates should answer.

With all this antecedents it is for me not only a pleasure but also an honour to respond the request received from the organizers, and to welcome the participants of this Symposium on behalf of SEFI Curriculum Development Working Group. I would also like to congratulate the Universidade do Minho, and especially the members of organization, for the splendid outcome of their efforts, and I praise for the best success of the Symposium.

Urbano Domínguez

Chairperson of SEFI CDWG.

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IBERO-AMERICAN SYMPOSIUM ON PROJECT APPROACHES IN ENGINEERING EDUCATION

Programme

July 21		EE0.19	EE0.22	EE0.17
Time				
08:30	08:45	Registration		
08:45	09:00			
09:00	09:15			
09:15	09:30	Opening and welcome		
09:30	09:45			
09:45	10:00	Plenary Session 1		
10:00	10:15	Keynote Speaker		
10:15	10:30	Alex Stojcevski		
10:30	10:45			
10:45	11:00	Coffee break		
11:00	11:15	Paper Session A1	Paper Session A2	Paper Session A3
11:15	11:30			
11:30	11:45			
11:45	12:00			
12:00	12:15			
12:15	12:30			
12:30		Lunch		
	14:00			
14:00	14:15	Plenary Session 2		
14:15	14:30	Keynote Speaker		
14:30	14:45	Jordi Segalàs		
14:45	15:00	Workshops A		
15:00	15:15	Project Approaches		
15:15	15:30			
15:30	15:45			
15:45	16:00			
16:00	16:15			
16:15	16:30	Coffee break		
16:30	16:45	Workshops B		
16:45	17:00	Evaluation and Assessment of Project Approaches		
17:00	17:15			
17:15	17:30			
17:30	17:45			
17:45	18:00			
18:00	18:15	Plenary Session 3		
18:15	18:30			
18:30	18:45			
18:45	19:00			
19:00	19:15	Social Programme		
19:15	19:30			
19:30	19:45			
19:45	20:00			
20:00	20:15			
20:15	20:30			
20:30		Dinner		

July 22		EE0.19	EE0.22
Time			
08:30	08:45		
08:45	09:00		
09:00	09:15	Plenary Session 4	
09:15	09:30	PAEE'2009 Student Best Project Award Presentations	
09:30	09:45		
09:45	10:00	Paper Session B1	Paper Session B2
10:00	10:15		
10:15	10:30		
10:30	10:45		
10:45	11:00		
11:00	11:15	Coffee break	
11:15	11:30	Workshops C	Paper Session C
11:30	11:45	Student and Staff Involvement	
11:45	12:00		
12:00	12:15		
12:15	12:30		
12:30		Lunch	
	14:00		
14:00	14:15	Plenary Session 5	
14:15	14:30	Keynote Speaker	
14:30	14:45	Arvid Andersen	
14:45	15:00	Workshops D	
15:00	15:15	Project Management and Team Work	
15:15	15:30		
15:30	15:45		
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16:00	16:15	Coffee break	
16:15	16:30	Workshops E	
16:30	16:45	Team Work in Project-Led Engineering Education	
16:45	17:00		
17:00	17:15		
17:15	17:30		
17:30	17:45	Plenary Session 6	
17:45	18:00		
18:00	18:15	Closing Session	
18:15	18:30		

Invited Speakers

PAEE'2009 attracted three renowned keynote speakers, who represent a variety of perspectives on project approaches in engineering education on an international level. We are honoured to have the following inspiring international keynote speakers: Alex Stojcevski from Victoria University (Australia), Arvid Andersen from Copenhagen Engineering College (Denmark) and Jordi Segalàs from the Polytechnic University of Catalonia (Spain). We are convinced that you will be inspired by their experiences around the world with project approaches to engineering education.

Keynote Speakers

Alex Stojcevski

Professor Alex Stojcevski is an Associate Professor of Engineering Education and the Director of the Office for Problem Based Learning in the Faculty of Health, Engineering & Science, Victoria University, Melbourne, Australia. He is also an external Associate Professor of Aalborg University, Denmark, and a Vice-Chair of the UNESCO Chair in Problem Based Learning (UCPBL). He holds a Ph.D. degree in Engineering, Masters by research degree in Engineering, a Bachelor degree in Electrical Engineering, a Master degree in Education, a Graduate Certificate in Tertiary Education from Victoria University, and a Master degree in Problem Based Learning from Aalborg University, Denmark. He has published over 100 book chapters, journals, and conference publications. His interests include pedagogical and organisational change management, educational leadership, organisational development, engineering education, and Problem-Project based learning.

Jordi Segalàs

Professor Jordi Segalàs works as a senior lecturer at Technical University of Catalonia (UPC), Barcelona, Spain. He received his engineering degree from Technical University of Catalonia. Since 2000 he has been working in curriculum greening policies and actions plans at the Technical University of Catalonia. He is leading the Education for Sustainable Development research group at the UNESCO chair for Sustainability. Since 2005 he has been working in TEMPUS (trans-European cooperation scheme for higher education) projects in relation to higher education for sustainable development. He is the director of the Catalan Research Network of education for Sustainable Development and the Vice-Dean for International Relations and Sustainability at UPC.

Arvid Andersen

Professor Arvid Andersen is the originator of the European Project Semester concept. He developed the program in Helsingør, Denmark with six students. A few years later, EPS later moved to the Copenhagen School of Engineering, Denmark, where nearly 70 students enrol in EPS each semester. Dr. Andersen is now retired from the university, lives in Copenhagen, and actively participates in international engineering education throughout the European Union.

Alex Stojcevski - The *Problem-Project-Practice* Approach in Engineering Education

A recent review of engineering education in Australia challenged universities to improve the quality of their programs by systematically embedding the development of graduate capabilities, such as problem-solving, communications, teamwork, ethics and lifelong learning, throughout programs. It also proposed strengthening engineering problem-solving, engineering application and practice, engineering design, the engineering life-cycle, complex systems, project management, global workflow and multidisciplinary. Finally, it argued that the curriculum should include 'engineering application activities that address contemporary issues and human dimensions, such as sustainability, environmental impact, risk, and social, business, legal, and economic factors'. Not surprisingly, perhaps, it also advocated the wider adoption of 'active-learning approaches, including project and problem-based learning'.

Over the past four years, Victoria University has been working towards a problem-based learning (PBL) model that is designed to address challenges such as these in a way that reflects our setting. The outcomes of this work have resulted in a PBL model for Engineering at Victoria University where the 'P' in PBL means more than 'problem' based learning. Rather, it is defined as Problem/Project/Practice based learning (P3BL). The model is built on the learning principles of Active Learning (problem/project based), Collaborative Learning (self-directed and team-based), and Integrative Learning (interdisciplinary knowledge and skills). Interwoven with these three principles are those of 'Engagement' and 'Practice'. In designing this model we need to ensure that these programs engage students and thus help them to succeed.

The majority of students entering our Engineering undergraduate programs have just completed secondary school, often with modest grades. Many are the first in their family to attend university, are typically from homes where a language other than English is spoken and come from areas with a relatively low average income, and their recent school experience has often prepared them to be passive receivers of information. We have taken these characteristics of our student intake into account in our P3BL model. In particular, we have designed the first two years of the program with a strong emphasis on managing the transition of these students from a secondary education environment that emphasises passive learning to a higher education environment that is built around PBL. For this reason, we have decided to use shorter problems in first year before moving on to longer community-based or industry-based projects in the remaining three years. We have also built in a range of student support mechanisms in learning, language, mathematics and technical skills.

One very special feature of the P3BL model is the fact that the problem or project is in the centre of the curriculum which indicates that the problem/project initiates and drives the learning process. This is an indication of an institutional or curriculum level practice. Integrating this with the learning principles of the model, such as interdisciplinary learning, it provides all engineering students to think and practice beyond engineering.

This presentation aims to describe pedagogical and operational issues associated with management of change towards problem and project based learning, provide a detailed overview of the P3BL model, as well as the benefits and challenges towards such a model in Engineering Education. In addition, the address will highlight the necessary support required not only during the change process, but also support for sustainability.

Jordi Segalàs - Effective Team Building in International Interdisciplinary Frameworks: EPS Experience at UPC.

The Technical University of Catalonia started a new educational program for Bachelor engineers: The European Project Semester (EPS) two years ago. In this program students from different nationalities and disciplines work together in teams to perform a real multidisciplinary project proposed by companies. The overall EPS program involves many actors which have to work in teams: students, faculty members (students' supervisors), administrative staff and company representatives. Therefore team building has become a must for the performance/success of the program.

There are many team building strategies, but we cannot say that some are better than others. The effectiveness depends on the final goal of the strategy; for example: motivating a team, teaching the team self-regulation strategies, helping participants to learn more about themselves (strengths and weaknesses), identifying and utilizing the strengths of team members, improving team productivity, etc. All of these require different strategies.

We developed three different tailored team building strategies for each group of actors.

The group of students: They have a clear goal - to perform a real project for a company.

Problems: they don't know each other, they have different specialties and different nationalities therefore different cultural backgrounds.

Team building goals: To train students to work in groups to solve communication problems, to build trust among the members of the team and to identify their individual natural behavioural tendencies in a team context.

Strategy: Students took a teambuilding course where they analyzed models of team behaviour, developed team communication skills and applied group bonding sessions; moreover several social activities were organized.

Faculty and company supervisors: Their goal is to guide the students in the learning process during the performance of the project and to assure a successful working atmosphere.

Problems: The faculty may lack experience in supervising students in multidisciplinary frameworks. EPS is process-oriented however the faculty is more capable at assessing products.

Teambuilding goals: To motivate faculty; to enhance effective collaboration between them, with the coordinator of the program and the students. Moreover they need training in teambuilding strategies to supervise the students more effectively.

Strategy: Training in teambuilding strategies in international frameworks, and training in project process assessment.

Administrative staff: Their goal is not so specific: to facilitate the necessary administrative infrastructure to the students and teachers for a successful EPS program.

Problems: Lack of cooperation culture between different administrative departments such as the international department, the career centre, academic administration, etc. Lack of motivation as the new program was seen as extra work.

Team building goal: To motivate the staff and to enhance effective collaboration between them. Strategy: To communicate their important role in the program and the importance of the program for the organization; to organize social activities and to involve them in all the extra-academic activities organized within the program.

These set of strategies have shown to be effective in all three groups of actors. The EPS program has been very challenging, and it has become a learning process for the organizational structure of the Engineering School where it has been implemented, increasing the team building culture at all levels.

Arvid Andersen - Project Management and Teamwork

A major supporting activity in all engineering courses, in almost all countries, is the use of an extended project based activity. This is now considered to be such an important part of the general technique of learning that it is being extensively employed. This teaching and learning technique is based on the dual concepts often referred to in the educational literature as collaborative learning and Scaffold Knowledge Integration. It is recommended that the project group should take the Problem Formulation Team Exercise provided to discuss the project brief initially handed to them by the project provider. The result of this exercise is a description of the problem as perceived by the project group. Thereafter it should be conferred and discussed with the project provider and the academic supervisor. Based on an approved project description the team can then work out a time activity plan and a GANTT chart for their project period. Project management software such as Microsoft Project should be used to plan and run the project. These techniques are particularly appropriate for project type activities. Collaborative learning refers to students working together in teams where they share and distribute the responsibility of learning. Through meetings team members support each other through questioning and elaboration, providing alternative points of view and by sharing expertise. Research has shown that cooperative settings produce positive results in elaboration of ideas, analysis and problem solving. There is now demand of a person to be proficient with open-ended problem solving and to be familiar with multidisciplinary problems to demonstrate teamwork skills. As described in the Scaffold Knowledge Integration Framework, autonomous learning is facilitated by having students work in groups to allow them to serve as social support for each other through sharing ideas providing feedback and providing some critical assessment of other ideas. Assessments undertaken by the students should be designed to make them listen to each other, to make mistakes in a benign atmosphere, to argue, to discuss and to explain their ideas to other students, to members of the academic staff and to industrial experts. Difficulties in the initial stages of group working between students from different cultural backgrounds need careful scrutiny by members of the project supervisor team. Working in cross-cultural and multidisciplinary teams we have to learn to cooperate with different mindsets. Each of us has our own paradigm. Our cultural codes are different. This is why it can be very cumbersome to deal with international project teams. A number of the key issues are differences between a deal focused and a relationship oriented way of conducting meetings and negotiating between different suggestions. For example a British level of informality and the more formality structured relationships encountered in several mainland Europe cultures can cause strained relationships. Sensitivity to status differences and the rigid hierarchies frequently displayed in a number of Universities may also provide initial uncertainty in students. The main contribution of the academic project supervisor is therefore to help the students to understand the content of their project and ensure they are making progress. It is also to nurture and facilitate the group work and the group process. This should be done by holding compulsory weekly meetings with an agenda determined by the project group. It is recommended that the group work is organized with folders. The supervisor must make sure that the advantage of working in a team is sustained. Thomas Kuhn introduced the paradigm shift in his book *"The structure of Scientific Revolutions"* and showed the significance of first break with tradition, with old ways of thinking with the old paradigm. Teamwork is group performance with regard to the product produced, the project process executed and the people involved. Project work in that sense is social rather than solitary. Participants learn what synergy means and they learn to value and appreciate diversity and differences, which is necessary to make a successful group-project. Students should be involved actively in order to learn to dare and to do. Engineers commonly describe themselves in terms of a single discipline, a convention increasingly misleading. Very few engineers totally work within the confines of a single discipline or industry. Fundamental changes in working attitudes with greater emphasis on multidisciplinary and multinational environments highlight the need for a radical different approach to education and training. It is important that our engineering students acquire an international dimension, and it is important to develop and strengthen links between university and the world outside. This will help develop significant communication and contribute to develop our societies. Aims in education must comprise professional as well as personal development goals since true effectiveness requires both elements. Future business needs people who are competent, responsible and able to contribute constructively in business projects across borders. Knowledge of a specific field will be of less importance. Environmental awareness and a good understanding of an optimum use of resources will be features of future products and manufacturing processes. Industry must find or invent responsible ways to increase production without environmental consequences. Fast technological development leads to faster product shifts on the market. At the same time the market become more global. The possibility of correcting failures will decrease or disappear. Things simply have to be right first time. That means increasing attention must be paid to development of high quality products. Product development will take place as an integrated process with collaborating skills such as design, planning, production, sales, marketing and recycling. Greater integration will be required and the developer must be able to overview the situation and make use of specialists and rely on their knowledge. The future engineer must be able to cope with frequent changes. Perspectives on future engineering education are discussed. Keywords: Project work, Teamwork, Project Management and Team Work, Integrated Engineering Skills.

Invited Lecturer - Special Paper Session on ICT and Projects

Susan M. Zvacek - Creating Engaging Online Courses

Faced with the prospect of developing, and then teaching, an online course, it is only natural to start by pondering, "What am I going to do?" The more important question, however, is, "What are my students going to do?" We know that humans learn by doing things – sometimes that "doing" is observable and easily measured, sometimes not -- but learning will not happen without the learner's involvement in the process. Based on this alone, online courses have an unprecedented opportunity to act as a catalyst for meaningful change in higher education by focusing on student engagement with online labs, remote-access content repositories, and collaborative interaction tools.

Paper Sessions D is a Special Session with invited lecturer Prof. Susan M. Zvacek. She is the Director of Instructional Development and Support at the University of Kansas, where she oversees classroom media support, coordinates instructional design and development consultation, and offers seminars and workshops related to technology integration. Her publications are in the areas of distance education, instructional design, and faculty development and she is co-author of a distance education textbook (Teaching and Learning at a Distance, currently in its third edition) and the recently-released Blackboard for Dummies. Her presentation will be on creating engaging online courses and will be combined with practical experiences in Portuguese Engineering courses.

Workshops

An important feature of the PAEE’2009 Symposium is the extensive workshop programme. Projects approaches to learning are usually aimed at the increase of student involvement in learning, therefore, a symposium on project approaches like PAEE’2009 count on active involvement of its participants. The Organising Committee defined five workshop themes that enable a wide range of discussions, reflections and learning experiences related to project approaches in engineering courses. The workshops are aimed at the active involvement of all participants and seek to contribute to the enhancement of project practice and reflection on practice. The themes are Project Approaches, Assessment of Project Work, Student and Staff Involvement, Project Management and Team work and Students Teamwork in PLEE. The first four themes are prepared by the Organising Committee, based on a number of teaching and educational research experiences at the Industrial management course of the last few years. For the last workshop theme we are very pleased to announce that Wim Weenk and Maria van der Blij from the University of Twente, the Netherlands, will be the workshop facilitators. The workshop programme is organized in such a way that we try to enable everyone to attend nearly all workshops. The workshops are given in a number of different parallel sessions, announced in the programme.

Workshop A – Project Approaches in Engineering Education

This workshop aims to explore the concept of project approaches in Engineering Education. The meaning of projects in engineering education, the dimension, the impact and the perceptions of projects in engineering education are discussed through a number of focused questions. As most engineering courses work with projects, being characterised by different scopes, dimensions and impact on student learning, this workshops seeks to reflect on how to define project approaches to learning, not only by contrasting project approaches to problem-based learning, but also by analysing characteristics of possible project approaches and identifying short and long term benefits of a project approach for engineering students. The participants of the workshop will discuss a framework that will enable them to consider different types of project approaches. This workshop is prepared by Anabela Alves and Natascha van Hattum-Janssen.

Workshop B – Evaluation and Assessment of Project Approaches

The main objective of this workshop is to discuss and reflect upon the current practices of evaluation and assessment within the context of project approaches in Engineering Education. The differences between evaluation and assessment will be discussed as well as ways of monitoring and assessing learning processes based on interdisciplinary projects. One of the main outcomes of this workshop is to develop a possible framework for project evaluation, including the identification of key aspects and questions to be addressed throughout the evaluation process. Also, assessment of student learning will be explored as an important feature for faculty staff involved in the design, implementation and evaluation of project based learning experiences. The preparation of this workshop is in charge of Sandra Fernandes, Rui M. Lima and Maria Assunção Flores.

Workshop C – Student and Staff Involvement

This workshop aspires to reflect on the preparation of teaching staff and students for project approaches. The way teachers are being prepared for working in a team that coordinates projects and for their different roles as tutors, teachers and coordinators will be discussed, as well as the necessary actions to support teachers in their new roles and what can departments, course directors and the University. What is the role of staff development in this process and how can performance be evaluated? The preparation of students for teamwork and the training sessions and other support that prepare them for rather intensive cooperation throughout an entire semester are being explored, from an organisational point of view. Activities to help students to perform effectively within the context of a project are to be reflected on. The facilitators or this workshop are Natascha van Hattum-Janssen, Francisco Moreira and Diana Mesquita.

Workshop D – Project Management and Team Work

Project management knowledge area processes have been developed to improve the management performance of projects. Some of these could be related with students' teams learning processes involved in project approaches in Engineering Education: project integration; time management; team development; risk management. The main objective of this workshop is to discuss management tools and methods, centred on project/team management, entrepreneurship, and motivation, for project students' teams involved in open learning projects in engineering education initiatives. This workshop is prepared by Rui M. Lima, Dinis Carvalho, Rui M. Sousa and Narciso Moreira.

Workshop E – Team Work in Project-Led Engineering Education

The Title of the workshop is *'Students Teamwork in PLEE'* (Project Led Engineering Education). This workshop is organised by Wim Weenk and Maria van der Blij from the University of Twente, the Netherlands, who have longstanding experiences in Project Led Engineering Education (PLEE). The outline of the workshop will be as follows:

1. Introduction on PLEE and soft skills
2. Hands-on exercise (simulation)
3. Belbin test on team roles.
4. Show an explanatory DVD on the team roles of Belbin.
5. Discussion

Communications

The accepted communications for PAEE'2009 include *full papers*, *extended abstracts* and submissions to the PAEE Students' Project Award. This chapter includes all these communications.

Paper Session A1

Forty Years of Teaching and Learning Science and Engineering

J. B. Martins

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Abstract

The paper presents brief notes on the History of the Engineering Education in Portugal and on the History of the Teaching and Learning Methods. The essentials of the modern Engineering Education Methodology are described, associated to the Bologna Process. The Bologna Process Recommendations are referred and its implementation in Portugal. Comments on the several interpretations of the PBL Learning Methods that are running in Portuguese universities are done. Some principles of Engineering Education as Art and Science are put forward.

Keywords: history of teaching and learning; PBL; learning methods; education art and science.

1 Introduction and History Notes

The teaching and learning is a very complex mental process. Teaching and learning in university Engineering Education in Portugal in the 950's was divided in two cycles. The first cycle include Science subjects: mainly Mathematics, Physics, Chemistry. The studies were in part teacher-centered through "magisterial" lectures. There were also practical exercises and laboratory works student-centered since the student had to go through library texts recommended by the teacher and study by himself the details of each laboratory work he had to do. In the lab the Assistant Professor supervised the works of the students only, checking the results obtained by each student. It was a kind of practical examination and the results of all the practical works done by each student counted for 50% of the his mark in each term (a trimester). The other 50% of the his mark was obtained in paper and oral examinations.

The teachers of the first cycle were, in general, Science PhDs, and knew noting about Engineering. Therefore, the "curricula" of the first cycle had no Engineering outlook: Mathematics was not Engineering Mathematics. People used to say that the Electricity given in the Science cycle did not flow in wires … The second cycle included subjects of the branch of Engineering concerned and also a few subjects of other branches.

The studies were in part teacher-centered through "magisterial" lectures. There were also practical exercises and design, laboratory and field works some of them student-centered since the student again had to go through library texts recommended by the teacher and study by himself the details of each laboratory or field work he had to do. In most cases the practical works were done in students groups of 4 or 5.

In the design room or in the lab or in the field, an Assistant Professor not only supervised the works of the students but also directed each group towards the goals to be obtained. During the Easter Holidays there were "Study visits" to production units of the region or even abroad. During August and/or September each student had to find an Engineering Entity (Constractor or Public Service) providing him a stage concerning some practical work related to a curricula subject, whose theme had to be approved by the teacher of the subject. The teachers of the second cycle were, in general, Professional Engineers with PhDs.

From 1960 to 1962 the author attended a MSc (Engineering) 2 years Course in UK (Imperial College) . In the first year the education Methods were a mixed of teacher-centered, with magisterial lectures, and student-centered with lab and problem design works done by 4 groups of 5 students. The lab works to be performed by the student's groups have been designed by the teachers and the problem and design works, within each subject, have been designed by the teacher responsible for the subject. In all cases the student's group had to produce reports showing and commenting results. There was also a meeting of each student's group with the teacher to discuss the reports handled. During holidays there were field trips directed by a teacher to see and discuss details of geologic structures and geotechnical works going on in the country.

In the second year each student had to perform lab work according to the plan he, and his supervisor, have choose. There were weekly meetings of the student with his supervisor to discuss the work going on. In the last

part of the year the student had to write his MSc. Thesis. The thesis was later discussed between the student and an external examiner with the presence of the supervisor.

In 1963 the author starts to teach at the foundation of the University of Mozambique and from the beginning strived to avoid the shortcomings he has found in his own Course. First of all it was looked for a good design of the entire 5 years “curricula” of each of the engineering courses: Civil, Electrical and Electronics, Mechanical and Chemical. The set of subjects in each course had to form a whole directed to the branch of Engineering concerned. The linkage of the subjects was studied in order to avoid lacks and duplications, in order to optimize the use of the total time allocated to each Course.

The teachers after the third year (in a Course of 6 years) were Professional Engineers with PhDs The teachers of the three years PhDs in Pure Mathematics, Physics, Chemistry and Mineralogy and Geology.

The “curricula” included not only subjects of the concerned branch of Engineering but also some subjects of other branches and a few Humanities.

In April the 25th (1974) the Portuguese Revolution changed abruptly the Education Methods, from teacher-centered to student-centered and student-directed learning. Students themselves took power in the universities in a kind of late China’s Cultural Revolution style. Although the situation last only one or two years, there still some small remains of all that.

It should be noted that along the Peoples History teaching and learning has much to do with the prevailing philosophical thoughts and political situation at the time and at the country. The Paris university student’s riots of May 1968 should not be forgotten together with the associated psychological complex of “stealed degree “of the new university graduates.

2 The Concept of Engineer and Engineering.

What distinguish an Engineer from other professional is essentially that he must be able to solve engineering problems. For that the Engineer must use “Exact” Sciences (essentially Mathematics, Physics and Chemistry) as instruments and, therefore he must have knowledgement of those Sciences oriented in the direction of the solution of engineering problems.

Further than that knowledgement, the future Engineer must learn how to use imagination; local experimentation and practical world accumulated experimental results for the purpose of solving a complex engineering problem.

Engineering is Ingeniousness, Art and Applied Science. Not Pure Science.

3 Teaching and Learning Methods and Strategies. Problem Based and Project Based in Engineering Education

There are today a large number of teaching and learning methods and strategies (Collaborative Learning, Cooperative Learning, Discovery-Based Learning; Engaged Learning; Problem-Based Learning; Project-Based Learning). However, the attempts to understand the Teaching and Learning are very older. Concerning the Western World only, it can be referred Jean-Jacques Rousseau (1742); John Dewey (1897, 1888, 1938); J. Piaget (1951 to 2001)

In what concerns problem-based learning (PBL) the first experiences seem to be made in the medical school at McMaster University in Canada (Barrows et al. 1975 to 1998). After, they has been extended to university schools of engineering in Europe (Gibson et al. 2002, Jones, G. 2004, UK; Heitmann, G. and Seiler, R. 2004, , Germany; Milgrom, Elie, 2004, Belgium; de Graaf, E. , 2004, Netherlands; Mohr, G., 2004, Denmark; Jonsson Lars-Erik , 2002, Ostlund, S., 2004, Sweden; Kaiser, H. 2004, Austria), to USA (Sheppard, S , 2004) and to Australia (Rojiter, J, 2006, Stojcevski et al. , 2006, Bronson, et al. , 2007, Krishan el al. , 2007, Venkatesan el al. , 2007). Perhaps due to the Bologna process some European universities start to implement PBL methods.

4 Problem Based Essentials for Engineering Education. E view

In reviewing these essentials, it is important to keep in mind the main objectives of the method: The acquisition of an extensive, integrated knowledgement base that is readily recalled and applied to the analysis and solution of

engineering problems. I.e,the development of effective and efficient skills in the domains of: -i- Problem-solving or engineering reasoning; -ii- Conceptual Design; -iii-Self-directed learning; -iv-Team working.

5 Students Centered Education as referred by many Authors

5.1 Students must have the responsibility for their own learning.

As in a problem-based learning curriculum the students work with a problem, they should be able to identify what they need to learn and what resources they are going to use, to accomplish that learning. In this way students might design their learning to meet individual needs (as they all have differing knowledge and experience) and their career aspirations. The faculty might allow the students to have the opportunity of assuming this responsibility. The faculty might prepares them to become effective and efficient life-long learners, which is-an absolute essential in a profession where new types of problems and new information increased in a almost exponential way. The old educational truism states that half of what the students learn in engineering school will be wrong or outdated by the time they are in practice, and no one knows which half that is. This means that the teachers should work with in the student's group but should not provide the students with what the teachers feel is the information the students need in their studies, nor give them reading or study assignments. The students might learn how to decide on what they need to learn and to seek out appropriate learning resources, using the faculty teachers as consultants, as well as books, journals, online resources (faculty resources) and other experts, also as consultants . This means that the learning should not be teacher-centered; the teacher should not direct what students should learn or what resources they should use. Instead the teacher should design and provide the problem simulations and engineering experiences that challenge the students to learn what is needed in their preparation for a career in engineering. Using their teaching skills, the teacher should guide the students in their work to solve the problem as the students develop a problem-solution. The teacher should identify what is needed to do for developing self-directed learning skills. In this role the teacher is usually referred to as a "tutor" and it needs to be well trained for the role.

5.2 The problem simulations used must be ill-structured and allow for free inquiry

In the real world based learning the problems may be ill-structured problems, with just the initial presenting situation stimulating learners to generate multiple hypotheses about their cause and possible solution. These ill-structured problems must be designed to allow students to freely inquire through history, local examination and the ordering of laboratory tests, in order to obtain the information needed to support or verify their hypotheses. Although many problems designed for problem-based learning are single engineering problems, it is important that the problems be designed similar to those the graduates will face, such as floods problems or problems associated with ways to reduce casualties in the crashing of vehicles, etc..

5.3 Learning should be integrated from the wide range of disciplines that are related to understanding and dealing with engineering problems and are basic to the practice of engineering.

If PBL methodology is adopted, PBL should not occur within a single discipline or subject. Information should be integrated from the many disciplines that are basic to the practice of engineering such as: Topography, Strength of Materials, Hydraulics, Structures, Highways, Geotechnics, Construction Materials, Territorial Planning, Hydrology, Construction Programming, etc. in what concerns Civil Engineering. During learning, students should be able to access, study and integrate information from all the disciplines that might be related to understanding and resolving the particular problem they are working with- just as the engineer must recall and apply information integrated from these diverse sources in solving an important engineering problem. This allows the design and construction problems to be the organizing focus for student learning, better ensuring the recall and application of basic science information in their subsequent professional practice.

5.4 Collaboration is essential

Student collaboration occurs naturally during the group's discussions with the tutor. However, the students must be encouraged to collaborate in all cases during their study. Collaborative work among the students in the group can be the most productive part of their learning process, since the students working together, helping each other to gain an understanding of what they are learning and of its application to the problem, can be rewarding. It is this collaboration that allows the students to develop the security and authority they need to be responsible for

their own learning. Collaboration is an essential skill the students must have in their careers, since they will be invariably working as members of a team.

5.5 A closing analysis of what has been learned from work already done in the problem, and a discussion of what concepts and principles have been learned is essential.

Before completing their work in a problem, the students should reflect on what has been learned and determine if there are any things missing in their overall understanding of the problem and the basic mechanism responsible. In addition, they must reflect on how their new learning relates to prior problems and prepares them for future problems. In doing this they can determine and discuss what important overall concepts or principles have been learned. This important step helps convert procedural knowledge, gained through problem solving, into declarative knowledge for use and recall with other problems in the future.

5.6 Continual opportunities must be provided for engineering skills to be learned.

The opportunity to develop effective engineering skills must be embedded within a problem-based learning curriculum. Many of the problems in the curriculum can be presented as standardized allowing the development of these skills along with problem-solving study and team skills. In addition, recurrent opportunities should be provided for students to work in public and/or private entities, mainly in the final years, applying what they have learned, so developing their engineering skills.

5.7 The sequence of activities carried out must accurately reflect engineering practice.

In any learning process students must go through the same activities, as they learn, as they will go through in their professional work with engineering problems. The problems used must be those that are prevalent and important in practice. This ensures that the activities undertaken by the students and the skills and knowledge acquired are relevant to effective practice as an engineer.

5.8 Student examinations must measure the student progress towards the ability to solve engineering problems.

Although a component of the assessment of students' progress may come from peer assessment that occurs at the end of every worked problem, additional formal assessments must assess the students' problem-solving skills, engineering skills and ability to recall and apply an integrated knowledgement in the solution of an engineering problem.

5.9 Curriculum modifications if PBL is adopted.

If PBL methodology is adopted an appropriated curriculum must be designed and appropriated faculty resources must be provided in order to avoid failure in students' motivation.

6 Interpretations given to the PBL in Portugal. Human Means and Material Conditions for Implementation.

A number of Portuguese universities are trying to implement PBL methodology, following the new laws related to Bologna statements that the Portuguese Government signed. However, several interpretations of that methodology are running. First of all, correct implementation of the PBL methodology requires increasing of costs of human and material resources (more staff, larger student’s labs and rooms larger space in libraries, etc.). However Government is reducing support to universities and does not allow the increasing of fees.

In fact, experiences in Australia and elsewhere show that to have good results in PBL in Engineering, each class should not have more than 20 students divided in 4 or five groups. This implies a large increase in the teaching staff.

Second, correct implementation of the PBL methodology requires a large change in the “curricula” and in the staff, witch takes a number of years.

Third, an important number of students are “worker-students”, employed in external enterprises and they have a special status in the university, since they cannot do work in labs, design rooms and libraries during the office hours. Evaluation of their performance is done mainly on the base of paper examinations at the end of each semester.

Regarding normal students, the PBL methodology process, in relation to evaluation of each student performance, seems to indicate self assessment by the student together with and peer examination. The self assessment can be done, but should not enter in the final mark. The peer assessment is much time consuming and there is no staff enough for it.

Despite these difficulties, there is a point where the PBL methodology is being fulfilled: magisterial lectures have been abolished.

However, in some cases a number of “perversions” to Bologna PBL ideal methodology is happening:

In some first years basic subjects the teachers, at the beginning of the semester; fix the maters to be read by the students and the corresponding literature. Also fix the problems to be solved and the lab works to be performed, but there is little help in the search for solutions and the way to do the lab works. Evaluation is done on the base of paper examinations at the end of each semester.

In other cases the responsible the teachers fix the maters to be read by the students and the corresponding literature. Divide the students in working groups. Give each group a large problem or a set of problems to be solved or lab or drawing work to be performed. Again, little help and little orientation are provided and there is little or no discussion with the teachers during the execution of the works. Evaluation is based on the final report of the accomplished results signed by the group. The mark for each student is the mark’s group. The best students, those who actually do the works, get frustration due to lack of merit reward and complain about the time lost in writing lengthy reports, which could be employed in deeper study of other subjects.

7 Misinterpretations of the PBL Methodology may give rise to Perverse Results.

Misinterpretations of the PBL methodology stated as student-centered learning, are giving rise to a number of perverse situations, not only in Portugal but also in other European countries. Using the EU ERASMUS interchange of students program a student has been sent from the Oporto Faculty of Engineering to a similar course in Belgium to attend heir the last semester of a 5 years Engineering Course. On arrival in Belgian University the student has been handled do a junior teacher for a program of work the teacher has designed. The program of student’s work was just part of the work the teacher had to do for his PhD. thesis and had nothing to do with the final year “formation” of the student, useless for the future of a professional engineer. Remaining in Oporto Faculty of Engineering in the final semester, the student would have 4 subjects centered in practical design, very useful for the professional engineer in the future. This does not mean that it was not good for the student to be in a foreigner country. She learned to speak fluently the French, made some friends, etc., nothing concerned with her future professional work.

The other way round, a foreign Italian student came over to an Engineering Course at the University of Minho using the ERASMUS program. In this case the student was not in the final year. Also he has some subjects in retard and did not know well the Portuguese language. On arrival the student asked for a special program of study that could match his position in his course and special examinations in Italian. Of course the Minho University Engineering teachers could not accept those conditions. What could be done was to make a special plan for him to attend the running subjects in the 3rd and 4th years. In each subject the foreign student had to pass examinations just like any other national student of the subject concerned.

The above examples, and others, show that an engineering student must have a senior teacher as tutor and, when going abroad for a program of study directed towards the future professional work of the student, his tutor must approve that program witch must have been in accordance with the teacher of the foreign university (or other foreign appropriate entity), responsible for the provision of the facilities for the performance of student’swork.

Concerning engineering student’s stages in external companies, a similar kind of cares must bee put forward.

An engineering student going to external company to do a final year stage must have a program of work (usually an actual engineering design) useful for the company and the company must provide for the student a senior engineer has supervisor. The program of the student’s work must be approved by both, the university tutor and

the company's supervisor. In many cases is useful the stage to be done by two students since they can help each other in doing field, design or computer work. The company must provide working space for the students and complements (computer access with appropriate software, drawing equipment, etc.).

A case can be referred were two Civil Engineering students of the University of Minho got a final year stage at a Municipal Authority. It was agreed ,for the student's work, the design of a short span bridge useful for the Municipality.

For the design of any bridge it is necessary, first of all, to have a topographic plan at the scale of 1/500. Also it is necessary to have in situ borings to know the depth of the "bed-rock". The Municipality did not like to spend any amount of money for those purposes. The students had to find other place for their stage.

There are also other cases with companies. In many cases the final year stage work done by Engineering University students is not understood by the Community as serious and useful. In other cases companies take the student's work as manpower at zero cost, giving the students minor jobs such as budgetary calculations, etc., repetitive work useless in the "formation" of a professional university engineer.

8 Engineering Education as Ingeniousness, Art and Science.

In Portugal the carrier of an Engineering teacher does not depends at all of his teaching skills and teaching dedication, but of the level of his research team, the number of papers he publishes in top journals of his specialty and from the importance of his professional works: Design and/or direction of the execution of Tall Buildings, Bridges of large spans, High concrete or earth dams, important Highways, etc., in what concerns Civil Engineering, as an example.

Therefore, the Portuguese university teacher does not spend much time in searching for new methods of teaching and, as a rule, is not much interested in providing good guidance to the first cycle students. Many of the teachers of the basic subjects such as Engineering Mathematics and Engineering Physics are much interested in research in Pure Mathematics, not in research in Mathematics Applied to Engineering Problems. Also, many of the teachers of Engineering Physics are much interested in research in Theoretical Physics, not in research in Physics Applied to Engineering Problems.

Therefore, these teachers do not care much for new Pedagogical Methods such as PBL or other. The Electricity teacher may even teach High Electricity that "does not flow in the wires"…

Of course, there are many exceptions, also.

Most Engineering Teachers understand Teaching as a "mission". Those teachers look for the best way of, within the time available for his subject, lead their students to wok hard from the beginning of the semester in order to "assimilate" the fundamentals of the matter, to "think deeply" on the proposed problems to be solved or on the lab and filed works to be done by their students.

Such teachers start to chose and prepare for their students a short list of text books to be read. A good text book must have in each chapter: the fundamentals of the topic clearly exposed; some solved examples starting with the simpler cases and finishing with those more complex; a sufficient number of problems to be solved by the student and its solutions. All the examples and problems should be related to actual engineering cases.

Surely, in a student-centered and student-directed PBL Methodology the student can search in the internet bibliography for the subject at stake, but he would fail to get the best and would take him most of the time needed for the "study" itself. It should be noted that only about 5% of huge technical literature available is useful to the solution of practical engineering problems. So, the advice of the teacher to the student in searching the right texts is fundamental. Otherwise the engineering student gets lost.

Concerning lab tests to be done by the students, the teacher must choose and prepare them carefully in advance and the staff must provide all pieces of equipment in good conditions for the tests. Furthermore, in many cases the full test would takes several hours or days. In that case the teacher has to choose the essential part of the test to be run by the students and the rest must be prepared by the staff. However, the whole set of results must be provided to the students and they must organize the results and take conclusions on their reports on the work done. In all this again the role of the teacher is essential. The pretended student-centered and student-directed PBL Methodology would fail in this case. The students would loose too much time in doing minor mechanical tasks not essential to the understanding of the phenomena concerned. The lost time might be better spent by the student in studding other parts of the mater.

"Mutatis mutandis" the same can be said in relation to students design and field work. The role of the teacher is always essential and cannot be discarded has it would be understood in a quick reading of the Bologna recommendations. Therefore, although Engineering Education must be student-centered it can not be student-directed. It must be teacher directed.

In the last two years, during the Easter Holidays, there must be planed study visits to site Works with a leading teacher. It is an opportunity for the students to contact the real world of their future profession, to ask questions about the Works going on, etc.. The students are divided in groups and at the end of the visit, each group must elaborate and produce a report to be discussed in a joint meeting.

One important role of the experienced engineering teacher is to orientate his students for the reading and application of the best Standard Codes of Practice in Design and Execution, available in the world technical literature. Codes of Practice are the repository of the best results of the world accumulated experience in the item concerned.

Also the engineering teacher must guide his students in the analysis of "history cases" (failures of works or equipments) searched by the students in the world technical literature, since actual failures are the best actual experiments to learn from.

From the analysis of "history cases" the student must find what was done wrong for the failure to happen.

Regarding evaluation of the knowledge of each student on a subject, again the role of the teacher is essential. The evaluation of each student's knowledge of a subject should be done not only through paper examinations at the end of the semester, but also along his work during the semester. Each student should be asked to do oral presentation of a part of the subject in front of his colleagues and the teacher. Learning to speech and to reason in public, plays an important part in the "formation" of the future engineer.

The author has used with success a kind of written-oral examinations. Three rows of about 5 students were seated far a way from each other in a quiet room with 3 three examiners, one for each row. A written question was put to each student, the question being different from student to student in each row. The students were asked to think, calculate and write the solution they understood to be adequate. After time enough for the answer, each examiner were going to each student's place to dialog with him on the question, registering the level of knowledge the student showd on the subject.

In this way a right mark could be given to each student. It was also an opportunity for the teacher to correct faults on the way of the student thought and in the way the student approached the solution of the problem.

In relation to works done in groups, the report of each group was discussed in a session assembling the teacher and the group. Questions about the problems involved were put to each student, allowing in this way the teacher to give a right mark to each student of the group.

At the University of Minho in the last session of a subject of a semester, the students fill a form with questions of evaluation of the work done by of the teacher and his performance. The student himself has to evaluate his own work and the conditions of the learning process (rooms, labs, equipments, libraries, etc.). The forms are kept in sealed envelops and handled to higher instances. A final mark was secretly transmitted to the teacher responsible for the subject taught.

Experience shows that every student is well aware of the teaching value of each teacher, regardless of the mark the teacher gave him, in the subject concerned.

9 Conclusions

-1-The University must prepare a graduate in Engineering for conceptual Design and Execution of Engineering Actions of the Branch concerned, just like the preparation of a graduate in Medicine. There are strong similitude between the Engineering Practice and de Medical Practice. As Medical Schools, in the final years, resource to practical work done by the students in hospitals, in the middle of professional doctors and staff, the students of Engineering must do practical work in Works going on outside the University in the middle of professional engineers and staff.

-2-The PBL Methodology well understood and well financed seems to be good for university Engineering Education.

-3- For the implementation of PBL the Engineering Schools must create larger classrooms, larger computer rooms for Engineering Design, larger Labs and better equipped, larger spaces in libraries, larger numbers of staff and teachers,

-4-The class of students in each year and subject must be divided in groups of 3 to 5 students. Due to this, the “Curricula” of the Course for each Engineering Branch must be redesigned. The time tables of the subject must also be remaked.

-5-The teacher responsible for each subject must fix the maters to be learned by his students within the time available. He also must select the best textbooks to be used.

He and his collaborators must design each lab work to be performed by each group of students.

They have to plan the study visits to Works , Factories , Companies and Public Authorities . At the same time the stages of the students in those entities can be discussed and fixed.

-6- University-Industry and University-Public Authorities agreements should play an important role in Engineering Education in what in what concerns students stages, etc.. The group stages must start in the 3rd year using the large holidays and should be planed one year in advance. Stages may be done in a foreign entity or university, but the program of work to be performed by the student or the group, must be agreed with the students tutor.

-7- The subjects of the “Curricula” of the Course for each Engineering Branch must be well linked, avoiding gaps and overlaps. At the same time, for each subject, the subjects preceding it, to be first attended by each student, must be assigned. Otherwise the student will not be in conditions to learn the matter.

-8- Regarding evaluation of the knowledgements acquired by each student it must be done trough paper examinations and oral discussions of the reports written by the student’s groups. The paper examinations or the paper–oral examinations referred above are quite important, because students in this way practice retrieval of memorized concepts. Researchers in Cognitive Science (Roediger, H.L. et al, 2008) found this is fundamental for long lasting of those concepts in the memory.

-9-The specific skills needed to be a very good Engineering Researcher are not the same to be a very good Engineering Designer nor those to be a very good Engineering Builder or Contractor. Nevertheless, every good Engineering Teacher, other than to have skill in Teaching, should be a reasonable Engineering Researcher, Designer and Builder. This is so because nobody can teach what, he or she, does not know and do not uses in practice.

10 Open Questions

Which are the skilnesses to develop in the Engineering student? How to develop them?

Is inventive power an innate skill? Is inventive power developable? How to develop it?

Can the innate skilnesses of a candidate to Engineering student to be accessed via psychological examinations?

Is intuition (instintictive knowledgment) innate? Is intuition developable? How to develop it ?

How to put internet in Practice helping in university Engineering Education?

How to create student’s motivation for Engineering Studies?

What are the roles of Lab and Field Shows in Engineering Education?

Can marketing techniques be applied and useful in Engineering Education? How to apply them?

Which is more effective in Engineering Education, Deductive Methodologies or Inductive Methodologies?. Does the best method depends of the subject?

All the Engineering senior university teachers might be Industry Professionals, rather then University Researchers?

Assuming that part of the Engineering senior teachers must be Industry Professionals, what part, Greater or smaller part?

An Engineering senior university teacher, Industry Professional must be a “Key note Lecturer” (Maître de Conferences) only, or should be involved in normal PBL, and in administrative work, also?

Engineering International Standards are repositories of accumulated world experience in the branch of Engineering concerned. How to fit the application of those Standards in Engineering Education?

How develop in the Engineering student a number of knowledgements in the Humanities domain (Economics, Art, Literature, Social subjects, Politics, etc.). (In the 1960's at the Imperial College (London) the Science and Engineering students attended between 12 and 14 o'clock (lunch time) and after 18:00 "Key note Lectures" by experts from other university colleges or from the Pres,s with debate from the floor given.

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Promoting Engineering Education through a Project

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Abstract

This paper is about promoting engineering education in Tartu region, Estonia. It is describing the major problems the educational system of engineering is facing today and searches for some solutions. An overview of how to change the learning process more interesting is given and a concept of the first PBL project is presented.

Keywords: education; engineering; co-operation; promoting engineering education; the first year of projects.

1 The Situation

The greatest problem for educating good engineers is the lack of well motivated students. Over the years our university has been facing the fact that mechanical engineering is one of the least favourite field of study. This has two major reasons. First, there is a worldwide lack of interest in natural sciences among youth. Second, the background of today's students and the need of specialists in the economy of Estonia have changed. Historically our faculty trained maintenance engineers for agricultural machinery of huge collective farms. Today the emphasis is on design and production engineering. Students used to come from rural families. Today the majority of students come from urban areas and they have less interest in farming machinery.

Currently we are facing the following problems in engineering education:

- Students are not very enthusiastic about their studies. There is a prevailing tendency to test what are the minimum requirements for getting a positive or desired grades;
- The percentage of bachelor students continuing their studies in the masters programme is too small. The students of bachelor level have a little idea what is waiting for them in the master's programme. (We consider bachelor level is not a separate degree but a part of 5 year studies.)
- The tasks students solve during the machine design course are not connected to real life.
- Young people are not used to doing something with their hands. It is affecting their ability to work as engineers in companies where it is expected that an engineer solves problems in a workshop as well.
- The high school students are not aware of possibilities of engineering education. Technical education has not been popular for years.
- Engineering education is not popular among high school pupils nor possible lecturers. The main reason is that it does not look interesting.

Our task is to find ways to make studies in our university interesting to the changed target group. We see one of the ways through developing interesting project works for students.

2 Initiatives of Making Engineering Popular

There have been several attempts of making natural sciences and engineering more interesting for the youth.

There are some national initiatives like the programme "Techno Tiger" which is focused on introducing schoolchildren to engineering. The program has supported equipping several schools with small CNC milling machines and CAD workstations. Every year there is a pupils' contest of design and manufacturing. This year the task was to design and manufacture an aero plane.

There is an "Engineering Students Club" – an initiative from the students of our university. The club`s aim is to join students who want to have some fun dealing with technical "projects". The faculty supports this club with premises and advise from staff. This year they took part in "Fun vehicles" contest during the students spring days event.

The national initiative is to promote a general interest in youth. The students initiative is more emphasized on having fun. These programs do not lead youth to the engineering education. It is necessary to create and present interesting example pieces to show what students are doing during their studies and thus make the option of learning in the Institute of Technology more visible to the high school youth.

3 The Need on Labour Market

Training in university should be aimed at preparing students for challenges in real life. The students graduating the Institute of Technology in majority go to work as designers, process engineers and maintenance engineers in local enterprises. The fields of occupation and tasks are different and changing. So it is impossible to teach our students how to solve problems which they face after graduating. What we can do, is to teach them to find ways of solving problems.

Tools for solving technical problems:

- ability to read (books and internet);
- ability to cooperate;
- ability to lead a project or part of it and ability to follow instructions;
- understanding of deadlines.

The best way to learn how to act in a certain situation is to simulate the situation during the learning process.

Description of a possible real life situation:

A customer needs a solution to a problem that is relatively new to you, but is not too far from previous experience. The engineering company has to:

- find information and learn how to solve the problem;
- design an appropriate construction;
- find manufacturers and lead the manufacturing project.

4 Objectives for Project Based Learning

The Institute of Technology has had an experience involving students in several projects. For example in the subject of Machine Design students have made a lot of projects about transmission for a conveyor throughout years. The majority of student projects have been just “paper projects” consisting of drawings and explanatory notes.

The staff has been urged to involve students more into projects and to put these projects into reality. Over the years involvement of students in projects has increased. The movement towards learning through projects has been stable but not very efficient and coordinated. As the objectives have not been set the results are not measured systematically and the output of those projects is not very obvious.

This leads to the need of formulating the objectives of the projects of the students in the Institute of Technology. It is necessary to establish the criteria how to:

- compose a project;
- how to put it into action;
- how to measure the results of a project.

A project should involve several subjects of several levels so that students of junior levels would get a hint what is waiting for them in the future. This should also give students a good opportunity to learn the skills of supervising the work of others.

The planned project should be multidisciplinary in a way that different grades have to complete different tasks.

Our approach to change the learning process is an evolutionary not revolutionary way. We will try the approach in a subject in which the evaluation of work of students has based traditionally on a project. Starting with relatively small changes in process it should have two advantages: 1. If the first project will be successful it is easier to encourage staff resisting change. 2. If the first attempt should have setback the damage made is not so big and it is possible to make some adjustments.

The project is aimed at fulfilling the following tasks:

- Make learning process more interesting and rewarding for students so that they will acquire knowledge better.
- Teach them what is waiting for them after graduation.
- Use the output as a sample of promoting studies in the Institute of Technology.
- To introduce bachelor level students what is waiting for them in masters programme.

Creating a project for a specific course should consider the following criteria:

- It must be related to the course.
- It must be attractive and challenging.
- It should be presentable to wider public.
- It should be completed through several subjects by different grades of students.

Introduction of PBL has to overcome some obstacles:

- The equipment of school workshop may limit the realisation of the ideas of the students.
- Some students may be difficult to motivate .
- The ability and motivation of staff to lead and supervise the projects.
- Limited budget for the projects.

A project starting during the autumn semester must be described and have the necessary equipment and materials for the coming spring semester.

5 First Multicourse Project

For the year 2009/2010 a project called "Gearbox for a Racing Car" is created. Students involved in this project will have to design and build a multigear transmission for a "racing car" that is equipped with 1,3 kW chainsaw combustion engine and an axles from a passenger car. They will also have to take part in a race with this transmission. The criteria for evaluating the project are:

- The transmission is designed and manufactured to suite the car.(There will be only one car on which all transmissions are tested.);
- The life expectancy of the transmission is 10 rounds on a chosen circuit. Every less performed or additional round will give penalty points
- All phases of the project are finished and handed over in time.
- Extra points will be rewarded for original design and low weight

As it is a pilot project, only two subjects and students learning it will be directly involved in this project. These subjects are:

- Design of Machine elements for the first year students of masters programme. This subject is scheduled to the autumn semester;
- Technology of mechanical engineering for the second year students of bachelor programme, which is scheduled to the spring semester.

There are some subjects that will be involved indirectly:

- Theory of automobiles and tractors
- Engineering graphics

The project will be announced during the first weeks of autumn semester. The deadlines and the date of completion will be announced. The workgroups for autumn semester courses will be assembled by cast lots, which helps to equalize the level of workgroups.

Each design group of 3..5 first year masters students will have to design a 3 gear transmission for the "Racing Car".

As there are some problems to solve with this car prior to fitting a transmission to it, every group will have their unique task. Those tasks are:

1. Design of a safety cage and frame of the car;
2. Design of controls and drivers compartment.
3. Placement and connection of axles and engine to the transmissions.

The students who will be involved during spring semester will be notified of their tasks as well but they will be assigned to a workgroup in the beginning of spring semester. The task for the students in spring semester is to manufacture all the transmissions and their parts.

6 Conclusions

In order to make studies in the Institute of Technology of Estonian University of Life Sciences more interesting to youth, our lecturers have a lot to learn and a lot to do. The year 2009/10 is going to be the first year when learning through projects is going to take place.

Steps to be taken

- Getting more information about project based learning
- Starting and carrying out the first project
- Making conclusions of the first project
- Improving the methods and spreading it to subjects not involved during the first year.

Benefits from the project

- Second grade students who have to manufacture parts for the project will have a real life experience of information necessary on a drawing
- Designing and manufacturing a real product should be rewarding enough to stimulate students to be more enthusiastic about their studies.

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Project-Oriented Courses for Freshmen Engineers

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Abstract

Retention of freshmen engineering students is a long-standing problem. There have been many attempts to solve this problem. Many of the proposed solutions get freshmen involved in design projects assuming that this will motivate and inspire them to stay in engineering while they take math, science and general education courses. The solution proposed here is a sequence of three, 1-unit courses taken during the student's first three quarters at the university. The first course introduces the product development life-cycle and gives students the opportunity to design simple robots. The remaining two courses team freshmen with senior engineering students who are working on capstone projects. The freshmen are given tasks by the seniors that are commensurate with their abilities. This is a work in progress and only limited results are yet available to prove or disprove the effectiveness of the approach.

Keywords: freshmen engineering; engineering project courses; project teams; student retention.

1 Introduction

The Institute of Technology at the University of Washington, Tacoma, UWT, is the home to Computer Science, Computer Engineering, and Information Technology programs. The Computer Engineering program was designed to meet the Accreditation Board for Engineering and Technology, (Wear & Baiocchi, 2007; Baiocchi & Wear, 2007).

Attracting students to engineering disciplines and retaining students in the programs are long-standing problems. There have been almost as many attempts to solve these problems, as there are engineering programs. Many of the proposed solutions attempt to get freshmen students involved in design projects assuming that this will motivate and inspire students to stay in engineering while they take math, science and general education courses. One conference that focuses on this approach is the "Real-World Engineering Projects," (IEEE) sponsored by the Institute of Electrical and Electronic Engineers. The conference stressed defining projects for freshmen that relate to contemporary issues.

Integration of just freshmen and seniors in capstone design courses is not entirely new. A few universities have developed programs that focus on getting engineering students involved in meaningful project starting in the freshmen year. The Engineering Projects in Community Service, EPICS, (Cole, Jamieson & Oaks, 2005) program at Purdue University began in 1995 is one such program. The EPICS program focuses on service learning projects that give students at all levels, freshen through seniors, the opportunity to get involved in project that benefit the community. The EPICS program differs in several ways from the program here at UWT. With the EPICS program students have the option to take the EPICS project class starting in the freshman year. However, they are not required to take it any given semester. The UWT program requires enrollment all three quarters of the freshman year. The EPICS program typically has much larger interdisciplinary teams than the projects teams at UWT. The EPICS program does not guarantee that freshmen will see the entire product development life-cycle but the UWT program does give the freshmen this exposure. The UWT program focuses primarily on attracting and retaining freshmen students whereas the EPICS program has broader objectives that include attracting and retaining students but also stress service learning and working on large teams that can include students from disciplines other than engineering.

The Virginia Polytechnic Institute and State University has also tried to integrate freshmen and seniors in the capstone design project. The experiment was housed in the Mechanical and Aerospace & Ocean Engineering departments and is described in one of the references (Marchman III and Mason, 1997). Their experiment seems to indicate that, contrary to the expectation fears, the quality of the projects was not compromised by the freshmen participation. It also indicates that the lack of engineering science background, which was a serious concern, did not prevent the freshmen to make significant contributions to the projects. The main challenge at the time the paper was written was how to accommodate the desire of departing freshmen to continue their participation as sophomores and beyond. Other outcomes of this experiment included the improvement of the

retention rate among the participant freshmen as compared with control groups, introduction of sophisticated CAD software earlier in the curriculum, radical change in the *Fundamentals of Engineering* courses and a paradigm change in the whole curriculum. Moving from an analysis-oriented approach to a design-oriented approach with emphasis on the engineering process was reported by the authors as causing a profound impact on their Aerospace & Ocean engineering program. However, in reviewing the current catalog and course descriptions in the VPI catalog (University Registrar Virginia Tech), it is not apparent that the combined freshman/senior capstone project approach is still being used.

2 Structure of the Freshmen Engineering Program

To address the problems of retaining students in the computer engineering and also attracting them to the program, the Institute of Technology at the University of Washington Tacoma has developed a sequence of three 1-unit courses: TCES 101, TCES 102, and TCES 103. The three courses are taken during the engineering student's first year at the University and are described below. The first course is just for freshmen but the second and third courses combine freshmen with seniors who are working on their capstone design projects

2.1 TCES 101 Introduction to Engineering I

The first course has three specific educational goals: 1) to introduce the product development life-cycle, 2) to give students the opportunity to design devices, including simple robots, that could be the basis for solving real-world problems, and 3) to familiarize students with the team-concept of project development. Students are also assigned simple construction projects that give them experience using breadboards and laboratory equipment. A secondary goal of the course is to help attract freshmen students to the computer engineering discipline. To this end, a presentation describing the sequence of courses is included in the freshmen orientation program. The schedule and topics for the course are shown in Table 1.

Table 1: Schedule and Topics for TCES 101

Wk	Topic	Assignments
1	What engineers do	Identify interesting engineering projects
2	Product Development Life-Cycle	Handout
3	Simple robots	LEGO team project lab 1
4	Simple robots continued	LEGO team project lab 1
5	LogicWorks software	Design a logic circuit
6	LogicWorks software continued	Design a logic circuit
7	Sensors and control	LEGO team project lab 2
8	Sensors and control continued	LEGO team project lab 2
9	Analog circuits and PSpice	Design an analog circuit
10	Analog circuits and PSpice continued	Design an analog circuit
11	Final Exam	

2.2 TCES 102 Introduction to Engineering II

The second course teams freshmen with senior engineering students who are working on capstone computer engineering projects. Senior students are given the title and responsibilities of Project Engineers and the freshmen are given the title and responsibilities of Interns. With the help of the instructors, the Project Engineers define tasks for the Interns that are commensurate with their abilities. During the first combined class, the Project Engineers are focusing on defining user needs, writing technical requirements and designing their projects. Typical tasks given to the Interns in this class include reviewing project concept documents from the users' point of view, participating in status report writing and presentation, reviewing design documents for completeness, and evaluating any prototypes that maybe developed as part of the design process. The Interns may also contribute by

finding availability and prices of parts needed for the project. The schedule and topics for the course are shown in Table 2.

Table 2: Schedule and Topics for TCES 102

Wk	Topic	Assignments
1	Working on project teams	
2	Review of Product Development Life-Cycle	Identify user needs
3	Components of requirements documents	Inspection of the project concept document
4	Social impact of project	
5	Environmental impact of project	Inspection of requirements document
6	Components of design documents	
7	Architectural design view	Write sample design document
8	Static design view	
9	Dynamic design view	Inspection of design document
10	Project review	Team performance appraisal
11	Team Presentation	Quarter Progress Report

2.3 TCES 103 Introduction to Engineering III

During the third and final course the Project Engineers build and test their projects. Interns help with the construction of the projects by performing soldering and wiring tasks. They are also involved in verifying correctness of the construction (wiring and mechanical assembly), testing components and the final project, and preparing and presenting project status presentations. The schedule and topics for the course are shown in Table 3.

Table 3: Schedule and Topics for TCES 103

Wk	Topic	Assignments
1	Review of requirements and design documents	
2	Project scheduling	Review schedule
3	Component selection criteria	Construct parts list and Help procure components
4	Construction techniques	Help with project construction
5	Unit test process	Help perform unit tests
6	Module test process	Help perform module tests
7	Integration test process	Help perform system test
8	Software testing techniques	Help identify test requirements
9	Acceptance test process	Help perform acceptance test
10	Project review and team presentation	Team performance appraisal Team project presentation
11	Course Sequence Evaluation	Course Evaluation

3 Project Teams

Project teams are formed at the beginning of the second freshman engineering course. At that time the seniors and freshmen students are introduced to each other and the seniors give brief presentations on the type of project they intend to develop. The freshmen give the seniors their resumes and rank their preference of projects on which to work, then the team selection process begins.

3.1 Teams selection

After the seniors have described their projects to the class, each freshman lists the top three choices of projects upon which they would like to work. The seniors then review the selections the freshmen have made along with their resumes. The seniors then have the opportunity to interview the freshmen Interns and in conjunction with the instructor, teams are selected. The freshmen are then extended offers to join the project teams.

3.2 Team training

The Center for Engineering Learning and Teaching Engineering (CELT) within the School of Engineering at the University of Washing provides help to engineering instructors throughout the University. One of the services they provide is a session on team training. After the teams have been selected, one of the CELT consultants provides a class on teamwork dynamics. Both seniors (the Project lLeaders) and freshmen (the Project Interns) attend the training.

3.3 Team evaluation

The evaluation process for the teams is bidirectional: Project Leaders evaluate Interns and Interns evaluate the Project Leaders. Approximately half way through the quarter, the freshmen Interns are given an opportunity to evaluate how well the class is going for them and how the interaction with the Project Leaders is progressing.

At the end of the quarter, Interns do a formal evaluation of the Project Leaders and Project Leaders do a formal evaluation of the Interns. The faculty teaching the freshman class and teaching the senior class meet with each team to share the results of the evaluations. If necessary, plans of action are prepared to rectify any problems that have been identified within the individual teams.

4 Accreditation Considerations

The Accreditation Board for Engineering and Technology, ABET, has developed eleven educational outcomes (ABET) that graduates from all accredited engineering programs must meet. Since the classes described in this paper are introductory, no attempt is made to assess mastery of the ABET outcomes. However, students are given the opportunity to start developing skills that will help them demonstrate proficiency in several outcomes. ABET outcome d), “An ability to function on multi-disciplinary teams,” is probably the outcome that is covered in the greatest depth. Students are given training described above in section 3.2 and they work on teams for two quarters.

ABET outcome g), “An ability to communicate effectively,” is another area where the freshmen are required to contribute along with the seniors. The freshmen are required to help prepare and deliver project status reports and the final project demonstration. ABET outcome k), “An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice,” is also an area when the freshmen do work that will help prepare them for later assessment of the outcome. In the first quarter course the freshmen are introduced to tools that are used to design and analyze both digital and analog circuits. In the third quarter class students are taught to use hardware tools such as meters, signal generators, and oscilloscopes.

ABET outcome c) “An ability to design a system, component, or process to meet desired needs,” is an area where the freshmen see how seniors accomplish this goal but they are not expected to perform any design work themselves.

5 Conclusion and Suggestions for Improvement

The sequence of freshmen engineering courses is being taught for the first time this year. The concept of mixing freshmen with seniors working on capstone projects has been tried before but is new, at least for our University and the approach taken at UWT is different from other attempts. Since our approach is new, we do not know for sure how effective it will be attracting new students to the engineering discipline or if it will aid in the retention of

engineering students. There have, however, been some encouraging preliminary results: the first female student declared computer engineering as her major, 9 of 11 freshmen who enrolled in the first course in the sequence are still in the program, and the freshmen are making useful contributions to the capstone project teams.

We have identified some areas that we think can be improved for next year's classes. We feel that the first class, TCES 101, was quite successful, based on student evaluations, participation and comments from students. However, the second class, TCES 102 did not receive good student evaluations. The main problem with this class seems to be related to the fact that the seniors spend most of their time developing user needs, requirements, designs and project plans. The Interns did make useful contributions to the user needs documents for the projects, but they did not have significant input to the more detailed requirements, designs, and plans. We have identified some way we think will improve the participation of the Interns in this class.

To help teams bond earlier, we will give the freshmen two laboratory exercises where they use laboratory equipment such as oscilloscopes, signal generators and multi-meters. The seniors will help the freshmen with a laboratory exercises and, if possible, explain how the exercises will relate to the capstone projects.

One of the Project Leaders developed a simple blog to communicate with the Interns on his team and both the Project leader and the Interns felt this was a very effective way for the team to communicate. In the future we will require that all teams use blogs as one method of communication.

The instructor for the senior capstone course has received a Curriculum Enhancement Grant supported by The Center for Leadership and Social Responsibility (CLSR) at UWT. She intends to use the grand to broaden students' perspectives of engineers' social responsibility. This will be done by adding several lectures and presentations by local professionals, video/DVD presentations related to professional responsibility, and group discussions and debates on social and professional responsibilities. These will serve as a platform for the students to develop a deeper understanding of their professional responsibility, organisational skills and teamwork capabilities which are essential for a productive and responsible engineer. Hopefully, these endeavors will also keep the Interns more interested and involved in the TCES 102 class.

Since the third course, TCES 103, is still in progress, student evaluations are not available to help determine the effectiveness of the class and the interest level of the Interns in the class. However, based on attendance and individual conversations with the Interns, they seem much more interested and involved in this class than in the TCES 102 class.

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An Academic Results Analysis of a First Year Interdisciplinary Project Approach to Industrial and Management Engineering Education

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Abstract

This paper presents an analysis of academic results of first year Industrial Management and Engineering students, achieved either in a PLE (Project-led Education) or in a non PLE teaching and learning approach. Data collected focuses on students' grades, including continuous and summative assessment results of four different courses, from the academic year 2006/2007 to 2008/2009. The evaluation indicators used are the ratio of students assessed and those enrolled in the course, the ratio of students approved and those enrolled in the course, the ratio of students approved and those assessed in the course, the arithmetic mean and the standard deviation of student grades. Findings suggest that PLE students, in average, have better results than the non PLE students at all courses and for the three academic years analyzed. However, these results need to be understood in a broader perspective which includes other variables such as student background, student engagement of given tasks, etc. which are beyond the scope of this paper.

Keywords: academic results; interdisciplinary project; engineering education; assessment.

1 Introduction

Strongly encouraged by the demands of the Bologna Process, interdisciplinary project approaches in engineering curricula have been adopted in a number of Higher Education Institutions (Heitmann, 2005; Helle, Tynjälä & Olkinuora, 2006). By learning through interdisciplinary projects and teamwork, students have the possibility to achieve a deep understanding of concepts, as they move from merely listening and reading about abstract concepts, to working with their teammates in applying those concepts to solve large-scale open-ended projects (Powell & Weenk, 2003). Project approaches also enhance student motivation and respond to the drop out problems and underachievement faced by first year students in Engineering programs (Tavares, Santiago & Lencastre, 1998; Tavares & Santiago, 2001).

In these kinds of approaches to teaching and learning, assessment of student learning has been subject to several discussions. Different concerns emerge when designing student centred assessment methods, as the emphasis is not only on the assessment of the outcomes but also on the process of learning. As the literature on the implementation of project and teamwork in engineering curricula shows, this approach to learning intends not only to deepen students' learning in regard to the technical competencies required for an Engineering profession, but also to improve students' ability to work and cooperate with others, as this is an important issue which is not enhanced or either assessed in traditional learning environments. Nowadays, engineers are, indeed, expected to demonstrate skills related to problem solving, project management, leadership and decision making, amongst others. Project approaches to teaching and learning strongly encourage the development and assessment of these transversal competencies (Becker, 2006; van Hattum-Janssen & Vasconcelos, 2007).

Formative assessment plays an important role in the learning process as it provides students with feedback about their performance, allowing them to improve their work. However, the effects of formative and summative assessment in learning, from students' point of view, are relatively different (Boud, 2000). It seems that the influence of formative assessment is subtler than summative assessment and that the latter seems to drive out learning at the same time it seeks to measure it. Students usually see assessment as the most important result of their learning process. No matter how or when it takes place, it is always the centre of their learning efforts (Boud 2000; Lindberg-Sand & Olsson, 2008). Assessment practices that enable students to grow and develop tend not to fit in with the kinds of tests and examinations that are set, mostly due to university guidelines and professional

requirements (Savin-Baden, 2004). Therefore, different attitudes towards assessment may be found ranging from those who believe that assessment is about measuring competence and improvement through tests that are seen to be reliable and valid, to those who see assessment as a means of demonstrating effective learning in the curriculum, and to those who see it as a means of ensuring that students have learned (Savin-Baden, 2004).

Students' academic achievement is an important indicator of the quality of a given program or project. This is particularly relevant when implementing new approaches to teaching and learning, in so far as both teachers and students are quite concerned with assessment results. Previous empirical studies, based on qualitative and quantitative data collected in the context of problem and project based learning experiences, stress the importance of understanding the impact of assessment on students (Sambell, *et al.*, 1997; Verhoeven *et al.*, 1998; Polanco, Calderón & Delgado, 2004; Savin-Baden, 2004; Struyven *et al.,* 2005). For instance, Verhoeven *et al.* (1998) compared the academic achievement of students by applying a Progress Test to students from two Dutch medical schools, one employing Problem-Based Learning (PBL) and one with non-PBL methods. Findings suggest that there were no systematic differences found in the two administrations of the Progress Test. The test scores indicated that the effects of PBL and non PBL instructional methods on medical factual knowledge were very similar. However, when analysing test scores split into three categories (basic, clinical and social sciences), the results show that the basic sciences favoured the non-PBL curriculum and the social sciences the PBL curriculum. Besides this, an interesting conclusion of this study was that medical students, at the end of their curricula, master the same kind of knowledge, it is only the moment in time that they learn it that differs.

Also, at the University of Minho, a qualitative study based on students' perceptions about assessment in Project-Led Education (PLE) stressed that students were rather concerned with PLE's grading system and often compared grades achieved in PLE with those achieved in other semesters, with non PLE approaches (Fernandes, Flores & Lima 2009a). Students argue that, at the end of the semester, they get a relatively low return in terms of marks, feeling unrewarded in regard to the heavy workload and study effort which the project-led education entails. For this reason, some students stated that they prefer traditional lectures and assessment procedures, as they are not dependent on a group component and the effort required to achieve the intended learning outcomes is much less. In this way, assessment is perceived as fairer and more appropriate in non PLE approaches, as it allows students to achieve higher grades which are exclusively focused on individual performance. By studying harder, some students claim to master the courses' main topics and to be successful in sitting exams.

The main goals of this paper are to analyse grades of students in PLE and non PLE teaching and learning approaches, and to discuss the main findings arising from the data analysis. For this purpose, comparable assessment elements will be used which, in this case refer to the final specific content assessment results from involved courses. In other words, for PLE students, academic final results for each course before adding the interdisciplinary project grade component will be used. In order to analyse the major differences in academic results between project and non-project students, it is important to understand that student's profile and background have influence on the learning success and students' outcomes in each of the learning approaches. Being a working student or being repeating a course are some aspects that could influence students' results, learning tasks, assessment methods, etc. However, these aspects will not be considered in this paper.

2 Case Study Context

In recent years, freshman students in Industrial Management and Engineering program (IME) at the University of Minho have participated in Project-Led Education (PLE), during the first semester of their Masters degree course (Lima *et al.*, 2007). Every year approximately 40 students have enrolled in PLE, forming teams of 6 to 7 students.

The first semester of the first year of IME includes five courses: Introduction to Industrial and Management Engineering (IEGI), Computer Programming (PC1), Calculus (CC), General Chemistry (QG) and Introduction to Economic Engineering (IEE). According to Powell & Weenk (2003), all courses integrated in a Project-Led Education experience are project supporting courses (PSC). In this Masters degree there is no course dedicated to the project content. So, the interdisciplinary project acts like an interconnection pedagogical mechanism amongst all PSC courses. All the courses of the first semester, except IEE, are project supporting courses (PSC). Most of the teachers involved in these courses have been the same over the last few years, being Calculus the only exception. Since the first semester of IME is based on an innovative project approach, the stability of teaching faculty has helped faculty staff involved in this approach to apprehend the methodology concept and to develop pedagogical materials and strategies, as changes in course contents and learning outcomes must be (re)adapted in order to meet the projects' goals and students' needs. The teaching faculty allocated to this programme is represented in Table 1. The larger variation can be identified in CC, where a new teacher (T6, T7 and T8) is chosen every year, by

the Math Department, to teach this course. This is the course in which higher difficulties of content integration have been identified both by students and teachers (Fernandes, Flores & Lima, 2009b).

Table 1: Teaching faculty in the first semester of the first year of IME (from 2006/2007 to 2008/2009)

Years	IEGI	QG	PC1	CC	IEE
2006/07	T1+T2	T4	T5	T6	T9+T10
2007/08	T1+T2+T3	T4	T5	T7	T9+T10
2008/09	T1+T2+T3	T4	T5	T8	T9+T10

In this project approach to teaching and learning, assessment is mainly formative based on continuous assessment and feedback both on PSC and project components (Carvalho & Lima, 2006). This paper focuses upon an analysis of students' grades, so a description of the grading model is necessary to contextualize the results. Students receive grades for each PSC course and these are based on PSC specific content assessment and project interdisciplinary assessment. Each PSC defines its own way of assessment based on different activities that can include small group tasks, work assignments and/or written tests. The project interdisciplinary grading is mainly based on the final project product with a 40% impact on PSC final grade. The final project product includes a group grade based on a final report (35%), its revision after feedback from teachers (25%), developed prototypes (20%) and a final public presentation and discussion (20%). This group grade has an individual correction factor that depends on intra-group peer assessment. This grade has an 80% weight and a written test on the group project has a 20% weight on final individual project grade. All courses have a complementary optional assessment opportunity for students to pass, which can be, for instance, a written test. Most of the impact on PSC specific content final grade in each course is related, as mentioned above, with continuous assessment activities. This is true both for PLE and non PLE students' assessment that is based mainly on individual performance, by completing the same courses' assignments. This is a component of assessment mostly equivalent between PLE and non PLE students. So, course's specific content assessment grades will be the core element of analysis.

3 Academic Results Analysis

In this paper, the academic results of first year students, achieved either in an interdisciplinary project approach or in a non PLE teaching and learning approach, in Industrial Management and Engineering will be analyzed. Data collected focuses on students' grades, including continuous and summative assessment results, throughout three academic years (2006/2007 to 2008/2009). In this analysis, two groups of students are included – those who participate in PLE, where the assessment method itself contributes to the students final classification in the different courses involved, and those students who do not participate in the PLE process (NPLE students). The number of students in each group (PLE and non PLE) varies from course to course and is also different in each academic year (Table 2).

Table 2: Number of Students in PLE and NPLE groups

Years	*Number of Students*	*IEGI*		*QG*		*PC1*		*CC*		*ALL COURSES*	
		PLE	*NPLE*	*PLE*	*NPLE*	*PLE*	*NPLE*	*PLE*	*NPLE*	*PLE*	*NPLE*
2006/07	*Enrolled*	39	14	39	15	39	18	38	61	155	108
	Assessed	39	10	39	4	39	4	38	25	155	43
	Approved	38	4	36	2	30	2	21	10	125	18
2007/08	*Enrolled*	41	23	41	35	41	50	41	42	164	150
	Assessed	41	23	39	12	41	11	40	40	161	86
	Approved	40	18	39	4	38	9	27	10	144	41
2008/09	*Enrolled*	38	27	38	32	37	35	38	72	151	166
	Assessed	38	14	38	18	37	13	36	46	149	91
	Approved	38	12	37	14	31	9	25	7	131	42
ALL YEARS	*Enrolled*	118	64	118	82	117	103	117	175	470	424
	Assessed	118	47	116	34	117	28	114	111	465	220
	Approved	116	34	112	20	99	20	73	27	400	101

The evaluation indicators used are the ratio of students assessed to those enrolled in the course, the ratio of students approved to those enrolled in the course, the ratio of students approved to those assessed in the course, the arithmetic mean and the standard deviation of student grades. Table 3 represents a set of evaluation indicators that were selected for this study. Max indicator represents the higher grade of each set of students. Min indicator represents the lower grade of each set of students. A student is considered approved with a grade higher

or equal to 9.5 out of 20. The Average and Standard deviation are other two indicators computed in each set of students. Three others indicators are the ratios between approved and assessed, approved and enrolled, assessed and enrolled students in each set.

Table 3 shows that in almost all cases the set of PLE students have better results than the other set of students. The only exception was identified in PC1 course with a similar average for both set of students. When Max indicator was compared for PLE and NPLE students, PLE students achieved higher grades than NPLE students, although in some courses the difference was more significant than others. When Min indicator was compared for PLE and NPLE students, PLE students achieved approximately equal grades than NPLE students, as expected because the sample included only the approved students. All these values were obtained using the Approved students, so the sample dimension varies from course to course each year (see Table 3).

Table 3: Grade analysis for the three academic years (2006/2007 to 2008/2009)

2006/07	*IEGI*		*QG*		*PC1*		*CC*	
Indicators	*PLE*	*NPLE*	*PLE*	*NPLE*	*PLE*	*NPLE*	*PLE*	*NPLE*
MAX [9.5, 20]	18.4	16.6	17.2	12.7	14.8	12.7	19.0	14.0
MIN [9.5, 20]	9.5	9.7	9.5	11.2	9.5	9.5	9.5	10.0
Average	15.0	11.7	11.9	11.9	10.9	11.1	12.6	11.4
STD	2.2	3.3	1.9	1.1	1.6	2.2	3.1	1.3
Ratio assessed/enrolled	100.0%	71.4%	100.0%	26.7%	100.0%	22.2%	100.0%	41.0%
Ratio approved/enrolled	97.4%	28.6%	92.3%	13.3%	76.9%	11.1%	55.3%	16.4%
Ratio approved/assessed	97.4%	40.0%	92.3%	50.0%	76.9%	50.0%	55.3%	40.0%
2007/08								
Indicators								
MAX [9.5, 20]	17.3	17.4	16.2	14.6	14.0	12.9	16.8	12.3
MIN [9.5, 20]	12.2	10.9	9.5	9.5	9.5	9.5	9.5	9.6
Average	15.4	14.3	12.0	12.2	10.8	11.0	12.1	10.6
STD	1.3	2.0	1.7	2.2	1.2	1.3	2.1	0.9
Ratio assessed/enrolled	100.0%	100.0%	95.1%	34.3%	100.0%	22.0%	97.6%	95.2%
Ratio approved/enrolled	97.6%	78.3%	95.1%	11.4%	92.7%	18.0%	65.9%	23.8%
Ratio approved/assessed	97.6%	78.3%	100.0%	33.3%	92.7%	81.8%	67.5%	25.0%
2008/09								
Indicators								
MAX [9.5, 20]	17.4	17.3	18.9	17.5	15.6	13.8	18.4	12.0
MIN [9.5, 20]	10.0	11.4	9.5	9.5	9.5	9.6	9.5	9.5
Average	14.6	14.1	14.0	12.2	11.6	11.5	13.4	10.5
STD	1.8	1.9	2.8	2.6	1.6	1.6	2.6	0.9
Ratio assessed/enrolled	100.0%	51.9%	100.0%	56.3%	100.0%	37.1%	94.7%	63.9%
Ratio approved/enrolled	100.0%	44.4%	97.4%	43.8%	83.8%	25.7%	65.8%	9.7%
Ratio approved/assessed	100.0%	85.7%	97.4%	77.8%	83.8%	69.2%	69.4%	15.2%

The ratios presented in the Table 3 show results that are more favourable for PLE students than for NPLE students, in all courses, and for the three academic years. In particular the ratio assessed/enrolled presents values above 94.7% for PLE students, whereas for NPLE students all values are below 63.4%, except one (IEGI 2007/08). Similarly the ratio approved/assessed is above 67.5% for PLE students, except one (CC 2006/07 with 55.3%), being above 90% in 7 out of 12 cases. For NPLE students, this ratio is placed between 15.2% and 85.7%. For the ratio approved/enrolled it can be verified that values are above 65.8% for PLE students, except one (CC 2006/07 with 55.3%), being above 90% in 7 out of 12 cases. For NPLE students, all values for this ratio are below 44.4% except for IEGI 2007/08 with 78.3%. The dimension of the sample for the ratio assessed/enrolled and approved/enrolled is the number of enrolled students on each course and each year. The dimension of the sample for the ratio approved/assessed is the number of assessed students on each course and each year.

Figure 1 represents averages of students' grades for each course in the three academic years. For PLE students these averages are predominantly above the average of NPLE students. However, there are 4 cases out of 12 where this is not true: QG 2006/07 with equal averages; QG 2007/08, PC1 2006/07 and 2007/08 with two decimal places of difference.

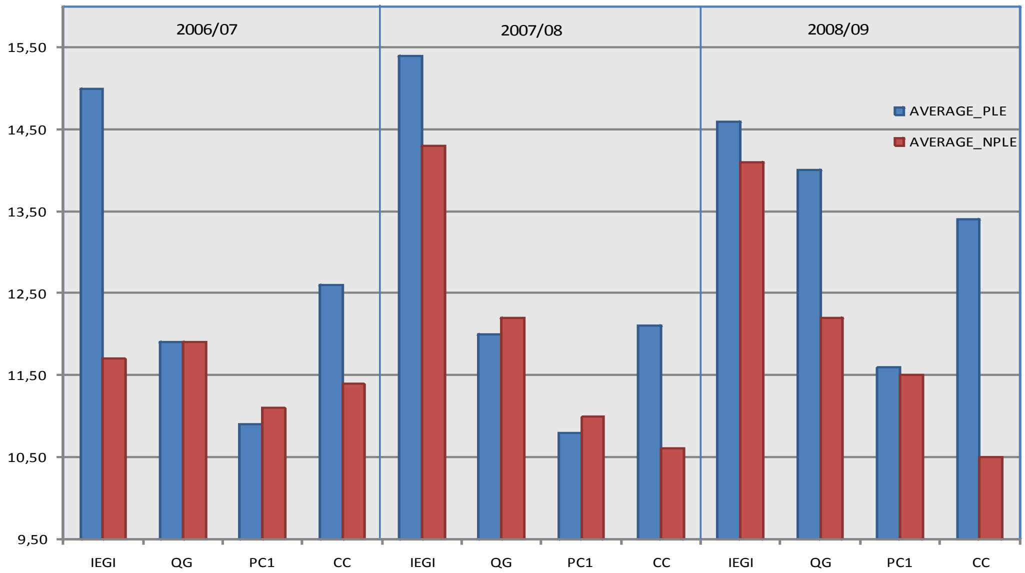

Figure 1: Average of students' grades for each course in the three academic years

Analyses were performed using Statistical Package for the Social Sciences (SPSS, version 17.0). To analyse the academic results of PLE and NPLE group of approved students in all years, a boxplot graphic was prepared (Figure 2), based on total number of approved students on all courses (PLE – 400; NPLE - 101). The middle line of the box indicates the median of the academic results for each of the two groups of students, PLE and NPLE (≈12.7 and 11.8, respectively). The highest and the lowest results are also presented (limits of the vertical lines). It can be observed that, though the minimum values practically coincide for both cases (9.5), the maximum occurs for the PLE students (19.0). The NPLE group of students presents lower amplitude, i.e. variability in academic results. It also can be observed that 75% of the of PLE students gets grades approximately lower than 15.0, and 13.6 for the NPLE students.

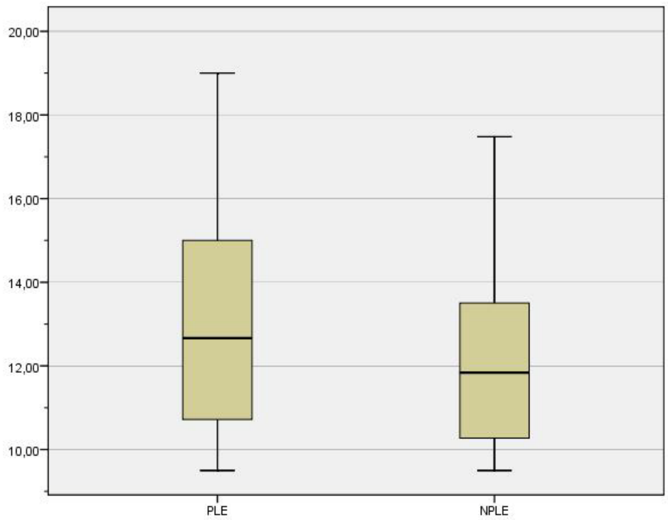

Figure 2: Distribution of grades for the PLE and NPLE students.

Kolmogorov-Smirnov test compare two distributions of values whereas the null hypothesis, for the present analysis, is that PLE and NPLE academic results are from the same continuous distribution. The alternative hypothesis is that they are from different continuous distributions. Analyses for each of the four courses (IEGI, QG, PC1 and CC) were performed, being the dimension of the sample equal to the number of approved students in all years for each course (see Table 2). Table 4 summarizes the Sigma values obtained for this study analysis. A Sigma (p) value less than 0.05 means that the two groups of students have different behaviours. For both groups, the distribution of IEGI and CC students' academic results were significantly different ($Z = 1.781$, $p = 0.004$ and $Z = 1.826$, $p = 0.003$, respectively). These results confirm the analysis previously made by using the average students' results, as presented in Figure 1, and that, for these courses, the averages of PLE students are higher than NPLE students.

Table 4: Statistical measurements values obtained in the Kolmogorov-Smirnov tests

PLE/NPLE	IEGI	QG	PC1	CC
Z	1.781	0.777	0.948	1.826
Sigma (p)	0.004*	0.582	0.330	0.003*

* Statistical significant at the 0.05 level.

4 Conclusion

We are aware that a large number of variables influence students' grades and that the teaching and learning strategy adopted is not the only variable to take into account when analysing students' academic success. However, as stated earlier in this paper, assessment is an important concern for both students and faculty staff, especially when innovative methods and procedures are adopted, in which student grading is sometimes questioned.

In regard to the statistical analysis carried out, some differences were found between PLE and non PLE students' academic results. PLE students, in average, achieved better results than the non PLE students at all courses and for the three academic years analysed. This is particularly relevant in the case of courses with a tradition of low approval rates, as Calculus C, for instance, where a higher number of students were approved due to the project methodology. Besides this, data analysis point out that 25% of PLE students achieved grades higher than 15.0, whereas, for non PLE, this value reduces to 13.6. However, although students' grades are mainly higher for PLE students than for non PLE students, the median values were quite similar (≈12.7 and 11.8, respectively). Therefore, there is not a big difference in terms of results.

This is an interesting finding as qualitative data collected from students, on a previous study, had suggested a different perspective (Fernandes, Flores & Lima, 2009a). PLE students argued, during focus group discussions and on answers to open-ended surveys, that one of the main disadvantages of PLE methodology was that students' final grades in this approach to teaching and learning were lower than in non PLE approaches This, however, was based exclusively on students´ own perceptions in regard to the assessment method and the results achieved in PLE. Students who participated in PLE experiences also recognised the importance of a set of other non technical competencies which were enhanced throughout the projects' development, such as the ability to work in teams, to manage time, to take responsibility, to solve problems and to handle motivation. Although this paper focuses mainly on the analysis of academic results in PLE and non PLE students, these outcomes cannot be put aside as they represent the added value of implementing interdisciplinary project approaches within first year Engineering students. Also, it would be interesting to do a more comprehensive study focusing not only on students' academic results but also on other variables that might help explain both similarities and differences in the two groups.

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Advanced Technology, a Broad Technical Bachelor Programme at the University of Twente

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Abstract

Advanced Technology is a unique bachelor program at the University of Twente that has a strong multidisciplinary character. The technical component is dominant but is clearly linked to social sciences with emphasis on entrepreneurship. The courses like “Introduction to Engineering” have a leading mathematical line that is applied to examples in mechanical and electrical engineering and physics and chemistry. Students follow several projects among which are the accelerometer project for designing, fabrication and testing, and an entrepreneurial project called Startrix for learning to write a business plan for bringing a real industrial product to the market.

Keywords: interdisciplinarity; integrated courses; project approaches.

1 Introduction

The University of Twente is a young entrepreneurial research university, leading on the area of new technology and its application for human beings and society. The organization has five faculties: Science and Technology (TNW), Engineering Technology (CTW), Electrical Engineering, Mathematics and Computer Science (EWI), School of Management and Governance (MB) and Behavioural Sciences (GW). Each faculty is divided in several departments. As an example, Science and technology has the departments Applied Physics, Chemical Engineering, Biomedical Technology, Advanced Technology and Technical Medicine and Nanotechnology. The research is concentrated in a number of Institutes. One of them is the famous MESA+ Institute for Nanotechnology. The overall structure is in fact a matrix structure. The total number of students at the University is around 8000. The university is well-known for the large amount of spin-off companies.

About 8 years ago the frequent discussions with industry revealed that there is a big need for well educated engineers with a multidisciplinary background. The University of Twente had already several education programmes which are more or less mono disciplinary, like physics, chemistry, mechanical and electrical engineering but a multidisciplinary technical bachelor closely connected to the more entrepreneurial disciplines was missing. In 2004 a bachelor program was established were all technical disciplines are represented, together with courses from social sciences such as Innovation and Entrepreneurship. The bachelor programme is unique in the Netherlands. Within Europe only a few comparable studies are present. We started with about 20 students and now between 60 and 70 students enter the program each year. Although the programme language is mainly Dutch we aim to fully transform the bachelor to the English language within a few years.

In this paper we will briefly describe the curriculum of the bachelor degree programme with special attention to the various projects.

2 Bachelor Programme Advanced Technology

The curriculum is built up of three years. The programme in the first year is compulsory for all students. The courses are:

- Introduction to Engineering I, II and III
- Materials Engineering I and II
- Fundamentals of mathematical methods
- Analysis of Technology in Society
- Innovation and Entrepreneurship

- Instrumentation practice
- Lab practice
- Two projects concerning Energy and Accelerometers.

In the second year the students have to follow a fixed programme (40 EC) but they can also choose a rather limited amount of courses of their interest (20 EC). The fixed courses are:

Engineering of complex systems I and II

- Mathematical modelling
- Differential equations
- Quantum phenomena
- Long term development of Science
- Two projects concerning Lab on a Chip and Entrepreneurship.

The student has to choose four courses from the next seven:

- Basic Chemistry
- Interfaces and Catalysis
- Production Technology
- Vibrations and Waves
- Electronic basic circuits
- Modelling of Physical systems
- Molecular and cellular biophysics.

Only one course in the third year is obligatory for the students:

- Modern Physics

In the third year a maximum of 30 EC (about a half year) is spent on following one of the special course packages that prepare for entrance in one of the regular master programmes. In some cases this package is a regular minor (20 EC) out of the large amount of minors that are offered by the university. Depending on the choice of the 3rd year package the Advanced Technology bachelor students can enter directly one of about 20 different Master programmes.

The third year is completed with a bachelor assignment (a 15 EC project), which is performed within one of the research groups at the university. Multidisciplinarity is one of the keywords for this research. The student is independently doing his own research under the guidance of a staff member, he has to write a report and defend it for an examination committee. It is the final proof that the student has met all the criteria of the bachelor degree.

Although the student can go to industry with his bachelor degree the majority of them follows a master programme. The student's choice for the master shows a broad variation: e.g. Nanotechnology, Sustainable Energy Technology, Mechatronics, Business Administration or a master at another Dutch university, and even at universities outside The Netherlands.

A significant number of AT-courses have a unique structure. In the three successive courses "Introduction to Engineering" (in total 17 EC) a special area of mathematics like first and second order differential equations is treated and applied to different fields, from mechanical and electrical engineering to physics and chemistry. In this way the student becomes familiar with the multidisciplinary character of science and applications which is so characteristic for many industrial fields.

The first two courses are given in a condensed block of four weeks. The students have no other courses in this period. The schedule of one day is: lectures in the morning, exercises in the afternoon and a test at the end of the day. This turns out to be a best practice. The results are very positive.

In "Engineering of Complex Systems" students work in small groups, solving assigned engineering problems. They have to gather and digest new information themselves, but staff and (student) assistants are available for

consultation. Each assignment is finished with an oral presentation. The problem directed learning is also one of the main elements of this program.

A very important part of the curriculum is constituted by the four projects the students have to execute in small groups (4-5 students). The projects are "Energy", "Accelerometers", "Lab-on-a-Chip" and Startrix. Al these projects have their specific learning goals, but a strong link with preceding and/or parallel courses is a major component in the project philosophy. Especially the possibility to apply the more theoretical learning from the various courses to practical 'hands on' projects helps the students to more effectively digest the offered knowledge.

3 Project Approaches in Advanced Technology

The four projects aim to develop different attitudes and experiences in the students. The theme of the first project is 'Energy'. With the current subject 'Fuel Cells' students learn the scientific principle, the current status of research and development and the major roadblocks towards general implementation in society. There is a strong correlation with the parallel course 'Analysis of Technology in Society'. The overall aim is to promote 'Academic Attitude and Aptitude' in the students, which includes working effectively in a group, communication skills, project organisation, literature search and evaluation. Also the students are introduced to 'scientific writing', the start of a continuous educational process. Each group is assigned a tutor who has the task to monitor and guide the process. The project is completed with an extensive group paper and individual 15 minute oral presentations, which are both graded by a 'jury' (staff members).

In the second project 'Accelerometer' the students are challenged to use their just acquired theoretical knowledge into a practical application. Starting point is the mathematics of a mass-spring system. Simple differential equations describe a real product. Accelerometers are widely applied and can be realised in bulk or in micro-system technology. The students are free in the choice of the application but often a bulk approach will be followed. The realisation of an accelerometer in a clean room does not fit in the curriculum in this phase of the study. The project follows the problem analysis, design and simulation, and finally actual realization route. A demonstration of the accelerometer with a poster presentation and a detailed report form the course requirements.

In the third project, 'Lab on Chip', the students are invited to explore novel ways in typical lab on a chip applications. They follow a short introduction course on (nano-) fluidics and related subjects. With relatively simple means designs are made and fabricated in PDMS or silicon. The results are presented in an open poster session but also in the format of a scientific publication.

In the final project a small group has to develop a business plan for a recently developed marketable idea, either from a (start up) company which has a relation with the university or from one of the research groups within the university. Within this project the necessary tools for building a proper plan are provided by various experts. Here a change is that the groups are no longer guided by a tutor, but information and feedback is provided on a demand basis. The quality of the business plans and the presentations of plans are judged by an external jury, selected from the economic area. Until now the best plan has been awarded with a significant prize, made available by one of the larger spin-off companies.

Within these four projects the students learn many aspects of science, technology, its relations with society and the economics of product development. It also brings them to a level of independency in learning, creative thinking and working in a group.

4 Conclusion

The educational program of the unique broad technical bachelor Advanced technology is characterised by several specific elements. A large part of the courses has a structure where integration of different disciplines has been realized. Students are trained in small groups performing various projects with each a typical set of learning goals. The bachelor programme prepares the students for entering a very wide range of Master programmes.

Human Factor as a Key Indicator of Project Success and Business Excellence: The Case of Poland

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Abstract

The article shows the importance of human factor as a key indicator of the success of projects and business excellence based on three research projects. Two of them concerned the engagement of Polish enterprises in initiatives aiming at business excellence and realized in the years 2004-2005 and 2006-2007. The criteria of evaluation adopted in the research were the determinants of the EFQM Excellence Model. The results indicate significant negligence in the management of human resources as one of the initiatives towards business excellence of Polish enterprises before Poland's accession to the EU. At the same time, the results from the years 2006-2007 confirm that after several years of the functioning of the Polish economy in the structures of the EU, the role of human factor as a key indicator of business activity results has increased. The third project called "Project management efficiency in the enterprises operating in Poland" was completed in July 2008. The results of the research projects carried out in 2008 show that among a few dozen of tested factors which are conducive to successful realization of projects, the most significant ones are those referring to people.

Keywords: project success factors; business excellence indicators; human resources management; polish case.

1 Introduction

The theory and practice of the functioning of present-day enterprises show that human resources constitute the most valuable and the most productive resources of any organization. It turns out that at the level of analysis of the whole organization from the point of view of the EFQM model as well as from the point of view of a single project realized within it, this fact has been confirmed with the results of various empirical studies. According to the findings introduced and discussed in Kristensen et al. (2001a) most of the areas critical to business excellence deal with people and more specifically people satisfaction. As appears from more recent research results, an increase in employee motivation and engagement will lead to an increase in customer satisfaction, which again leads to improved customer loyalty followed by increasing financial results (Kristensen et al., 2007). Thus if an organization wants to achieve business excellence it must create a change-oriented environment where the creativity of the employees is nurtured, developed and sustained through education and training, involvement and teamwork (Eskildsen et al., 1999). All findings quoted above deal with human resources management improvement of which positively influences business performance. The same relationship can be observed in case of people management and project success. According to K. N. Jha and K. C. Iyer the three Cs called 'competence', commitment' and 'coordination' become the key factors of the success of the project. So if in a project these three factors are managed efficiently better overall performance can be expected (Jha & Iyer, 2007).

The purpose of this article is to display the role of human factor in the efficient project realization and reveal the engagement of Polish enterprises in the management of human resources as one of the initiatives aiming at business excellence.

Within the last dozen of years, the leading Polish enterprises made significant progress in the implementation and development of quality management systems. At the beginning of the 1990's, systems dominating in Polish enterprises were the company quality systems, the second half of the 1990's marked the expansion of ISO 9000 systems, whereas the beginning of the 21st century meant taking the first steps in the direction of Total Quality Management (TQM). Polish companies entered the path towards the TQM by implementing is as a cohesive management concept, more often, however, by adapting selected components of the TQM system (Haffer, 2002). Thus, it proves that the leading Polish companies take the same path of quality management system development as most enterprises in highly developed countries that is laid out by the environment pressure on increased effectiveness of both the quality system and the enterprise itself (Haffer, 2005). One of the phases of the path is

activating in the enterprises a self-assessment process realized in accordance with the criteria of holistic management model (leadership) which supplies an organization in an objective and comprehensive set of standards allowing the identification of its strengths as well as areas that require improvement, and provide the basis for the preparation and implementation of plans of activity integrated with its strategy (Porter & Tanner, 1996).

Apart from the commonly used holistic management models, such as the EFQM Excellence Model or Malcom Baldrige's Excellence Model, Polish enterprises may choose to apply the model of business excellence based on the guidelines of the Polish Quality Award called the Management Improvement Model (MDZ). Starting from 1995, each year on average 50 organizations compete for the Polish Quality Award, which illustrates the scale of this phenomenon in Poland. This means that self-assessment according to the criteria of the model of excellence is not yet too popular among Polish managers. Despite this fact, the activities aiming at business excellence become more intense in Polish enterprises even without the intentional use of the self-assessment model.

In the last decade also project management became an important discipline and gains more and more interest in the global and Polish economy. This concept – which was once an internal matter of an organization – today is a competitive tool increasing the quality and value offered to the clients and constitutes a justified and right approach towards organization management, the environments and conditions of contemporary business. What in reference books is described as 'project success' constitutes one of the fundamental concepts in project management and is identified with successful realization of projects which lead to the achievement of the intended goal. Project management aims at facilitating the entire project realization process in order to accomplish its intended goal in an efficient and effective way. Project management efficiency constitutes a comprehensive set of project success factors in relation to organizational and external circumstances in which an organization operates.

Project management is a very complex discipline that may be examined from various angles and within multiple generalizations. Strategic paradigm assumes that a project may be perceived through its product as the method of realization of an organization's strategy. Organizations and clients always look at the project through the prism of a generated product. On the other hand, process paradigm wants the project to be seen as a sequence of activities and processes which are to be accomplished. These processes need to be managed in such a way which ensures that the project will be completed. Finally, the project may be seen through the prism of human paradigm as a certain area of exchange, relations and activities among people. Projects are created by people, and so project management relates first of all to the formation of groups of specialized individuals from various areas of an organization for a specified period of time in order to fulfil a particular task. Once a given project is complete, the group is dissolved and its members are delegated to other tasks, projects, or back to previous operational tasks connected with their positions. Also for this reason human factor plays an incredibly important role in project management and is called by many authors its key element (Van Der Merwe, 2002).

2 Research Methodology

The data presented in this article come from three research projects. The first two of them were concerned with the engagement of Polish enterprises in the initiatives aiming at business excellence carried out in the years 2004-2005 and 2006-2007. As a result, two sample groups of enterprises were researched: sample group PL2005 composed of 79 companies, and PL2007 of 230 enterprises. Selection of the sample groups was carried out with the use of various sources of information about enterprises, including the lists of "the five hundred" and "the thousand" best enterprises in the Polish economy published in economic magazines as well as three databases: "2005 firms. Marketing CD", "Polish quality leaders" and "Business gazelles". That means that achieved samples were purposeful ones as they were drawn from the databases including the most active companies in the Polish economy. Both studies applied a similar research procedure and used the same research questionnaire.

Representatives of the highest managerial positions were asked to assess the engagement of the companies that they managed in initiatives aiming at business excellence on a scale from 0 to 100, regardless of the fact whether they use any of the holistic management models or not. Assessment criteria adopted in the research were the indicators of the EFQM Excellence Model. Measurement scales included 51 sub-criteria forming 9 more aggregated criteria, identical to those that make up the EFQM Model. Based on these criteria the respondents were able to assess the progress that the organizations they manage have made towards organizational excellence. Next, with the gathered data, a model was created basing on the Danish Business Excellence Index (DBEI) (Kristensen et al., 2001a). Estimation of the model was conducted with the use of the method of least squares with the SmartPLS software (Ringle et al., 2007). The results of correlation and estimation of the created model encouraged the

discussion of the conditions of Polish enterprises and made it possible to determine the efforts which should be made for their further development.

The third research project titled "Project management efficiency in the enterprises operating in Poland" was realized between June and July 2008. The research resulted in purposive sample PL2008, mostly formed on the basis of the member list of the Polish Project Management Association. From the full list of 658 entities (considering only one representative for each entity) the entities representing different organizations than enterprises were removed (e.g. universities, agencies, foundations and state entities). This way 363 entities were selected. An Internet survey was distributed mainly in the environment of the Polish Project Management Association, however, it was also directed individually to selected enterprises which, as it was arbitrarily decided, showed certain advancement in project management. In total, 70 respondents participated in the research.

The respondents were asked among all to verify a list of project success factors in order to assess their importance in a recently realized project, using the scale from 0 to 5, where: 0 meant that a given factor was insignificant for project success, 1 meant that a given factor had very little significance, 2 – little significance, 3 – medium significance, 4 – big significance, and 5 – very big significance in project success. This way it was possible to identify factors increasing project management efficiency in enterprises operating in Poland.

3 Characteristics of the EFQM Model and the Danish Business Excellence Index (DBEI)

The main reason for founding the European Quality Award by the European Foundation for Quality Management was the need for appreciating organizational excellence of European companies. The EFQM Excellence Model provides methodical frames for those who apply for the award and has also become the most commonly used model for the implementation of the Total Quality Management (TQM) model in Europe (Westlund, 2001). The EFQM Model consists of nine elements grouped in two categories of assessment criteria: enablers and results. The enablers include five criteria, namely: leadership, policy and strategy, personnel management, partnership, resources and processes, whereas the group of results includes four criteria: client results, employee results, social results and financial results. The enablers represent how the organization is functioning, while the results concentrate on the achievements in relation to organization stakeholders, their measurement and determining their target levels (EFQM, 1999). The EFQM Model is based on the logical assumption that there is an internal interrelation between the enabler criteria that may be expressed as follows: leadership drives the policy and strategy, personnel management, partnership and resources, and these three elements have an impact on the results of activity by means of processes (EFQM, 1999). This approach emphasizing the need for balancing the model, allows for the optimization of the synergy effect between its elements which is in agreement with the general assumption of the model (Westlund, 2001). Sustainable development implies such an internal enabler structure according to which the improvement of results is accomplished only when the input of all the enabler elements is the same.

The Danish Business Excellence Index (DBEI) was published by the Danish Association for Quality Management together with the Aarhus School of Business and an independent research company Markeds/Consult A/S in order to determine a universal benchmarking system for Danish enterprises based on business excellence principles. The ideas behind the index were introduced and discussed in Kristensen and Juhl (1999) as well as in Kristensen et al. (2001a, 2001b, 2003). The EFQM Model was selected as an obvious starting point for the development of business excellence measurement system, as it is the most popular self-assessment tool in Europe. The studies conducted by the European Foundation for Quality Management show that nearly 60% of enterprises conducting self-assessment apply the EFQM Model (Hakes, 1997). The DBEI accounts for nine criteria of the EFQM Model, however, it was assumed that there are four underlying fundamental components (management, people, systems and results) which interact in the way shown in figure 1.

Thus, the DBEI suggests combining nine areas of the EFQM Model, which makes it possible to explain their mutual relations. The explanation of these interrelations is based on the following assumptions:

- management quality is the primary cause (causative factor) of business excellence;
- good results are the function of both the effective use of the system and the intellectual capital (people) of an enterprise;
- the quality of people has a direct and an indirect impact on the achieved results through systems.

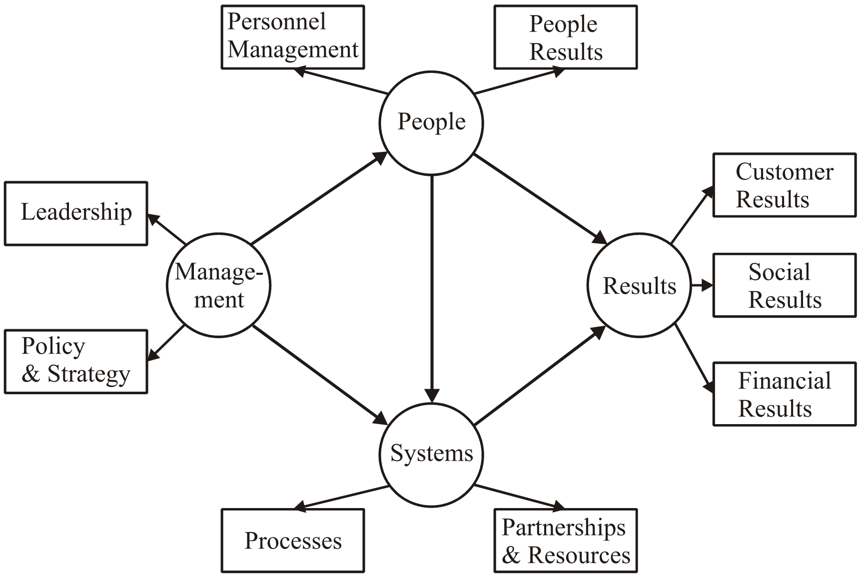

Figure 1: Danish Business Excellence Index (DBEI)

The Danish Model of Business Excellence is estimated with the least square method (PLS). This estimation technique allows for receiving results for each model element in relation to any enterprise. Consequently, all four components of the model may be analyzed at an aggregated level, with the division into the nine elements of the EFQM Model, as well as at an operational level based on evaluations within the 0 to 100 scale for each question of the measurement instrument (Kristensen et al., 2003). This article focuses on the evaluation made at the aggregated level.

4 Progress of Polish Enterprises Towards Organizational Excellence

Figure 2 presents the results of self-assessment of chief management showing the efforts that the Polish enterprises make in the four self-assessment areas of the DBEI model calculated for both research groups: PL2005 and PL2007.

Polish companies are seen by their managers as fairly well managed. This is good news, since the quality of management is the main factor determining business excellence. However, it turns out that managers of Polish enterprises place a lot of emphasis on systems but tend to neglect the people. The data clearly show that human resources management is a weak point for Polish enterprises. Still, the consoling fact is that self-assessment results in all four areas of the DBEI model have improved for both of the researched sample groups: PL2005 and PL2007. It appears that through several years of Poland's functioning within the EU structures, the Polish companies have made visible progress on their way to excellence.

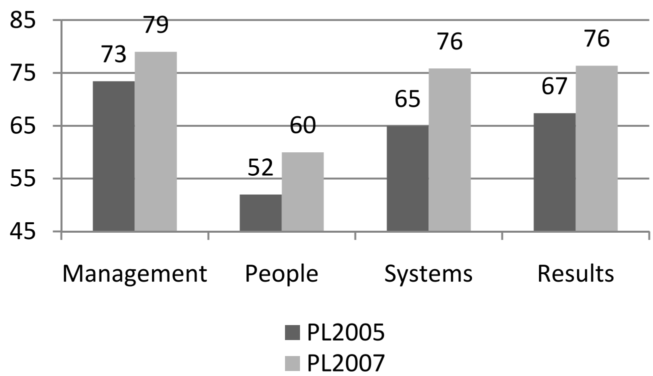

Figure 2: Self-assessment results of Polish enterprises according to the DBEI model (PL2005 and PL2007)

Figure 3 presents the results of the Danish Business Excellence Model estimation on the basis of the data received from Polish enterprises.

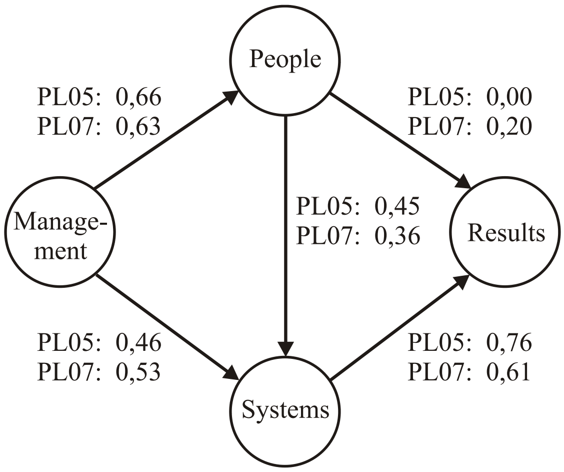

Figure 3: Estimation results for Polish enterprises according to the DBEI model (PL2005, PL2007)

Standardized regression coefficients allow for the assessment of the impact of independent variables (explanatory) on dependent variables (explained) depicted in the figure as circles to which arrows are pointing. The higher their values, the more significant their impact[1]. Standardized regression coefficients shown in figure 3 indicate that the increase in the "management" index will have a positive impact on the "people" index and the "systems" index for both presented samples. However, the impact on the "people" index will be much greater than on the „systems" index. Moreover, in the sample PL2005 we can observe the lack of strong relationship between the indices of "people" and the "results". However, this relationship appears in the sample PL2007. This means that Polish companies in 2005 were still in a phase of accomplishing their results through system solutions rather than through human resources management which confirms the previously drawn conclusions. After a few years of functioning of the Polish economy within the EU structures the role of human factor as the indicator of business activity results has increased. This means that managers of Polish enterprises begin to attach greater importance to human resources management, but also that efficiency and, what follows, the employees' contribution to the results achieved by the Polish companies are growing.

5 Project Success Factors in Companies

Project success factors are key variables explaining its success (Diallo, Thuiller, 2005). Paying attention and caring about the factors improves the effectiveness of all project management processes. They can also be referred to as "lever" or "stimuli" which can be used by project managers or project organization to increase the probability of achieving the desired project result (Westerveld, 2003). Project success factors enjoy a considerable interest as a research area investigated by scientists worldwide (Hyvari, 2006). The first attempt to define them was made in a paper written in 1967 by I.M. Rubin and W. Seeling, in which they studied the impact of project manager's experience on project success. Empirical studies showed that the previous experience of the person heading the project exerted a marginal influence on its success. However, most of the works written later completely opposed the thesis. Some of them were quoted above.

Although individual projects differ one from another, which is a result of their nature, some common factors can be found which considerably increase the chances of success of any project. This is reflected in empirical studies

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[1] Regression analysis provides values of standardized regression coefficients (β) for particular explanatory variables. Standardized values of regression coefficients (β) indicate how much the value of an explained variable changes due to standardized change in a given explanatory variable, that is with the change in an explanatory variable by one standard deviation. The comparison of the values of standardized regression coefficients (β) allows determining which of the explanatory variables had the greatest impact on process efficiency. In other words, the Beta values refer to the net impact on single variables.

Paper Session A2

An Experience of Trans-disciplinary Learning: Students of Engineering and Anthropology Focused on the Intelligent Use of Water

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Abstract

The article presents some reflections on the project based learning experience developed by a multidisciplinary research team of students (both undergraduate and graduated) and professors of the anthropology and civil engineering courses at University of Brasilia throughout the year of 2007. In this project a real problem was chosen, which was the consumption of the water in the campus. The students were presented to a holistic approach of this problem, through the construction of the dialogue between material evidences and symbolic evidences; dialogue that doesn't exist in the scope of the graduation courses in its conventional format. The research aimed to construct a picture of the material conditions of the physical water installations in the campus, the way as it is used and if, eventually, would have some type of behaviour that could be classified as "wastefulness". The focus, therefore, was the development of field research, to produce new data on the use of the water in the campus.

Keywords: interdisciplinary; project based learning; transversal projects; project approaches.

1 Introdução

O artigo apresenta um conjunto de reflexões sobre a experiência de aprendizado através de projeto desenvolvida por equipe de pesquisa multidisciplinar composta por estudantes (de graduação e pós-graduação) e professores dos cursos de antropologia e engenharia civil na Universidade de Brasília ao longo do ano de 2007. Neste projeto tomou-se um problema real, qual seja o consumo da água no campus da universidade de Brasília e buscou-se expor os alunos a uma abordagem holística deste problema, através da construção do diálogo entre evidências materiais e evidências simbólicas, debate este inexistente no âmbito dos cursos de graduação em sua formatação convencional. Tratava-se de mapear as condições materiais das instalações da água no campus, o modo como é usada e se, eventualmente, haveria algum tipo de comportamento que pudesse ser classificado como "desperdício". O foco, portanto, foi o desenvolvimento de pesquisa de campo, com vistas a produzir dados novos sobre o uso da água no campus.

2 Metodologia

Com tal horizonte, o projeto de aprendizado se desdobrou em 6 etapas: montagem da equipe; a criação de um campo comum de significados entre os diferenciados participantes; a definição dos procedimentos metodológicos; o levantamento dos dados empíricos; a análise dos resultados; e avaliação dos alunos.

2.1 Montagem da equipe

Nesta etapa foram realizados os procedimentos de seleção de alunos em ambos os cursos, e montagem da equipe, com definição de papéis e atribuições.

2.2 Criação de um campo comum de significados

Foram realizadas reuniões temáticas coordenadas pelos professores com o intuito de discutir: as percepções e usos da água da perspectiva antropológica e o funcionamento e os padrões das instalações sanitárias da perspectiva da engenharia civil e a importância institucional do problema abordado.

2.3 Definição de procedimentos metodológicos

Foram realizadas reuniões de discussão sobre como proceder para o levantamento das informações necessárias à compreensão das temáticas previamente debatidas, bem como visitas exploratórias aos banheiros tanto em

horários no quais não estavam sendo utilizados como também na presença de usuários. Nestas ocasiões foram definidas técnicas para o registro de três dimensões: material, comportamental e de valores e opiniões. Ficou estabelecido também que as equipes que atuariam no registro destas dimensões seriam formadas por estudantes de ambos os cursos.

2.4 Levantamento de dados empíricos

Consistiu da realização propriamente da pesquisa de campo e foi desenvolvida de forma seqüenciada, ou seja, cada dimensão foi pesquisada por vez, permitindo assim a participação de um maior número de alunos em cada uma delas.

No desenvolvimento foram realizadas atividades destinadas a determinar: (1) aspectos materiais das instalações por observação direta e registro fotográfico, (2) observação cotidiana dos usos dos banheiros e registro em caderno de campo e (3) questionário auto-aplicável para estudantes e professores usuários dos ambientes pesquisados.

Ao final de cada atividade foram realizadas reuniões de apresentação dos resultados parciais e ao término foi realizado um cruzamento de dados e consolidação do aprendizado.

2.5 Análise dos resultados

A análise dos resultados se deu de modo a conectar as informações obtidas em diferentes momentos da pesquisa, propiciando aos alunos reverem parâmetros que, definidos anteriormente, mostraram-se ao cabo da pesquisa inadequados ou insuficientes.

2.6 Avaliação

A avaliação do aprendizado se deu pela leitura dos cadernos de campo, dos relatórios parciais e pela observação de características de organização, liderança, capacidade de comunicação e de "escuta" de perspectivas não usuais à sua formação de origem.

A elaboração do documento final da pesquisa e da apresentação dos resultados à Reitoria da Universidade de Brasília constituiu momento de auto-avaliação dos alunos e do processo desenvolvido.

3 Resultados

O projeto obteve resultados de duas naturezas distintas: orientações para intervenções da administração da universidade com vistas a promover o uso inteligente da água; uma formação diferenciada e, usando um jargão da gestão de projetos, com um alto valor agregado para os estudantes envolvidos.

No caso em questão, doze graduandos de Antropologia, 9 graduandos de Engenharia Civil e uma doutoranda em Antropologia, foram apresentados a um problema do mundo real, multidisciplinar e com facetas absolutamente estranhas à sua formação profissional: a observação do comportamento humano, para os alunos de engenharia, e a identificação de elementos técnicos de sistemas hidráulicos, para os alunos de antropologia.

Frente a este desafio, e tendo os professores como facilitadores e não como fontes primárias de conhecimento, os alunos precisaram buscar conhecimentos necessários em suas áreas de formação e fora delas, aprenderem a trabalhar em equipes multidisciplinares, superando conflitos de linguagem, abordagem metodológica, objetivos e gênero para, propor metodologia, cumprir prazos e apresentar um produto final.

PBL in the Teaching of Biomedical Engineering: a Pioneer Proposal in Brazil

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Abstract

The aim of this work is to describe the project of Pontifícia Universidade Católica de São Paulo Biomedic Engineering course hereafter using the problem-based learning methodology. The structure of the course is based on five thematic axis integrated in a five years course: Medical Images, Clinical Engineering and Health Management, Medical Electronics, Bio-informatics and Biomechanics and Rehabilitations Engineering. The five themes are structured in Central and Associated Modules treating the technical, ethics, human, legal, business, phsycological and social aspects. In that methodology the students receive a problem based on a daily situation, creating a learning context. The problem is the fuel of the challenge and motivates the students to understand and solve it. The teamwork discussions as tutorial session use the previous knowledge to create a learning network. In this scene the learning occurs in co-operative mode not only to learn but in a modern perspective: learning to learn.

Keywords: biomedic engineering; problem based learning; tutorial session; teamwork.

1 Introdução

A idéia da proposição do Curso de Graduação em Engenharia Biomédica na PUC-SP nasceu de um estudo estratégico do mercado.

Como resultado do considerável avanço tecnológico vivido nas últimas décadas, surgiram novas técnicas e novos produtos com o objetivo de melhorar a qualidade de vida do ser humano, tanto em sua condição saudável quanto por ocasião da ocorrência de alguma doença. A área médica, por seu papel preponderante nesse aumento da qualidade de vida, tem usufruído bastante destes novos recursos, o que tem tornado mais tênues as linhas que algum dia segregavam o conhecimento tecnológico da prática médica. Procedimentos informatizados, acessos cirúrgicos minimamente invasivos, exames cada vez mais confiáveis e seguros, novas possibilidades em próteses e órteses e instrumentos com maior portabilidade tornam a busca pela saúde humana cada vez mais eficiente. Neste sentido, a área médica é sem dúvida uma das que mais aplica conceitos físicos e produtos tecnológicos, sempre com o objetivo de suprir a vontade inata de se viver mais, com o menor sofrimento e desfrutando de uma condição saudável.

Nesse panorama, é crescente a necessidade por profissionais com habilidades em ciências exatas, particularmente de engenharia, mas que também tenham um bom conhecimento dos fundamentos das ciências biológicas e médicas. Esse profissional, que já vem sendo formado há algumas décadas nos EUA e Europa, tem sua formação contemplada num curso de graduação em Engenharia Biomédica.No Brasil, tanto os fabricantes de equipamentos médicos e hospitalares quanto os próprios hospitais ou empresas de desenvolvimento de engenharia, apresentam uma necessidade crescente por um profissional que conheça e desenvolva tecnologias e suas aplicações, bem como consiga dialogar de um modo natural com profissionais da área médica e da saúde. O engenheiro biomédico deve cumprir com muito mais eficiência e preparo tarefas que hoje em dia são desempenhadas por engenheiros formados nas diversas áreas e que acabam atuando profissionalmente em aplicações tecnológicas na área da saúde, possivelmente com formação complementada em cursos de especializações.

A Associação Brasileira da Indústria de Equipamentos Médicos e Odontológicos (ABIMO, 2007), reúne desde 1962 as principais indústrias de equipamentos, instrumentos e acessórios para a área de Saúde. Atualmente, a ABIMO atua nos setores de Implantes e Material de Consumo Médico-Hospitalar, Equipamentos Médico-Hospitalares, Odontologia, Radiologia e Diagnóstico por Imagem e Laboratórios, podendo fornecer um panorama de como anda o mercado de atuação do profissional em engenharia biomédica. Segundo dados econômicos disponíveis no sitio da ABIMO, referentes ao ano de 2005, os números apontam, além da grande movimentação do mercado de

produtos médico-hospitalares no Brasil, uma diferença significativa entre as importações (muito altas) e as exportações (muito baixas). Ainda, em dados recentes disponíveis, o ano de 2006 registrou um crescimento de 24,7 % das importações. Um dado importante é que cerca de 30% dos equipamentos médicos adquiridos são sucateados em pouco tempo por falta de manutenção, o que se torna extremamente caro para um país em desenvolvimento como o Brasil, com carência de recursos para investimentos em todas as áreas, principalmente na saúde.

Outra pesquisa, realizada pelo DataSus de 2006, mostra que no Brasil existiam 2745 hospitais públicos (40 federais, 605 estaduais e 2100 municipais), 4671 hospitais privados (sendo 1728 sem fins lucrativos e 2943 com fins lucrativos) e mais 127 hospitais universitários e de ensino, perfazendo um total de 7543 hospitais no Brasil. Trata-se, pois, do maior parque hospitalar da América Latina. A maior parte deste parque hospitalar está concentrada na região metropolitana de São Paulo, onde justamente não é ainda oferecido um curso de Engenharia Biomédica.

Por outro lado, apenas para exemplificar a carência da área, e considerando a Engenharia Clínica como uma das especialidades possíveis da Engenharia Biomédica, apenas 6% dos hospitais com mais de 120 leitos possuem um Departamento de Engenharia Clínica, o que representa 1% de todos os hospitais em atividade no Brasil. Logicamente, este número incorpora tanto os serviços de manutenção hospitalar corretiva como preventiva. Estimando-se que seja necessário um engenheiro clínico para cada 350 leitos, existia em 2006 então no Brasil um déficit estimado de 1400 engenheiros clínicos. E esta defasagem tende a ser cada vez mais contundente nos próximos anos.

De uma maneira global, enquanto o Brasil forma anualmente cerca de 20 mil engenheiros, temos cerca de 80 mil formandos em engenharia por ano na Coréia do Sul. Ainda, no Brasil temos seis engenheiros para cada mil pessoas consideradas economicamente ativas, enquanto que nos Estados Unidos e Japão, essa proporção é de 25 profissionais para cada mil habitantes economicamente ativos. Estes números levaram a Confederação Nacional da Indústria (CNI, 2006) a criar um programa de modernização da engenharia no Brasil: o programa **Inova Engenharia**. Este programa, lançado pela entidade em Maio de 2006, em Brasília, pretende mobilizar academia, poder público e empresas em torno do assunto. Como primeiro resultado desse programa, foi produzido pelas entidades ligadas a CNI um documento que traça um quadro e apresenta propostas para melhorar a formação dos engenheiros brasileiros. Esse documento diz que a engenharia nacional apresenta problemas quantitativos e qualitativos. Inicialmente, os problemas na educação básica, especialmente em português e matemática, se acumulam ao longo da vida do estudante, e culminam com uma formação pobre nestas áreas básicas, para os jovens que ingressam no nível superior. Em seguida, os alunos e as universidades se interessam menos pelas áreas de exatas hoje em dia: cerca de 75% dos alunos do ensino superior estão nas áreas de humanas. Segundo Marcos Formiga, assessor da Diretoria de Operações do Departamento Nacional do Senai e coordenador do estudo, “metade dos estudantes desiste nos dois primeiros anos dos cursos de engenharia, e então temos uma grande evasão”. Marcos completa: “os cursos de engenharia, por vezes, dão muita ênfase à matemática, cálculo, teoria, e esquecem-se de desenvolver outras habilidades – como trabalho em grupo, idiomas, empreendedorismo e lideranças, que as empresas valorizam”.

A área da saúde foi a pioneira na implantação da metodologia de ensino chamada aprendizagem baseada em problemas – ABP. Teve seu início na Universidade de McMaster em Hamilton, Ontário, Canadá, no meio dos anos 60 (DELISE, 1997), onde foi criada como uma “filosofia orientadora” para o desenvolvimento de uma nova escola médica. O modelo de McMaster tornou-se um referencial a partir do qual outros se desenvolveram. Por exemplo, a Case Western Reserve University incorporou métodos semelhantes de instrução em um laboratório de aprendizagem que servia de cenário para muitas disciplinas (SARNOFF, 1996).

Do final dos anos 60 em diante, muitas outras Universidades (por exemplo, em Maastricht, na Holanda e Newcastle, na Austrália) adotaram esta abordagem para melhorar a educação médica. Na América do Norte, centros conhecidos pela sua excelência educacional passaram a desenvolver suas próprias concepções educacionais, baseadas nesses novos princípios. Isto ocorreu de Harvard a Boston, do Missouri ao Havaí, de Pittsburgh ao Texas, e também da Suécia para a África do Sul (FINUCANE; JOHNSON; PRIDEAUX, 1999; BOUHUIJS; SCHMIDT, 1995).

No Brasil, alguns cursos de medicina foram os primeiros a adotar a ABP como estratégia de ensino/aprendizagem. Na ABP os estudantes recebem um problema, extraído e re-elaborado a partir de uma situação do cotidiano, o que cria um contexto de aprendizagem significativa. O problema tem a função de desafiar e motivar os estudantes a compreendê-lo e resolvê-lo. A discussão do problema num pequeno grupo (sessões de tutoria) faz com que os conhecimentos prévios sejam postos em jogo e dessa forma propiciem a ancoragem das novas informações,

Innovation in Higher Education through Teachers Training: The Debate on Cooperative Curriculum

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Abstract

This paper presents results of bibliographical and field research concerning curricular projects know as "innovative" in the Brazilian higher education. It highlights the following aspects : 1- Innovative projects in education are those that broach a set of carefully planned and integrated factors; (ii) selection and continuous dev elopement of the participants in the innovative project is essencial and basic for its success; (iii) due to the new educational necessities and work opportunities , it is necessary to rethink the initial and continuous development of educators in Brazil and in this case concerned with Engineering Education .

Keywords: professional development; cooperative curriculum; higher education innovation; engineering education.

1 Introdução

Compartilhar uma reflexão sobre o Currículo Cooperativo em Engenharia e a formação docente para o ensino superior constitui-se como uma oportunidade muito rica de aprofundamento para os estudos que vimos realizando no Programa de Pós Educação: Currículo da Pontifícia Universidade Católica de São Paulo (Brasil).

Este Programa de Pós-graduação sedia um Grupo de Pesquisa que se intitula "Formação de Professores e Paradigmas Curriculares", registrado no Conselho Nacional de Pesquisa – CNPq, coordenado pelo Prof. Dr. Marcos Tarciso Masetto e composto por estudantes de pós-graduação e pesquisadores mestres e doutores.

O Grupo de Pesquisa iniciou suas atividades em 2005 e estabeleceu como objetivos investigar e identificar projetos inovadores em ensino de graduação e aprofundar questões teóricas sobre inovação, currículo e formação de professores. Baseia-se em estudos bibliográficos e de casos, análises documentais, pesquisas individuais e coletivas, participação dos membros do grupo em seminários e eventos específicos ligados à temática. Publica artigos em periódicos e capítulos em coletâneas sobre o resultado de suas investigações.

Esse trabalho oferece a oportunidade de discutir um dos estudos que vimos fazendo sobre os "Cursos Cooperativos na Engenharia", suas característica de inovação curricular e a formação docente exigida para a realização deste novo currículo. Consideramos como ponto de partida refletir sobre a contextualização histórico-social, educacional, profissional e política que hoje envolve as discussões sobre a formação dos profissionais engenheiros.

2 Sociedade do Conhecimento ou da Aprendizagem

O conhecimento se apresenta hoje com uma multiplicidade quase infinita de fontes de produção. Se até bem pouco tempo poderíamos dizer que as universidades se constituíam no grande e privilegiado "lócus" de pesquisa e produção científica, hoje, e já faz algum tempo, as investigações e conseqüente produção de conhecimento partem também de outros espaços: organismos e institutos de pesquisas desvinculados da universidade, laboratórios industriais, empresas, organismos públicos e privados voltados para projetos de intervenção na realidade e realizadores de programas e de políticas governamentais em todos os níveis. Chegamos mesmo, hoje, a produzir conhecimento em escritórios de atividades profissionais, e até, em nossas bancas domiciliares, graças aos computadores.

Ao mesmo tempo em que se multiplicaram as fontes de produção e conhecimento, o acesso a ele também se transformou: acesso imediato em tempo real aos periódicos, artigos, livros, palestras, conferências, sites, e ao

próprio pesquisador e especialista que publica. A partir disso as áreas da ciência se aproximaram: os fenômenos a serem compreendidos, explicados passam a exigir mais que uma só abordagem, um só especialista, uma só explicação: a multidisciplinaridade e a interdisciplinaridade são chamadas a colaborar para o desenvolvimento da ciência O conhecimento e a interação entre as ciências exatas e humanas se torna uma exigência para o desenvolvimento do mundo, mas não desligada da comunidade humana, de sua evolução e desenvolvimento dos povos.

Por isso mesmo, há quem denomine esta sociedade de "learning society". Aprendizagem com o significado de desenvolvimento da totalidade do homem e da sociedade em seus aspetos educacionais, políticos, éticos, econômicos, culturais, de direitos individuais e responsabilidades sociais, enfim da própria cidadania humana. Por isso mesmo, uma aprendizagem ao longo da vida, "life long learning", para além dos espaços escolares e presente durante toda a existência humana.

Este novo mundo do conhecimento se coloca para o professor de engenharia. Antes ele poderia se considerar como um "expert" em determinada área de conhecimento que domina, compreende, sintetiza e assim representa o conjunto de informações a ser repassado e transmitido aos alunos para que se formem competentes engenheiros. Hoje ele se pergunta como estar atualizado e trabalhar com o universo de informações que está disponibilizado para todos, inclusive para seus alunos, que podem trazer novas informações e questionamentos para sua aula e, partilhar com os alunos em sua carga horária e programa estabelecido. Como ajudar o aluno a acessar a internet e dela retirar com criticidade as informações que sejam relevantes. E por fim, a grande questão: o quê o aluno precisa aprender para se formar um engenheiro competente?

De uma coisa o professor começa a desconfiar: o papel de expert em uma determinada disciplina cujo conjunto máximo de informações deve ser ensinado ao aluno, Qual é então? Como trabalhar com os conteúdos em aula?

Hargreaves também se propõe a mesma questão e ousa respondê-la indicando algumas pistas. Para ele, os professores se verão na necessidade de

> "promover a aprendizagem cognitiva profunda, aprender a ensinar por meio de maneiras pelas quais não foram ensinados, comprometer-se com aprendizagem profissional contínua, trabalhar e aprender em equipes de colegas, desenvolver e elaborar a partir da inteligência coletiva, construir uma capacidade para a mudança e o risco, estimular a confiança nos processos" (Hargreaves, 2004:40)

3 A Profissionalidade do Engenheiro.

Outro mundo diante do qual nos encontramos é a profissionalidade do engenheiro. Nos cursos de graduação em engenharia, geralmente, o perfil do concluinte costuma estar bem definido tendo em vista as atividades profissionais específicas que lhe cabem e a organização curricular, em geral, atende a essa demanda. No entanto, hoje, a formação do engenheiro é questionada por esse mundo de profissionalidade.

As necessidades para atuação de um engenheiro hoje em dia são outras, diferentes das tradicionais, assim como as exigências que a eles se fazem até por conta das inovações tecnológicas e dos avanços da ciência da computação. A inserção do engenheiro nas atividades profissionais a ele ligadas continua exigindo suas especificidades, mas cada vez mais exigem também a colaboração de outras áreas que permitam compreender melhor os fenômenos e encontrar melhores soluções para os problemas que se lhes apresentam. A definição do perfil do engenheiro na atualidade está em crise, como em crise estão todas as carreiras que procuram responder aos desafios profissionais da sociedade contemporânea.

As próprias Diretrizes Curriculares (CNE/CES, 2002) que hoje orientam no Brasil a organização curricular da formação do engenheiro procuram abrir estas competências profissionais.

O Artigo 3º. delas assim se expressa:

> O Curso de Graduação em Engenharia tem como perfil do formando egresso/profissional o engenheiro, com formação generalista, humanista, crítica e reflexiva, capacitado a absorver e desenvolver novas tecnologias, estimulando a sua atuação crítica e criativa na identificação e resolução de problemas, considerando seus aspectos políticos, econômicos, sociais, ambientais e culturais, com visão ética e humanística, em atendimento às demandas da sociedade.

Estas orientações não são apenas decorativas. São para valer. O Art. 8º. determina:

> A implantação e desenvolvimento das diretrizes curriculares devem orientar e propiciar concepções curriculares ao Curso de Graduação em Engenharia que deverão ser acompanhadas e permanentemente avaliadas, a fim de permitir os ajustes que se fizerem necessários ao seu aperfeiçoamento.

No pensamento de Sacadura (1999),

> *"a profissão moderna da engenharia inclui uma grande diversidade de conhecimentos, competências, funções exercidas e posicionamentos profissionais. Da engenharia civil à eletrônica, da mecânica às telecomunicações, desenvolveu-se um universo tecnológico variado no qual o engenheiro pode exercer funções de administrador ou de "manager", ao lado de missões mais tradicionais de designer de objetos ou de sistemas, ou de chefe de produção.O engenheiro pode ser pesquisador, ou vendedor de produtos e serviços.De funcionário público a assalariado de empresa privada ou consultor independente, as situações profissionais dos engenheiros também mostram grande diversidade."* (Sacadura, 1999:16)

Este mundo da profissionalidade do engenheiro também se apresenta ao professor dessa área, se não pelos documentos do Ministério da Educação ao menos pelas mudanças no exercício da engenharia percebidas por aqueles que a exercem.

O cenário da sociedade contemporânea leva os docentes a se preocuparem com suas aulas e o modo como tradicionalmente as vêm ministrando. Percebem que não é mais possível num cenário de tanta inovação e mudança permanecerem nos moldes convencionais de aulas como se nada estivesse acontecendo. Também a profissionalidade docente precisa ser revista.

Como dissemos acima, esses dois mundos atuais interligados, o do conhecimento e o da profissionalidade, exigem revisão tanto do currículo de formação dos engenheiros, como da maneira com que enfrentamos a ação docente nos cursos de engenharia.

Com estas preocupações vamos discutir os "Cursos Cooperativos de Engenharia", como alternativa válida para a formação de profissionais dessa área, no contexto da sociedade do conhecimento e da aprendizagem e como incentivo à reflexão da ação docente mais profissional no ensino da engenharia.

4 A Educação Cooperativa no Contexto das Práticas Curriculares Alternativas em Engenharia.

No âmbito de uma organização curricular alternativa que objetiva ressignificar o ensino da engenharia brasileira frente às tendências atuais, algumas universidades têm enfrentado o desafio de implantar uma proposta de formação diferenciada por meio da Educação Cooperativa.

Trata-se de uma proposta voltada para o desenvolvimento de competências pessoais e profissionais na complexidade do mundo real, por meio de um processo formativo que promove uma estreita integração entre as instituições de ensino e os ambientes profissionais, mesclando módulos acadêmicos com módulos de estágio. Há uma reorganização do tempo e espaço promovendo a aprendizagem dos alunos além da sala de aula, integrando instituição de ensino superior e empresa, promovendo um trabalho conjunto entre docente e profissional da empresa.

Esse currículo é chamado Cooperativo por promover a cooperação entre empresas conveniadas e instituições de ensino na formação de profissionais habilitados para as rápidas transformações e inovações tecnológicas dessa área de trabalho. A experiência com esse currículo, introduzida na Inglaterra no inicio do século passado no curso de engenharia, foi estendido em 1906 à universidade de Cincinnati, (USA) e em 1957 em Waterloo (Canadá). No Brasil em 1989 na Escola Politécnica da Universidade de São Paulo incorporou-o aos cursos de Engenharia da Computação e Engenharia Química, em 2001 foi introduzido na Engenharia de Materiais da Universidade Federal de Santa Catarina (UFSC) e em 2002 na Universidade Estadual do Amazonas com o curso de Engenharia Mecânica.

A organização curricular divide o ano letivo em três quadrimestres, alternando períodos de aulas na universidade e estágios nas empresas e demais setores produtivos, o que traz importantes alterações na organização do tempo e espaços educativos convencionais. Nesta estruturação de currículo, os estudantes dos cursos cooperativos ganham

uma compreensão mais enriquecida do programa acadêmico abrindo a possibilidade de articulação dos aspectos teóricos e práticos do ensino da Engenharia. A alternância entre módulos acadêmicos e módulos de estágio favorece a construção do conhecimento numa relação dialética entre o mundo acadêmico e o da profissionalidade, onde questões, problemas, casos e desafios encontrados nos ambientes profissionais em que se realizam os estágios podem se constituir como ponto de partida e ponto de chegada das aprendizagens que concorrem para a formação do engenheiro.

O estágio nesse modelo, inserido ao longo do curso e constituindo-se numa ampliação dos espaços tradicionais de aula, apresenta-se como um aspecto distintivo do currículo cooperativo.

> “O estágio coloca-se em posição de destaque, porque proporciona ao aprendiz um desenvolvimento de suas competências profissionais atuando em ambientes próprios de sua futura profissão. Ao mesmo tempo em que integra prática e teoria, o estágio colabora para que o aprendiz viva o ambiente, o cenário, os personagens, os grupos, os companheiros, o ambiente físico, os problemas e as questões do dia a dia de sua profissão” (Masetto e Pacheco, 2007)

Frequentemente os estágios não são compreendidos como oportunidade de aprendizagem, inseridos apenas ao final do curso numa relação dicotômica entre teoria e prática. Não é raro serem percebidos apenas como uma exigência burocrática.

Nos cursos cooperativos em desenvolvimento no Brasil, a inserção do estágio no currículo segue distintas formatações, podendo ocorrer desde o primeiro ano da graduação ou a partir do terceiro ano. No primeiro caso o curso, com duração de cinco anos é dividido em 15 módulos quadrimestrais, sendo nove módulos acadêmicos e seis de estágio. Na segunda possibilidade os alunos cursam quatro semestres acadêmicos e a partir de então seguem cursando módulos quadrimestrais que alternam módulos acadêmicos e de estágios. Essas duas possibilidades estão representadas na tabela abaixo:

Tabela 1: Exemplos de Formatação de Cursos Cooperativos de Engenharia - Masetto e Pacheco (2007)

Ano	Exemplo 1			Exemplo 2		
	1 Q	2Q	3Q	1Q	2Q	3Q
1	MA1	MA2	ME1	Dois semestres acadêmicos		
2	MA3	ME2	MA4	Dois semestres acadêmicos		
3	ME3	MA5	ME4	MA1	MA2	ME1
4	MA6	ME5	MA7	MA3	ME2	MA4
5	ME8	MA8	MA9	ME3	MA5	ME4

MA – Módulo Acadêmico; ME – Módulo de Estágio; Q – Quadrimestre.
1Q (Janeiro-Abril); 2Q (Maio – Agosto) ; 3Q (Setembro a Dezembro)

Destaca-se como significativo que em um currículo assim estruturado, em cinco anos de curso o estudante agrega no mínimo dois anos de experiência em diferentes ambientes produtivos da engenharia. Tal inserção no mundo do trabalho oferece o cenário para o desenvolvimento de um novo perfil profissional.

Pesquisa realizada em 2002, pela Associação dos Engenheiros Politécnicos da Universidade São Paulo (EPUSP), revelou que na análise comparativa entre os grupos dos alunos dos diversos cursos da escola politécnica, aqueles dos cursos cooperativos mostraram um desenvolvimento favorável com relação à tomada de decisão e tempo de execução. Esses dados coincidem com os estudos realizados pelo professor Brighenti, quando comparou o perfil dos formandos da EPUSP de 1997 em seus cursos tradicionais com os alunos de duas modalidades de curso cooperativos. Os últimos mostraram-se superiores aos dos cursos convencionais em maturidade profissional e pessoal, senso crítico, capacidade de aplicar a teoria na prática, disciplina profissional e pessoal, iniciativa e espírito de liderança, espírito empreendedor, capacidade de comunicação, relacionamento humano, compromisso com a sociedade (Matai e Matai, 2005).

Ressalta-se ainda, segundo o mesmo autor, que os índices de evasão nos cursos cooperativos praticamente inexistem.

A ênfase colocada em torno de um aluno aprendente, ativo, autônomo na busca do conhecimento, capaz de construir suas aprendizagens de forma crítica, responsável e comprometida mediante a articulação de vivências

acadêmicas e situações reais e concretas, recontextualiza e reposiciona o papel do professor e exige uma atuação docente também diferenciada.

Pesquisa realizada em 2004, envolvendo 143 alunos dos cursos cooperativos da EPUSP para definir o perfil ideal do docente pontuou como mais significativas as seguintes competências: ter forte identificação, dedicação, envolvimento e estar atento para com as suas atividades; conseguir engajar e motivar outras pessoas na solução dos problemas; demonstrar criatividade na realização do trabalho, quebrando regras e paradigmas ultrapassados; gostar de trabalhar em grupo, em equipe e com o público; possuir habilidade para negociação e para demonstrar respeito pela opinião dos outros; interessar-se por assuntos profissionais que vão além das atividades específicas das suas funções; apresentar força e estabilidade de caráter e posicionamento moral firme; ser persistente para alcançar metas e objetivos; ser flexível, encarar obstáculos e problemas de forma racional, lógica e construtiva; saber apontar criticamente aspectos a serem corrigidos e melhorados na atuação de pessoas com as quais convive. (Matai e Matai, 2005)

A reconceptualização e alterações propostas nos projetos cooperativos também apresentam um processo avaliativo diferenciado, que deve ser contínuo e intencionalmente planejado. Na avaliação da aprendizagem discente propõe-se um atendimento no sentido de reorientação das aprendizagens na medida em que o professor-orientador ao acompanhar o estudante durante seu estagio em ambiente profissional, tem a oportunidade de avaliar e alterar os rumos das situações de aprendizagem no ambiente acadêmico, incorporando elementos que poderão ser retomados ou ampliados nos módulos teóricos. Para compor a nota final do estágio discutem-se os pareceres do professor-orientador, do engenheiro supervisor na empresa e o relatório elaborado pelos alunos.

A avaliação no currículo cooperativo busca um envolvimento efetivo do aluno no seu próprio projeto de aprendizagem em termos de auto-desenvolvimento, de um auto-conhecimento e também de auto-avaliação. O ambiente profissional é bem adequado para este processo avaliativo e proporciona ao estudante identificar seus pontos fracos e pontos fortes, conscientizando-se melhor do seu potencial pessoal e profissional com indicadores críticos para fazer a sua história.

5 Considerações Finais

Esta rápida análise dos Cursos Cooperativos nos aponta para duas considerações finais.

A primeira diz respeito a identificarmos nesta proposta um currículo que tem condições de responder às reflexões que fizemos no início deste trabalho sobre a Profissionalidade do Engenheiro numa Sociedade do Conhecimento e sua respectiva formação. Afirmamos que a inserção do engenheiro em suas atividades profissionais a continua exigindo especificidades, mas cada vez mais exigem também a colaboração de outras áreas do conhecimento de forma a lhes permitir compreender melhor os fenômenos e encontrar soluções mais eficazes para os problemas que se lhes apresentam atualizando assim sua formação.

A segunda, igualmente válida e instigante é podermos identificar que esta proposta curricular só teve condições de se apresentar como uma alternativa para a formação de engenheiros para nossos tempos porque teve a ousadia e a coragem de inovar na questão curricular alterando aspectos importantíssimos e fundamentais para esta formação.

Assumiu a contextualização de uma formação de engenheiros numa sociedade do conhecimento; explicitou perfis profissionais correspondentes à competência e à cidadania; deslocou o foco do processo de instrução e transmissão de informações e experiências realizado prioritariamente na universidade para o processo de construção do conhecimento significativo e prática profissional atualizada a partir das experiências profissionais em ambientes de empresas de engenharia. A forma de desenvolver esta aprendizagem foi colaborativa onde professor, alunos e profissionais descobrem significados para as informações pesquisadas e as reconstroem de modo crítico.

A organização curricular valorizou a integração da teoria e da prática desde o início do curso, re-significando o estágio. As atividades práticas e teóricas planejadas de forma integrada, e com complexidade crescente à medida que a formação se desenvolve; os conteúdos foram reorganizados para atenderem aos quadrimestres na universidade e na empresa.

Com perspicácia e inovação soube explorar espaço e tempo tanto nos quadrimestres na universidade, quanto nos quadrimestres nas empresas, não se sujeitando aos tradicionais 50 ou 100 minutos de aulas por disciplina, mas abrindo espaço e tempo necessários para atividades investigativas e profissionais.

Dignos de atenção também são as alterações construídas com relação aos papéis do professor, do aluno, do grupo de alunos e dos profissionais das empresas, com valorização da relação de trabalho em equipe e da co-responsabilidade.

Incentivo à mudança de atitudes dos alunos através do planejamento de atividades concretas que lhes garantiram, e deles exigiram, participação, trabalho, pesquisa, diálogo e debate com outros colegas e com o professor, produção individual e coletiva de conhecimento, atuação na prática integrando nela os estudos teóricos, as habilidades e atitudes e valores a serem desenvolvidos, integração das várias áreas de conhecimento;

Quanto ao professor, destaca-se nesse caso a quebra de paradigma das funções da docência, sob dois aspectos: (i) ao exigir um novo papel do professor (ele também um aprendiz) como intelectual pesquisador, crítico, cidadão e planejador de situações de aprendizagens; mediador e incentivador dos alunos em seus processos de aprender; trabalhando em equipe e em parceria com os alunos e seus colegas professores; (ii) ao abrir a perspectiva ao professor de rever sua prática a partir das experiências dos alunos nos estágios, integrando efetivamente a teoria à prática.

E, por fim, toda a metodologia de aprendizagem e processo avaliativo foram significativamente alterados. A metodologia privilegiando estratégias e técnicas que favorecem a participação do aluno, a interação entre eles o professor, a realidade e os profissionais das empresas, a colaboração na construção do conhecimento e na aprendizagem na prática.

O processo de avaliação integrado ao processo de aprendizagem, como elemento motivador e incentivador da aprendizagem, com feed backs contínuos, oferecendo novas oportunidades de aprendizagem ao aluno, incentivando-o a novas aprendizagens.

É de se notar que tal currículo inovador produziu alterações significativas em muitos pontos simultaneamente, o que permitiu conseguir os resultados que aparecem nas pesquisas citadas no texto, afirmando que os alunos dos cursos cooperativos mostraram um desenvolvimento favorável com relação à tomada de decisão e tempo de execução, à maturidade profissional e pessoal, ao senso crítico, capacidade de aplicar a teoria na prática, disciplina profissional e pessoal, iniciativa e espírito de liderança, espírito empreendedor, capacidade de comunicação, relacionamento humano, compromisso com a sociedade (Matai e Matai, 2005).

Não se pode deixar de considerar que a proposta dos Cursos Cooperativos promove uma série de reflexões sobre como desenvolver e implantar um currículo de formação do engenheiro para os novos tempos. Pode parecer um desafio impossível de ser realizado. Certamente esta foi também a sensação de outros grupos pioneiros nessa área há duas ou mais décadas atrás. Mas, eles acreditaram no seu sonho e o realizaram.

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Projects' Laboratory: The Project of Buildings as Inducer of Trans-disciplinary Learning

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Abstract

The transdisciplinary nature of the problems of engineering is lost in the structure of classical courses in engineering, because of a strong emphasis on Cartesian structure based on individual disciplines. If the presence of an integrated vision is precarious in the internal structure of each course, it tends to be totally absent when considering the relationship between courses of different qualifications of engineering. This article presents the experience developed in the Laboratory of Projects in the Faculty of Technology of the University of Brasilia, using the design of real buildings as a locus of transdisciplinary learning involving students of different engineering courses taught at University of Brasilia.

Keywords: project-based learning; transdisciplinarity; inductive learning.

1 Introdução

Em seu Parecer CNE/CES 1.362/2001 (2001) favorável à aprovação das novas Diretrizes Curriculares Nacionais dos Cursos de Engenharia o relator, ao falar da necessidade de egressos altamente qualificados, afirma que:

"... o próprio conceito de qualificação profissional vem se alterando, com a presença cada vez maior de componentes associadas às capacidades de coordenar informações, interagir com pessoas, interpretar de maneira dinâmica a realidade", acrescentando que "o novo engenheiro deve ser capaz de propor soluções que sejam não apenas tecnicamente corretas, ele deve ter a ambição de considerar o problema em sua totalidade, em uma cadeia de causas e efeitos de múltiplas dimensões".

Na continuação de seu parecer, o relator afirma que "as tendências atuais vêm indicando na direção de cursos de graduação com estruturas flexíveis... ênfase na síntese e na transdisciplinaridade... possibilidade de articulação direta com a pós-graduação e forte vinculação entre teoria e prática".

Em conformidade com o parecer do relator, a Resolução CNE/CES 11/2002 (2002) que institui as Diretrizes Curriculares Nacionais do Curso de Graduação em Engenharia lista em seu Art. 4o quatorze habilidades e competências gerais a serem desenvolvidas durante a formação do engenheiro em seu curso de graduação, de forma a fornecer ao mesmo a capacidade de "absorver e desenvolver novas tecnologias, estimulando a sua atuação crítica e criativa na identificação e resolução de problemas, considerando seus aspectos políticos, econômicos, sociais, ambientais e culturais, com visão ética e humanística, em atendimento às demandas da sociedade", habilidades e competências estas reproduzidas na Tabela 1.

De forma a garantir a "ênfase na síntese e na transdisciplinaridade" e a "forte vinculação entre teoria e prática", a Resolução CNE/CES 11/2002 em seu Art. 5o estabelece que "... ênfase deve ser dada à necessidade de se reduzir o tempo em sala de aula, favorecendo o trabalho individual e em grupo dos estudantes", contando para tal com a existência de "trabalhos de síntese e integração dos conhecimentos adquiridos ao longo do curso" (Art. 5o §1o), aliada ao estímulo às "... atividades complementares, tais como trabalhos de iniciação científica, projetos multidisciplinares, visitas teóricas, trabalhos em equipe, desenvolvimento de protótipos, monitorias, participação em empresas juniores e outras atividades empreendedoras" (Art. 5o §2o).

As diretrizes apresentadas buscam corrigir uma estrutura curricular com ênfase na acumulação de conhecimentos técnicos e científicos, classificados por CUNHA (2002) como uma coleção de conteúdos com profundas barreiras e forte enquadramento, apresentados de maneira seqüencial e linear, partindo do pressuposto de que o aluno precisa ter um domínio da teoria para posteriormente entender a realidade. Segundo BORDOGNA (1993) tal

abordagem leva a uma segregação cronológica dos alunos (calouros vs. veteranos) assim como a uma segregação por disciplinas, apresentadas como conteúdos isolados nas disciplinas teóricas, deixando a integração de conhecimentos apenas para os últimos semestres quando das disciplinas práticas e estágios.

Tabela 1: Competências e Habilidades dos egressos dos cursos de graduação em engenharia (Resolução CNE/CES 11/2002)

I - aplicar conhecimentos matemáticos, científicos, tecnológicos e instrumentais à engenharia; II - projetar e conduzir experimentos e interpretar resultados; III - conceber, projetar e analisar sistemas, produtos e processos; IV - planejar, supervisionar, elaborar e coordenar projetos e serviços de engenharia; V - identificar, formular e resolver problemas de engenharia; VI - desenvolver e/ou utilizar novas ferramentas e técnicas;	VII - supervisionar a operação e a manutenção de sistemas; VIII - avaliar criticamente a operação e a manutenção de sistemas; IX - comunicar-se eficientemente nas formas escrita, oral e gráfica; X - atuar em equipes multidisciplinares; XI - compreender e aplicar a ética e responsabilidade profissionais; XII - avaliar o impacto das atividades da engenharia no contexto social e ambiental; XIII - avaliar a viabilidade econômica de projetos de engenharia; XIV - assumir a postura de permanente busca de atualização profissional

Em contraste à organização de currículos na forma “coleção” CUNHA (2002) apresenta a possibilidade do currículo tipo “integração”, no qual não existem barreiras rígidas entre os conteúdos. Tal conceito pode levar a uma formulação just-in-time da relação ensino-aprendizagem, na qual os conceitos teóricos são introduzidos na medida em que se fizerem necessários, em um contexto de aplicações reais de engenharia.

Em artigo recente, PRINCE e FELDER (2006) advogam que a formulação just-in-time é parte de um leque de metodologias de ensino-aprendizado denominadas “Inductive Teaching and Learning Methods”, ao lado de formulações tais como “inquiry learning”, “problem based learning”, “project based learning”, “case based teaching”, “discovery learning” e “just-in-time teaching”. Embora com características diferenciadas, como mostrado na Tabela 2, todas as formulações encampadas pelo “aprendizado indutivo” têm as necessidades do aluno como foco, em uma tradução literal do princípio bem estabelecido na psicologia educacional de que as pessoas sentem-se mais fortemente motivadas a aprender algo quando percebem claramente a necessidade de sabê-lo.

A comparação das características dos métodos de aprendizagem indutiva, constantes da Tabela 2, com as habilidades e competências listadas na Tabela 1, aliada às exigências quanto ao estímulo ao trabalho em grupo, ao desenvolvimento de posturas de cooperação, comunicação e liderança, constantes no Art. 5o das Diretrizes Curriculares Nacionais para Cursos de Graduação em Engenharia sugere a adoção da metodologia de aprendizagem baseada em projeto/problemas na organização dos trabalhos de síntese e integração (projetos integradores) a serem criados em cada curso de graduação.

Já tradicionais no ensino das ciências da saúde, conforme descrito por diversos autores entre eles PRINCE e FELDER (2006), experiências com a metodologia da aprendizagem baseada em problemas/projetos no ensino da engenharia vêm sendo desenvolvidas há mais de trinta anos, como a apresentada por FINK (1999) e conduzida na Universidade de Aalborg, Finlândia, desde 1974.

Na experiência desenvolvida por Fink, é apresentado um currículo flexível para a formação do Engenheiro Eletricista Eletrônico e de Computação, aliado a uma forte cooperação entre universidade e empresa em um processo de realimentação e desenvolvimento de novos produtos.

Como resultado desta abordagem, Fink enumera claras diferenças no perfil do egresso deste modelo de aprendizagem em relação ao ensino tradicional, todas elas favoráveis ao aprendizado baseado em problemas/projetos, em especial no tocante a: (1) Comunicação oral e escrita, (2) habilidade para identificar e definir problemas de engenharia, (3) habilidade para levar a termo projetos completos de engenharia, (4) habilidade para pesquisa e desenvolvimento, (5) capacidade de trabalho cooperativo com pessoas de diferentes formações educacionais e culturais e (6) capacidade de considerar as questões sociais nas soluções técnicas apresentadas.

Tabela 2: Características dos métodos de aprendizagem indutiva (adaptada de PRINCE e FELDER 2006).

Características	Método					
	Inquiry	Problem	Project	Case	Discovery	Just-in-time
Questões ou problemas geram contexto do aprendizado	1	2	2	2	2	2
Problemas do mundo real, complexos, com soluções abertas e dados fracamente definidos geram o contexto do aprendizado	4	1	3	2	4	4
Um projeto definido gera o contexto do aprendizado	4	4	1	3	4	4
Estudos de casos geram o contexto do Aprendizado.	4	4	4	1	4	4
Estudantes descobrem por si mesmos o Contexto do aprendizado	2	2	2	3	1	4
Respostas dos alunos a questões conceituais orientam o professor na organização do conteúdo	4	4	4	4	4	1
Aprendizagem auto-direcionada	4	3	3	3	2	4
Aprendizagem ativa	2	2	2	2	2	2
Aprendizagem colaborativa ou cooperativa	4	3	3	4	4	4

1 – por definição, 2 – sempre, 3 – usualmente, 4 - possivelmente

Vê-se, portanto, que uma conjugação da metodologia da aprendizagem baseada em problemas/projetos aliada à existência de projetos integradores baseados em problemas/projetos reais da engenharia ao longo do curso de graduação, apresenta-se como uma alternativa promissora para a construção de um perfil de egresso nos termos das Diretrizes Curriculares Nacionais do Curso de Graduação em Engenharia, Resolução CNE/CES 11/2002.

2 O Projeto de Edifício como Projeto Integrador

De forma a propiciar ao egresso as competências e habilidades listadas na Tabela 1, algumas características devem ser apresentadas pelos projetos integradores, no âmbito dos cursos de graduação em engenharia.

Como características gerais, exige-se do projeto integrador que contextualize os conteúdos desenvolvidos nas disciplinas, que promova o desenvolvimento do senso crítico em relação ao papel da engenharia, que estimule o auto-conhecimento e a auto-aprendizagem, bem como a formação continuada, proporcionando um ambiente de amadurecimento das relações inter-pessoais e profissionais.

A estas, somam-se a necessidade de introduzir os alunos ingressantes em um ambiente de identificação e solução de problemas de engenharia, através da formação de grupos de trabalho multidisciplinares, estimulando assim a sua capacidade para inovação e uma visão holística da engenharia. O ambiente de trabalho colaborativo deve, ainda, estimular o desenvolvimento da liderança crítica, da habilidade de planejamento e da capacidade de comunicação e expressão.

O processo de projeto de um edifício, tomado sob um enfoque sistêmico, no qual é considerado já na etapa de projeto todo o ciclo de vida do edifício, apresenta as características requeridas para um projeto integrador em cursos de engenharia, em especial, mas não apenas, no curso de engenharia civil.

Em primeiro lugar, o processo de projeto de edifícios é um problema multidisciplinar, ou seja, envolve múltiplas lógicas disciplinares: engenharia civil (estruturas, fundações, sistemas hidrossanitário, sistemas construtivos, orçamentação), engenharia elétrica (instalações elétricas, sistema de proteção contra descargas atmosféricas), engenharia de redes (cabeamento estruturado, rede wifi), engenharia mecânica (climatização, ventilação mecânica, elevadores), engenharia mecatrônica (automação predial), engenharia florestal (paisagismo), engenharia de produção (gestão de projetos, organização da produção) e arquitetura (planejamento físico, definição de layout).

A produção de um edifício - um produto real que deve atender a requisitos de funcionalidade, custo, prazo, durabilidade e facilidade de operação/manutenção – contextualiza disciplinas clássicas dos cursos de engenharia, levando aos alunos a necessidade de identificar, formular e resolver os problemas que lhe são apresentados, de uma forma crítica, em um ambiente de trabalho colaborativo no qual são forçados ao diálogo não só com profissionais de outras especialidades como também com os usuários do edifício a ser projetado. Neste processo de identificação, análise e construção coletiva de uma solução, a capacidade de comunicação (oral, escrita e gráfica) e a postura de liderança tornam-se fundamentais.

Aspectos de projeto como sustentabilidade, eficiência energética, conforto ambiental e a própria viabilidade técnica e econômica do empreendimento, expõem os alunos a uma realidade na qual a abordagem cartesiana e segmentada não produz resultados satisfatórios, exigindo dos mesmos uma intervenção transdisciplinar, na qual a identificação e análise dos problemas devem se dar de forma integrada, com o objetivo de gerar respostas em comum que levem a uma otimização do todo e não de suas partes.

Quanto às habilidades e competências apresentadas na Tabela 1, o ambiente de projeto de edifícios, quando conduzido como um processo de aprendizagem baseada em projeto, é propício ao desenvolvimento de treze das quatorze listadas, excetuando-se apenas “supervisionar a operação e manutenção de sistemas”.

Do ponto de vista da integração, o processo de projeto de edifícios abre a possibilidade não só de uma atividade integradora de alunos pertencentes a diferentes cursos de graduação, em um enfoque intercursos, como possibilita um processo de aprendizado que integra alunos em diferentes estágios de formação, possibilitando, inclusive, a integração entre alunos de graduação e pós-graduação.

Tal proposta vem sendo implementada, em caráter experimental, na Faculdade de Tecnologia da Universidade de Brasília desde final de 2003 quando no Departamento de Engenharia Civil e Ambiental foi criado um espaço, denominado Laboratório de Projetos, destinado à pratica e discussão do processo de projeto de edificações, com uma abordagem transdisciplinar e focada no aprendizado baseado em desafios reais da engenharia.

3 O Laboratório de Projetos

A Universidade de Brasília (UnB) apresenta um espaço propício à implantação de uma experiência didática nos moldes discutidos nos itens anteriores, alicerçada em duas características singulares de sua estrutura.

A primeira delas é a existência de uma fonte própria de recursos, oriunda de seu patrimônio imobiliário, destinada exclusivamente construção de novos edifícios no campus.

A segunda é sua estrutura administrativa que comporta dois organismos diretamente ligados a Reitoria: o Centro de Planejamento Oscar Niemeyer (Ceplan), responsável pelo planejamento físico dos campi universitários e pelo projeto, licitação e fiscalização das obras da universidade; e a Prefeitura do Campus (PRC) responsável pela operação e manutenção do espaço físico construído.

Desta forma, todo o ciclo de vida dos edifícios da UnB, da fase de concepção à operação e manutenção e reutilização, passando pelas fases de projeto, construção e recebimento, desenvolve-se no âmbito da própria universidade, possibilitando à comunidade acadêmica interferir no processo de uma forma sistêmica.

Ao longo da história da UnB, o Ceplan foi responsável pelo desenvolvimento dos projetos de arquitetura das edificações e pela contratação externa à UnB dos projetos de engenharia para os mesmos, em um processo de projeto tradicional e segmentado, no qual o aspecto transdisciplinar e holístico do projetar é substituído por uma visão cartesiana e interdisciplinar do mesmo.

Em 2003, foi proposto ao Ceplan e ao Departamento de Engenharia Civil e Ambiental, e aceito pelos mesmos, que os projetos de engenharia passassem a ser também desenvolvidos no âmbito da própria universidade, em uma abordagem oriunda da engenharia simultânea e destinada a perceber o edifício como um produto único a ser concebido segundo uma lógica transdisciplinar, em um ambiente que envolvesse professores, alunos de graduação

e pós-graduação das diversas disciplinas/especialidade envolvidas, em um ambiente de trabalho colaborativo voltado ao aprendizado baseado em projetos reais de engenharia.

Os conceitos de interdisciplinaridade e de transdisciplinaridade são aqui utilizados segundo as definições apresentadas por MOSER (2005).

A interdisciplinaridade é aqui entendida como uma abordagem múltipla e paralela de um mesmo problema, na qual diferentes disciplinas intervêm com sua lógica específica gerando, portanto, uma solução com referência à sua própria lógica científica. As confrontações interdisciplinares ocorrem no estágio final do processo, de forma a garantir a coerência do produto apresentado.

A transdisciplinaridade, por sua vez, é entendida como uma abordagem que incorpora as diferentes disciplinas em colaboração em todos os estágios do problema. Desta forma, a definição do problema, o propósito da intervenção, as estratégias a serem implementadas e as recomendações emitidas são fundamentadas em uma abordagem comum do problema, gerando proposições integradas das soluções possíveis.

3.1 Recursos materiais e humanos

Para a implantação da proposta metodológica apresentada, o Departamento de Engenharia Civil e Ambiental disponibilizou uma sala em seu edifício, à qual foram sendo agregadas novas salas à medida que a experiência acolhia um número maior de alunos, chegando aos 83 m2 hoje disponíveis.

À Reitoria coube fornecer equipamentos e disponibilizar recursos para pagamento de bolsas aos alunos participantes, recursos estes oriundos da fonte destinada à sua ampliação física.

Parcerias com empresas privadas voltadas ao desenvolvimento de softwares destinados aos projetos de engenharia possibilitam que os participantes da experiência tenham acesso às novas ferramentas de projeto disponíveis no mercado, assim como a palestras, treinamentos e cursos, em um processo contínuo de atualização profissional.

A existência de projetos reais para os alunos é garantida pela expansão física da universidade, em uma parceria firmada com o Ceplan, assim como por solicitações de colaboração oriundas de órgãos do poder público, tais como a Presidência da República e o Fundo Nacional de Desenvolvimento da Educação.

Como dito anteriormente, o projeto de edifícios visto de um ponto de vista sistêmico necessita do engajamento de agentes, professores e alunos, dos diversos cursos oferecidos pela Faculdade de Tecnologia da Universidade de Brasília.

Para cada projeto, portanto, são alocados alunos de pós-graduação dos cursos envolvidos, que atuam como facilitadores do aprendizado dos alunos de graduação, propiciando assim a articulação direta entre graduação e pós-graduação advogada pela Resolução CNE/CES 11/2002.

Aos professores cabe um acompanhamento do desenvolvimento do projeto, interferindo apenas quando da necessidade de correção de rumo em função dos condicionantes externos do projeto ou para realçar determinado desafio a ser vencido pelos alunos.

3.2 Metodologias de projeto e de aprendizagem

A utilização do processo de projeto como projeto transversal e ferramenta de aprendizado, obriga a uma reformulação na própria dinâmica de desenvolvimento de projeto de edifício consagrada no mercado.

O fluxo de projeto tradicional, no qual existe uma prevalência tanto hierárquica quanto temporal do projeto arquitetônico sobre os demais, em uma abordagem seqüencial e interdisciplinar, deve ser substituído por uma visão do conjunto do edifício a ser projetado, em uma abordagem paralela e transdisciplinar.

Para tal, a participação dos alunos dos diversos cursos se dá desde a primeira reunião, envolvendo arquitetos e engenheiros responsáveis pelo projeto, a equipe responsável pela fiscalização da obra, a equipe de manutenção, os financiadores e os usuários do edifício, na qual são definidos os requisitos funcionais, técnicos e estéticos do edifício a ser projetado.

A seguir, os alunos passam ao desenvolvimento do projeto de suas “especialidades” em um ambiente de contato permanente com os responsáveis pelos projetos das outras especialidades. Este contato, estimulado pelos professores, deve conduzir a uma postura permanente de integração entre as diferentes soluções propostas gerando a necessidade do exercício da argumentação, questionamento e convencimento, em um contexto multidisciplinar. É neste ambiente que a capacidade de argumentação técnica/científica e o respeito a outras

lógicas profissionais devem ser desenvolvidos. E, assim como diz FINK (1999), “argumentation is a good way of learning”.

De forma a garantir a o exercício da abordagem transdisciplinar no projeto de edifícios, e a permanente postura de integração acima descrita, desenvolveu-se o conceito de uma estrutura de produção denominada “célula de projeto” que engloba todos os recursos necessários ao completo desenvolvimento do produto edifício, organizados de forma a estimular o trabalho em equipe, o fluxo permanente de informações, proporcionando redução do tempo de produção e facilitando a inclusão de inovações no produto final. Tal estrutura, inspirada no conceito de produção centrada no produto (células de produção) descrito por HYER e WEMMERLÖV (2002) é proposto e desenvolvido pelo primeiro autor deste artigo, em seu trabalho de doutoramento, sendo objeto de trabalhos específicos.

Por sua vez, a integração de alunos de diversos níveis de formação em um mesmo projeto permite que cada aluno seja submetido a desafios adequados ao seu nível de conhecimento, gerando uma cadeia de problemas e projetos que em um nível crescente de dificuldade levam ao projeto do edifício em si.

O conhecimento de que o projeto em desenvolvimento é de um edifício real, que será construído e utilizado - e não um trabalho acadêmico hipotético - é utilizado no desenvolvimento da responsabilidade e da ética profissional, assim como na capacidade de visualizar soluções factíveis dos pontos de vista técnicos e econômicos.

O trabalho de projeto é complementado por visitas periódicas a obras e edifícios prontos projetados pelo Laboratório de Projetos, nas quais são discutidos os aspectos de produção, operação e manutenção dos mesmos, em um processo de realimentação das soluções técnicas adotadas.

Em certos casos, é possível a um aluno que atuou no projeto de um determinado edifício acompanhar sua construção e utilização tendo contato, ao longo de sua graduação, com um ciclo completo do edifício, da concepção à operação.

3.3 Seleção e avaliação dos alunos

Face ao caráter ainda experimental da metodologia proposta e à impossibilidade de absorver todos os alunos dos cursos ministrados na Faculdade de Tecnologia, a participação no Laboratório de Projetos é facultativa e limitada a dezoito meses. Durante este período o aluno dedica vinte horas semanais ao trabalho no laboratório e recebe uma bolsa de estágio correspondente ao seu nível de formação.

Com o objetivo de mesclar as atividades do Laboratório de Projetos com o desenvolvimento das disciplinas ministradas no curso de graduação das engenharias, busca-se envolver no trabalho do laboratório o maior número possível de professores responsáveis por disciplinas de projeto.

Tal envolvimento não só permite que problemas do laboratório sejam transformados em desafios aos alunos das disciplinas, como estimula os alunos a buscarem um lugar na equipe do laboratório.

Quando tal não é possível, procura-se junto ao professor da disciplina permissão para que um professor, ou aluno de pós-graduação, do laboratório ministre uma ou mais aulas práticas em sua disciplina. Tal estratégia, estendida às disciplinas de Introdução à Engenharia e Representação Gráfica, ministradas nos períodos iniciais dos cursos, tem gerado bons resultados não só na oferta de candidatos como também na motivação dos novos alunos.

Dentre os candidatos, a seleção é feita com base em análise do histórico escolar e em entrevista realizada pelos alunos de pós-graduação, com acompanhamento de um professor, na qual são valorizadas a iniciativa, a motivação e a capacidade de organização de idéias e argumentação.

A avaliação dos alunos se dá em três níveis: um parecer do professor responsável, uma avaliação pelo aluno de pós-graduação ou engenheiro de sua equipe, e uma auto-avaliação.

No entanto, como por questões administrativas ainda não é possível atribuir créditos ao trabalho desenvolvido no Laboratório, percebe-se que a avaliação com maior impacto nos alunos é o “check list” final do projeto, no qual são detectadas e discutidas pela equipe as falhas do projeto. A avaliação mais almejada pelos alunos é um “check list” em branco.

4 Alguns Projetos Desenvolvidos

No período de cinco anos, o Laboratório de Projetos desenvolveu cerca de trinta projetos, em um total de aproximadamente 142.000 m2 de área construída.

A seguir, apresentam-se alguns exemplos de edificações da Universidade de Brasília desenvolvidas com participação do Laboratório de Projetos.

- **FACE/UnB**

A nova sede da Faculdade de Economia, Administração, Contabilidade e Ciência da Informação e Documentação (FACE), em construção, constituiu o primeiro projeto inteiramente desenvolvido por alunos e professores da Universidade de Brasília, em um trabalho conjunto do Centro de Planejamento Oscar Niemeyer (Ceplan), Faculdade de Arquitetura e Urbanismo (FAU) e Laboratório de Projetos do Departamento de Engenharia Civil e Ambiental (LABPRJ/ENC).

O conjunto de edifícios soma 8.400 m2, constituído por quatro blocos de dois pavimentos.

Neste primeiro projeto foram desenvolvidos no Laboratório de Projetos os projetos de estruturas de concreto, estruturas metálicas, fundações, instalações elétricas e de lógica, instalações hidrossanitárias e instalações de climatização.

Figura 1: FACE – Maquete eletrônica (Fonte: arquivos de projeto)

- **Observatório Sismológico**

A ampliação do Observatório Sismológico da Universidade de Brasília, com 800 m2 de área construída, com garagem, salas de aula, oficina mecânica, salas de professores, sala de reuniões, biblioteca, salas de aula e de exposições.

Elaborados projetos de estrutura de concreto, fundações, instalações elétricas e lógicas, instalações hidrossanitárias.

O Projeto de arquitetura foi desenvolvido pelo Ceplan.

Obra entregue em 2008.

Figura 2: Ampliação do Observatório Sismológico.

(Fonte: www.obsis.unb.br)

- **Laboratório de Geocronologia**

Edifício térreo com 1.532 m2 de área construída, com estrutura pré-fabricada em concreto.

Primeiro projeto a ter a plena integração das especialidades desde a sua concepção.

Obra entregue em 2006.

Figura 3: Laboratório de Geocronologia

(fonte: www.unb.br/ig/labo/geocron)

- **Instituto de Biologia**

Conjunto de 15 edifícios com estrutura em concreto, interligados por passarelas metálicas, somando 27.000 m2 de área construída.

Primeira experiência com a proposta do Laboratório de Projetos.

Obra em execução.

Figura 4: Obra do Instituto de Biologia

(Fonte: Laboratório de Projetos)

- **Projeto ProInfância - FNDE**

Projeto contratado pelo Fundo Nacional de Desenvolvimento da Educação, objetivando o desenvolvimento de projeto de referência para a construção de creches no âmbito do Programa ProInfância do Ministério da Educação.

O projeto apresentou desafios não só pelo seu caráter inovador de ser um projeto de referência adaptável às diferentes localizações geográficas gerando não um, mas um conjunto de projetos intercambiáveis, como pelo prazo e pelas condições de interação com órgão externo à universidade.

Como resultado foram gerados 29 projetos executivos, compostos por 169 desenhos, 28 memoriais técnicos, 32 cadernos de especificação, 32 planilhas de quantitativos, 08 planilhas orçamentárias, 01 caderno de componentes, 01 manual de projeto, 01 maquete física e 01 maquete virtual.

Figura 5: Maquete eletrônica para o Projeto Proinfância. (Fonte: Laboratório de Projetos)

5 Considerações Finais

Ao longo dos cinco anos de experimentação da metodologia proposta passaram pelo Laboratório de Projetos cinqüenta alunos de graduação e dez alunos de pós-graduação dos cursos de engenharia ministrados na Faculdade de Tecnologia da Universidade de Brasília.

No mesmo período quinze professores, dos quatro Departamentos (Engenharia Civil, Engenharia Elétrica, Engenharia Florestal e Engenharia Mecânica) assumiram orientação de projetos.

Todos os egressos dos cursos de graduação que passaram pelo laboratório estão atuando na engenharia, em empresas de projeto, manutenção, construção e consultoria, ou em cursos de pós-graduação.

No aspecto financeiro, a experiência gerou economia superior aos gastos efetuados pela universidade.

A proposta de utilização do processo de projeto de edifícios em uma metodologia de aprendizagem baseada em projetos mostra-se promissora em termos de resultados acadêmicos, além de mostrar-se viável financeiramente caso aliada a um processo de captação de recursos pela prestação de serviços à própria universidade ou a clientes externos.

Está em curso um processo de avaliação qualitativa da experiência, baseado em questionários enviados aos alunos que já passaram pela experiência, assim como reuniões com os engenheiros e professores que atuaram e/ou ainda atuam no laboratório.

No entanto, alguns desafios já se apresentam para a continuação da experiência: o comprometimento de um maior número de professores, a vinculação formal da atividade ao currículo dos cursos de graduação e a ampliação da capacidade de absorção de alunos.

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Fostering Students' Entrepreneurial Attitude through Project-based Learning and Multidisciplinary Teams

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Abstract

This article reports on a research work that took place along with a project-based learning initiative called PIEI project. This PIEI project takes place on a 2nd cycle degree of higher education in the School of Engineering, University of Minho. This project aims to develop, in an integrated way, with interdisciplinary teams, not only technical skills but also a wide range of soft skills as well as the entrepreneurial attitude. For this, a project focused on a real problem from a local company was proposed. Four teams of students, including cross-skilled members, compete with each other by seeking an integrated and innovative solution for the problem. These teams are supported by a team of teachers and researchers (called coordination team) as well as members from the company. In this paper, we present the main entrepreneurial characteristics which were developed deeper amongst the students from this PIEI experience.

Keywords: entrepreneurship education; project-based learning; soft skills.

1 A Aprendizagem Baseada em Projecto

Como consequência do Processo de Bolonha, foi criado em Portugal o “Grupo de Trabalho para a Reorganização da Rede do Ensino Superior” que descreve as actuais metodologias de ensino praticadas como predominantemente magistrais, não atendendo às exigências de um ensino superior massificado, acentuando que o ensino é pouco motivador para os alunos (Simão, Santos & Costa, 2004). O Ministério da Ciência Tecnologia e Ensino Superior (MCTES) português refere essencial a adopção de um sistema de ensino que privilegie o desenvolvimento das competências de trabalho experimental e por projecto (MCTES, 2008), valorizando “metodologias (…) necessariamente activas, cooperativas e participativas, capazes de facilitar o enfoque na resolução de problemas e de criar o ambiente de aprendizagem propício ao desenvolvimento não só das competências específicas de uma área profissional, mas também de capacidades e competências horizontais, como sejam o aprender a pensar, o espírito crítico, o aprender a aprender, (…) exigindo uma preparação prévia dos docentes”, de modo a corresponderem às novas exigências propiciadas pela Declaração de Bolonha (Simão, Santos & Costa, 2004: 5.4).

Fazendo ainda referência à importância que a aprendizagem por projecto assumiu com o Processo de Bolonha, a Universidade do Minho (UM) refere que as metodologias de ensino-aprendizagem foram “completamente reformuladas”, induzindo um maior realce ao trabalho desenvolvido pelo aluno “introduzindo (…) a aprendizagem activa, a aprendizagem baseada [na] solução de problemas, orientada a projectos” (UM, 2008: s.p.). Deste modo, a UM promoveu acções de carácter inovador e que indicassem um progresso no sentido proposto pelo Processo de Bolonha. Nesse sentido, em 2002, a UM procurou que o desenvolvimento da aprendizagem baseada em projectos – Project-Led Education (PLE) – fosse adoptada no ensino superior, tendo organizado acções de formação onde participaram diversos grupos de docentes.

O PLE foi inicialmente desenvolvido por Powell e Weenk (2003) que indicam a adopção de uma metodologia de ensino-aprendizagem activa e colaborativa, baseada no aluno e no seu desempenho. Deste modo, o PLE centra-se no trabalho em equipa, desenvolvendo competências de ordem técnica mas fomentando, simultaneamente, competências transversais como o trabalho em equipa, o espírito crítico, de iniciativa e criatividade, a capacidade de comunicação, gestão do tempo, gestão de conflitos, gestão de projectos e relacionando conteúdos interdisciplinares de forma integrada. Assim, Powell e Weenk definem PLE do seguinte modo:

“Project-led education focuses on team-based student activity related to learning and to solving large-scale open-ended projects. Each project is usually supported by several theory based lecture courses linked by a theme that labels the curriculum unit. A team of students tackles the project, provides a solution, and delivers by an agreed

delivery time (a deadline) a 'team product', such as provides a prototype and a team report." (Powell & Wenk, 2003: 28)

Por conseguinte, verifica-se que, com esta metodologia, se procura uma articulação entre a teoria e a prática, através de um projecto, com a apresentação de soluções para um problema retirado de uma situação real. Permite igualmente o desenvolvimento de competências multi e interdisciplinares, permitindo a integração de vários conteúdos abordados em diferentes unidades curriculares que participam no projecto, visto que a aprendizagem dos alunos decorre num contexto de projecto colaborativo. Apesar do referido, neste trabalho em equipa, existem tarefas atribuídas que se realizam individualmente de modo a que cada elemento possa contribuir para o projecto comum (Carvalho & Lima, 2006).

Com estas metodologias pretende-se que os alunos se preparem para – e num – contexto real, preparando-se para uma mais adequada inserção profissional, desempenhando um papel activo na sua aprendizagem, ensaiando o desenvolvimento do trabalho num ambiente empresarial.

2 Projecto Integrado em Empreendedorismo e Inovação (PIEI)

O Departamento de Produção e Sistemas (DPS) da Escola de Engenharia (EE) da UM dando seguimento ao desafio lançado pela Reitoria da UM, tem desenvolvido desde 2004 um projecto PLE – financiado pela Reitoria da UM – que se destinou aos estudantes de Engenharia, inicialmente aos estudantes da Licenciatura em Engenharia e Gestão Industrial e do Mestrado Integrado em Engenharia e Gestão Industrial, em que se desenvolveram as metodologias preconizadas na Declaração de Bolonha. Mais recentemente (no ano lectivo 2007/2008) a este Projecto de Aprendizagem acrescentou-se um outro (no seguimento do primeiro) que integrou o Mestrado Integrado em Engenharia e Gestão Industrial, o Mestrado Integrado em Engenharia de Polímeros e o Mestrado Integrado em Engenharia Industrial e de Computadores, sendo actualmente denominado como Projecto Integrado em Empreendedorismo e Inovação (PIEI).

O PIEI, em curso no âmbito do DPS da EE da UM, enquanto experiência de aprendizagem centrado em projecto, desenvolve-se no quadro do segundo ciclo universitário, através da conjugação das abordagens tanto multidisciplinar como de convergência de diversas áreas de Engenharia e tem por propósito central proporcionar a construção de soluções integradas para problemas contextualizados e apresentados por empresas (Carvalho, Lima & Fernandes, 2008: 1).

Na prossecução dos seus fins, o PIEI propõe-se não só desenvolver competências técnicas, inscritas nas áreas específicas dos Cursos de Engenharia, como transversais a essas mesmas áreas presentemente requeridas de modo integradas pelos contextos de trabalho reais (Mesquita, Lima & Pereira, 2008: 1), mas também suscitar nos futuros profissionais da Engenharia a adopção de uma atitude empreendedora consequente, designadamente através de comportamentos de criatividade, iniciativa, capacidade de tomar decisões e liderança, bem como da capacidade de fazer coisas de uma forma não apenas diferente mas também inovadora (Carvalho, Lima & Fernandes 2008: 3).

2.1 Organização PIEI

Na sua primeira edição, no ano lectivo de 2007/2008, o PIEI contou com a participação voluntária de 24 alunos de três cursos diferentes, sendo 8 alunos do Mestrado Integrado em Engenharia e Gestão Industrial (MIEGI), 8 alunos do Mestrado Integrado em Engenharia de Polímeros (MIEP) e 8 alunos do Mestrado Integrado em Engenharia Electrónica Industrial e de Computadores (MIEEIC). No presente ano lectivo, 2008/2009, aos 8 alunos de cada um dos cursos referidos acrescentaram-se 8 alunos do Mestrado Integrado em Engenharia Mecânica (MIEM), totalizando 34 alunos. Estes alunos foram agrupados, aleatoriamente, em quatro equipas multidisciplinares de oito elementos, contendo cada uma delas dois elementos pertencentes a cada um dos cursos envolvidos.

O projecto desenvolve-se no 1.º semestre do 4.º ano de cada um dos referidos cursos.

O peso do projecto em ECTS (*European Credit Transfer System*) não é igual para os 3 cursos por questões de organização interna de cada curso. Neste projecto contribuem as seguintes Unidades Curriculares (UC) em cada um dos cursos: MIEGI – Projecto Integrado I, Sistemas de Informação para a Produção, Simulação e Gestão Integrada da Produção (12,5 ECTS); MIEP – Unidade Curricular Integradora VII (9 ECTS); MIEEIC – Projecto I e Projecto II (10 ECTS); MIEM – Teoria de Projecto e Integradora VII (10 ECTS).

Todo o trabalho desenvolvido é coordenado por uma equipa que inclui os seguintes elementos: 11 docentes de quatro departamentos – incluindo os docentes envolvidos em unidades curriculares de apoio ao projecto e tutores

das equipas de alunos, 3 investigadores que dão apoio pedagógico ao projecto, 1 associação especializada em inovação, empreendedorismo e transferência de tecnologia – TecMinho, 1 empresa – Petrotec.

O PIEI é apresentado aos alunos no semestre anterior ao seu início, sendo seleccionados os alunos e criadas todas as condições físicas e organizacionais para o seu desenvolvimento. No primeiro dia do semestre do PIEI o projecto é apresentado aos alunos e as equipas começam a trabalhar. A cada equipa é atribuída uma sala de projecto onde podem trabalhar em grupo e manter todo o material do projecto. É também atribuído a cada equipa um tutor que acompanha e apoia a equipa nos aspectos de organização e gestão de projecto e da própria equipa, realizando-se reuniões formais semanais com o tutor. Ao longo do semestre existem pontos de controlo (ver tabela 2) para que toda a equipa de coordenação pudesse acompanhar o estado do andamento de cada uma das equipas e dos seus projectos.

Interessa ainda referir que para este projecto foi criada a figura do Tutorial Alargado com o objectivo de colocar frente-a-frente cada uma das equipas de alunos com toda a equipa de coordenação para resolver possíveis problemas de forma integrada. No início de cada projecto é entregue a todos os alunos envolvidos um documento designado "Guia do PIEI" com informação relevante para o projecto.

2.2 O desenvolvimento da atitude empreendedora no PIEI

A relevância atribuída pelo PIEI à incorporação da promoção da atitude empreendedora junto dos seus alunos corresponde de modo exemplar às orientações referentes às políticas e aos programas de implantação do conceito de *educação para o empreendedorismo* avançadas pela União Europeia, ou seja, "o desenvolvimento de determinadas qualidades pessoais" – e que, por conseguinte, "não está directamente centrado na criação de novas empresas" (CCE, 2004: 6) – sendo que o "espírito empreendedor desenvolve-se num ambiente que encoraje as formas activas de aprendizagem" (CCE, 2002: 8), encorajamento esse precisamente incentivado pelo Processo de Bolonha e partilhado pelo PIEI.

O empreendedorismo não deve, portanto, ser entendido como um conteúdo formal a ser abordado em contexto escolar, mas sim como uma proposta que adopte metodologias e estratégias de ensino-aprendizagem que "favoreçam e incentivem atitudes e posturas como: autonomia, iniciativa, autovalorização, ética, criatividade, cidadania, liderança, diálogo, participação, desenvolvimento de projectos, resolução de problemas, boa utilização de informação e dos recursos, inovação e pioneirismo" (Andrade, 2005:13). Deste modo, dissemina-se a cultura empreendedora, dotando os estudantes de uma consciência colectiva, adquirindo competências técnicas, tornando-se num melhor profissional, participando mais, tendo, portanto, uma atitude empreendedora (Andrade, 2005: 14).

Para além da sua preocupação em promover a atitude empreendedora junto dos alunos, o PIEI advoga em particular que essa promoção deve ser executada no âmbito da respectiva estrutura curricular, perspectiva esta que, também ela, corresponde a uma das opções de implantação da *educação para o empreendedorismo* no ensino superior avançadas pela Comissão Europeia, nomeadamente quando esta instância europeia declara que "[as] universidades e os institutos técnicos devem incorporar o empreendedorismo como elemento importante dos currículos, repartido por várias disciplinas", sendo a outra opção – até numa perspectiva de complementaridade da primeira – a de "exigir ou encorajar a participação em cursos de empreendedorismo" (CCE, 2006a: 9). Deste modo, o PIEI pode contribuir para o desenvolvimento da Universidade Empreendedora (Etzkowitz *et al.*, 2000), ou seja, os estudantes, docentes, investigadores e colaboradores, devem, eles próprios, ser treinados para "adquirirem e/ou desenvolverem uma atitude empreendedora" no seu quotidiano devendo tomar decisões de carácter empreendedor, incluindo-se neste aspecto, nomeadamente, os valores e as práticas de governação e gestão, para além da necessária interacção com o meio (Silva *et al* 2007: 2822) que o PIEI já promove ao cooperar com entidades externas à UM (empresas).

Não conferindo o PIEI prioridade a uma concepção do empreendedorismo cujo seu propósito é a criação de empresas, torna-se relevante problematizar o conceito de *intra-empreendedorismo*, enquanto concepção do empreendedorismo que assenta e se traduz pela construção de propostas de soluções inovadoras susceptíveis de responder aos problemas emergentes no seio de uma empresa já estabelecida, devendo essas soluções ser concebidas e desenvolvidas pelos seus próprios profissionais (Mesquita, Lima & Pereira, 2008), tornando-os "conscientes do seu trabalho e aptos a aproveitar oportunidade" (CCE, 2006b: 4).

Deste modo apresenta-se como relevante perceber quais as percepções dos alunos relativamente ao processo de ensino-aprendizagem que estão envolvidos no decorrer do PIEI, assim como o que o precede, de modo a tentarmos detectar quais as dimensões/características empreendedoras que são mais desenvolvidas, numa primeira instância, no seu percurso no 1.º ciclo do ensino superior e numa segunda instância no decorrer do PIEI.

3 Metodologia

3.1 Participantes

A população do estudo é constituída pelos alunos que integram o PIEI, ou seja, alunos dos quatro anos dos Mestrados Integrados em Engenharia e Gestão Industrial, Engenharia Electrónica Industrial e Computadores, Engenharia de Polímeros e Engenharia Mecânica.

Toda a população do estudo, respondeu aos dois questionários apresentados, ou seja, os 32 alunos que integram o PIEI (100%).

3.2 Instrumento

Com vista à obtenção de dados para a concretização do propósito deste estudo, e em função da relevância do questionário, como recurso preponderante de recolha de informação correspondente privilegiada pela generalidade tanto dos estudos científicos que têm examinado a questão do empreendedorismo como da educação para o empreendedorismo, recorreu-se a esta modalidade de inquérito, incluindo o anonimato dos respondentes para efeitos de libertação de constrangimentos vários decorrentes da identificação nominal dos participantes (Bravo, 1991), com a presença do investigador demonstrando-se este disponível para proceder a esclarecimentos sobre o conteúdo e a formulação dos itens, se bem que esta presença foi discreta e distante, evitando-se criar situações de condicionamentos/constrangimentos, implícitos e/ou explícitos, intencionais ou acidentais, de vária ordem (Ghiglione & Matalon, 1997).

O primeiro questionário está dividido em cinco secções (A, B, C, D e E). Na Secção A, deste questionário, pretende-se caracterizar os alunos, nomeadamente no que diz respeito aos itens sexo, idade, curso, se é ou não Trabalhador Estudante (TE) e se pertence a órgãos associativos.

Na segunda secção (B), questiona-se os alunos acerca da situação profissional dos dois familiares mais próximos e se convive diariamente com pessoas que sejam quadros superiores de empresas ou empresários. Colocou-se este item pois alguns estudos indicam que a situação profissional dos familiares influi no desenvolvimento da atitude empreendedora.

Na Secção C questiona-se o aluno acerca do desenvolvimento de trabalhos nos primeiros anos de Ensino Superior, nomeadamente no que diz respeito ao seu envolvimento nos denominados "trabalho de grupo".

Na quarta secção (D), através de questões com escolha múltipla, é pedido ao aluno que indique quais as suas percepções acerca de uma hipotética tomada de decisão, acerca do processo inovação, do processo de empreendedorismo, das características que mais se adequam a um perfil empreendedor e, por último, se o aluno considera ter um perfil empreendedor e que indicassem, por ordem de importância, cinco motivos que justificassem a sua resposta.

Por último, na Secção E, apresenta-se uma tabela onde se coloca a mesma questão para duas situações distintas. Assim, estando os alunos inseridos em Mestrados Integrados e, neste momento, a iniciar o denominado 2.º Ciclo do Processo de Bolonha, o primeiro questionário administrado inquire, por um lado, como a percepção dos alunos acerca das características mais desenvolvidas no decorrer do Processo Ensino Aprendizagem anterior, mais concretamente, aos três primeiros anos de formação superior anterior e, por outro lado, tendo como base as mesmas características, quais as suas expectativas relativamente ao projecto que naquele momento iniciavam. Esta secção do questionário, e atendendo ao propósito do estudo em determinar as percepções dos alunos em relação ao processo de ensino/aprendizagem em causa, o instrumento recorre, para o efeito, a uma escala de classificações aditivas, comummente designada *escala de (tipo) Likert*, que apresenta um *continuum* entre um pólo *muito desfavorável* e outro *muito favorável*, escala essa constituída, nesta situação, por seis pontos – *1. Discordo completamente*, *2. Discordo bastante*, *3. Discordo*, *4. Concordo*, *5. Concordo Bastante*, *6. Concordo completamente* – aos quais se encontra anexado um ponto designado *SO. Sem opinião/Não sabe*, de modo a recolher o ponto de vista de cada respondente em relação a um conjunto de itens através da indicação do grau de concordância/discordância em relação às afirmações correspondentes. A inclusão no instrumento da *escala de Likert* de seis pontos correspondentes às definições qualitativas supra indicadas decorre do facto de os respondentes se encontrarem familiarizados com a referida escala, pois os referidos pontos e as definições qualitativas são os consagrados no questionário institucional de avaliação do Processo de Ensino Aprendizagem da Universidade do Minho.

No segundo questionário está dividido em apenas três secções (A, B, C). Na Secção A, deste questionário, apresentam-se as mesmas questões genéricas de caracterização e identificação do respondente.

A segunda secção (B), corresponde à quarta secção do questionário anterior, tendo-se eliminado neste questionário as Secções B e C do primeiro, uma vez que as respostas a estas questões tinham já sido respondidas e não haveria lugar a confrontação de percepções pois estas centravam-se na situação profissional dos dois familiares mais próximos e/ou amigos, assim como, no desenvolvimento de trabalhos nos primeiros anos de Ensino Superior.

Por último, na Secção C deste questionário, apresenta-se a mesma tabela, mas neste caso troca-se as expectativas dos alunos pelas suas percepções acerca do desenvolvimento das características apresentadas, por comparação com os três primeiros anos de formação.

3.3 Procedimento

O processo de administração dos questionários decorreu em dois momentos distintos, no início do primeiro semestre do ano lectivo de 2008/2009, isto é, na sessão de apresentação do PIEI (22/09/2008) onde se questionou o perfil de entrada dos 32 alunos presentes, e, por comparação, o perfil de saída, foi questionado no final do mesmo semestre, mais concretamente na sessão de apresentação final do projecto pelos grupos (30/01/2009). De modo a não induzir respostas, o primeiro questionário foi realizado imediatamente antes de se iniciar a sessão de apresentação do PIEI, e no final das apresentações. Ou seja, entre cada um dos questionários passaram mais de 4 meses. O questionário foi preenchido com a presença do investigador singularmente por cada respondente/alunos sem discutir/debater o conteúdo do instrumento e/ou acertar/comparar o sentido das respostas correspondentes com outrem, mormente com quaisquer dos seus pares.

4 Resultados

Dado que as análises continuam a ser desenvolvidas, neste documento não se apresentam a totalidade dos resultados, mas apenas aqueles que melhor corresponderem ao propósito aqui desejado.

O estudo que foi desenvolvido, tal como já foi referido, teve como base as percepções dos alunos do PIEI acerca do desenvolvimento de diversas características, por esse motivo, torna-se pertinente caracterizar a público do estudo. Dos 32 respondentes (100% do público-alvo), 9% são do sexo feminino e 91% são do sexo masculino.

No que diz respeito à idade, os alunos situam-se, na sua maioria, no intervalo entre os 20 e os 22 anos (52%) e outra parte substancial entre os 23 e os 25 anos (44%).

No que diz respeito aos cursos dos quais os alunos são provenientes, sendo que todos os alunos foram questionados, o estudo teve como base 25% de alunos de cada um dos cursos, ou seja, tal como o projecto exige.

Nestas três questões iniciais, não se verificaram, naturalmente, diferenças do primeiro para o segundo questionário, nem mesmo no item idade.

Já no que diz respeito a outras questões ainda relacionadas com a caracterização dos alunos, podemos acrescentar, de um modo breve, que no que diz respeito ao facto dos alunos trabalharem em simultâneo com o curso que estão a frequentar, as respostas não se diferenciaram significativamente do primeiro para o segundo questionários. Assim, no primeiro questionário administrado as respostas dos alunos indicavam que 12,5% dos alunos trabalhavam e estudavam, sendo que no segundo este valor desceu para o 9,7.

Ainda nesta secção, Já no que diz respeito ao desenvolvimento associativo, verifica-se uma ligeira diferença, no primeiro questionário 18,8%, de alunos faziam parte de um movimento associativo e no questionário final o resultado foi de 23,3%. Os restantes itens desta secção não são aqui apresentados pois não se verificaram diferenças significativas para serem neste documento apresentadas.

Numa outra secção, questionamos também os alunos acerca das suas percepções sobre uma hipotética tomada de decisão, sobre a inovação e sobre o empreendedorismo.

Figura 1: Posição dos respondentes relativamente a tomada de posição perante situação concreta

Assim, na primeira questão apresentada, pretende-se saber o que faria o aluno perante a seguinte situação: “Coloque-se na posição de um colaborador de uma determinada empresa. No decorrer do desenvolvimento da sua actividade profissional teve uma determinada ideia que considera poder ser uma excelente oportunidade/ideia para o crescimento da empresa que trabalha. De entre as seguintes tomadas de decisão optaria por adoptar:”. Para esta questão, eram apresentadas 4 alternativas de resposta (ver figura 1) de entre as quais os alunos teriam de seleccionar apenas uma tomada de posição.

Assim, comparando-se os dados obtidos em cada um dos inquéritos, verificamos que antes do PIEI os alunos recaem de forma significativa as suas respostas para a primeira opção, ou seja, “após reflexão acerca do assunto apresentaria a ideia ao Director da Empresa, mostrando-me disponível para a desenvolver até ao fim”. Deste modo, os alunos posicionam-se naquele que o paradigma mais próximo das práticas desenvolvidas pelo PIEI, ou seja, pretende desenvolver a ideia que teve na empresa onde trabalha. Curiosamente, quando vamos confrontar os resultados das respostas no final do PIEI, verifica-se que os alunos desenvolveram, de um modo genérico mais competências empreendedoras no sentido de desenvolver planos de negócio que resultassem na criação de empresas. Ou seja, verifica-se que há um retrocesso (em cerca de 13%) do desenvolvimento da ideia no seio da empresa e um avanço/aumento de 10% no que diz respeito ao desenvolvimento da ideia tendo como finalidade a criação de uma empresa (20%).

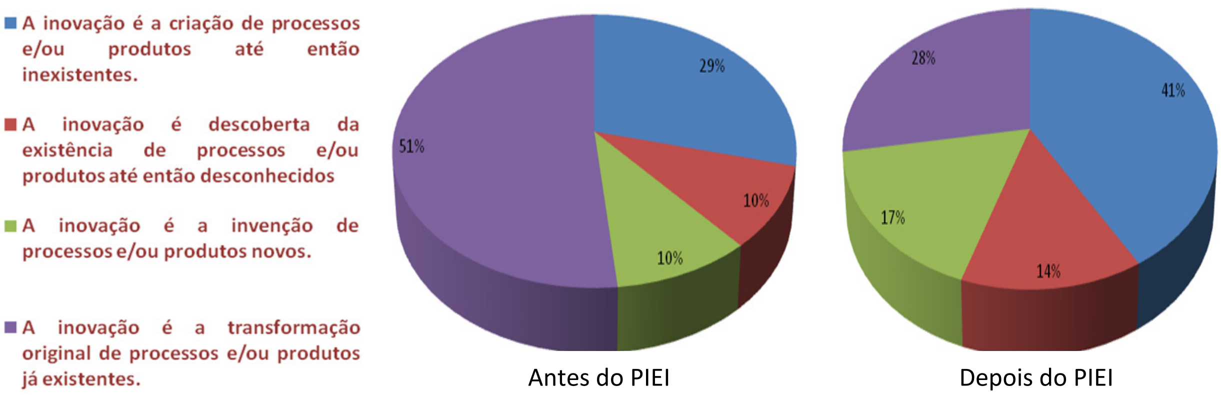

Figura 2: Posição dos alunos perante a sua percepção sobre o processo de inovação.

Quando os alunos foram questionados acerca das suas percepções sobre o processo de inovação, tendo igualmente quatro alternativas de resposta (ver figura 2), as suas respostas foram no sentido de considerarem o processo de inovação como a “transformação original de processos e/ou produtos já existentes” com 51 %, sendo a resposta com mais percentagem que se seguiu a que a criação de processos e ou produtos até então inexistentes.

Neste caso em particular as alterações que se verificaram foram no sentido de atribuir uma menos importância à resposta inicialmente preferida, notando-se o aumento significativo da alternativa que indica a inovação como a criação de processos e/ou produtos até então inexistentes (41%). Nesta situação em particular não encontramos uma ligação e justificação directa que indique quais os motivos para esta mudança, no entanto, podemos especular que o facto do PIEI ser desenvolvido sobre um produto já existente e a equipa de coordenação

incentivava e desafiava os alunos a criarem novas soluções, pode ter dado um apoio no sentido desta diferença de resultados.

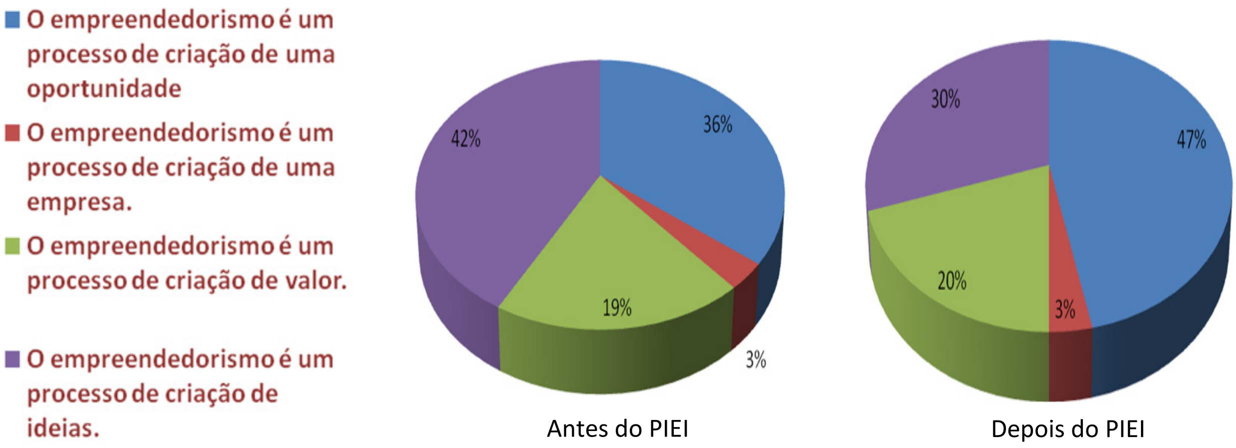

Figura 3: Posição dos alunos perante a sua percepção sobre o processo de empreendedorismo

Quando os mesmos alunos foram questionados sobre, de entre as alternativas, qual a que mais se adequava ao processo de empreendedorismo (figura 3), verificamos que a maioria das respostas foi ao encontro daquele que foi o desenvolvimento de acções no decorrer do PIEI. Assim, diminui a perspectiva de que o empreendedorismo é simplesmente um processo de criação de ideias, ganhando maior realce a perspectiva de que o empreendedorismo é o desenvolvimento de esforços que resultem na criação de uma oportunidade, seja ela uma nova empresa ou outra (no seio de uma empresa já estabelecida). Esta mudança pode estar relacionada com o facto das perspectivas apresentadas pela TecMinho nas suas sessões, irem ao encontro desta perspectiva, mas também porque a equipa de coordenação incentivava a descoberta de opções que resultassem em novas oportunidades.

No decorrer do PIEI foram apresentadas aos alunos as competências que desembocam no perfil empreendedor e, neste questionário, perguntou-se se os alunos consideravam que o PIEI tinha desenvolvido neles essas mesmas competências. Verificou-se que 100% dos alunos responderam que sim, sendo esta resposta de destacar pela sua irrefutável afirmação do desenvolvimento das competências empreendedoras (figura 4).

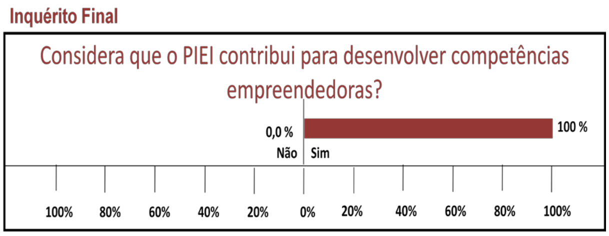

Figura 4: Percepção dos alunos perante o desenvolvimento de competências empreendedoras

No primeiro questionário que foi apresentado aos alunos, havia uma secção onde se inquiria quais as suas expectativas em relação ao PIEI. Os alunos responderam, de um modo genérico, que as suas expectativas (mais concretamente no que diz respeito ao desenvolvimento de características empreendedoras) eram – à data – extremamente elevadas. Verificou-se que as expectativas superavam em larga medida as suas percepções acerca dos três primeiros anos de formação no ensino superior.

No segundo questionário, foi apresentado aos alunos uma tabela onde tinham de classificar quais as suas percepções acerca do desenvolvimento das características não empreendedoras e empreendedoras, nos três primeiros anos de formação (antes do PIEI) e de que modo essas mesmas competências foram desenvolvidas no PIEI. Assim, no que diz respeito às competências de carácter não empreendedor, é visível (figura 5) que durante o PIEI todas essas características (ansiedade, hesitação, inconstância, indecisão, individualismo, passividade e rotina) foram menos desenvolvidas de forma significativa, por comparação com os três primeiros anos de formação. Com isto, percebe-se que o PIEI desenvolve-se de modo a que estas características não sejam tão desenvolvidas, deixando mais espaço para as características empreendedoras.

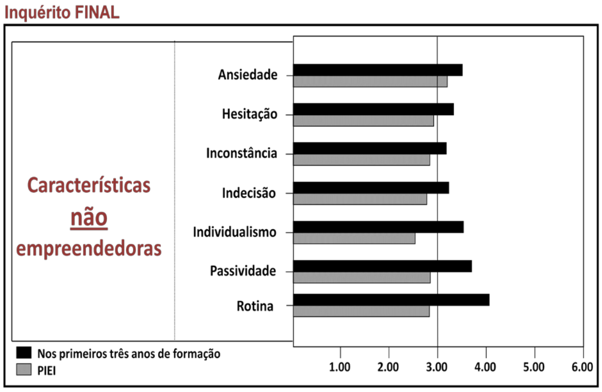

Figura 5: Percepção dos alunos perante diferentes características não empreendedoras

Assim, os alunos, perante as características empreendedoras (autoconfiança, capacidade de decisão, determinação, espírito de equipa, iniciativa, mudança e perseverança) demonstraram que o PIEI permitiu desenvolvê-las de um modo significativo (figura 6). Ou seja, existem diferenças significativas em relação aos três primeiros anos de formação, com maior desenvolvimento destas características no PIEI, e, se compararmos estes resultados com os resultados das características não empreendedoras, as diferenças são ainda mais significativas.

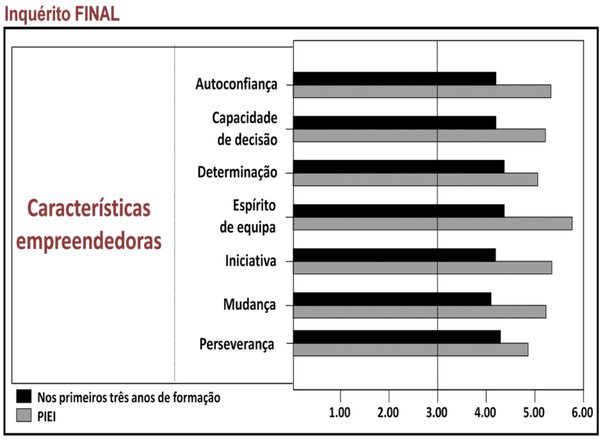

Figura 6: Percepção dos alunos perante diferentes características empreendedoras

5 Conclusões

No decorrer do PIEI desenvolveram-se acções no sentido de suscitar diversas competências de carácter técnico, mas também de carácter pessoal, sendo que as competências referidas no Guia do PIEI são, em parte, as referidas pelos referenciais científicos como referentes ao perfil empreendedor. Neste sentido, ao verificarmos o desenvolvimento de competências transversais no decorrer do PIEI, estamos igualmente a verificar de que modo os alunos estão a desenvolver a atitude empreendedora e o projecto a desenvolver a cultura empreendedora. Assim, as percepções deixadas pelos alunos demonstram-se extremamente claras quanto ao desenvolvimento destas competências com o desenvolvimento da aprendizagem baseada em projecto.

Como foi referido anteriormente, as expectativas para o PIEI eram extremamente elevadas, no entanto, podemos afirmar que o PIEI – de forma genérica – não só correspondeu às elevadas expectativas criadas, como também as superou em algumas situações. De acordo com as expectativas e com as percepções registadas, podemos dizer que os alunos criaram fortes expectativas no que diz respeito ao PIEI, em comparação com os anos transactos (três primeiros anos de formação). Se é verdade que estas expectativas poderiam ter proporcionado algum desalento no decorrer do projecto, também podemos dizer que apoiou no desenvolvimento do esforço por parte dos alunos em concretizar as aprendizagens referidas como mais essenciais e mais significativas para este projecto.

Verificou-se que durante o desenvolvimento do projecto os alunos alteraram a sua percepção acerca do processo de empreendedorismo, aproximando-se mais neste momento do entendimento do empreendedorismo como processo de criação de oportunidade e menos de criação de ideias. Pensamos que o desenvolvimento de acções de clarificação do processo de registo de patentes, de apresentação de programas de apoio e formação no

desenvolvimento de planos de negócios, todas estas acções realizadas pela TecMinho no decorrer do PIEI, podem ser um dos principais motivos para esta mudança. Apesar do PIEI não estar particularmente vocacionado para o desenvolvimento de competências que resultem na criação de empresas ou oportunidade de negócio, é verdade que o desenvolvimento de ideias inovadoras pode promover o desenvolvimento de uma oportunidade e é natural que suscite nos alunos que o integram uma motivação para desenvolverem acções mais criativas, autónomas e empreendedoras de um modo individual. Estas acções contribuíram igualmente para uma maior reflexão acerca do processo de empreendedorismo em que os alunos estavam envolvidos.

Dado que as competências transversais que são referidas como promovidas pelo PIEI coincidem com a do perfil empreendedor, existem indicadores de que o PIEI está a promover o desenvolvimento da atitude empreendedora, perante a percepção dos alunos. Os mesmos alunos estão também a ficar com uma percepção mais clara e adequada sobre a relevância do desenvolvimento dos processos inovadores e empreendedores. Para além das óbvias e necessárias competências de carácter técnico que estão a ser desenvolvidas, este projecto desenvolve nos alunos competências de carácter transversal que são úteis nos mais diversos contextos da vida profissional e pessoal. Por outro lado, o desenvolvimento do PIEI, até pela expectativa que no projecto foi depositada, poderia ter promovido o desenvolvimento de características como a ansiedade ou a hesitação, mas até neste ponto verifica-se um recuo durante o desenvolvimento do PIEI.

Torna-se relevante referir que de entre as sete características de carácter empreendedor apresentadas os alunos consideram que o PIEI, em todas elas, promoveu o seu desenvolvimento. Ou seja, em comparação com os três primeiros anos de formação, o PIEI, na percepção dos alunos, promove mais as competências transversais, com especial realce para o espírito de equipa e iniciativa.

O PIEI, através da metodologia de aprendizagem baseada em projecto, tem proporcionado o desenvolvimento de competências transversais que por sua vez, em conjunto, resultam no desenvolvimento de uma atitude empreendedora, não havendo indícios quanto ao desenvolvimento da cultura empreendedora em todo o projecto.

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Portugol IDE – A Tool for Teaching Programming

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Abstract

Teaching of programming usually resorts to programming languages and development environments directed to commercial purposes. When used to teach programming basics, these languages and environments do not always facilitate the development of programming logic. Portugol IDE is a learning environment particularly directed to higher education which has an algorithm specification language based on the students' mother tongue (portugol), a graphic language that reinforces the concept of sequential execution (flowcharts), and a set of characteristics that makes it suitable for first steps in programming. This paper presents the learning environment Portugol IDE and its use in class environment as well as some innovations to be introduced in the future.

Keywords: Portugol IDE; flowchart language; Portugol language; programming teaching.

1 Introdução

A programação de computadores é uma actividade complexa e com nível elevado de abstracção que, tradicionalmente, é ensinada recorrendo a linguagens de programação e a ambientes de desenvolvimento projectados para o contexto industrial da produção de software.

Os cursos e as unidades curriculares de programação de nível introdutório têm tradicionalmente elevadas taxas de reprovação (Butler & Morgan, 2007; Jenkins, 2002; Lahtinen, Mutka & Jarvinen, 2005). Este fenómeno é geral, não sendo exclusivo de um grupo de Instituições ou de um curso específico, ou mesmo de um grupo de alunos com um determinado perfil de formação. Este nível de insucesso no ensino da programação tem merecido a atenção de vários investigadores (Giangrande, 2007). A investigação vai desde os aspectos mais técnicos aos aspectos pedagógicos. Relativamente aos aspectos técnicos é o paradigma da programação que se deve usar, o que suscita mais divergências (Lister, Berglund, Clear, Bergin, Garvin-Doxas, Hanks, Hitchner, Luxton-Reilly, Sanders, Schulte & Whalley, 2006). Existem aspectos que são comuns aos paradigmas de programação orientados a objectos e procedimentais, nomeadamente, a definição de variáveis e de estruturas, a modularização, a definição de estruturas de dados e o uso de estruturas de controlo de execução. Com vista a dar resposta a estes problemas foi desenvolvido um ambiente de execução de algoritmos que designámos de Portugol IDE (Manso & Oliveira, 2006). A expressão dos algoritmos na língua materna do aluno, ou sob a forma gráfica, permite que a sua atenção e se concentre na expressão lógica do algoritmo, e não na linguagem e no ambiente de programação.

2 Portugol IDE

A reforma introduzida pelo processo de Bolonha em Portugal reduziu a carga horária presencial de muitas unidades curriculares do Ensino Superior e veio trazer alterações importantes nas metodologias de ensino-aprendizagem, dando grande ênfase à aprendizagem activa. O Portugol IDE é um ambiente de execução de algoritmos onde os alunos têm acesso a ferramentas que lhes permitem expressar os algoritmos, realizar a verificação formal e a sua depuração em caso de erro. Por conseguinte, este ambiente permite melhorar a eficácia do método tradicional de desenvolvimento e verificação de algoritmos baseado na resolução de problemas em papel.

O Portugol IDE possui duas linguagens de suporte aos algoritmos: o portugol, uma linguagem formal baseada no português estruturado que permite a definição de algoritmos computacionais; e a linguagem fluxográfica, uma linguagem gráfica constituída por formas executáveis e por ligações entre elas que representam o fluxo de execução do algoritmo. Estas linguagens permitem realizar as operações necessárias para a codificação de algoritmos simples, são compatíveis entre si e é possível alternar entre as duas nas fases de edição, execução e depuração.

2.1 Linguagem Portugol

A definição da linguagem portugol norteou-se por três princípios: possuir as estruturas de programação necessárias para o desenvolvimento do raciocínio algorítmico; ser fácil de aprender e permitir uma transição suave para as linguagens de alto nível.

Na tabela 1 é apresentado um resumo das instruções definidas na linguagem portugol. As operações definidas são os blocos básicos do desenvolvimento de software e os algoritmos complexos formam-se pela aglutinação desses componentes.

Tabela 1: Definição da linguagem portugol (Manso & Oliveira, 2006).

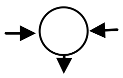
Tipo de operações		**Portugol**
Definição de tipos de dados	Variáveis e constantes	Inteiro, real, lógico, carácter e texto
Operadores	Atribuição	<-
	Aritméticos	+ , - , *, / , % , ^
	Relacionais	= , =/= , > , >= , < , <=
	Lógicos	ou , e , não , xou
Entrada e saída de dados	Leitura	Ler
	Escrita	Escrever
Decisão condicional	Alternativa	Se então , senão
	Selecção	Escolhe, caso
Repetição	Controlo inicial	Enquanto faz Para de até
	Controlo final	Repete até Faz enquanto

A linguagem portugol permite que os alunos codifiquem os seus algoritmos numa linguagem próxima da que usualmente utilizam para comunicar, que aliada a uma sintaxe simples e flexível possibilita que se concentrem na resolução dos problemas e no raciocínio abstracto do algoritmo e não no ambiente e na linguagem onde expressam esse mesmo algoritmo. Por fim, a linguagem possui algumas características presentes nas linguagens de programação mais modernas, tais como a definição de variáveis quando elas são necessárias e a definição do tipo texto como básico.

2.2 Linguagem fluxográfica

A linguagem fluxográfica foi definida para fazer a representação gráfica das instruções presentes na linguagem portugol. Esta permite desenhar, visualizar e executar o algoritmo sob a forma de grafo dirigido. De forma a tornar a execução automática fizeram-se algumas alterações aos símbolos do fluxograma que tradicionalmente são utilizados para descrever os algoritmos. Procedemos ao desdobramento do símbolo de entrada/saída em dois: um símbolo para entrada de dados que permite que o utilizador introduza dados no algoritmo e um símbolo para impressão de informação na consola. De forma a manter a coerência com os fluxogramas tradicionais, o símbolo de entrada de dados também permite a definição de variáveis: se o utilizador introduzir uma variável que esteja definida na memória do algoritmo o símbolo altera o seu valor, se a variável não estiver definida, o símbolo define a variável e determina o seu tipo através do valor introduzido. O símbolo de processo é outro dos símbolos que ficou com as suas funcionalidades estendidas: para além de avaliar expressões e atribuir os seus resultados a símbolos que estão definidos em memória, também executa a definição de símbolos caso eles não existam. A tabela 2 apresenta os símbolos fluxográficos e a respectiva descrição.

Tabela 2: Símbolos e sintaxe da linguagem fluxográfica

Símbolo	Descrição funcional
Início/fim	**Terminal** – Marca o início/fim do algoritmo. O fluxograma inicia-se com o símbolo terminal de início e termina com o símbolo terminal de fim.
Variável	**Ler** – Lê a variável da consola e se necessário define-a em memória.
Expressão	**Escrever** - Escreve a expressão na consola.
Variável <- expressão	**Processo** - Calcula o valor de uma expressão, e se necessário define a variável de suporte em memória.
F Condição V	**Decisão** - Desvia a fluxo de execução através do valor da condição. Marca o início das estruturas de decisão condicional e das estruturas de repetição com controlo inicial.
	**Conector** - Unificação de fluxo. Marca o início das estruturas de repetição com controlo final e o final das estruturas de decisão.

A linguagem fluxográfica permite a visualização dos blocos operacionais de um programa e o fluxo de execução que esses mesmos blocos geram. Os algoritmos são desenhados através de símbolos e fluxos tornando-se mais clara a execução sequencial das instruções dos programas. O desenho de algoritmos também é menos atreito a erros que as linguagens escritas uma vez que as formas são parametrizáveis e dotadas de funcionalidades inteligentes.

2.3 Evolução e caracterização do Portugol IDE

O Portugol IDE foi desenvolvido em 2004 no âmbito de um projecto de fim de curso e introduzido em 2005 nas unidades curriculares dos cursos de licenciatura e de especialização tecnológica da Escola Superior de Tecnologia de Tomar (ESTT) do Instituto Politécnico de Tomar (IPT). O projecto iniciou-se com a definição da linguagem algorítmica (versão 0.5). Na versão 1.0 foi introduzido o núcleo de cálculo e de execução da linguagem algorítmica. Na versão 1.5 foram introduzidas as variáveis do tipo vector. Na versão 2.0 foi adicionado o editor, o parser e o executor de fluxogramas. A versão actual é a 2.2, que se caracteriza pelo reforço da compatibilidade entre o portugol e a linguagem fluxográfica. O Portugol IDE rege-se pela licença GNU e por conseguinte é de utilização livre e de código aberto. Esta forma de licenciamento permite que qualquer instituição o use livremente e que outros grupos de investigação adicionem novas funcionalidades.

O Portugol IDE dá especial importância ao desenvolvimento do raciocínio algorítmico, por isso, os algoritmos podem ser executados passo a passo, mostrando as instruções que são executadas e a forma como essas mesmas instruções afectam as variáveis que estão definidas em memória.

A figura 1 apresenta o algoritmo de Euclides para o cálculo do mínimo múltiplo comum. O módulo de fluxograma permite fazer a prototipagem rápida do algoritmo em que as variáveis manipuladas são deduzidas pelos valores introduzidos pelo utilizador ou calculados pelo algoritmo. O símbolo de “leitura” deduz e define as variáveis a e b e o símbolo de “processo” define a variável resto.

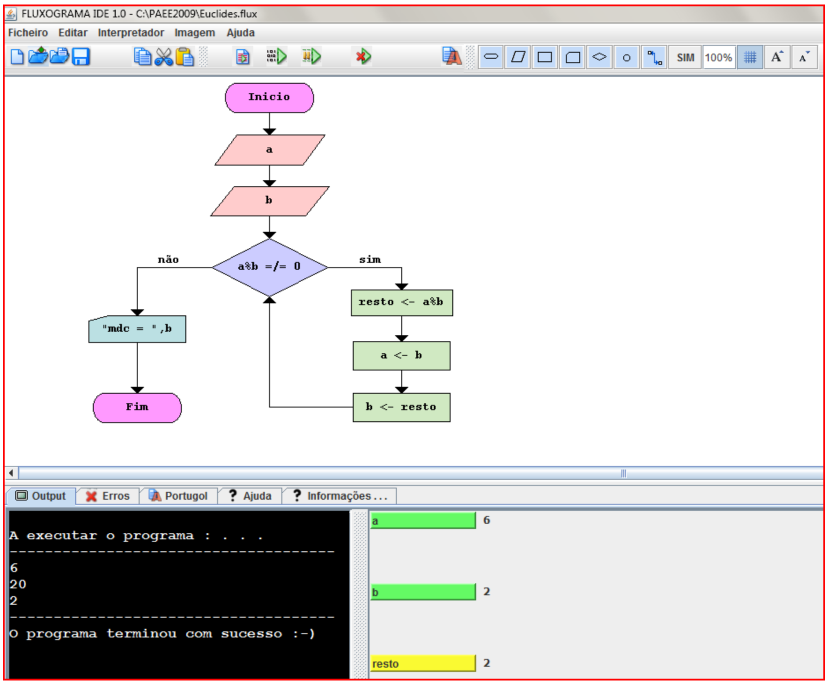


Figura 1: Algoritmo de Euclides em linguagem fluxográfica

Depois do utilizador correr pelo menos uma vez o fluxograma o sistema traduz o fluxograma para linguagem portugol com uma sintaxe correcta. Se o fluxograma não tiver sido executado, o sistema identifica as variáveis que são necessárias para a sua execução mas não consegue deduzir o tipo de dados que lhes está associado. A figura 2 apresenta o programa escrito em portugol que foi deduzido a partir do fluxograma da figura 1. A tradução da linguagem portugol para a linguagem fluxográfica não levanta qualquer ambiguidade uma vez que a cada instrução do programa escrito em portugol corresponde um símbolo na representação fluxográfica (Manso, Oliveira & Marques, 2009).

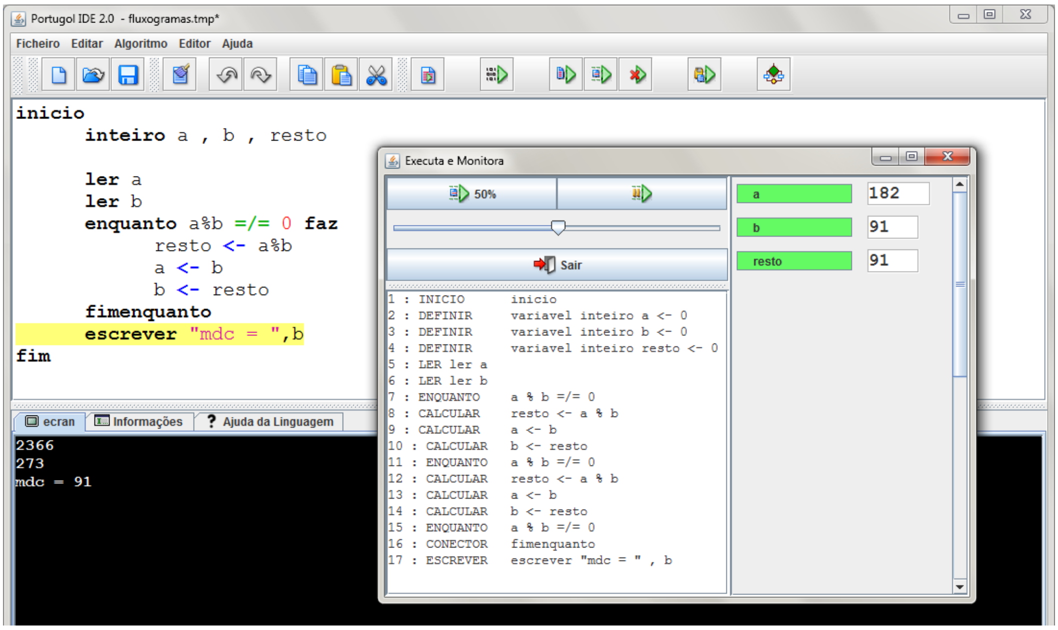


Figura 2: Algoritmo de Euclides escrito em portugol

O ambiente de edição, execução e depuração de algoritmos é mais simples que os ambientes desenvolvimento que servem de suporte às linguagens de programação mais tradicionais. O ambiente agradável e intuitivo do Portugol IDE, a simplicidade das linguagens de suporte e as ferramentas de auxílio à execução e depuração do algoritmo facilitam o desenvolvimento do raciocínio algorítmico.

3 Utilização em Contexto de Aula

A adequação dos cursos do Ensino Superior ao modelo de ensino e aprendizagem preconizado pelo Processo de Bolonha veio alterar profundamente os papéis do professor e do aluno. O aluno passou a ter um papel mais activo na aprendizagem, conduzindo o próprio processo de aprendizagem, ao invés, o professor passou a ser um orientador, um facilitador da aprendizagem. Pretende-se desta forma, transitar de um sistema de ensino baseado na ideia de transmissão de conhecimentos para um ensino baseado no desenvolvimento de competências (Decreto-Lei n.º 74/2006, de 24/03).

Nesta mudança de paradigma, assumem especial importância: a associação da carga horária lectiva das unidades curriculares ao trabalho autónomo dos alunos (e o consequente aumento do trabalho docente de acompanhamento da aprendizagem), a redução do número de horas de contacto em sala de aula, e a aprendizagem ao longo da vida (Guedes, Lourenço, Filipe, Almeida & Moreira, 2007).

Este modelo de ensino e aprendizagem pretende implementar uma abordagem construtivista, segundo a qual o conhecimento é construído pelos próprios alunos e não é algo que é transmitido pelo professor e memorizado pelos alunos (Arends, 1995).

Esta abordagem é baseada em dois pressupostos: a realidade é subjectiva e a aprendizagem resulta da construção que o sujeito faz do que o rodeia (Carvalho, 1999). Segundo a corrente construtivista, o conhecimento é temporário, passível de desenvolvimento, não objectivo, estruturado internamente e mediado social e culturalmente e a aprendizagem é como um processo auto-regulador do conflito entre o conhecimento preexistente do mundo e os novos conhecimentos com que o indivíduo se vai deparando (Fosnot, 1996). Esta abordagem implica que os conteúdos curriculares tenham que ser elaborados de acordo com necessidades dos alunos e que sejam facilmente personalizáveis para satisfazer necessidades individuais (Reigeluth, 1999).

As tecnologias de informação e comunicação assumem, por isso, um papel muito importante neste novo paradigma pois promovem uma aprendizagem centrada no aluno, exigindo-lhe uma atitude mais pró-activa no processo de ensino-aprendizagem.

É neste contexto que surge o Portugol IDE, um ambiente de execução de algoritmos onde os alunos têm acesso a ferramentas que lhes permitem expressar os algoritmos, realizar a verificação formal e a sua depuração em caso de erro. Esta ferramenta baseada na corrente construtivista permite que o aluno tenha um papel mais activo na aprendizagem, melhora a eficácia do desenvolvimento e verificação de algoritmos e promove o raciocínio algorítmico.

O ensino da programação na ESTT inicia-se no primeiro semestre com a unidade curricular de Introdução à Programação. A carga lectiva semanal é distribuída em 2 horas para a componente teórica e em 3 horas para a componente prática laboratorial, sendo também contempladas horas de acompanhamento tutorial.

O relatório Computing Curriculum 2001, elaborado pela ACM (Association for Computing Machinery) e pelo IEEE (Institute of Electrical and Electronic Engineers) identifica seis estratégias que podem orientar o ensino da programação: imperativa, objectiva, funcional, abrangente, algorítmica e maquinal (Guerreiro, 2003; IEEE Computer Society, 2008). A estratégia imperativa caracteriza-se por se concentrar nos aspectos relacionados com as instruções, procedimentos, estruturas de decisão e de controlo de fluxo. A estratégia objectiva, aborda numa primeira fase aspectos relacionados com a programação orientada a objectos. Na estratégia funcional, começa-se por abordar os aspectos relacionados com aspectos fundamentais à resolução de problemas computacionais como, por exemplo, a recursividade, a manipulação de estruturas de dados e de funções. Na estratégia abrangente, a programação é apenas um dos aspectos que são abordados na primeira disciplina de nível introdutório, a par desta são abordados assuntos relacionados com a arquitectura de computadores, bases de dados, entre outros. Os aspectos específicos da programação são abordados em disciplinas posteriores. Na estratégia algorítmica, não é usada uma linguagem de programação formal, em vez desta usa-se uma pseudo-linguagem. A linguagem de programação é introduzida numa fase posterior. Por último, surge a estratégia maquinal, na qual se começa por abordar aspectos relativos à arquitectura e ao funcionamento da máquina. Na estratégia maquinal são usadas linguagens de programação de baixo nível, as linguagens de alto nível são introduzidas depois.

Nas unidades curriculares de Introdução à Programação é usada a estratégia algorítmica. Segundo o ACM todas as estratégias são válidas mas todas apresentam problemas. No caso da estratégia algorítmica, um dos problemas identificados está relacionado com o facto de não existirem ferramentas que permitam a simulação dos algoritmos e a depuração de erros. Por conseguinte, a resolução dos problemas é realizada com recurso a papel e lápis. Este método não facilita o trabalho do aluno fora do período lectivo, porque não dispõe de ferramentas que lhe

permitam verificar se a solução de um problema está correcta, e no caso de não estar onde estão os erros. O Portugol IDE pretende dar resposta a estes problemas.

Nas aulas laboratoriais não são resolvidos problemas no quadro, em vez disso é fomentado a aprendizagem activa. São distribuídos aos alunos guiões que contêm problemas e orientações que devem ser tidas em conta na sua resolução. Estes guiões são elaborados tendo por base que parte do trabalho é realizado pelo aluno fora do horário lectivo. A resolução dos guiões é classificada e entra no cálculo da nota final.

O Portugol IDE facilita a aprendizagem activa dentro e fora da sala de aula porque permite validar os algoritmos, facilita a depuração dos erros e suporta duas linguagens: linguagem portugol e linguagem fluxográfica. Acresce ainda o facto da utilização do Portugol IDE permitir que sejam propostos aos alunos exercícios mais complexos que suscitam mais interesse e que são fundamentais para o desenvolvimento do raciocínio algorítmico.

Os alunos sentem-se mais motivados já que o Portugol IDE permite a construção de algoritmos de uma forma mais rápida e agradável, bem como, uma correcção imediata dos mesmos. O professor deixou de ser o detentor da solução e passou a ter mais tempo para os orientar.

O facto de usarmos uma ferramenta de software para expressar algoritmos facilita a sua entrega através do nosso sistema de gestão de aprendizagem, o Moodle (http://moodle.dei.estt.ipt.pt).

Para procedermos à avaliação da ferramenta Portugol IDE relativamente à sua facilidade de utilização, eficiência, facilidade de recordar e satisfação (Nielsen, 2003) realizámos um estudo com 32 alunos do 1.º ano do curso de Engenharia Informática da ESTT. Foram utilizados dois questionários: questionário de opinião e questionário de ícones. Através do questionário de opinião pretendeu-se registar a posição dos sujeitos relativamente a diversas características da ferramenta. Com o questionário de ícones pretendeu-se verificar se o sistema é fácil de recordar. Ambos os questionários foram criados e distribuídos através da ferramenta da Web 2.0, SurveyMonkey (http://www.surveymonkey.com).

Os sujeitos consideraram o aspecto da interface agradável, a estrutura dos menus adequada, o tipo de letra de fácil leitura e os ícones sugestivos. Estes consideraram útil, o módulo de execução do fluxograma, a escrita em forma de fluxograma, a visualização do estado das variáveis e a ajuda na correcção dos erros. Segundo estes, os modos de execução ajudam muito na compreensão dos algoritmos e a execução em modo passo-a-passo auxilia muito a detecção de erros. Estes referiram ainda que é fácil codificar algoritmos em linguagem estruturada e em fluxograma no Portugol IDE.

Através do questionário de ícones constatámos que os sujeitos identificaram facilmente os ícones, o que é um bom indicador de que o sistema é fácil de lembrar.

O Portugol IDE está também a ser utilizado em outras instituições de ensino superior da comunidade lusófona, como a Universidade Regional Integrada e o UDF - Centro Universitário, e em várias escolas secundárias nacionais, entre elas, a Escola Secundária da Sertã e a Escola Secundária de Foz Côa.

4 Conclusão

Os métodos de ensino com recurso a tecnologias de informação e comunicação que fomentam a apreensão progressiva e intuitiva de conteúdos e a capacidade de raciocínio abstracto, estão a ter imenso sucesso na sociedade de informação em que hoje vivemos.

O Portugol IDE foi desenhado de forma a auxiliar o ensino e a aprendizagem das técnicas basilares de programação de computadores. A definição de um conjunto mínimo de instruções para as linguagens portugol e fluxográfica facilita a aprendizagem dos comandos e dos símbolos, mas não impede que estas linguagens sejam suficientemente poderosas para a construção de algoritmos complexos. O ambiente de desenvolvimento, execução e depuração foi concebido de forma a facilitar a tarefa de programar e de correcção dos erros de lógica e de sintaxe que eventualmente os alunos possam cometer.

Os resultados dos testes realizados com vista a apurar a aptidão do Portugol IDE, ou seja, a sua utilidade e usabilidade (Grudin, 1992) mostram que os alunos estão bastantes satisfeitos com este ambiente de execução de algoritmos considerando as suas inovações de grande utilidade para uma melhor aprendizagem da programação. Estes consideram também que se trata de um ambiente de estudo eficiente, fácil de utilizar, agradável de utilizar e fácil de recordar. Também os professores que ensinam programação e que utilizam o programa se encontram satisfeitos, fazendo chegar a sua opinião através de correio electrónico.

5 Trabalho futuro

O ensino de conceitos mais avançados de programação de computadores requer a utilização de estruturas de dados complexas e a modularização dos programas. Estamos neste momento a redefinir a linguagem algorítmica para dar suporte a estruturas de dados heterogéneas e á execução de funções iterativas e recursivas. A evolução do IDE passa de desenvolvimento um módulo de avaliação lógica dos algoritmos. Este módulo aumentará a autonomia da aprendizagem autónoma do aluno e está previsto o acesso a repositórios de problemas através de tecnologia Web.

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Paper Session A3

Students' led Projects at UP and the Cars Projects

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Abstract

PUKHA (To Project, To Undertake, to Know How to Achieve) is a pedagogical framework launched at Faculdade de Engenharia da Universidade do Porto to foster the so called soft skills on its students. These projects support engineering students to become entrepreneurs and to bear other concerns than merely technical ones to face the unplanned complexities that have created disequilibrium in the world. In 2008/09 this pedagogical model has been extended to the University of Porto under a new name: LIDERA. Based on the 'Challenge, Desafio Único' and other cars projects hands-on experience, we show how such framework enables the acquisition of crucial competences of the 21st century engineer.

Keywords: leadership; entrepreneurship; pedagogy; PUKHA; LIDERA.

1 Introduction

World vulnerabilities have peaked last few months, demanding more than ever a re-examination of the role of the engineers in society. Engineering must go beyond pure technology. Clearly, technical skills alone are not enough to constitute what employers expect from engineers, but other sorts of skills would help them being prepared to cope with an ever increasingly demanding world and to overcome real problems and to respond to real needs.

The pedagogy in engineering more oriented to an active role of the students gained echo over the past decade. Team work and students leadership to develop skills became crucial to face the current challenges. New pedagogical PUKHA ('to Project, to Undertake, to Know How to Achieve') projects launched at Faculty of Engineering of Porto University in 2004 and later (2008) extended to all faculties of the University of Porto under the name LIDERA, are efforts on this direction. It meant to be an incubator to foster a shift in the engineering education paradigm.

'Challenge Desafio Único' is an example of such projects. It started in 2005-2006 and engaged a growing number of students. The goal was to create a low cost car competition. As a result of this experience, new groups were formed, currently with clear concerns related to ambient and sustainability. This is the case of four projects that aim to develop bio-combustibles and also to use retreaded tires in automobile competitions.

At the first sight we could think that a race car is something that does not respond to real needs and then, would not be stimulated or even accepted in Lidera model. In fact it was in race cars that much of the technologies used in all the cars has been developed and checked. And as the evolution of the project in order to consider bio-fuels and recycled materials is exactly the proof that ambient and sustainability concerns are also in the 'Desafio Único' and other related projects.

The reminder of the paper is as follows. In Section 2 we show how the current challenges demand a new type of engineer. PUKHA and LIDERA projects are introduced in Section 3. Section 4 presents the "Challenge Desafio Único" project. Section 5 gives a brief overview of other LIDERA projects on cars and other related issues.

The paper ends with the main findings and conclusions drawn from Challenge and other projects in light of PUKHA or LIDERA framework.

2 The Rediscovery of Present Date Real Needs and Challenges and the New Concept of Engineer

During the last century and up to now, most of the technical development and economic activity was directed to a very small percentage of the world population, the rich people of rich countries. Political leaders and the economic interests behind them have worked much more for the benefit of a very small and powerful elite then to respond

to the real needs of the large majority of the world population. Speculation and corruption have contributed to a greater economic and social injustice, at global scale, and to the development of a fake economy. To improve the profit of a small group, artificial needs where created by the propaganda and most of the resources of the planet were used to satisfy those artificial needs instead of responding to the real needs of the large majority of poor people. The focalisation on profit and the corresponding development of the consumer society, without sustainability concerns, have put at risk the living conditions of future generations. The result was the development of revolt feelings and terrorism, the beginning of climate changes and dangerous sustainability risks. Even the present financial and economic crisis is related to this. Clearly, the aforementioned concerns show that «*society needs responsible leaders and entrepreneurs*» (see Magalhães et al., 2007)

In the last decades it became clear that the society needed engineers to be not only good technicians, but also to have societal, environmental and sustainability concerns. They must have also ethical concerns and behaviour. They have not only to be able to solve problems presented to them by others, but also to identify, evaluate and formulate problems themselves, in order to solve them. And, for that purpose, they have to develop their accuracy to see the reality, to have a global perspective of the problems and to be able to address and solve them together with other people and specialists.

In response to this the President of the American Society of Mechanical Engineers (ASME), Sam Y. Zamrik, in the foreword of the report of the 2008 Global Summit on the Future of Mechanical Engineering, stressed that «*Mechanical engineers must provide solutions to the drivers of change (…)*». Furthermore, the same author states that they should: «*Develop sustainably through new technologies and techniques, and respond to the global environmental pressures brought about by economic growth; (…) Be at the forefront of implementing a system design approach across large and small-scale systems; Engage in international collaboration around our critical knowledge and competencies; Work in the emerging Bio-Nano technologies to provide solutions in such diverse fields as healthcare, energy, water management, the environment and agriculture management, and create engineering solutions for the other 90 percent that live on less than two dollars a day.*»

The «*2028 Vision for Mechanical Engineering*» addressed by this report expresses a new step on the concept of the future (mechanical) engineers. We completely agree with this evolution, with two slight differences: we look upon this as concept for today and not as a vision for 2028, and we consider that engineers must not only provide solutions for the drivers of change but also to take a direct part in driving the change (with others, obviously).

To be realist and give a contribution for the solution of real problems and to respond to real needs, it is important also the understand market functioning. To be able to sense and size opportunities is very important for an entrepreneur. And sometimes it is even necessary to create the opportunities.

Within this context, Engineering academic programs have to be redesigned to tackle the new trends and needs of the 21st century. Some steps have already been done in the best schools. The focus of engineering education has already turned from instruction to learning (Wang 2004). It has been assumed that while knowledge is important, it is of even greater importance that students understand and can apply and evaluate knowledge and thus develop capacity (Chisholm 2003).

The most important condition for learning is the interest of the learner. To stimulate deep learning the students need to be active and involved in the learning process (they must be knowledge constructors). Nowadays, the ability to work on flexible and always changing teams became a critical job requirement, as well as the capability to recognise and establish the interconnection among a broad range of activities. These skills can make students to become leaders through their ability of influencing and inspiring the work of others. This is also important to develop responsibility through freedom of work and learning, and concretisation skills through the achievement of multidisciplinary team work projects with social utility under personal responsibility and leadership. Only then we can help responsible and entrepreneur leaders to be formed and change the economy and the world to the extent it so much needs.

3 PUKHA and LIDERA Projects at University of Porto

This is why, in 2004, students' led PUKHA ('to Project, to Undertake, to Know How to Achieve') projects have been launched at the Faculty of Engineering of the University of Porto (FEUP) (Magalhães et al., 2007).

The Faculty of Engineering Board not only approved the new pedagogical model but also allocated € 25,000 for the 10 projects intended to be launched in 2004-2005.

Initially the Coordinator of PESC projects (A. Barbedo de Magalhães, one of the authors of this paper) suggested each team to have around 8 students, two at each year of their courses, from the 2nd to the 5th years, and from at least two different courses. In fact the teams created followed very closely this suggestion.

The following year the intention was to keep the number of projects (10), but in fact, due to the enthusiasm of students there were almost twice this figure.

In 2006-2007 there were 250 students engaged in 26 PUKHA projects at the Faculty of Engineering. The financial support provided to those projects by the Board of Directors of FEUP increased to around € 50,000 that year and the same amount was provided in 2007-08 and in 2008-09. The students, themselves, got support from companies and other institution with a value quite higher then this, every year. This last value is not easy to calculate precisely because most of the external contributions are materials, equipments, parts, courses, trips to visit factories abroad and the alike.

In 2007-2008 the total number of PUKHA projects reduced, because several of them joined in larger projects. Those larger projects, or even clusters then created had more (some times much more) then 8 students and not one single leader but a team of leaders each.

The success of students' led PUKHA projects at the Faculty of Engineering made the University responsible to think on the possibility to extend the model to the whole University of Porto,.

The project to extend this model to the University as a whole was part of a greater project, called 'To live the Innovation' («Viver a Inovação») that received the Prize of a private organisation for innovation (COTEC) as the best entrepreneurship training project for Portuguese students. This prize was received by the University of Porto, in October 2007. So in 2008, the same model was extended to the UP (with its 14 faculties) under the name of LIDERA Projects. The Coordinator of those Lidera projects is A. Barbedo de Magalhães, who was the one who first proposed the students' led projects model and who did coordinate the PUKHA Projects at the Faculty of Engineering since the beginning.

These projects are aimed at helping students in developing their capabilities and skills, namely the following ones:

- identify, evaluate and formulate problems after observation and critical analysis of the reality;
- successfully implement theory into practice;
- communicate, to understand and to be understood;
- work in groups, namely in multidisciplinary and multicultural groups;
- manage with freedom, responsibility and efficacy, human, financial, natural and other resources;
- and also entrepreneurial skills.

The main characteristics of those projects are the following ones:

a)- Each project has one leader (or eventually more) who is, necessarily, a student of the University of Porto). It is the leader who determines the composition of his team, under the condition that she/he respects the Lidera bases for teams' constitution; The leader is also the responsible for getting most of the funds necessary to reach the goals of his project.

b)- Each team has students from different years of their graduation courses and eventually secondary school students so that they learn with each others;

c)- Each team must be multidisciplinary. This means that each team must have students from at least two courses and two different schools; this is the way we have found to promote their skills to work in multidisciplinary teams;

d)- The projects are aimed to lead to the concretisation of something, real or virtual, useful and with commercial value;

e)- Each team must have one main UP supervisor and at least one more supervisor, from the university, industry or any other institution.

f)- The projects can take more than one academic year, even if they must be approved every year.

Lidera Projects were launched in 2008-2009 at the UP and in January 2009 there were 52 projects underway.

We consider that it is the leader's faculty that determines the faculty to which the project is allocated.

Under such conditions, we may say that those 52 Lidera projects had leaders from 9 of the 14 faculties of the University of Porto, as we can see below.

- Faculty of Architecture [Faculdade de Arquitectura]: *13 Projects*
- Faculty of Fine Arts [Faculdade de Belas Artes]: *2 Projects*
- Faculty of Sciences [Faculdade de Ciências]: *3 Projects*
- Faculty of Nutrition and Food Science [Faculdade de Ciências da Nutrição e Alimentação]: *2 Projects*
- Faculty of Sport [Faculdade de Desporto]: *5 Projects*
- Faculty of Law [Faculdade de Direito]: *No Projects*
- Faculty of Economics [Faculdade de Economia] : *No Projects*
- Faculty of Engineering [Faculdade de Engenharia]: *18 Projects*
- Faculty of Pharmacy [Faculdade de Farmácia]: *No projects*
- Faculty of Arts and Social Sciences [Faculdade de Letras]: *2 Projects*
- Faculty of Psychology and Education Science [Faculdade de Psicologia e Ciências da Educação]: *5 Projects*
- Institut of Biomedical Sciences Abel Salazar [Instituto Ciências Biomédicas Abel Salazar]: *No Projects*
- Faculty of Medicine [Faculdade de Medicina]: *No Projects*
- Faculty of Dental Medicine [Faculdade de Medicina Dentária] : *2 Projects*

In October 2008 13 Lidera projects proposals were related to aged people concerning their problems and needs. Three of the initial proposals did not get the interest of a number of students enough, in Lidera conditions, to start. So, in January 2009 there were 10 projects related to aged people, a very important problem in Portugal.

Those last projects counted with the participation of students and co-sponsors not only from the UP but also from two other non UP schools, Nursing and Social Service, and from other institutions.

The ten projects related to aged people conditions and improvement became a cluster, with a large team of supervisors from UP, from other high education institutions and also from private institutions of social solidarity. This cluster had already several meetings to share experiences and knowledge. Up to now, the leaders of each specific project of the cluster are well identified.

In the case of the cars projects, there is also some kind of cluster or, as we can also consider, a larger project with a team of leaders and a number of participating students much bigger than the eight initially suggested for each team.

The number of students engaged in the 52 Lidera projects is around 500. Some students complain that their work in students led projects is not taken into consideration for their classification. Even so (or eventually exactly for that…), the enthusiasm of most of the students is high. Sometimes, very high indeed.

To provide orientation to about 50 Lidera projects, there is around one hundred UP teachers and some 20 non-UP supervisors. Some of them spent many hours with their Lidera team students although this work is not considered (yet) for their official work hours accounting.

UP Lidera Projects get a small funding from the rectory of UP. The Faculty of Engineering keeps funding Lidera-FEUP projects.

4 'Challenge, Desafio Único' and Related Car Projects

«Challenge Desafio Único» started three years ago with several students from UP. They all felt a great passion for the automotive world and competition triggered by this PUKHA project. The main aim of this project was to create a low budget automobile competition. A team of students was formed and soon (due to their motivation) the work began on searching an interesting basis for the car. All the definitions on the car and the necessary modifications to able the car to race using FIA specifications, were carried out by this team. Such efforts succeeded and proved that it was possible to race cars with an extremely low budget basis.

Due to concerns with sustainability, the students selected an old model car, FIAT UNO 45s, which is reaching its end of life.

a) Braga Circuit 2007 b) Braga Circuit 2009

Figure 1: Challenge Desafio Único – FEUP 1.

Figure 2: Challenge Desafio Único – FEUP 2 – Braga Circuit 2009.

After one year developing a race car all the necessary ingredients were gathered to have a long list of potential race cars and drivers who saw in this project the opportunity to get into automobile races. So students realized that it could be possible to launch a model of car races with this low budget basis. Soon later the regulations for a specific new low cost championship were defined and students started leading national races involving drivers, companies and federations, among many others.

During 2008 a new category as been developed using a higher performance car FIAT Punto 85 16v nevertheless based on the same philosophy – low budget races. Nowadays this competition entails two categories FEUP 1 (Figure 1) and FEUP 2 (Figure 2) involving more than 70 race cars and over 140 race drivers. In 2009 a new challenge has been imposed to the competition – to race with ecological tires (retreaded tires).

All of this demanded students to put in place a very effective organisation and develop a market and funding policy, also.

The students have established dialogue and cooperation with so many and different people:- students of different courses and schools, race drivers and their teams, sponsors, journalists and so on. In total this amounts to more then one thousand people. Dialogue and cooperation skills had to be developed. And a very consistent and resilient leadership was also indispensable.

Furthermore, for this new category the students studied the dynamic behaviour of the car towards a higher safety level design. A theoretical study on a new roll bar (Figure 3) using Finite Element Simulation software was carried out by them.

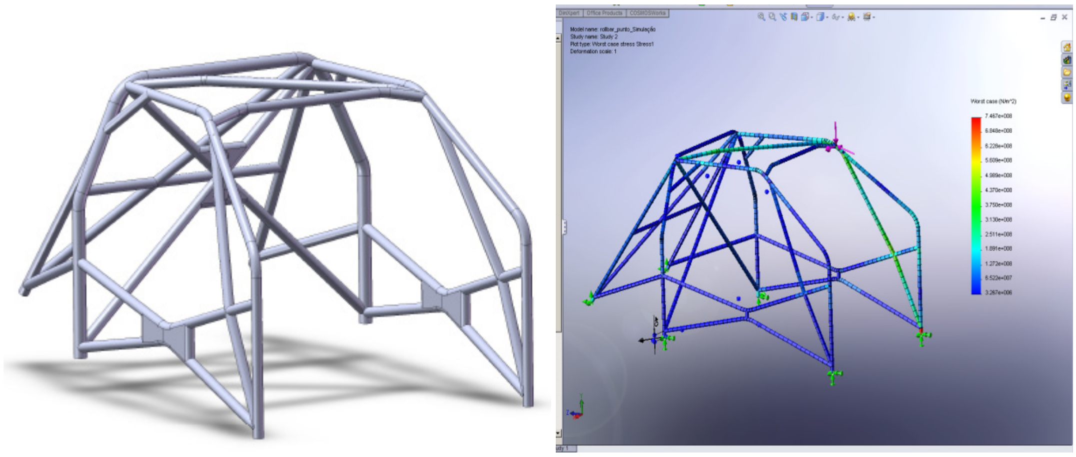

Figure 3: Roll bar designed for the category FEUP2 and Finite Element Modelling result.

A strategic consortium has been established with the enterprise Recauchutagem Nortenha S.A to develop the retreaded tires for the competition. The students have participated in the definition of the rubber mixture for the tires based on track tests. All the procedures during fabrication and selection of these tires have been followed by students.

Nowadays, the team is composed by 25 people from different Faculties and Universities. This project has now a national dimension/recognition; more than two hundred articles have been published in newspapers and online pages. The organization budget is around 165,000 Euros. The four race cars of FEUP competition team, account for a total budget of 20,000 Euros. Most of this money comes mostly from registration fees and a small part from sponsors. FEUP gives also a small contribution, the necessary to start and render the initiative possible.

«Challenge Desafio Único» could have, as Lidera project, but does not have, profit objectives. In fact it is a very effective and successful pedagogical project.

Some news:

"FEUP decided to promote a low cost car competition and the result was a huge success, proved by the 40 teams that have entered the race."
Jornal MOTOR 1-05-2007

"It is a breath of fresh air that the Faculty of Engineering brings to the Races and to the Fiat Punto national trophy, achieving another great success with that seal. Moreover, if it wasn't FEUP and the dedication of engineer Jose Ferreira Duarte and some of his students and ex-students, almost no track races would have been organized in our country in 2009."
Jornal MOTOR 28-04-2009

Some testimonials:

Challenge Desafio Unico
"Since early in life I was a passionate by the car world and this was an opportunity to realize the dream that moves me since childhood: working with cars. From the first day I knew that it would not be easy to overcome the challenge of running with Fiat Unos, but with hard work, commitment and great help, we launched successfully the Desafio Unico. Personally I must say that the "Challenge" was and remains a truly unique experience. It is not only an opportunity to bring out an experience of real work, but also way of performing a complete project at all levels, from the design of a car competition, the definition of regulations, the organisation of races, through the relationship with competitors among many other skills that we have developed in the last year. I have the feeling I have learned more this year than in the past ten... ."
Sergio Moreira (student leader from 2005 to 2008)– Jornal Motor 13-11-2007

A great experience

For me, the "Challenge, Desafio Unico" was a great experience both on personal and professional levels.
As a member of this team, the satisfaction is immense when you see something that we have developed becoming a great success in Portuguese motor sport. To ensure that everything would run satisfactorily, there was a hard work that required extra efforts to our current duties at FEUP as students. In the beginning, we had never really the notion of the impact and feedback we would get, but now we feel the great responsibility of continuing the work and efforts to keep up the "Challenge" attractive for the Portuguese Motor Sport.
Agata Sousa (student leader from 2005 to 2008)– Jornal Motor 13-11-2007

The total satisfaction

"In addition to the competition itself, above all I liked what I saw and experienced. It was a different experience with very young people, with spirit and with a different approach to racing than usual. I was perfectly aligned with a team of students that values the human relations, treating one another as equal, never forgetting the professionalism required for competition cars. Driving a Uno car in the "Challenge" in Vila Real gave me a total satisfaction."

Ligia Albuquerque (race driver) – Jornal Motor 13-11-2007

The freedom students enjoy in PUKHA/LIDERA projects allowed them to start working in race cars. The same freedom is giving origin to new projects in which environment and sustainability concerns are more present. There are already new LIDERA projects studying the use of animal fat to produce bio-diesel and to develop a city and other electrical cars. An electrical cars' race is in the mind of some students that have participated in the «*Challenge, Desafio Único*» and in other younger students too.

5 Other LIDERA Projects on Cars and Related Subjects

μCAR – Electronic microCar (Figure 4): the main aim of this project is to develop the dynamic control of an electric car already produced in the Faculty of Engineering of Porto University.

Race with Biofuel:- the main aim of this project is to study the behaviour of a diesel car when using a biofuel. In Figure 5 the power and torque curves are plotted for different fuels. The power tests have shown a reduction in power and torque when using this fuel. The goal now is to increase the power of the car in order to obtain the same power achieved when using the diesel fossil fuel.

Figure 4: μCAR – Electronic microCar

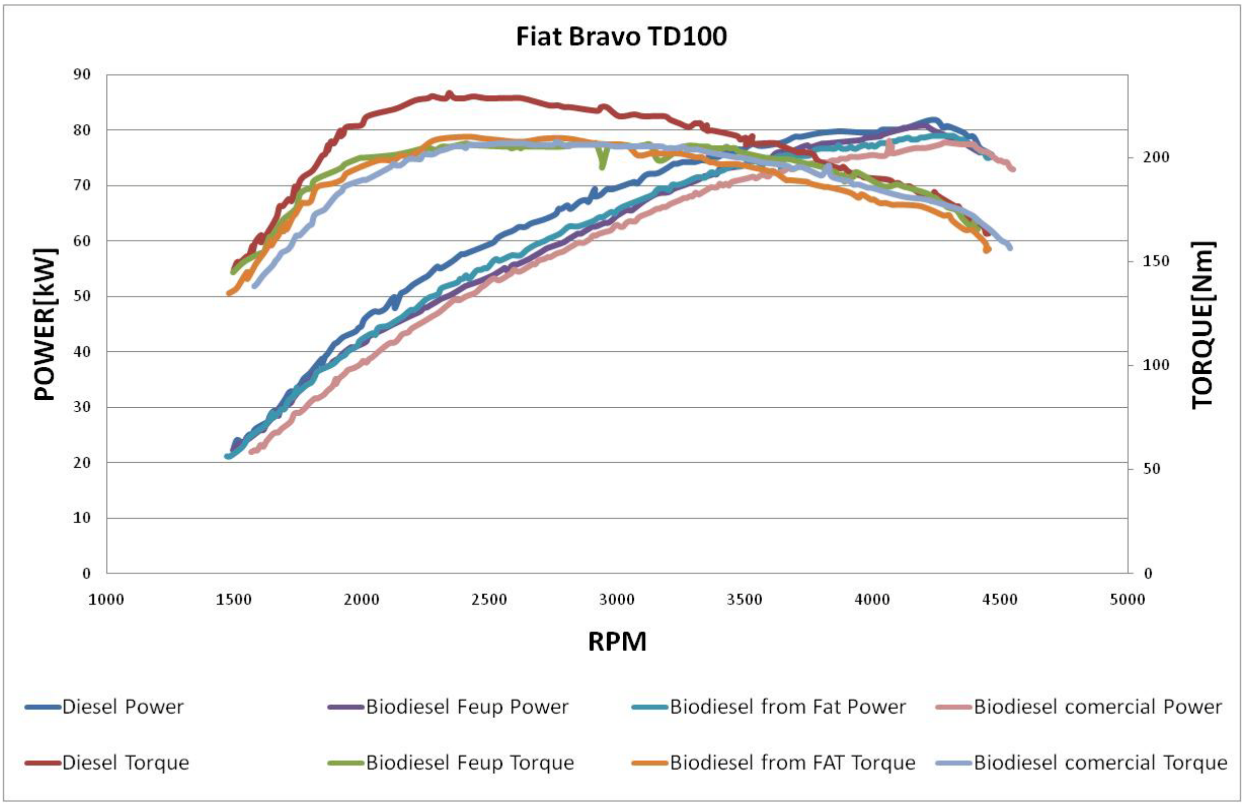

Figure 5: Power and torque curves for different fuels.

6 Conclusion

The testimonies of the students engaged in Lidera projects, namely those who have led or participated in 'Challenge Desafio Único' above reproduced show how a so simple and low cost pedagogical model can get the enthusiasm of students and make them learn and develop important team work responsibility, leadership and entrepreneurship skills.

Its national success shows how students, when committed, can work with high professionalism and achieve the desired results and even overcome their initial expectations.

In 'Challenge Desafio Único' project quite numerous teams of students at different levels and from several courses have cooperated with astonishing efficiency and accomplishment.

Students leaders have changed, meanwhile, but the spirit of the team was kept the same. The main teacher adviser (or supervisor) of the team, Professor José Ferreira Duarte (one of the authors of this paper) played a very important role in all of this. The good relations between him and the students were crucial for the success of this cooperative work.

Freedom students enjoy in PESC/LIDERA projects is a condition for them to assume responsibilities, to run risks and to develop their leadership and entrepreneurship skills.

The pleasure most of the supervisors enjoy advising and cooperating with the students, in this pedagogical context, free from the normal constrains related to the obligation of «teaching» the pre-established programs and the traditional evaluation methods, was very clearly expressed in their comments to students reports that every semester the students do.

The time those professors spent with students is, often, very long in hours. This time is not (yet) considered in time lecturing work of them and they don't receive any other pay then the pleasure of contributing for the development of their students' skills and knowledge.

The formal inclusion of students led projects in the courses of UP, with the corresponding attribution of ECTS, has been a subject of debate. Up to now there has not been consensus. And probably there will not be as long as the development of students' skills is not assumed as being as important as the improvement of their knowledge.

The problems the world faces now demand new attitudes and a new culture. Knowledge, in depth, is crucial, human skills too. We hope that soon this will become more and more clear and that the university will become, more and more, the place and the ambient where both can be exercised and developed together.

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Nanotechnology and the Effects on Engineering Education

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Abstract

When in 1958 Nobel Laureate Richard P. Feynman gave his famous speech " There's Plenty of Room at the Bottom", to the American Physical Society at CalTech, his brilliant look into the future predicted one of the most revolutionary changes we are experiencing. Nanotechnology is what he was talking about and it will spawn changes in materials and products that most of us can not even imagine. Certain aspects of Engineering and Science will change dramatically and Material Science and the Medical fields will see new materials and applications never experienced before. Many of the new applications will be very beneficial and helpful to mankind but there could also be some hidden dangers of misuse and dangerous or evil end use of this new science. :Engineering Educators should prepare themselves to understand the changes that will be forthcoming and will affect the way we look at and comprehend this new field.

Principles of Nanotechnology should be taught and discussed from the first semester of Engineering Education and should involve the theory and the lab aspects. TDM or top down manufacturing and BUM or bottom up manufacturing are techniques that should be looked at and if possible should have at least a laboratory demonstration. TDM is really the process of creating Integrated Circuits and involves all of the thin film processes. Intel has developed a MOSFET of 35 nanometers, with oxide thickness of 1.5 nanometers which means that now we are playing with devices at atomic levels. This is where the TDM process can demonstrate the principles of Nanotechniques. The BUM process however demonstrates that a building of new combinations of atoms can create materials never seen before. The Scanning Tunneling Microscope (STM) and the Atomic Force Microscope (AFM) make it possible to characterize and design at nanoscale. There are many products now that have nano written all over them and there will be many more in the near future.

Keywords: nanotechnology; TDM; BUM; STM.

1 Introduction

In order to discuss Nanotechnology, it is imperative to have a historical understanding of how we got to our present involvement with this technology. The definition of nano is the following: One nanometer is 10^{-9}meter. It has always been a desire in Engineering to make things smaller, lighter, and more efficient. A good example is the number of transistors that will fit on a chip. We have gone from a few transistors to millions and we are still trying to best that figure. In 1905, who else but Albert Einstein, was making measurements at nanoscale to determine the size of sugar molecules. The invention of the electron microscope in 1931 made it possible to look at nano particles but it was Richard P. Feynman (1918-1988) in 1958, whose vision opened the door to present day nano scale experimentation and research. A flurry of activity in the 1980's and 1990's and early 2000's in the area of physics, chemistry, materials science and engineering produced devices and materials that would advance nanotechnology to a level recognized by the Federal Government in 2001 with the National Nanotechnology Initiative (NNI). In 2008 the NNI budget was 1.5 billion.

Some of the inventions and experiments that propelled Nanotechnology into the forefront were the following: The Scanning Tunneling Microscope (STM) in 1981, The Atomic Force Microscope (AFM) in 1985, The discovery of C 60, known as buckyballs, in 1985, Discovery of Carbon Nanotubes in 1991, Foundation for nanobiotech laid in 1992 with ATP synthase, Quantum dots in 1993, Nanotransistor in 1997, DNA motor in 2000, Prototype fuel cell from nanotubes in 2001, Stain repellent pants in 2002.

Just about every day a news article shows a nanoscale invention or use and it is predicted that within a few years the total worldwide market for nanoengineered products will be close to 1 trillion dollars.

2 Nanoscience and Engineering Curriculums

Just about every major university has a special program in Nanotechnology or Nanoscience at this time. What about the normal Engineering curriculum? Is there room for this topic that will change the way we deal with applications in just about every area of Engineering? It is absolutely necessary that from the Freshman year on, students have an idea and basic knowledge what this topic is about. Use the seminar time to generate interest, use the basic Freshman course in Engineering applications to possibly have a project in the nanotechnology area, collaborate with the Physics, Chemistry, or Biology department to set up a laboratory session. NSF is funding numerous programs in Nanotechnology to reach not only Engineering students but students in High Schools, Community Colleges and teachers and faculty in those areas. It is important that Engineering faculty avail themselves of these opportunities so they can be knowledgeable in the basics of Nanoscience.

2.1 Information from ASEE “First Bell”

In order to keep up on what is happening in the area of Nanotechnology research, applications and products, the ASEE website of First Bell offers daily updates from major publications from the US and from around the world. A sampling of recent articles is given below

UC Riverside, Community College Partner To Bring Nanotechnology To Market.

The San Bernardino CQuntyJCA) Sun (3/31, Hughes) reports on "the synergy developing between the scientific advances at UC Riverside and the hands-on technology coming online at the San Bernardino Community College District," the combination of which "promises big benefits" for both automotive fuel cells and the local area. At UC Riverside, Yushan Van, a professor and chairman of the Chemical and Environmental Engineering Department, is said to be "making substantial progress on a practical automotive fuel cell with nano design." Van is using platinum-coated nanotubes as a catalyst. Meanwhile, nanotechnicians will be needed to "assemble the fuel cell with nano design," and to that end "UCR and the [San Bernardino] Community College District have partnered to develop a 90-hour curriculum of training" that "will include nano characterization, micro/nanofabrication, materials characterization, device characterization, electronic devices and optoelectronic devices."

Researchers Developing Piezoelectric Nanowire Technology.

The Washingtonjirnes (3/27, Harper) reports that engineers from the Georgia Institute of Technology recently discussed potential applications of nanotechnology in terms of power generation. The researchers are developing technology incorporating piezoelectric nanowires, which generate "energy from the environment' by converting low-frequency vibrations...into electricity." The Times notes that "the researchers are particularly keen on embedding nanowires into shoes or clothing to harness the rhythmic resources of daily activities," but "also hope to develop biomedical sensors to monitor blood sugar, blood pressure, heart rate or other body signs for those facing health challenges." Lead researcher Zhong Lin Wang predicted it would be another five years before such devices reach the market. The Financial Times (3/27, Cane) adds, "The zinc oxide wires could be 'grown' on a variety of surfaces including metals, ceramics, polymers, clothing and even tent material, where the wind could create enough movement for power generation."

Device Combines Nanogenerator, Solar Cell.

Technology Review (4/9, Bourzac) reports that "researchers have combined a nanogenerator with a solar cell to create an integrated mechanical- and solar-energy-harvesting device." The device "combines two previously developed technologies in a layered silicon substrate, both of which rely on zinc oxide nanowires. The top layer consists of a thin-film solar cell embedded with dye-coated zinc oxide nanowires," while "the bottom layer contains [the] nanogenerator," which uses "a jagged array of polymer-coated zinc oxide nanowires in a toothlike arrangement" that "scrape against an underlying array of vertically aligned zinc oxide nanowires, creating an electrical potential." Technology Review notes, "The prototype device can generate 0.6 volts of solar power and 10 millivolts of piezoelectric power."

Nanoparticle Coating Turns Glass Into Motion Detector.

Popular.Science (3/23, Barnard) reported on "a novel new motion sensor developed by the Fraunhofer Institutes for Applied Polymer Research IAP" in Germany, in which door and window glass "is coated with a fluorescent material containing nanoparticles that convert light into fluorescent radiation. When the invisible light of a UV lamp 'illuminates' the glass panes, the fluorescent radiation generated is channeled to the edges of the window, where it is detected by sensors." And, "when sensors are installed on all four sides of the window or door frame, statistical

conclusions can be drawn from the data as to how large, how fast and in what direction the [object] is moving." Further, the software can "interpret different light signals," which "enables the system to easily distinguish between the frequency of the UV lamp and the slowly changing light from a passing car's headlamp."

Nanotube Ribbons Conductive, Transparent, And Flexible.

Technology Review (3/19, Patel-Predd) reported that researchers have developed carbon-nanotube ribbons that "can stretch to more than three times their normal width but are stiffer and stronger than steel or Mylar lengthways. They can expand and contract thousands of times and withstand temperatures ranging from -190 to over 1,600 °C. Additionally, the ribbons "are almost as light as air, and are transparent, conductive, and flexible." According to the researchers, "the new actuators...expand by up to 200 percent but generate small forces per unit area, making them less than ideal for many applications, including robotics, However, their novel properties, especially their temperature range, could open up exciting new applications" in areas such as aircraft wings.

2.2 Top Down Manufacturing (TDM)

To show how manufacturing of devices that have nanoscale dimensions can be done, the TDM method can be used very successfully. This is basically a method that employs the techniques used in the manufacturing of integrated circuits and can simulate photolithography and deposition and etching and sputtering. The equipment necessary is fairly standard and includes a vacuum pump, vacuum chamber and some special devices which also are readily available In some cases equipment can be borrowed from institutions that have obtained it through NSF funding. This type of lab lends itself well to a one time show and tell for Freshmen Engineering students.

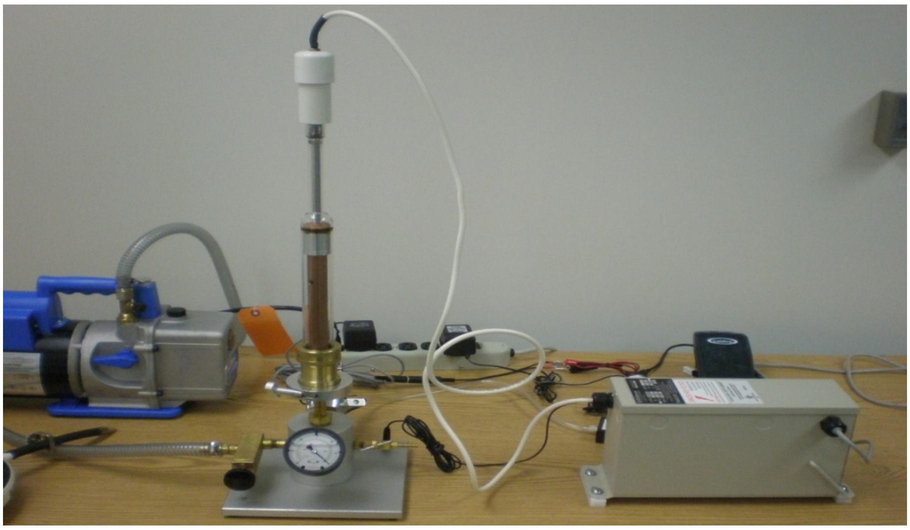

Figure 1: A typical setup for a sputtering experiment

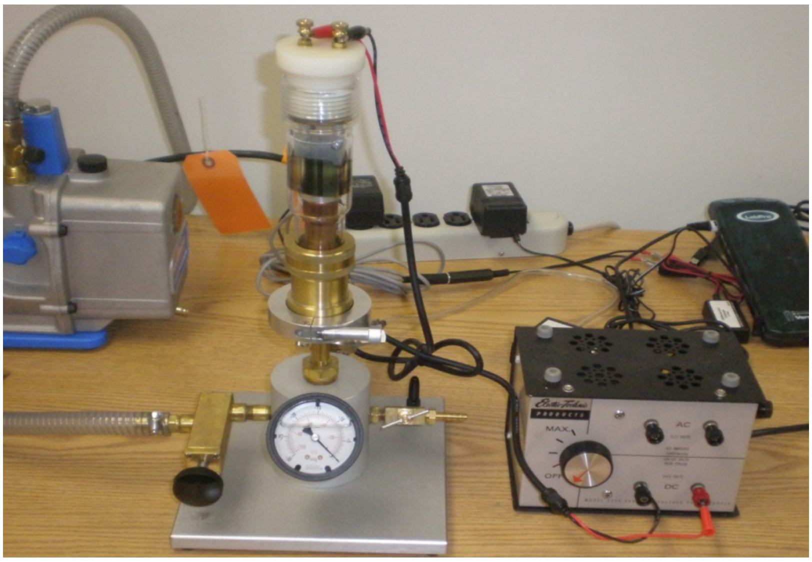

Figure 2: A typical setup for a deposition experiment

2.3 Bottom Up Manufacturing (BUM)

Research in nanotechnology is essentially this process. Life on earth was based on the spontaneous assembly of raw materials into well organized structures. Now we can duplicate these processes by this process. However this is not the area that Engineering curriculums are concerned about unless they have a full fledged nanoscience curriculum. It is an area that should be understood and can be demonstrated with equipment known as the Atomic Force Microscope (ATM). This is an instrument developed after the invention of the Scanning Tunneling Microscope (STM) and is able to trace the surface of a specimen. The AFM has a microscale cantilever that is used to scan a sample and can detect the nanometer differences in a surface. Although not cheap it can be affordable to many Engineering schools, especially if it is also used in the Physics and Chemistry departments.

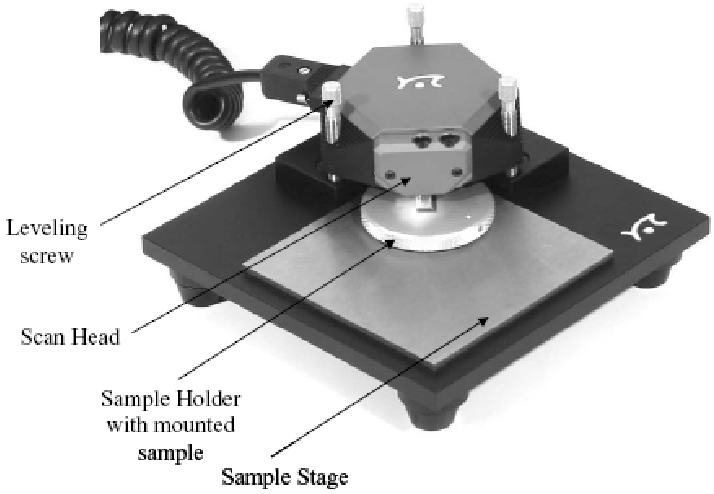

Figure 3 Scanning Head of an AFM with none of the Electronics shown

3 Conclusions

The successful introduction of Nanotechnology principles into the Engineering curriculum is dependent on many factors. Foremost is the willingness and ability of the faculty to introduce these concepts. Administrators should also be aware that this is a field of study and concepts in need of large monetary support. We are at the threshold of a complete revolution in how to design, how to research, yes, in how to teach. When we can build completely new devices and structures from the assembly of atoms and molecules, when devices and materials can be designed for specific purposes, we have reached a level of sophistication that can be extremely beneficial, but can also be dangerous.. The meaning of self assembly is that atoms can arrange themselves in a fashion that will lead to devices that can be useful and possibly lifesaving. There is however a number of people that worry about the influence of nano materials in the food chain, the biosphere and the area of robotics. Is it possible that nanotechnology could make humans an endangered species? Bill Joy, cofounder and chief scientist at Sun Microsystems certainly thinks so and has great reservations about runaway self assembly. Should we disregard voices like his? No, we should not. We should make sure that when we enter this new world that we will caution our students about possible abuses, that can lead to unwanted consequences.

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A Teaching-Learning Environment for the Development Process of Building Projects

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Abstract

This work presents the construction and analysis of a teaching-learning environment in the development process of building projects. An exploratory case study was conducted through a simulation of a professional environment, in which two competing teams developed a project. The students that integrated the teams were attending a class in the Civil Engineering course from the University of Brasilia, Brazil. Real and spontaneous interaction between the student and the simulated process was prioritized. Theoretical references for the development of the simulation were the modern approaches of building design and discussions on learning with the use of simulation. The simulation itself was presented as a result of the case study analysis and a product to be re-used for teaching and learning purposes.

Keywords: building project process; learning by simulation; teaching-learning environment; low-fidelity simulation for education.

1 Proposal

Most engineering project courses in Brazil still exhibit traditional methods of teaching such as expositive classes, in which the teacher takes over the responsibility over the teaching-learning process and the student behaves like a passive listener. This teaching model has been perpetuated in engineering schools in the country since their creation and was implemented under the conditions existing at that time for teacher training and with the few resources, which are summarized in two manners, the blackboard and the oral presentation of contents by teachers. Over the years new technologies have emerged and new teaching techniques too, but putting them into practice requires an adequate educational, administrative and technical organization.

The demands of these changes occur according to the exponential increase of human knowledge and due to the continuous emergence of new and sophisticated technologies that require the preparation of professionals to work in their field of activity in a flexible way and presenting capacity for innovation and interaction. The development of products in the different areas of engineering and in civil construction, in particular, must be included in a projecting process, in which the assemblage of information directs the actions of designers. Designers are demanded to develop and exclude solutions in a collaborative manner in order to deal with the multiple problems in the project.

The current demand for highly customized products turns the process of projecting an essential link to the production chain. Besides being a tool for decision making, concerning the product characteristics, the project directly affects the economic results of enterprises and interferes with the efficiency of their processes. Decisions taken in the early stages of the venture have great importance in costs reduction and building failures, and represent significant information to the entrepreneur as well as to the user with respect to legal requirements and standards.

The final product is the result of the interrelationship among the various subjects needed for its development. Thus, the preparation of the participant engineer in the project process must occur during the period of the undergraduate course, in order to raise positive attitudes related to the development of collaborative work in future professionals. To include this guidance in the curriculum of the Civil Engineering course at the University of Brasilia, analysis of a simulation of a building project process was performed focusing the importance of project coordination and the needs of compatibility at all stages that constitute a building project.

Viewing the identification of elements to include this orientation in the Civil Engineering course curriculum from the University of Brasilia, a study was developed from the analysis of the process simulation of building projects. It allowed the experiencing of different situations by students. Two distinct situations were provided: a) the

development of the project under the coordination of a student previously designated for this purpose and b) the development of the project without a student having previously being designated. Thus, in addition to the goal of developing a didactic procedure for teaching the project process, the objective of comparing the effects of the existence or absence of a previously defined coordinator for the development of this process was added.

Theoretical and practical aspects have been integrated to achieve this objective involving since the concept and terminology to be used, to the place where the simulations would be developed. Besides procedures for the development of the simulation, procedures and instruments were established to enable the analysis of the two cases studied.

These questions were answered during the development of the study as the team appropriated themselves of theoretical and methodological tools which are explained in the following items: the theoretical structure established, the research methodology used, and the results and analysis performed.

2 Theoretical Framework

2.1 Simulation in the context of the project process of buildings

Two theoretical approaches were considered for the study: the product development process (PDP) in house building and the teaching and learning in the engineering process. This section will present the relevant points found in literature for the theoretical framework of the study.

As for PDP in house building, the Brazilian literature is sufficiently systematic and the principal authors are: Melhado (1994); Picoral & Solano (1998); Souza e Silva et al. (1996); Tzortzopoulos (1999); Rodriguez & Heineck (2001). The definition of PDP appointed by Fabrício, Melhado, & Grilo (2002, p. 75) is appropriate for this study:

> "PDP involves all decisions and formulations that subsidize the production and creation of an enterprise, beginning at the real estate planning, moving on to the organization of a program of necessities and to the product project, then into the production development, followed by the building design and the evaluation of users' satisfaction with the product".

The author takes into account both the PDP objective as well as attributions performed. The product's life cycle is also considered. In this context, the PDP is represented as shown in Figure 1.

For the simulation, a specific reference model was adopted, following the trend for the integrated development of products. This model enables the mapping of the inputs that are part of the scenario of PDP and understanding their relationships and contexts. In addition, it allows a comprehensive overview of the PDP. This overview was very important for the simulation that was prepared.

In Figure 1, the three macro phases that are normally considered by experts in PDP were considered: pre-design, design and post- design. In literature, experts discuss the importance of considering these macro phases to emphasize the difference between the action and its resulting product.

In this perspective, the word project design has two meanings: the result and the projecting of the process. The difference between these meanings is highly emphasized in the course were the simulation would be performed, in order to make students aware of the process of organization more than to the resulting product, since that is already emphasized in other Civil Engineering subjects. It is considered that this approach helps the students to deepen the understanding of systemic thinking applied to engineering problems.

Furthermore, with this emphasis, one seeks to overlap the prevalence of terms commonly used by subjects from architecture, based on the products from each step of the PCP, which are the outline project; the scheme design, design for legal requirements and detail design (Romano et al., 2006). Fontenelle (2002, p. 101) presents the justification for the authors concern with the terminology that will be used in the simulation: "this can lead to confusion in understanding the various intervenients of the new multidisciplinary focus and shared project management". The simulation developers considered it important to adopt a nomenclature for PDP, whose focus is "the characterization of the global project and not one particular characteristic of the subjects involved". The terminology adopted follows the trend of the industrial environment, where a consensual model consisting of three well defined macro phases is considered. Nevertheless, Rozenfeld et al. (2005) considered four phases: project information, conceptual project, preliminary project and the detailed project.

According to what is exposed above, one may outline the complex theoretical concepts involved in determining a reference model for the simulation of a project process. Besides the fact that it is a new study area, it is known

that in order to have the simulations performed, some simplifications should be carried out to be developed in only one of the two weekly meetings that the subject would have.

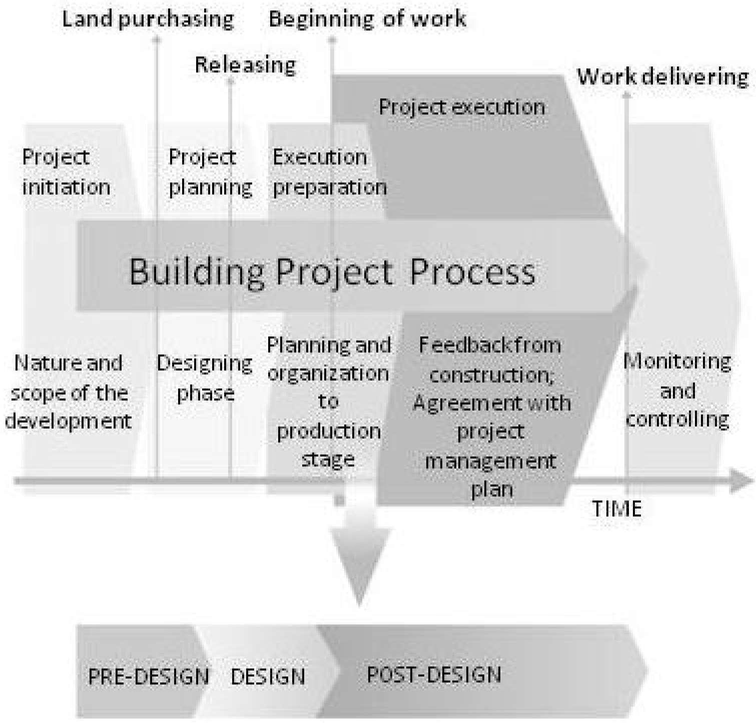

Figure 1: The Process of a Building Project. Source: Romano *et al*. (2006).

Another theoretical and conceptual concern was covering the additional aim to examine the influence of participation of a previous designated coordinator to the team. Further understanding of the issue was sought in specialized literature.

Although the need to coordinate and reconcile project has origin in the separation between the activity design and production, there are other reasons which justify it in the present work, such as increasing specialization of different areas of projects; training project teams working with participants at distance, via Internet and; increasing numbers of technological solutions attached to enterprises.

PDP improvement is achieved by observing a set of guidelines, involving the coordination of projects, the systematization of information to PDP and the adoption of instruments to guarantee and control project quality (Novaes, 1998).

For the different types of projects for building the PDP and its coordination there may be different configurations. However, the task of coordinating projects presents some general guidelines that are inherent to any enterprise, as described in Table 1.

The project coordination is performed by a recognized professional such as an engineer or an architect, but professional experience is relevant here. The Construction Technology Constructions Center (1997) considers two separate but related aspects in the coordination of building projects. One is referent to the planning and control of the process – management coordination, and the other is referent to the coordination itself, integration activities between projects of different specialties - technical coordination. In Portuguese it is also called “compatibility”.

In this context, the main tasks considered for project coordination management are: identification of all activities necessary for PDP, distribution of these activities in time, identification of capabilities and specialties involved in the nature of the product that is being designed, other planning resources for the development of the project, process control, such as time and other resources, including required corrective actions, making managerial decisions of character as the adoption of intermediate products and release to initiate the various stages of design, routing and monitoring operational arrangements for the project development.

The main tasks of the technical project coordination are: identification and characterization of the technical interfaces to be solved, establishing project guidelines and technical parameters, from the product characteristics of the production process and the strategies of the company incorporated to the construction, coordination of information flow between individuals involved in the development of project parts, analysis of technical solutions and the degree of global solution reached, decision taking on the need for integration of solutions.

Table 1: General Guidelines for Coordination

ASPECTS	DESCRIPTION
Definition of parameters	Requirements for the preparation of projects that should be passed to participants of the project team.
Selection of project professions	The project team should be composed of professionals, based on their qualifications, experience and the challenge posed by the enterprise.
Standardization of documents	The definition and standardization of the presentation of information, including their graphical representation.
Efficient communication	Project coordination should promote clear communication among all members of the project team, including the establishment of rules for communication.
Systematic evaluation	The registration of problems occurred during the preparation, so the company can continually improve technology through experience acquired.
Integration between design and production	The coordination should extend itself during the production of the building. The design team may address any questions or work with non planned changes, and the work can contribute with its experience to enhance the constructability of projects with the aggregation of technology and rationalization to the solutions proposed.

In the business practice, the activities of project coordination and management may often be confused. The activity of coordinating projects may include some tasks of project management. There are situations where the coordinator is responsible for the selection and hiring of designers, consultants and other professionals. He can also check the solutions for planning work and constructability, in addition to approving other technical services.

2.2 The simulation in the engineering teaching-learning process

To identify the pedagogical model that can characterize the simulation of a teaching- learning process, reference was sought with Not (1981). Having social-integrationist and constructivist characteristics, the simulation would fit according to the categories of the author in question, as an inter structuring pedagogical model.

The engineering area has no tradition in the implementation of constructivist teaching methods, which determined the possible limitations of the application of the simulation. The main one would be the requirement for collaboration between the coordinators of the activity and the participating students. In this cooperation it is assumed that students have minimal knowledge of the subject, in addition to intellectual maturity and independence. Students who prefer more structured learning environments, such as lecture classes, and/or have low conceptual level with little experience in generating their own concepts are expected to have some difficulties in participating in activities based on the constructivist theory. These activities don't have as a main purpose to make students solve problems, but to confront problems in an active way, leading their learning process and responding to some of the issues discussed. This was not the case of the students participating in the simulation. In addition, students accustomed to structured problems, when faced with non-structured problems, may feel disoriented and confused. Furthermore, on the teacher side, limitation may be his/her lack of preparation to establish a propitious environment to questioning (Costa & Souza, 2009).

For being the first time that this simulation would be applied, a series of measures were taken to prevent or alleviate the constraints identified in literature. The objective of the simulation was not to abstract from "the exact look and the objective action" that according to Schnaid, Zaro, & Tim (2006, p. 40) characterize the engineers action throughout history, but to add "the new skills allowed - required - by time ".

The Buck Institute for Education (BIE, 2003) points at two important events in the last twenty-five years, which have boosted the demand for new teaching and learning methods. The first is the Learning Theory revolution provoked by the expansion of cognitive and behavioral models carried out by research in neuroscience and psychology. These studies show that knowledge, reasoning, action and learning contexts are inexorably linked. The second event is a change in the world, which requires more than expertise. Besides contributing with the technical

part, the professionals have to solve problems, plan activities, monitor and evaluate results and perform and communicate their ideas to a diverse public.

These events have been reflected in the academic environment, provoking efforts towards the preparation of students both with technical and non technical knowledge, so that students may achieve success in their future professional careers. These efforts are reflected in the study and/or experimental methods of teaching and learning known as Problem Based Learning, Problem Learning Education and Driven by Learning Project ((Lima, Carvalho, Flores, & van Hattum-Janssen, 2007).

Studies on the application of these methods in the case of civil engineering are rare, probably because the main concern in these courses is the integration of content and not the development of non-technical skills by students. A study by Librelotto, Rados, & Ferroli (2000) corroborates this assertion.

In this context, this simulation study, aims at providing an environment for teaching and learning soft skills considered as non-technical ones. The level of detailing for the development of these skills would depend on the time available for the development of the simulation. For the situation studied, this time was one hour and forty minutes, with the expectation that during this time, only the awareness of students to the importance of these skills would occur. The development of the simulation in longer periods of time is being studied in the research group, in which this study was conducted.

As already indicated, the pedagogical model adopted was the interstructuring model, but its format was the simulation games. In a simulation game, the description of a fictional situation is created with its financial situation, strategic plan, management coordination, and all information that is deemed relevant to the composition of the context and situation-problem. The participants of the game have to make decisions in successive rounds and monitor the results of their decisions. A simulation game refers to an exercise developed in a context, in which feasible decisions are taken, mainly on the view of the consistent implementation and financial sustainability for a period of time. The results of these decisions are communicated and then new decisions for the subsequent period of time are taken. To Sauaia (1995) there are no right or wrong ways to conduct the simulation. The work of several groups simultaneously produces several solutions for the same activity proposed.

Martinelli (1987) notes some important aspects of the simulation game: extremely dynamic nature, comprehensive as an educational method and personal development in terms of skills and attitudes, sequential aspect, which allows the student get closer to the reality that is being simulated.

Based on considerations of the authors mentioned above and from Motomura´s proposal (1980) of the development of simulations and the assumptions of limitations and possibilities of developing the desired simulation, the methodology for structuring and analysis as intended in the next item was formulated.

3 Development and Analysis of the Simulation

An exploratory case study was conducted through a game that simulated a professional environment. The results of the simulation were based on the following research techniques: observation, analysis of documents and the application of questionnaires. The application of these techniques for research aimed at obtaining the replication of the theoretical results through triangulation of data. Figure 2 represents the summary of the methodology developed for the study.

The teaching-learning environment for the project process of buildings was structured according to divisions of design: architectural, structural, hydro-sanitary installations, electrical and telephone installations. The target building in the case study was a popular pattern single residence with an area of 48 m^2, consisting of two bedrooms, a living room, a kitchen, a bathroom and service area.

The simulation was performed in a class consisting of 34 students enrolled in the subject named PCC - Planning and Building Control of the Civil Engineering Department from the University of Brasilia. Most participants were last-year students. This class was chosen because the above-mentioned subject provides a schedule with the study of the product development process in house buildings and related issues. The learning of this subject facilitated the implementation of the simulation, and allowed students to develop soft skills and to aggregate knowledge. Four meetings were planned of about two hours each, for performing the activities related to the simulation. In the first meeting a lecture about introduction to project process was presented. The members of the two teams were defined and the assignment of roles was accomplished. In the second meeting the simulation took place.

The students had prior knowledge of the target project. To perform the simulation, it was presented again considering the configurations of the different stages of their development, namely: the preliminary project, the project planning, the legal project and the executive project. The activities for each of these steps are described in Table 2. For each step, a checklist of information relating project documents was presented. The designers should verify that each step of the project was in accordance with the checklists. We created some situations where this adaptation does not occur and where the architectural project was clearly incompatible to the other elements in one or more constructive elements.

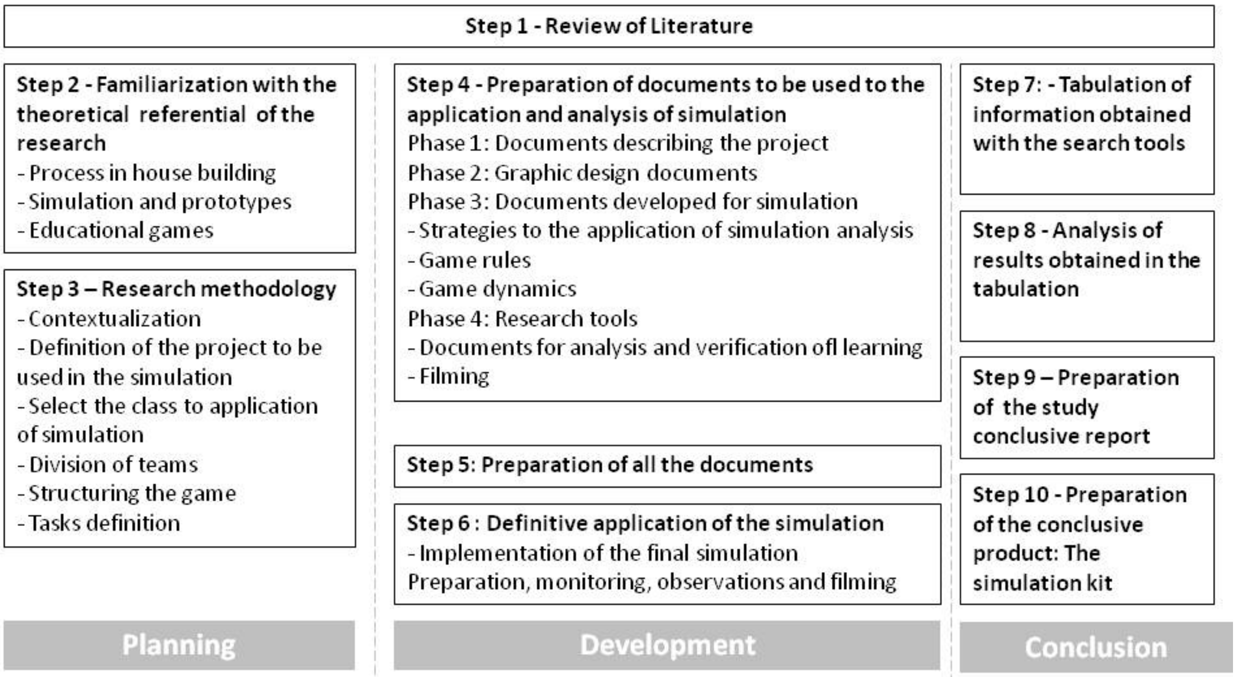

Figure 2: Summary of Research Methodology.

As it can be seen in Table 2, the project process was designed in four phases under NBR-13533 (1995): the preliminary project, the project planning, the legal project and the executive project. Five meetings were planned for compatibility. The first meeting was called “Compatibilization 0", which involved only the structural and architectural designers. The purpose of the compatibilization meeting was to verify the existence of inconsistencies in the information necessary for the development of subsequent phases of the project and possible constructive incompatibilities.

Table 2: Simulation timeline for A and B teams

Beginning (duration)		**Activity descriptions**
Provision	16 hs 00’(5’)	Reception of the students in the classroom
	16 hs 05’(5’)	Split the teams and occupation for students of the simulation rooms
	16hs10’(15’)	Delivery of control documents and re-reading of the rules and special dynamics for each team
16hs25’	16hs25’(5’)	Step 1: Definition of the product (in the simplified form – the teams already knew the product)
Stage1-	16hs30’(2’)	Step 2: Delivery of co-ordination documents of the project process to teams A and B.
Preliminary study	16hs32’(15’)	Step 3: Delivery of the preliminary architectural and structural projects and checklists (CL)
16 hs 47’ Stage 2 - Draft	16hs 47’ (10’)	Step 4: Compatibilization "0" Meeting – Meeting with the designers - architectural and structural
	16hs57’(2’)	Step 5: Delivery of architectural and structural drafts, with their respective CL
	16hs59’(10’)	Step 6: Compatibilization 1 – Meeting with all the designers to spread the concept of the project and participation rules. Delivery of the preliminary projects of the real-estate installations and the respective CL
	17hs09’(5’)	Step 7: Preparation of the preliminary projects and drafts for the designers of real-estate installations simulated by the conference of the respective CL
	17hs14’(10’)	Step 8: Compatibilization 2 – Devolution of all the drafts and the respective CL and alterations proposed in the graphic representation to the co-ordination. Eventual incompatibilities resolution
	17hs24’(2’)	Step 9: Delivery from the co-ordination of the legal projects and the respective CL
17 hs 26’	17hs26’(15’)	Step 10: Delivery from the co-ordination of the legal projects and the respective CL

Stage 3 – Legal project	17hs42(2’)	Step 11: Approval of the legal projects for the responsible government agencies
	17hs44’(2’)	Step 12: Compatibilization 3 – Delivery to the designers of the legal projects approved by the public responsible agencies and the executive projects and respective checklists
17 hs 46’	17hs46’(15’)	Step 13: Conference of the CL and listing of necessary modifications in the executive projects
Stage 4 – Executive project	18hs01’(10’)	Step 14: Compatibilization 4 - Discussion of the executive projects in terms of available information and Compatibilizations
	18hs11’(3’)	Step 15: Delivery to the co-ordination of the executive projects and the respective CL
Conclusion	18hs14’(3’)	Step 16: Leading the seminar to discuss the simulation predicted for the next meeting of the subject

The teams represented the hypothetical companies A and B. The companies were characterized by two different situations: A) The process management from the coordination of projects, carried out internally by the presence of a formal coordinator and B) The process management under the responsibility of the outsourcing architect and designers, who were contracted to develop projects. In this case, the coordinator function was not formally determined. In situation B, although there was not a formalization of the coordinator, all the project process was previously referred to the determination of deadlines for the development of the characteristic stages of the project process development.

The roles played by members of both teams were: an owner of the company, two architectural designers, two structural designers, two designers of hydro-sanitary installations, two designers of electrical and telephone installations, two representatives of public agencies, two consultants, two observers, two writers and a camera-man. The observers described the behavior of designers and the editors were responsible for the meetings registrations. In addition, a coordinator was previously chosen for team A by the group that developed the simulation. Team B had two students that exerted spontaneously the coordination of the process. The layout of team A´s room where the simulation was developed was composed of pre-set work stations for each specific group of designers and other participants. The layout of team B´s room was not defined: all the participants sat around the same table except for the developer and consultants that were separated. The two cases were filmed during their implementation. Figure 3 shows a diagram that represents the set of documents for the simulation.

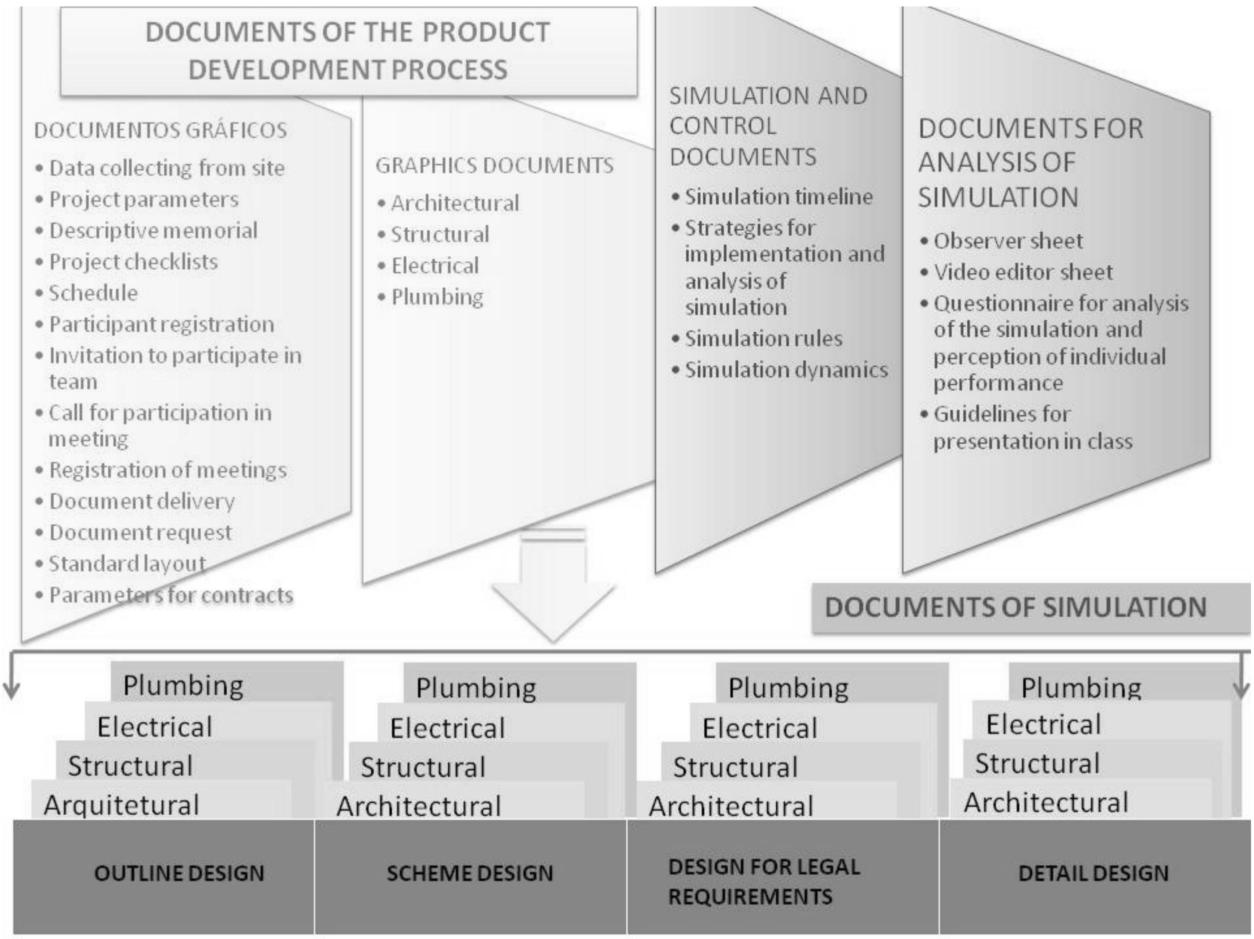

Figure 3: Representative Diagram for the Documentation of the Simulation.

4 Results

The results obtained by observation and through the film allowed the evaluation of team participation in the game and the effect of determining a prior coordinator in their performance. The analysis of documents aimed at the identification of limitations and technical, administrative and educational potentialities to the accomplishment of the simulation. In the first part, two comparative analyses were conducted in order to characterize the performance for each of the teams. With regard to the knowledge of rules and dynamics of the game before the simulation, the two teams had low performance, because students did not prepare in advance, preferring to rely on the possibility of obtaining good performance with the use of improvisation during simulation time.

As for the accomplishment of the schedule of activities involved in the simulation, the analyses showed that Team B was more effective and also presented more involvement from participants. As for obeying the game rules and the collaboration of participants, both showed good performance. The other comparative analysis was conducted regarding the prior choice of a coordinator in team A and not previously determined in Team B.

The two teams have not respected the PDP schedule. Team A was delayed and team B was accelerated, although both had a good control of PDP including the time, documents, communication and recording of corrective actions required in each step. The two teams also conducted effective communication and had good coordination of integration meetings between different sub-systems. Team B had better interaction among participants during the stages of the game. But their performance on the technical aspects such as the integration between different sub-systems to lower the cost of the product, analysis of technical solutions and the degree of global solution and the decision reached on the need for integration of solutions were lower than those of team A.

The second part of the document analysis was aimed at technical, administrative and educational aspects. It was done through the records previously made by students on the observation form, through meeting registrations, lists of changes in each stage of the PDP and questionnaires and guidelines for PDP learning assessment. The questionnaires were prepared to identify level of knowledge acquired by students on the PDP with the simulation, the ability of these to apply the knowledge acquired along the course during the simulation, and their perceptions about the simulation as a teaching tool.

The analysis of these documents reinforces what was observed in the first part. The checklists were considered effective, productive and well prepared by students. One of the concerns during the initial structuring of the simulation was the development of a checklist hampered by the need of keeping them consistent with the reality of a project execution and accomplishing this adjustment in the short time available to develop the simulation. According to observers, the simulation achieved its purpose by showing the PDP dynamics.

In B team, the two coordinators emerged spontaneously; they played the role of architectural designers and representatives of the public power. It was noticed that there was greater organization of meetings as the simulation developed. Observer B found that the presence of consultants should be reviewed. They could not help with technical aspects because they had not been previously prepared. This is an indicative that they should be previously prepared for future simulations. The analysis of meeting registrations of Team A highlighted the participation of the project coordinator. He had control and management of the steps and focused on integration between different sub-systems and technical solutions aimed at reducing costs. This once again clearly showed that the presence of a coordinator favors the achievement of the project objectives. Analyzing the meeting registrations of B team, there was a single concern with the completion of the period of the sub-systems integration meetings and the completion of a checklist. The student that was coordinator in A had experience in work with design teams and was one of the best students in his year of entry. Analyzing the change of control, it was observed that all the checklists had been properly checked; emphasizing collaboration and involvement of participants in activities that did not require advanced preparation. This is known as the “student’s syndrome."The problem knows what conditions are emerging in the professional life of this student and what effects that cause.

In summary, the analysis showed that the majority of students demonstrated not to know what had been proposed and was held in class, hindering the simulation process and delaying its schedule. This posture may be a sign of resistance to participate in activities which are different from the usual, and shows the non existence of a participatory and collaborative culture in the context of subjects developed over the course and the experience of multidisciplinary activities that can give students the opportunity to apply their knowledge in correlated way.

The students' learning was less than expected. The seminar provided in the methodology of this study, in which the students should present their perceptions of the simulation, could have contributed to the students showing conceptual domain of the subject. Some students, despite showing understanding of the project experience, proved difficulty to expatiate on their perceptions and situations experienced in the process.

As already emphasized in the literature review, it is common to observe among students of science and technology difficulty to express themselves orally and in written ways. The view of the simulation presented by students and the questionnaire was positive. They have good references to the proposed activity as an instrument of knowledge analysis and the opportunity to experience a real situation. However, it also identified a superficial perception presented after the simulation, since they didn't present any discussion of ideas and critical analysis. For the developers of the simulation, this is the most important aspect of the study because it confirms what is reported in literature about the limitations of students that prefer more structured learning environments, such as lecture classes and/or have low conceptual level with little experience in generating their own concepts. It is expected that they have difficulties in participating in activities based on the constructivist theory. In fact, the students completed the schedule for the PDP, as they "solved problems". But the majority did not “face the problem in an active way, leading the learning process, asking and responding some of the issue discussed”

5 Contributions/Originality

This article presented the study for the preparation and analysis of a learning environment established from a simulation of the PDP of buildings to support the process of constructivist teaching and learning in the course of Civil Engineering. The simulation consists of several documents that enable the development of the project in its different stages and the integration between different sub-systems, focusing on the collaborative process of building projects from the dissemination of accurate information at each stage of the same. These documents enable students to identify the need of information and its consistency throughout the PDP, sensitizing them to the importance of the information process in the PDP environment to promote interaction between designers and conceptually, distinguish the coordination task from the task of the coordinator and also to realize that the adoption of systematic procedure facilitates the recovery of content and communication. The simulation was evaluated in the second half of 2008. Through various search tools applied, the validity of the proposal was verified and it was identified that efforts are necessary to implement an integrated tutoring in the course where the study was conducted. Limitations to the simulation performance are student's lack of ability in activities prepared for such aim, and little administrative support available for teachers to suggest activities that are different from the classroom exhibition option.

As future work, it is suggested the application of simulations in learning situations in a short space of time, and in situations that focus besides the coordination, the development of solutions for the product in design.

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New Project Approaches in Advanced Microelectronics: The Students' Perspective

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Abstract

This paper describes how microelectronics can be regarded as a compelling work topic among students when experienced within their own built work environment. Undergraduate students from several degree years have formed a group in which have been developing microelectronics related projects in an autonomous way. In this initiative, the topics are freely chosen by the students, mainly addressing the design of integrated circuits. For that reason, the projects entail scientific concepts with very high-degree of complexity. Nonetheless, with an outstanding enthusiasm and well-organized as a team, the students manage to surpass the lack of great knowledge in technical details. Throughout basic understanding of essential concepts, this autonomous group of students demonstrates how an extracurricular activity within an academic environment can effectively enhance productivity and motivation for working on scientific areas that are often considered interesting, yet difficult in practice. The present paper describes the key activities of the group, its organization, and the chosen strategies for the definition of a high-complexity project within distinct heterogeneous levels of knowledge and expertise among students.

Keywords: project approaches; microelectronics learning; student-led projects; microelectronics students' group.

1 Introduction

Engineering programs often undertake certain curricula that involve great technical detail and thus require a lot of students' effort to achieve reasonable learning requirements. Microelectronics is one of such courses but with the particularity of being regarded as theme of great popularity in terms of modern industry and commercial interests. However, today's technology evolves rapidly and as a consequence also the complexity of electronic related topics increases. New industrial applications and fast emerging technologies offer a wide range of quick renewable issues, both technical and theoretical. Such issues are extremely dense, most of times requiring deep understanding of interdisciplinary concepts. It is therefore hard to find such wide-ranging topics in any electrical engineering study plan, at least within an acceptable level of detail. On the other hand, a well planned course cannot forget the motivational component throughout all the teaching and learning processes. Motivation and understanding are sometimes difficult to accomplish as a simultaneous process and in order to include motivation for the main topics the understanding goals require elaborated planning and very clear definitions. According to (Perkins & Blythe, 1994), the basic definition of understanding is not just being able to solve a bunch of routine problems from a textbook, but also being able to apply the topic to real life situations. This is obviously of extreme importance in any engineering course. Hence, a project approach can be an excellent exercise to induce the professional environment needed for the motivation of students. In fact, students often demonstrate noticeable lack of interest when they do not see an immediate usefulness of certain topics or professional needs to understand them. As projects are common tasks in microelectronics engineering, a project based process can be quite efficient in developing knowledge in this field.

Distinct approaches have been addressed for the motivation of microelectronics students in engineering courses, e.g. (Hashim, Jamal, Phang, Nurzaihan, Halim, & Razak, 2006; Reis & Indrusiak, 1998). A remarkable example is reported in (Hashim, Jamal, Phang, Nurzaihan, Halim, & Razak, 2006) where a clean room was built in a Malaysian University. This initiative aims to expose the students to the "real-life" of clean room environment, protocols, safety requirements and good laboratory practices in clean rooms. Another way to emulate the industry-like

environment is to introduce tools that are commonly used by semiconductor industry in the course when teaching the design of integrated-circuits, or chips as popularly known. This can successfully increase the interest of students in these specific subjects. Although such commercial tools are not much user-friendly, students know by hand that the hard knowledge can actually benefit them as future professionals. Moreover, computer aided-design (CAD) tools are becoming more and more important in teaching of microelectronics (Reis & Indrusiak, 1998). Nonetheless, this hands-on approach cannot and should not be a substitute for the most theoretical aspects. Both are indispensable in the teaching and learning aspects of a very in-deep subject like microelectronics.

Project (or problem) based learning (PBL) is well-known by its capability to improve quality of the learning process through real problem solving and can be straightforward exploited in microelectronics learning. Conversely, people-oriented management theories also have interesting features that are highly compatible with PBL. People processes from total quality management (TQM) and PBL are compared in (Hadgraft, 1995) focusing approaches on how to improve the productivity in University departments. Some noticeable issues are highlighted in the referred work, such as how unfavorable can be considering undergraduate students as external to departments. In general this is traditional and, for instance, in the case of our present institution, each year our department is missing more than two hundreds of young minds in research and community activities. On the other hand, any quality program in industry contexts involves worker empowerment, giving the responsibility to the workers to improve their productivity in their workplaces. TQM can be applied to PBL, and in the specific case of University departments, a new culture can arise based on trust and respect for student contribution (Walsh, 2007; Hadgraft, 1995).

This paper is about an autonomous group working within great professional resemblance although within an academic environment. Students demonstrate they can manage themselves, especially in creating self-motivation. The present paper describes, from the point of view of most experienced students, a new experience on how undergraduate students can enhance noticeably the interest in microelectronics, improving the theoretical and technical knowledge through their projects. As further described in this paper, within specific work environments microelectronics can be found not only an attractive research activity by undergraduate students but also quite self rewarding. The paper reports the activities and organization of the group in which have been developing complex projects such as the design of integrated-circuits.

The paper is organized as follows. First the motivation for group establishment is presented following by the description of group organization and activities. A brief overview of work methodologies and the established work environment are also included together with the approach adopted for the ongoing team project.

2 The Microelectronics Students' Group

The idea of starting a small set of engineering projects initially motivated a group of seven undergraduate students of the Integrated Masters degree in Electrical and Computer Engineering from the Faculty of Engineering of University of Porto (FEUP). The projects mainly address microelectronics, particularly focusing integrated-circuits design. Several reasons led to the preference of this key topic. First of all, fundamental electronics at FEUP as long-term courses have traditionally sustained the attraction of students in these fields with good quality and extensive lectures material, e.g. (Ferreira, Oliveira, & Tavares, 2004). Secondly, microelectronics at FEUP had recently received increased interest by new Ph.D. students working in wireless communications circuits. Moreover, a wide set of professional software tools dedicated to integrated circuit design has been continuously made available by the Department of Electrical and Computer Engineering (DEEC) at FEUP through the Europractice academic program (Europractice, 2009). Most of European research institutes renew every year the Europractice agreement from which low-cost integrated-circuit manufacturing and a variety of software tools are provided. Some of these software tools are difficult to work with, yet are widely used in semiconductor industries and starting a small professional environment resemblance also motivated these students. Thus, the students recognized that they had it all to initiate a small set of projects. The initiative aimed to develop specific microelectronics topics that were proposed and originally assisted by a PhD student with fundamental research knowledge in this theme. The group was then named *Microelectronics Students' Group* (MSG, 2009).

Generally, it takes some time for a group to bring out the capabilities to a point where it can be effective. During the initial period the undergraduate students had not any background regarding integrated circuit technology. Nevertheless, the students promptly demonstrated sustained interest and revealed pertaining autonomy. The first project tasks required considerable time devoted to its development, which the students had to accomplish in their free time and usually that meant late in the evening. Along just a couple months of work, the students accomplished circuit designs that usually demand considerable effort. Two Professors readily recognized the

importance of such initiative and strongly encouraged its continuity. The Professors formally presented the group as a project of DEEC/FEUP having themselves as supervisors and managed to provide facilities and equipment for the students develop their projects. The following sections report on how the students' group structured their activities, work flows, and methodologies in order to establish their own productive work environment.

2.1 Group organization and activities

The supervisors support the idea of the group consisting on an autonomous unit. Although the supervisors have no direct participation in group activities, they provide management whenever required and still confer responsibility to the members to freely promote new activities. Following such formal establishment of the students' group within the department, the early members realized that a much more suitable structure was needed to extend their activities as a group foreseeing the inclusion of new student members. At first, the students started in a more or less conscious way to establish a preliminary course of actions. A technical concern that has been considered unavoidable was an infrastructure for managing the technical information, both in terms of data and hardware management. This is so because the development process of their projects relies almost entirely on it. In the microelectronics field this implies a computer network properly configured and well-structured for the use of computer-aided design software (CAD) in an efficient way. In the semiconductor business, companies have teams exclusively dedicated to this issue, i.e. the information technology section (IT). However, this is not an immediate task, even for an IT professional it requires significant effort and interdisciplinary concepts that are hardly found in young electronics engineers. Nonetheless, the group has nominated some students in charge for this task and, in fact, they accomplished the design of their own computer network environment, almost resembling a professional system used in semiconductor industry. These students are responsible for continuously improving this framework and for providing support to other users when needed. In the case of any non-autonomous students' group, such infrastructure would not be held by students. However, this is a technical implication that is inherent to the principle of this group autonomy.

In a certain way, technical concerns started to sketch out the group structure. For instance, due to the infrastructure requirements, students had to nominate individuals for certain "job titles" and respective tasks, each one with its specificity such as: CAD managers for different software vendors, a System Administrator for the computer network, and a Webmaster. Having ensured the platform functionality, knowledge is the subsequent key issue for making use of the tools. Technical guidance is in fact crucial for the group activities. Therefore, Ph.D. students can large contribute to it. They must provide essential assistance by initially giving undergraduate students enough theoretical and technical backgrounds to launch their works. Monitoring the quality of their work along time is important as well, since it can have strong impact in the way students gradually expand their knowledge. It is also indispensable in any kind of extracurricular work that students are kept in an environment featured by high motivation and creativity. Actually, along one year of group activities, motivation has demonstrated that sometimes is just enough to be conducive to excellent results.

Projects are always an excellent approach to promote team work among the students of the University and to enhance their scientific activities. In the area of microelectronics it is mandatory that the projects should be funded, otherwise integrated-circuits cannot be produced and so the "visibility" of the work would be inexistent. The present group proposed a team project to the University of Porto by the *LIDERA* program (LIDERA, 2009). This program consists on funded projects that must be led by students and can be also proposed by themselves. The project proposal of this group had surprising acceptance exalting in rank by the highest number of candidates among all the other projects. The group incorporated new members in their recent self-established team organization. Currently, the group includes more than twenty students, from the first to the last year of the Integrated Master programme in Electrical and Computer Engineering. Figure 1 shows how the students are distributed along degree years. Three major groups of undergraduate students can be distinguished in number: *1)* the last year, which encloses most of the students, *2)* the from the second to the fourth degree year; and *3)* first year and Ph.D. students that together form a subgroup that is even less in number than the previous ones. This student diversity has great impact on how the projects are planned. We will describe later some of the adopted strategies addressing this issue.

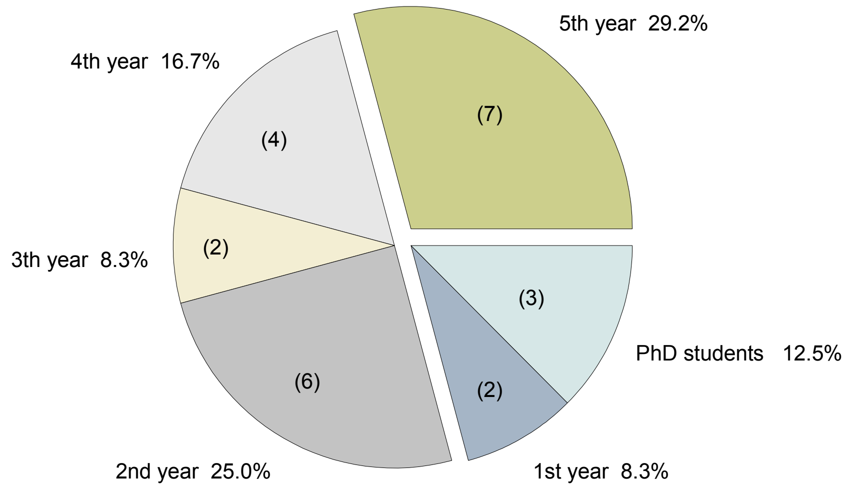

Figure 1: Students' diversity in the group in terms of degree years

New members often inspire new ideas and in this case new activities. The group became aware of the need to motivate students for this engineering area, starting with younger students from high-school. Therefore, a set of workshops have been organized taking place at FEUP along all the year. These workshops involve two high-school institutions having specific technical courses wherein the students have already learned some basic concepts about electronics and telecommunications. Most of these young students have in mind choosing FEUP as their graduation school in a near future. Thus, these workshops help them to have a snapshot about modern technologies such as microelectronics. As so, these workshops are also exceptional opportunities to learn from the academic experience of students nearly the same ages.

The extensive practice acquired along the students' activities allowed them to collect a great deal of technical information regarding the use of software tools, optimized practical procedures, and solving turnarounds found in common problems. They even felt the need to develop new tools to easier some routine tasks, which are particularly suitable for beginners. All this built up knowledge led them to write didactic material, which the students share in the internet (MSG, 2009). The developed material is considered to be extremely useful in lectures of four courses at FEUP, e.g. detailed information about tools usage in design of integrated-circuit. Also, whenever new members arrive, the students run short introductory courses based on these resources for the new participants. It is important to mention that this helps the group to establish positive self-sustained dynamics, that is, by creating the culture of being responsible for continuously transmitting the essential knowledge acquired in the group along time.

2.2 Project methodologies

The group is very heterogeneous in terms of degree years, which can be reflected in fundamental knowledge for this kind of activity. Nonetheless, the proposed projects have a multidimensional structure and everybody fits in. In microelectronics three important domains are mainly distinguished: digital, analog and radio-frequency (RF). Typically, the list of domains as ordered is also associated to the increasing complexity of related topics. The project tasks are then planned in a way the students are allocated in a domain that can fit their levels of knowledge and training. Figure 2 shows a representation of how students are allocated to the different domains based on the task planning just mentioned. As can be seen, the resulting effort for each student is almost similar. Although the students have distinct tasks, they need to interact with other students in order to define the operation of the circuits when connected between them. This kind of interfaces between workers is natural in microelectronics and it is the basis of several technical discussions, which constantly motivate the understanding of new concepts. Moreover, it brings on "negotiation" of technical specifications between students to make the implementation of the circuits feasible. Therefore, this work environment mimics somehow a professional environment that the students might experience in future.

When working with junior circuit designers, different learning stages can be noticed. During the initial stages, the students often become mired in minor technical details in their tasks, such as transistor sizing and recurring circuit simulations. Interaction with most experienced students helps younger students to consider structural changes in their circuits. In general, this leads to greater performance improvements, both in the circuits and in the

motivation of the students. Gradually, with experience, the students learn how to identify the main design trade-offs. Leadership of such a wide group requires lots of effort and dedication. In the meantime, one of the Ph.D. students is responsible for the group guidance, but more Ph.D. students are required also for project planning and continuous management. Since their knowledge is wider in technical scope, the system architecture must be specified by them. The drawing of interfaces between students' tasks is however natural. Nonetheless, the interaction between adjacent works needs Ph.D. students to help providing better technical decisions to undergraduate students. At the moment, the most experienced undergraduate students are contributing to this very important task.

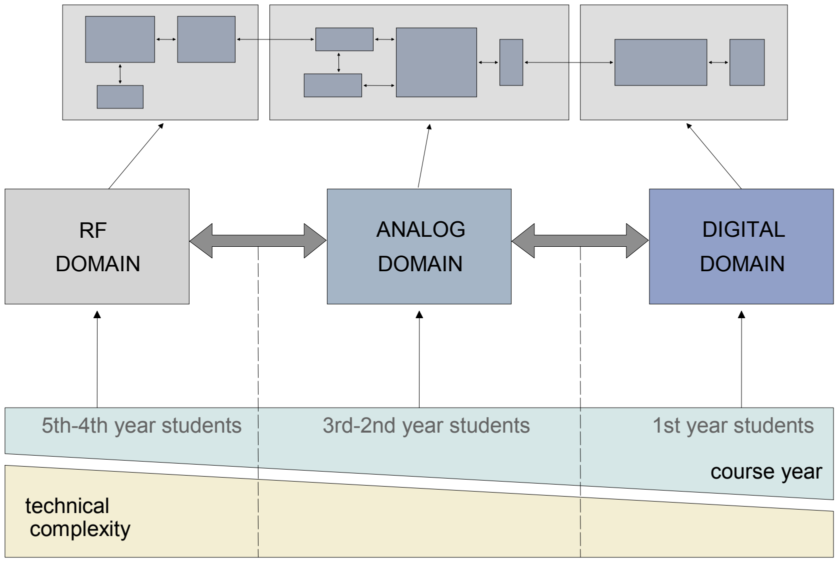

Figure 2: Allocation of students into the areas of study per group degree year

Whenever possible, the group performs public presentations of developed works, which is not limited to just the other students of the faculty. During the last "Meeting of Young Researchers of the University of Porto" (IJUP) the students' group has presented eight oral presentations of the works just developed, which is at least representative of the quality of the work developed. Moreover, when visiting the faculty, people from the semiconductors industry and researchers from related fields are commonly invited to know the group activities. The shared insights, both with academics and professionals from industry, are always welcome and in general visitors have very positive comments about the activities performed in this students' group.

3 Conclusion

This paper describes the student's perspective on microelectronics design as research and development activities. This is an initiative in which undergraduate students from different degree years, throughout their own built work environment, have constituted a group for designing integrated circuits. Even though the different levels of experience of microelectronics design among the students of the group, focusing more on the concepts than the extensive technical details the students manage to deal with scientific concepts of high degree of complexity. Working in an autonomous way and defining their proper organization, the group established professional similarities both in their work environment and results. This experience shows that an extracurricular activity can effectively enhance the productivity and motivation for scientific areas that are often appealing, however considered extremely difficult in practice.

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PLC and Petri Net Training Based on a 3D Virtual Car Park Modelling and Control

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Abstract

This paper describes a PC application, behaving as a virtual maquette, that emulates a three-dimensional real world where an external PLC controls its behaviour receiving feedback from the environment. The developed interface connects the PLC to the PC. The virtual maquette is composed by a car parking where user requests gate open order while the PLC supervises gate open/close command, parking availability lights and free parking places. The virtual maquette also supports a Petri net viewer where the car park behaviour is modelled. State changes and resources allocation can be seen in real time. The virtual maquette supports different ways of control, allowing several simultaneous student groups to work on different solutions.

Keywords: computer aided engineering; control engineering; laboratories and Petri nets.

1 Introduction

The Bologna's declaration introduces, in the European Union Education Space, a significative change in the learning process, by changing the focus from a paradigm oriented to the transmission to a paradigm oriented to the learning process. However, it is necessary to go further by introducing new tools that motivate and involve teachers and students in the learning process (Bourne 1995). Individual learning is the base concept and practice is nowadays a common answer to industry requirements (Kroumov 2003).

One of the graduate automation lessons skills is to prepare students to develop PLC (Programmable Logic Controller) programs. The real PLC applications are applied in several industrial designs (Culley 2001). The student PLC programs can usually be tested in laboratories resorting to maquettes. A classical 2D maquette connects to the PLC through wires and basically contains several switches and lights. A 3D maquette, based on hardware, is easier to perceive but harder to control and prototype. The movement of objects that emphasize the model and capture the attention of students is a difficult task in a hardware based solution. Even more, usually there are several groups, forcing the use of more than one maquette at the same time.

A virtual maquette is a tridimensional reconstruction of a model (industrial parts, buildings, cars , etc.) inside a computer containing realistic textures, lightning, different views stretching the distance from virtual to real (Foley 1995).

The developed virtual maquette is composed by a PC application, reducing some hardware problems and allowing an attractive visualization. The student programming task is done resorting to development tools provided by the PLC manufacturers. This approach is better than a stand-alone simulation because allows students to practice with a real PLC, accessing to real hardware.

The developed car parking maquette scene is presented in Figure 1.

This paper is organized as follows: Initially, the virtual maquette, its world behavior based on a Petri net model and hardware interface are described. In the next section, the PLC programming issues are presented, where a first approach and a sample solution are shown. Finally, last section rounds up with conclusions and future work.

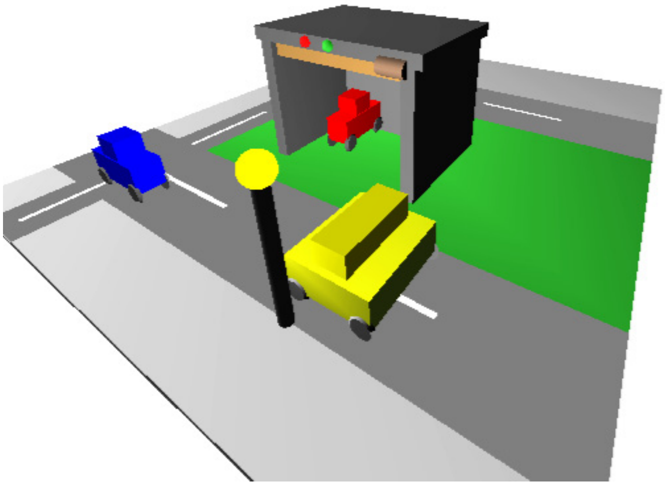

Figure 1: Developed virtual maquette

2 Virtual Maquette Description

The developed virtual maquette gathers the advantages of a classical maquette and some extra features supporting students to test their work. The disadvantages presented in a 3D classical maquette such as hardness to prototype and the hard control due to some hardware limitations are not presented in a 3D virtual maquette. It is also a low cost solution because the software can be easily changed to different requisites and distributed to several work groups. These advantages are not presented in solutions based only on hardware.

The developed virtual maquette is composed by three cars, two of them are small cars and another is a big one, a garage, a road, public artificial (which can be controlled) and day light (which can be sensed) providing a more realistic environment than a conventional maquette. The parking availability can be shown by a red and a green light presented in the garage top. The 3D scene, the zoom and the move around the world feature emphasizes the appearance (Tan 2006). It is desired to control the gate command (open and close), parking availability lights and street illumination by gathering information from the environment. The closed loop is achieved resorting to an external PLC (where students develop the Ladder Program) connected through the PC. The interface joints the PLC and the PC through the parallel port as presented in Figure 2.

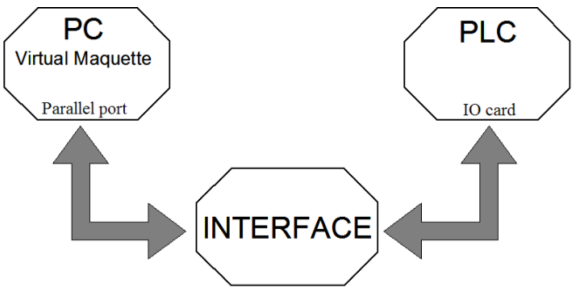

Figure 2: Virtual maquette connection

The developed interface, which connects the PC to the PLC, is presented in Figure 3. The PLC (at the left) has onboard inputs and outputs where the black wires are connected. Otherwise, an external Input/Output card should be attached to the CPU of the PLC. On the right side, the interface connects the PLC to the PC parallel port. The interface is further presented in subsection 2.3.

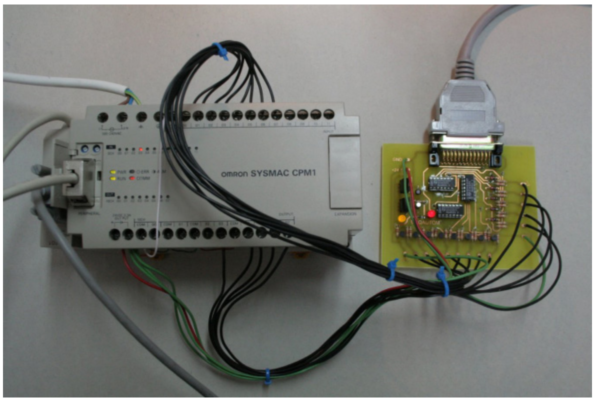

Figure 3: PLC - PC Interface

The virtual maquette provides to the PLC (CPM1 from Omron (Omron 2009)), in this example, the boolean status of the eight environment variables as presented in Table 1. The PLC Addresses with its symbolic names and the corresponding PC Parallel Port bits are also presented. Symbolic names allow programmers to easily decode the developed software as illustrated in the subsection 3.1 of PLC Programming Example. The same symbolic names are also used in the Petri net model and Grafcet example, further presented in this paper.

Table 1: Virtual maquette outupts map

Virtual Maquette Status	PLC Address	PC Parallel Port bit	Symbolic Name
Big car open door request	0.0	D0	BOP
Small car open door request	0.1	D1	SOP
Sensor of gate opened	0.2	D2	SGO
Sensor of gate closed	0.3	D3	SGO
Sunlight presence	0.4	D4	SLP
Small car 1 parked	0.5	D5	SC1P
Small car 2 parked	0.6	D6	SC2P
Big car parked	0.7	D7	BCP

The PLC must control the Boolean status of the five actuators in the virtual maquette as presented in Table 2. The PLC addresses with its symbolic names and the corresponding PC parallel port bits are also presented. The presented tables are included in the virtual maquette application, when requested by user.

Table 2: Virtual maquette inputs map

Virtual Maquette Actuator	PLC Address	PC Parallel Port bit	Symbolic Name
Red availability light	10.3	S3	RAL
Green availability light	10.4	S4	GAL
Street illumination switch	10.5	S5	SL
Close door command	10.6	S6	CDC
Open door command	10.7	S7	ODC

The virtual maquette application software is presented in Figure 4. It was developed in Object Pascal language resorting to GLScene, an OpenGL 3D library. It provides visual components and objects allowing description and rendering of 3D scenes (Glscene 2009).

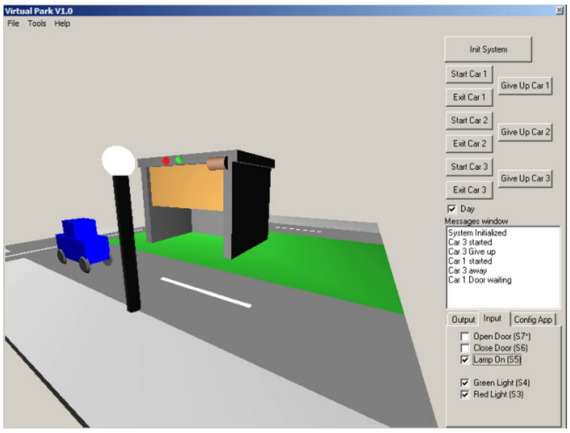

Figure 4: Virtual maquette application

2.1 World behavior

The virtual maquette control must obey to some requisites. The garage capacity allows either two small cars or just a big one. The parking availability signal (red light) must be turned on in the following circumstances: A small car is parked and the big one requests the open door command or the big car is parked and a small one requests the open door command. Otherwise, the parking availability signal (green light) should be turned on when a car can be parked and the gate should be opened. The gate status is closed by default. If a car is getting in or leaving the park, the gate must be completely opened. When the gate is opened, the open command should be turned off, avoiding motor damage, just as well in closing operation. The street light must be turned on at nightfall. This example is important since allocation of shared resources (park places) is an essential issue in automation systems.

The cars movement is autonomous. User starts-up the desired car, which moves until the garage entrance and remains static waiting for the gate to be opened. Once opened, the car gets into the garage with an autonomous movement too. Otherwise, user can cancel the parking operation guiding the car to move away.

These actions must be provided by the PLC, based on the developed software as a student challenge task. If a PLC program malfunction occurs, the virtual maquette remains still and presents a visual warning informing the fault to the student.

2.2 Petri Net viewer

A Petri net is a graphical and mathematical modeling tool. It consists of places, transitions, and arcs that connect them. Input arcs connect places with transitions, while output arcs start at a transition and end at a place. Petri nets have been originated from Carl Adam Petri's doctoral dissertation "Communication with automata" in 1962 (Petri 1962). He described, using a net, the casual relationships between events in a computer system. Further developments by A. W. Holt and others illustrate how Petri nets could be used to model and analyze systems of many concurrent components (Zhou 1999).

A reference tutorial paper was given by Professor T. Murata in 1989, which comprehensively presented properties, analysis, and applications of Petri nets and a list of references of significance (Murata 2009).

The virtual maquette contains a Petri net viewer, where the car park behavior is modeled, supporting students a better understanding of what is intended for their PLC control software in an early stage. It is also important, in a final stage, to monitor if their software is working as requested. The Petri net viewer was developed specifically for this software, having in mind the proposed requisites in previous subsection.

Students can monitor, in real-time, the several states, having special attention to the allocation of the shared resources. The initial state is presented in Figure 5, where the shared resources are shown as available represented by two tokens. The big car, in order to park, consumes two tokens in opposite of the small ones.

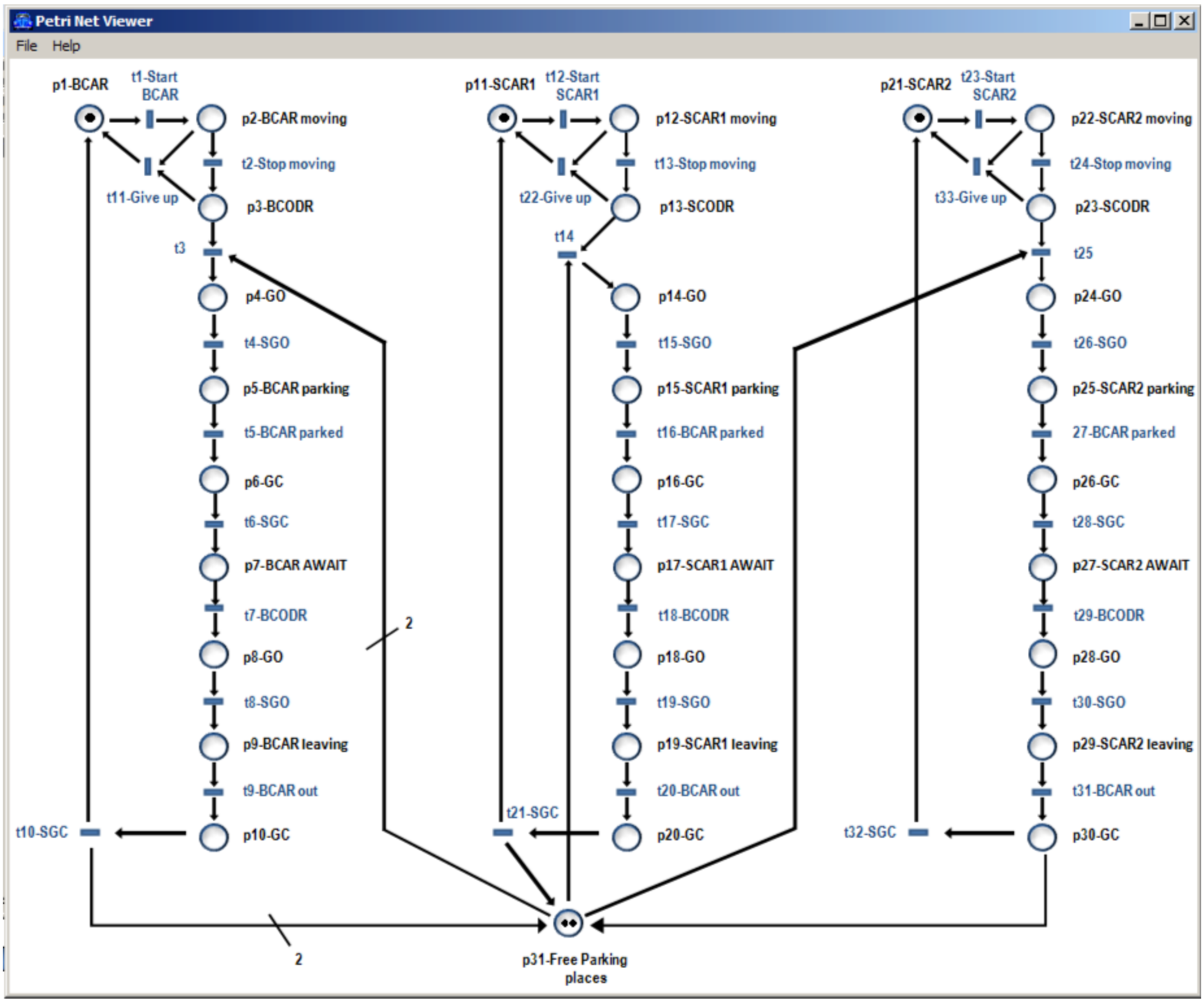

Figure 5: Car park Petri net viewer screenshot

This item is visible in the weights of some arches of Petri net when the shared resources are consumed or when they are reinstated. The used symbols in the Ladder program are the same as the automated system modeling in Petri net.

2.3 Hardware interface

The basic objective of this interface is to adapt two different Voltage levels. The PLC standard Voltages are 24V whereas, the PC parallel port Voltages are 5V. It is basically composed by digital logic circuitry and voltage limiters as presented in Figure 6 and Figure 7.

The PC parallel port is protected by a 5V1 Zener diode. Then, a buffer gate is applied allowing by this way the conversion of 0V and 24V inputs (from the PLC) to 0V and 5V outputs to be applied in the status address of the PC parallel port (Gadre 1998).

The PC parallel port output data address bits connect to a buffer to achieve the base current of the NPN transistor, working as an open-collector switch. In both situations a pull-up resistor is used.

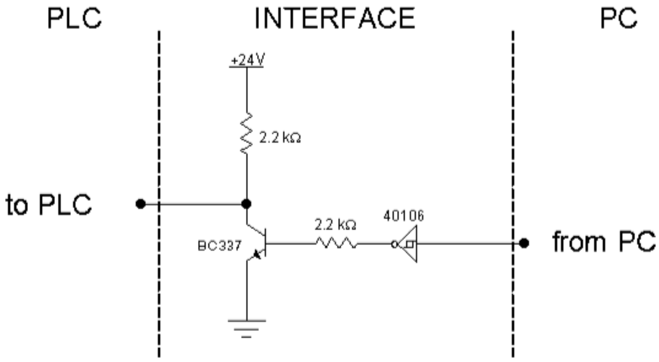

Figure 6: PC to PLC interface

On the one hand, for the interface output, the pull-up resistor places 24V to the PLC when the transistor is switched off and approximately 0V when in saturation.

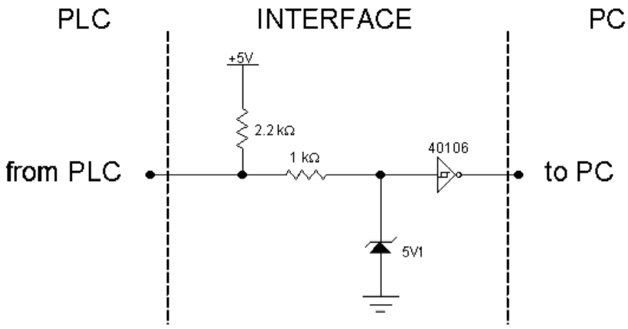

Figure 7: PLC to PC interface

On the other hand, a pull-up resistor defines the default state supporting the PLC relay and open collector types (Pallas-Areny 2001). The impedance adaptation is guaranteed applying a NOT gate for both input and output signals.

The developed interface circuitry is shown in Figure 8 that replicates eight outputs and five inputs. The parallel port output signals are implemented in the data register whereas the input signals are implemented in the status register, allowing a standard parallel port protocol (Gadre 1998).

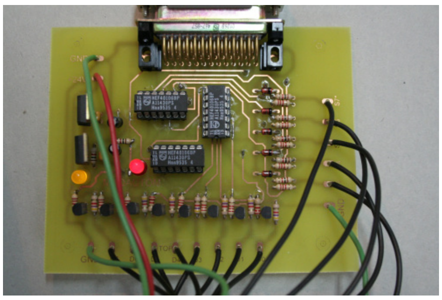

Figure 8: Interface Printed Circuit Board

This card can also be used for different applications as a standard I/O interface card through parallel port.

3 PLC Programming Example

3.1 First PLC programming approach

Ladder logic is a method of drawing electrical logic schematics. It was originally applied to describe logic made from relays. Ladder logic is widely used to program PLCs, where sequential control of a process or manufacturing operation is required. Ladder logic is useful for simple but critical control systems, or for reworking old hardwired relay circuits. For complex systems, Petri net or Grafcet tools should be used to develop and to translate to ladder logic or structured text in a systematic way once programmable logic controllers became more sophisticated.

An introductory example of a ladder logic program that controls one of the features of the virtual maquette is presented in Figure 9 (Dunning 2006).

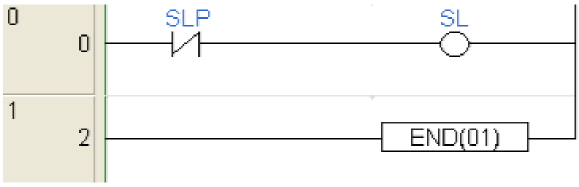

Figure 9: Introductory Ladder Programming Example

If Sunlight presence (SLP) is detected then the Street light (SL) is turned off. This simple Ladder program includes only two *rungs* - a Ladder logic line. Nowadays, in real PLC industrial applications, there may be hundreds of them.

An other solution can be done resorting to Grafcet language. The Grafcet standard is used as a mean to reduce the complexity of large programming tasks and to formalize the state-machine structure often used in the control of discrete-event dynamic systems (R. a. David 1992). A Grafcet is a graph having two types of nodes, i.e., steps and transitions (R. David 1995). The Grafcet, Petri net and structured text interconnection is possible and is discussed in (G. Frey 2000) and (G. a. Frey 2000).

The Grafcet solution for the same PLC program is presented in Figure 10, where the light problem is solved. Once again, the SLP sensor allows to change between state 1 and state 2 turning on and off the SL actuator (street illumination).

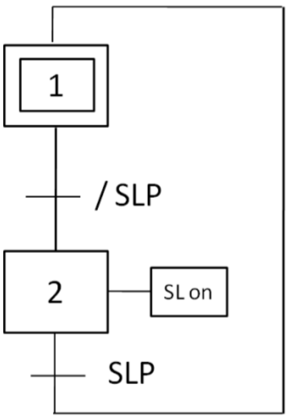

Figure 10: Introductory Grafcet Example

3.2 Programming challenge

The forward program, presented in Figure 11 and its brief following explanation based on its symbolic names, is an example of one small car parking request (Rohner 1996).

- The SOP (small car open door request) is only attended if BCP (big car parked) is false.;
- If SOP is attended then the ODC (open door command) is activated;

- The gate is requested to open until it is completely open: SGO (sensor gate open);
- The green parking availability light (GAL) is turned on for 3 seconds when gate is opened.
- When the car is parked, the closed door command (CDC) is activated until it is completely closed (SGC)

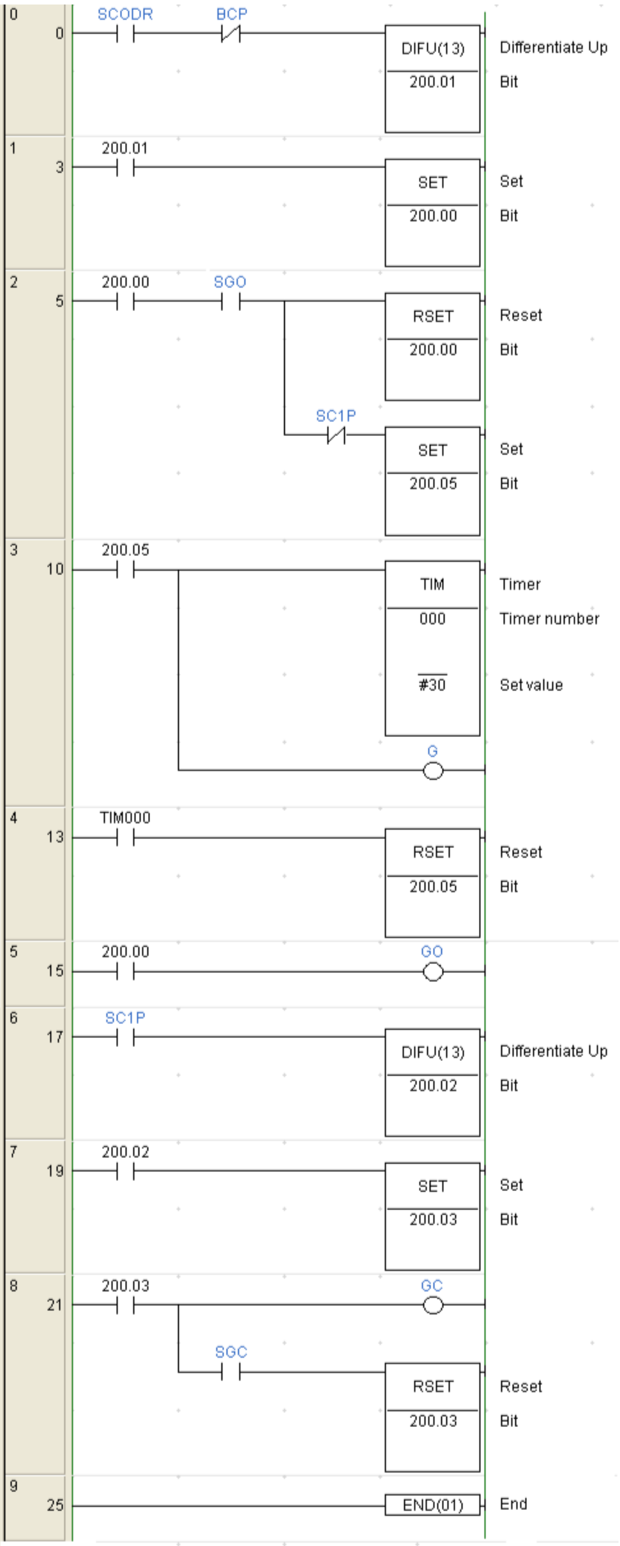

Figure 11: Challenge Ladder Diagram Solution

This simple program concerns only one small car and has different solutions for the same conduct. The red parking availability light should be turned on when parking places are unavailable. For three cars there must be a more complex Ladder diagram that remains to students having in mind important concepts such as shared resources.

4 Conclusion and Future Work

The developed system, composed by a PC application and a hardware interface, allows students to develop their programs in the PLC, interacting with the virtual maquette while actions are displayed in the PC monitor, based on 3D realistic pictures. The cars movement, the zoom feature, the camera positioning freedom and the easy interact commands captivate students attention and increases their learning motivation. The Petri net viewer is an important issue, because it allows to enhance students perception of PLC program goal: mainly the initial and evolution states.

As future work, the presented maquette can be joined in other lectures such as embedded systems allowing students to control the virtual park using a microprocessor or microcontroller programmed in assembly or high level languages. In the PLC lessons context, an auto evaluation can also be created for this virtual maquette where each student has an established time to solve and experiment the PLC program and, at the end, the software application verifies the final behavior punishing each fault and giving a final classification.

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New Project Approaches in Advanced Microelectronics: The Instructors' Perspective

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Abstract

New and different approaches need to be pursued in order to respond to the new habits of students. Furthermore, Portuguese Universities have gone recently through deep reforms under the Bologna Process, with strong repercussions on the way higher education was traditionally exercised. The classical university model of teaching follows a well structured sequence of pre-defined subjects that are formally and orderly presented to the students by an instructor. The students are expected to be able to assimilate and understand it. The level of understanding is then measured through assignments and exams. This corresponds to a paradigm that is off-centred from the student, meaning that the importance is put on how well the subjects and contents are delivered and not much on what the students will be able to do with the knowledge at the end of a degree. The Bologna process leads to a paradigm that shifts from teaching (professor) to a learning (student) centred approach, a move from course goals to learning outcomes. This approach stimulates the student to be active and take part of the planning of their own learning. The teacher is the one that guides the learning process. Learning outcomes can be found in the Dublin descriptors [1] or the Tuning project [2]. The student-centred paradigm has many repercussions at different levels, both operational and at the resource level. The teacher liberty is somehow compromised since learning outcomes demand strong coherence, in the sense that the modules need to be built to fit a set of competences expected to be achieved by the student at the end of a degree. Naturally the number of formal contact time tends to decrease, while tutoring hours and informal individual contacts will tend to increase. This new line of action, required by the Bologna Process, represented a significant change on the common studies program in Portugal.

Keywords: project approaches; extra-curricular activities.

1 Long Abstract

Technical and social progress has changed the life and cultural paradigms of today's students. However, the pedagogic and teaching methods have not always changed accordingly. The ICT is ever (or always) present demanding constant discover from the user. This may be one strong reason why many students prefer to establish their own learning pace and path, tending sometimes to be absent from conventional lectures. New and different approaches need to be pursued in order to respond to the new habits of students. Furthermore, Portuguese Universities have gone recently through deep reforms under the Bologna Process, with strong repercussions on the way higher education was traditionally exercised. The classical university model of teaching follows a well structured sequence of pre-defined subjects that are formally and orderly presented to the students by an instructor. The students are expected to be able to assimilate and understand it. The level of understanding is then measured through assignments and exams. This corresponds to a paradigm that is off-centred from the student, meaning that the importance is put on how well the subjects and contents are delivered and not much on what the students will be able to do with the knowledge at the end of a degree. The Bologna process leads to a paradigm that shifts from teaching (professor) to a learning (student) centred approach, a move from course goals to learning outcomes. This approach stimulates the student to be active and take part of the planning of their own learning. The teacher is the one that guides the learning process. Learning outcomes can be found in the Dublin descriptors [1] or the Tuning project [2]. The student-centred paradigm has many repercussions at different levels, both operational and at the resource level. The teacher liberty is somehow compromised since learning outcomes demand strong coherence, in the sense that the modules need to be built to fit a set of competences expected to be achieved by the student at the end of a degree. Naturally the number of formal contact time tends to decrease, while tutoring hours and informal individual contacts will tend to increase. This new line of action, required by the

Bologna Process, represented a significant change on the common studies program in Portugal. The new teaching procedures, pedagogy and how learning progress should be assessed, need to be better understood by the university community. It requires a change in attitude from both teacher and students. Within this line of thought, extracurricular projects take an important role, not only because it is student centred, but also for consolidating knowledge and putting into practice the skills and competences built within the courses. If well designed, extracurricular projects are a perfect test bed to understand the effectiveness of this all new structure brought in by the Bologna process, and can effectively complement some aspects of professional profile that is difficult to cover within the regular courses.
Recently a group of students have shown interest in developing skills and learn more on Integrated Circuit (IC) design. The initial group started by getting together, after school hours, to design almost ad hoc circuits that allowed them to learn new techniques and to use professional CAD tools more commonly employed for IC design. This initial small group has grown to more than twenty students and is now, for the professor point of view, a reach pedagogical experiment. Fully equipped installations were made available, and a project was instated. The project was specified almost entirely by the group that is led by a PhD. student. The professor acts as supervisor, but keeping the group autonomous. The practical aspect of the project is of relatively high difficulty; executed with a very heterogenic team group, composed by undergraduate students that span from the fist to the last year of their Integrated Master degree. The operational methodology employed requires team work and is strongly rooted in collaborative learning procedures. This paper reports on how these students organize their work, how they coped with new topics, never covered before in any course. The issues of autonomy, how they build the ability to structure a problem, how well an environment like this promotes a critical sense over results, and the sense of discipline and behaviour, necessary to a team work, will be addressed.

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[1] www.jointquality.nl
[2] www.tuning.unideusto.org

Paper Session B1

Management of Interdisciplinary Project Approaches in Engineering Education: a Case Study

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Abstract

This paper describes project management processes of coordination teams, in the implementation of interdisciplinary project approaches in Engineering Education. These interdisciplinary projects are based on the Project-Led Education (PLE) concept and are being implemented since 2004/2005 in the Industrial Management and Engineering (IME) master degree course (1st and 2nd cycle of Engineering Education) at University of Minho. Usually, these approaches involve a coordination team of 10 to 15 members with different roles: teachers, tutors and education researchers. This team is responsible for preparing the project for the semester and forming the students' teams. The coordination of these two types of teams is centred on a project manager that is responsible for, and supports, all the work developed during the semester, e.g., prepare the initial presentation of the project to the students, prepare the web site that supports the work, establish the communication between students and the rest of the team, prepare the students' guide, and so on. Managing these projects is an intense task that demands a lot of time and different competencies. In this work it is presented a project management framework based on project management knowledge areas, to aid coordination teams to achieve better results.

Keywords: project management; interdisciplinary project approaches; engineering education.

1 Introduction

Traditional teaching methods being adopted in higher education across European Universities are not contributing effectively to the real needs of today's world. The current challenges that the world is facing, concerning the new economic paradigms, centred on eco-sustainability along with global and unbalanced competitiveness, demand new answers from the universities. The professionals that universities must create should be prepared with the right set of hard and soft skills so they can rapidly contribute with new energy to the existing enterprises and other organizations.

The Bologna process, besides the objectives of making the European higher education more comparable and more compatible, includes also the objective of finding solutions to the reality described above. The Bologna process emphasizes the importance of student-centred approaches, promotes the implementation of more effective active learning practices and considers as a fundamental issue the reduction of the gap between learning outcomes and real world needs. This process also advocates that greater efforts should be made to create learning activities with "meaning" for students to provide additional motivation to the students as they are able to understand the reasons why they should learn the proposed course subjects.

One of the methodologies used to achieve the previously described objectives is based on interdisciplinary project approaches. A project can be looked as a field of application of more theoretical stuff, and can also act as a driver for better comprehension of theory. Interdisciplinary projects bring up the necessity to understand the interaction between different curricular units (CU) and develop project elements to address this issue. Powell & Weenk (2003) presented an interdisciplinary project approach, the Project-Led Education (PLE), which is based on a project supported by some of the curricular units of a semester (PSC - Project Support Courses), developed by teams of students. All the teams develop the same project theme in order to create similar evaluation conditions. Nevertheless, the proposed project is open enough to allow quite different solutions, allowing thus the development of student's initiative and their ability to take decisions with incomplete/redundant/fuzzy information. These teams should be large enough to impose difficulties both in the project and in the coordination team. These are conditions to improve the development of several additional transversal competencies such as: team work skills; leadership skills; project management skills; communication skills; and so forth.

These learning project approaches are different every year, and can be characterized by different ways of implementation during a pre-defined time period. Managing this process is equivalent to manage different operations every edition with scarce resources during a pre-defined time period. This "one of a kind" characteristic is the fundamental difference between project management and operations management, and reinforces the need to manage these processes as projects. In these projects, the following subset of PMI (2004) PMBOK Guide's project management knowledge area processes get a higher attention from the coordination team: management of one team of staff and several teams of students; management of physical resources like class rooms and project rooms; management of communication between stakeholders; management of time; management of risks.

The main objective of this paper is to present a management framework, centred on time and team management, for project coordination teams, oriented to project led engineering education initiatives. These projects involve a coordination team and several students' teams engaged in medium/large projects as close to reality as possible. To accomplish this, there is a sub-objective of characterization, in several project oriented learning initiatives, of the following project management knowledge areas: team management, time management and communication management.

Next section describes the project oriented learning initiatives that will be used as case studies. A characterization of processes from three different project management knowledge areas is presented in the following sections. In this learning project approaches the areas of human resources (team development), time and communication management were considered the most important because they get most of the attention of the project management team.

2 Project Oriented Learning Initiatives

This work is based on the project oriented learning editions that have been undertaken during the last four years with students mainly from the Integrated Master Degree on Industrial Management and Engineering (IME). Three of those PLE editions were implemented in as many different semesters of the IME course, and the corresponding projects will be identified as follows: IME11 (1st year, 1st semester); IME41 (4th year, 1st semester); IME42 (4th year, 2nd semester). The IME41 project involves all the six curricular units (CU) of that semester while both IME11 and IME42 include four out of five CUs of the corresponding semesters. The total work load of the project should be based on the total ECTS (European Credits Transfer System) allocated to the PSCs (Project Support Courses). This is not an easy task because every PSC has some competencies developed outside the project theme, which are not considered for the project evaluation process. It can be said that total load ranges from 12 to 25 ECTS in the first year project and from 15 to 30 ECTS in the fourth year projects.

Another initiative in project based learning at University of Minho is designated as Innovation and Entrepreneurship Integrated Project (IEIP) and it is a multidisciplinary optional curricular project with teams of students from four different technical backgrounds, all of them from the fourth year of an engineering integrated master course. These four different Engineering Integrated Master courses are: the already referred IEM; Polymer Engineering (PE); Industrial Electronic and Computers Engineering (IECE); and Mechanical Engineering (ME). Two editions of this innovative experience were already completed in 2007/08 and 2008/09, involving four teams of six and eight students respectively (two students from each master course). They have worked during the entire semester, on proposals to improve industrial products and production systems. The problems to be solved by those multidisciplinary groups of students were presented by local companies willing to get real improvements in their products and processes. This project had different workloads allocated to each master course, ranging from 7.5 to 12 ECTS.

3 Project Management Team Characterization

All project based learning initiatives presented above (IEM and IEIP) undertaken at the Engineering School of University of Minho require coordination by academic staff. The characterization of the staff project teams is presented in Table 1. These teams are more or less constituted by the same people, changing one or two persons from one year to another, e.g., in the coordination team of IEM11, almost all members have been the same, except the CC teacher. This brings the additional difficulty of explain the PLE project and accept the decision of participate/not participate of the responsible teacher of this CU.

Typically the coordination teams for those initiatives include lecturers, tutors as well as researchers from the educational field. Sometimes the same staff member accumulates both the role of PSC lecturer and of tutor of a

given team of students. According to Alves *et al.* (2007) and Fernandes *et al.* (2007) tutors play an important role in this process since they get very closely involved with different tasks and aspects of the students' teams.

Table 1: Coordination team characterization

	IEM11	IEM41	IEM42	IEIP
Elements of the Coordination Team	11	10	11	15
Teachers	6 (teachers of several PSCs from different departments and from different schools)	8 (teachers of several PSCs from different courses. IEM course director is one of them)	6 (teachers of the five PSCs)	11 (teachers of several PSCs from different departments; one company representative)
Tutors	6 (3 are also teachers of PSCs)	4 (3 are also teachers of PSCs)	5 (1 is also teacher of 2 PSCs)	4 (1 from each department)
Education Researchers	2	2	2	2

These coordination teams are characterised by a matrix organisation, where each element is associated with different knowledge areas and has a high level of autonomy. According to Lima *et al.* (2007) the members of the coordination team also have to deal with project management and personal interrelationships issues. Project management has to do, mainly, with the schedule coordination, deadline achievement and project's tasks planning and organization. In the personal interrelationship area, the main challenge is the management of conflicting situations due to: divergences on opinions, ideas and individual objectives; attitudes and position confrontation; lack of communication inside the team. To deal with these difficulties, which occur during the entire project, adequate strategies are demanded. Understanding and overcoming these difficulties are two important components both of the learning and the coordination process.

Each coordination team needs a project manager which is the semester coordinator nominated by the Course Director. However, there is no hierarchy in the coordination team - the project manager should negotiate all important decisions. Project manager, as described in PMI (2004), acts like a coordinator in a loose matrix organisation type. The results of the project cannot be totally assigned to the project manager; nevertheless, he has the responsibility to build a coherent pedagogical model and motivate colleagues to embrace it. He must be prepared to deal with conflicts, absences to scheduled meetings, delays in tasks' delivering and to deal with teachers that, by nature, are more sensitive to criticism from colleagues. Some resources, like project rooms, are dedicated to the project but must be allocated to all the projects of the semester and that must be negotiated with both the IEM course director and the director of the Production and Systems Department director.

The project manager also has to manage the students' teams and solve all problems related with them, like schedule training sessions provided by the Courses Council and assure that the students go to these sessions in the IEM11 or assure that, in the final of the semester, the project rooms stay clean and the laptops are returned to the department. During the semester there are several activities and milestones to be delivered by the students where the presence of project manager is fundamental - Alves *et al.* (2009); Carvalho & Lima (2006). The compilation of final grades for the project is a task of project manager and this compilation involves a grading model which is somehow complex - Moreira *et al.* (2009); Fernandes *et al.* (2009).

4 Project Time Management

Before the beginning of each PLE semester, several informal brainstorming sessions take place in order to prepare the incoming project – the main purpose is the definition of the project's theme. Neither the number nor the duration of these sessions is predefined, but usually they start in the months before the semester begin. After this, and to manage the entire semester, the coordination team builds up a schedule for a horizon of 18 weeks. This schedule includes not only the specific activities of the coordination team, but also the activities involving both staff and students. In the beginning of the semester, during one to two weeks, students must execute a mini-project with the objective to simulate the whole semester process. Table 2 presents some activities developed during the execution of the project, along with the correspondent number of occurrences (semester basis), for each of the four project oriented learning initiatives.

Some activities occur every week (e.g. PSCs classes and tutorial meetings) while others are distributed along the semester (e.g. staff meetings and teachers' feedback). Table 2 shows that the number of occurrences of some activities varies significantly depending on the PLE project and, naturally, this implies some differences in the effort associated to project time management. However the time spent on each type of activity is not so different from project to project, except, eventually, for the IEIP case, due to its nature (section 2).

Table 2: Activities involved in the project oriented learning initiatives

	IEM11	IEM41	IEM42	IEIP
Staff Meetings	10	4	4	4
Milestones (for students)	10	6	6	6
Teachers Feedback Events	7	3	4	3
Extended tutorial meetings	2	1	4	3

The higher number of staff meetings, milestones and feedback events associated to IEM11 demands an accurate monitoring and control of the time spent. The duration of each staff meeting should be, approximately, one hour. The agenda is defined in the previous meeting and includes the expected duration of each topic. During the meeting a time controller (in every meeting this role is attributed to a different member of the coordination team) monitors the time spent on each topic and immediately announces any delay. Thus the president of the meeting can take the adequate action (conclude the topic, if possible, or postpone it to the next meeting). Despite this time management effort, sometimes the one hour duration is exceeded (e.g. in the IEIP staff meetings, probably due to the dimension of the coordination team – 15 members).

The time management associated to students' milestones is simple but, mainly due to the number of occurrences along the semester, it is somehow laborious - Alves *et al.* (2009). One of the staff members should verify if all the students' teams have met the correspondent deadlines and if they have delivered the expected elements (reports, presentations, prototypes, etc.).

The feedback activities referred in Table 2 are of two types: presentations' feedback and reports' feedback. During the semester, and depending on the PLE project, there is a minimum of three multimedia presentations (initial, intermediate and final) and two written reports (final preliminary and final). Typically the presentations' feedback is not time-consuming and it is usually provided in oral form to the students. On the contrary, the reports' feedback demands a lot of time, except for the final report (this report is assessed but no written feedback is provided). Each PSC teacher should perform a detailed analysis of each team's report and write down a full set of relevant comments/corrections/suggestions. Each teacher has its own time management approach to deal with these activities but, occasionally, some teachers do not meet the deadline. However, the semester coordinator, which is also the project manager, should continuously monitor the execution status of all the activities, in order to avoid deadlines' overcoming (both by teachers and students).

In terms of time management, the extended tutorial meetings are similar to the staff meetings. The time controller and the president ensure that the meeting with each team of students does not exceed 20 minutes, approximately.

An estimative of the time spent on project supporting activities, by project manager, teachers and tutors, is presented in Table 3, including some of the activities listed on Table 2.

Table 3: Time spent on project supporting activities

	IEM11	IEM41	IEM42	IEIP
Project Manager	One hour per week	One hour per week	One hour per week	One hour per week
Teachers' time for project support	Approximately 1,2 hours per week per PSC	Approximately eight hours per week	Approximately eight hours per week	Approximately eight hours per week
Tutors' time for project support	One hour per week per team.	One hour per week per team.	One hour per week per team.	One hour per week per team.

5 Project Communication and Information Management

The communication and information management in this type of projects includes mainly the staff team internal communication, the communication between the staff team and student teams, the communication inter and intra-student teams, the communication between student teams and the company representatives when applied,

and the communication to the outside community. There is a concerned not only with the exchange and understanding of information between all the elements, but also with the preservation of the necessary privileges and restrictions to data availability.

The projects presented in this paper typically involve 7 to 9 lecturers (some of them acting only as tutors), 3 to 4 researchers and 30 to 50 students. The communication network can be quite complex not only due to the number of people involved but also because of the complexity of roles and complexity of privileges/restrictions to data availability. Managing all the communication, documentation and information in this type of projects can therefore be quite demanding. Different levels of confidentiality must be preserved and managed in the network of teams and from the outside world. Examples of restriction are:

- In some cases the company/product information must be preserved from the outside world while being available to all students and staff members. On the other hand the company may not be interested in part of the important information shared among staff members.
- Each students' team may want to preserve to themselves some data that may be or may not be shared with their tutor or with some other staff members.
- Students' teams must keep updated information and data available to every member and to their tutor, keeping the track of document changes, keeping accurate plans, etc. On the other hand most of such data must not be available to other student teams.
- The staff team must feed all students' teams with some critical updated information: re-planning information, changes in resource availability, feedback information, assessment information, etc.
- Researchers require information that may or may not be available to students, tutor or other lecturers.

A list of the main types of tools and types of documents used for communication and information sharing is presented on table 4, for the Project Led Education projects reported on this paper.

Table 4: Main tools and types of documents used for communication and sharing of information.

	IEM11	IEM41	IEM42	IEIP
Documents	Project Guide Tutor guide Instructions for Reports Templates for Evaluation Bibliographic referencing rules Templates for the peer evaluation	Project Guide Instructions for Reports Companies documentation sent directly for related team	Project guide Instructions for reports List of topics to be deal with	Project Guide Instruction for Reports Company documentation Rules for company access
Repositories	Moodle forum accessible by the students team and teachers	Moodle forum accessible by the students team and teachers Students used "Microsoft Groove" and "Yahoo Groups"	Moodle forum accessible by the students and teachers	Moodle forum accessible by the students team and teachers
Email	Based on direct email; using the moodle participants list	Based on direct email; using the moodle participants list	Based on direct email; using the moodle participants list	Based on direct email; using the moodle participants list
Elearning	Moodle environment configured for the project Different teachers use different platforms to communicate with students: Moodle and Blackboard	Moodle environment configured for the project Different teachers use different platforms to communicate with students: Moodle and Blackboard	Moodle environment configured for the project Different teachers use different platforms to communicate with students: Moodle and Blackboard	Moodle environment configured for the project Different teachers use different platforms to communicate with students: Moodle and Blackboard
Informal	Direct contact is facilitated by proximity	Direct contact is facilitated by proximity	Direct contact is facilitated by proximity	Direct contact is facilitated by proximity

In terms of information management it may be said that special attention must be paid to the communication channels and what information should be exchanged with students' teams. Students' teams tend to be very demanding - they want to get information as accurate as possible at the precise moment when they need it. This may not be easy especially when companies are involved. Special attention must also be given to the internal organization of students' teams since they must learn how to plan and manage their formal meetings as well as keeping accurate records of team decisions and task assignments. In order to help them in managing their projects students must deliver results on several milestones along the semester, which keep teams alert without losing the track of the project.

6 Project Management Framework

Characterization of processes from three different project management knowledge areas was presented in the previous sections. In these learning project approaches the areas of human resources, time and communication management were specially analysed. Specifically on the time management knowledge area, and based on the analysis of the referred data, it was possible to foresee the project life cycle with five main phases illustrated in Figure 1: Preparation; Set-up; Start-up; Execution; End

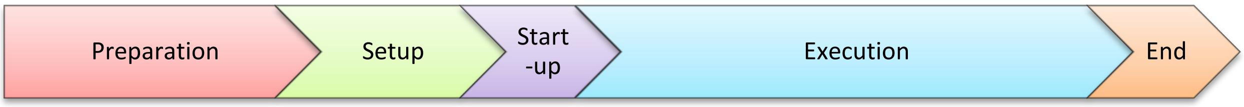

Figure 1: Project Life Cycle Framework – Project Main Phases

Preparation phase starts 0.5 to 3 months before classes begin. During this phase, based on informal communication, a few team members start to contribute for the definition of fundamental aspects of the project: project theme; human resources; project support courses. This is the phase with lower workload demand for team members.

For the project specification it must be defined a project theme that is challenging and actual for both the students and the staff for increasing motivation. So in this context, some of the team members propose ideas that will be considered during setup phase in formal meetings of the coordination team. In the cases previously described a project can be purely academic (IME11 and IME42) or can have interaction with the industry (IME41 and IEIP). In the first case the limit conditions are imposed by course contents of the semester. In the other cases there is an additional constraint related with industry partners that must be found and also that must agree with objectives and main contents applied to the project.

Human resources and project support courses are closely related because teachers of courses associated with the project will be part of the team. Additionally there will be team tutors (also teachers) and, usually, researchers also. It is desirable that staff team members have prior knowledge and experience in the methodology. Nevertheless, in all editions there are teachers that participate for the first time. There is a key role decided during this phase which is the team coordinator that will act as a project manager. This should be a teacher with good organization skills and with in-depth knowledge about the methodology. The coordinator should maintain a high motivation and the project under control, both from the staff and students perspectives.

Setup phase starts 1 week to 1 month before the beginning of the semester and has the following main objectives: project theme definition and specification; milestones definition and planning; project and PSC assessment process definition; project process evaluation definition; project guide elaboration. During this phase the coordination team builds up a coherent plan for the entire semester that is materialised in the project guide. This guide works as a project charter for the project, describing the main objectives, the scope, milestones and evaluation process.

Start-up has the duration of 1 to 2 weeks, beginning at the first day of classes with a project presentation session. Depending on the project, students' teams will be created before this session (IEIP), at the end of this session (IEM11), or during the following few days (IEM41; IEM42). This phase can comprise students' training, mainly on first year edition. Start up phase is based on the idea of one week simulation of all semester process and also to get teams working on the project right from the first day of classes. At the end of this phase, students' teams make a presentation of their own project objectives and organization model that will act as a guide for project work.

Execution phase has the duration of 16 weeks with classes, tutorial meetings, deliveries, presentations and feedback sessions. Each PSC has classes for both theory and project support during the entire semester that can be mixed each week. The tutors are expected to have one hour meeting per week to support students' teams on aspects of transversal competencies development and project management processes. The coordination team should also prepare and control project milestones, and in some occasions prepare formal feedback to deliver to the students. During this phase students assessment his fundamentally formative and the summative aspects corresponds to approximately 20% of final grade.

The End phase has duration of 1 to 3 weeks. At the beginning of this phase, teams have to deliver final reports. In one case (IEM11), this final report is followed by a written test. Prototypes can be delivered jointly with the reports or with the presentation of project. In all cases the project must be presented and discussed with all coordination team and only after this event students will receive their final grade.

There is not an intention to create a detailed work breakdown structure (WBS) for this type of projects in this framework but it is possible to describe some of the main types of activities that should be included. The main activities envisaged on the analysis developed in this work are: theme definition; project support courses definition; human resources management; evaluation process management; assessment process management; milestones management; internal resources management (non HR); external resources management. It is clear from the above text that some of these activities have sub-activities spread along project phases. As an example, theme definition has one sub-activity related with generation of ideas during the preparation phase and others for theme selection, definition and specification during setup phase.

From the point of view of knowledge area of human resources management these project approaches are based on teams of 10 to 15 members that include teachers, tutors and educational field researchers. These teams are characterised by a loose matrix organisation. In this type of organisation the project manager act more a project coordinator that have to negotiate all important decisions. In order to build real team's spirit, team members should identify themselves with the organisation. In this context members should be part of the decisions and should contribute for project management processes. So, these teams must share activities and roles, both pleasant and unpleasant. Presence in most of the project events is a step for accomplishing the objective of team's spirit building. As an example, members should actively participate in staff meetings and act like chair, note keeper and time controller in accordance with a rotational schedule. After contributing for project guide construction, several members should aid and participate on project presentation execution. During execution phase team members should participate in assessment and feedback activities. Acting simultaneously with different roles and with commitment to the team objectives is the foundation stone for team's spirit development and high performance achievement, in these interdisciplinary project approaches. Figure 2 represents the main roles that staff members must interpret in different situations during the project. Most of these roles were explicitly referred previously in this work, but roles referred as "outside" were not.

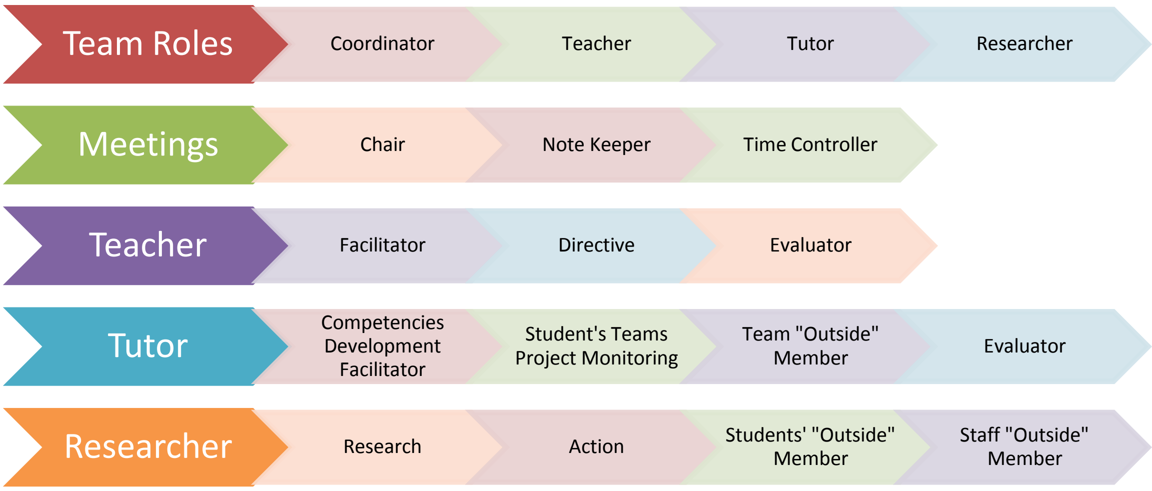

Figure 2: Roles of different staff team's members

As an example, tutor is an "outside" member of students' teams because he (she) should simultaneously be close enough to understand teams' main conflicts and problems and far enough to restrain any temptation to execute activities for the team. Researchers have similar roles because they must be close to students to understand fundamental learning issues. Furthermore they execute some activities of the staff team but they are not involved in teaching activities and don't have responsibility on students' assessment.

7 Conclusion

The coordination of projects like the ones here presented is not very different of other projects with different teams to manage, limited resources and time. Project management of these types of projects faces challenges that overcome the traditional teacher role. Thus, teachers that want to embrace this type of project have to be prepared for this.

Characterization of team management and communication management in these project oriented learning initiatives allowed the identification of different roles for staff stakeholders. Interdisciplinary projects for a whole semester need a coordination based on a real team spirit. Clarification of these roles and sharing them between

coordination team's members help feeling the project from different angles, and to share responsibilities and decisions. Sharing responsibilities and decisions help to interact with commitment and to achieve higher interdisciplinarity. Building a characterization of time management activities for project oriented learning initiatives can help coordination teams to identify and develop time management processes. These processes should help staff to keep the project under control. Among these there are several main processes that can be classified in learning facilitator activities, organization activities and communication activities.

PMI (2004) presented several project management knowledge area processes that can help project managers to select, develop and execute adequate processes for each project. Nevertheless, the project lifecycle for a specific domain is not known a priori and can be different for each team or project manager. Based on four cases of interdisciplinary project oriented learning initiatives it was built a project lifecycle for this kind of projects. This project lifecycle includes five phases with different durations and capacity demand that can be adapted for each project instance: preparation; setup; start-up; execution; end.

This framework allowed clarifying and formalising project management life cycle processes of these similar learning project approaches. This can be used for re-evaluation and reorganization purposes of these approaches. Furthermore, it can be used for new project approaches as a possible way to manage processes. It is now clarified where human resources are used during project management processes, what are the main types of activities developed and also what are the interactions between successive phases of the project life cycle.

Valuable inputs for management of this type of learning projects could be done in several domains: team building; information management; communication management; risk management; etc. It is now commonly accepted that people can make management decisions to be highly effective or to fail. So, understanding teams that perform well and trying to build organization models based on those cases is one way to develop this area. Furthermore, investing time on augmenting the effectiveness of management teams could help to get better learning results with less staff effort. This could be done based on improved processes of information and communication management and also on reducing risks.

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Monitoring Active Learning in Engineering Education using Classroom Observation: a Case Study

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Abstract

The paper reports on work in progress in a project centred on the adoption and dissemination of good practice with regard to Active Learning in engineering education at institutional and inter-institutional level in Portugal. The development and implementation of a classroom observation tool that facilitates the introduction of Active Learning techniques in lecture classes are described. This is achieved through the development of a semi-quantitative Learner Activity Monitor Matrix (LAMM) and a methodology that assists faculty professional development.

Keywords: active learning; classroom observation; semi-quantitative matrix; learner participation.

1 Introduction

The aims of the project are centred on the adoption and dissemination in engineering education at institutional and inter-institutional level in Portugal of good practice with regard to Active Learning (AL). It is aimed to achieve this over a three-year project lifetime through a two-phase strategy:

i) Initial implementation of AL techniques in formal teaching contexts at departmental level in an engineering college through the use of self and peer observation using a semi-quantitative tool Learner Activity Monitor Matrix (LAMM).

ii) Subsequent dissemination of the approach using Community of Practice (CoP) cultivation strategies and Web 2.0 tools.

Since the appearance in 1988 of Felder's paper on Learning and Teaching Styles in Engineering Education (Felder et al 1988) which concluded that there was a mismatch between most engineering education and the learning styles of most engineering students, there has been an increasing interest in developing teaching techniques to address all learning styles with a particular emphasis on the importance of active learning supported by pedagogies of engagement, often involving a cooperative or problem-based approach, with the aim of improving the outcome of Engineering Education in Europe, the US and Asia. Examples can be found at subject level such as Krezel and Pocknee's work with project-based learning on a first year Civil Engineering course and Braga's (Krezel & Pocknee, 2004; Braga, 2002) use of computer-enhanced learning to study Heat-Transfer on a Mechanical Engineering course. Vos describes the implementation of active learning organisation at departmental level in the area of Electrical Engineering at the University of Twente (Vos, 2006) while De Graaff et al have described a variety of applications in engineering courses at Delft (Graaff, 2006). Other institutions have implemented an active learning approach at a broader curriculum level: INSA-Lyon (Freud et al, 2004) offers a two-year curriculum in Technology Science and Innovation using active learning while the Amsterdam University of Professional Education provides a competency-based program leading to a primary degree in Engineering Design and Education in the belief this approach leads to active-learning and will produce technical engineers better equipped to meet the needs of industrial enterprises (Schat-Zeckendorf, 2004).

Simultaneously to these developments, as the implementation of the Bologna Process in European Higher Education requires higher education courses to accommodate competence-based and learner-centred curricula, for those involved in engineering education in Portugal this would seem to present an ideal opportunity to ally the competence-based and active and cooperative learning approaches being developed in engineering education at international level with the general philosophy of Bologna and the associated Tuning Methodology for developing

and assessing learner competences in the European context. The Tuning Methodology has been developed at European level to establish reference points for common curricula on the basis of agreed competences and learning outcomes. This approach considered two broad types of competence: generic and subject-specific and attempted to identify such competences across the higher education curriculum. From 2000 to 2004, nine subject areas were studied, including Chemistry, Physics, Earth Sciences and Maths and subject specific competences were presented for each. As the implementation of the Bologna Process in European Higher Education over the next four years will require higher education courses to accommodate competence-based and learner - centred curricula, this would seem to present a good opportunity to ally the competence-based and active learning approaches being developed in Engineering Education with the philosophy of Bologna and the Tuning Methodology.

At institutional level, high failure and drop-out rates for students on engineering courses have been a matter of concern for many Portuguese higher education institutions as evidenced from external evaluations carried out by the European University Association and internal quality reports compiled by institutions.

Felder carried out a longitudinal study following the effect of active and cooperative techniques designed to address a broad spectrum of learning styles on a cohort of students over 5 semesters (Felder et al, 1998) and found that an experimental group using these techniques in chemical engineering subjects outperformed a comparison group on a number of measures, including retention and graduation, and many more of the graduates in this group chose to pursue advanced study in field. He also notes that academic performance in other course subjects was better in the groups studied. A study by Ramirez and Velasques at the Univ. of Puerto Rico also found significantly higher academic grades were earned in cooperatively taught offerings (Morell de Ramirez & Velazquez, 1996) while Paulson claims the overall pass rate in organic chemistry classes using these techniques was 20-30% higher than those in the traditional lecture model (Paulson, 1999). Various authors have described studies which show the effectiveness of active and cooperative learning in engineering education as an important element of course design in encouraging engagement of undergraduate students and contributing to active learning (Paulson, 1999; Johnson et al, 1991).

The majority of engineering lecturers have not had specific training in Education Sciences and the provision of “pedagogical training” is often mooted as a way to tackle perceived skill gaps in this area. Such training typically takes the form of short-duration workshops run by staff from educational rather than engineering fields and in many cases may not lead to significant change in the faculty practice at the “coalface” of the lecture hall/classroom/laboratory or in course design.

Furthermore, many lecturers, although keen to improve their teaching do not feel completely comfortable with the language and concepts of pedagogy and this may lead them to put their faith in technological solutions (e.g. e-learning platforms) rather than analyzing the learning process itself and adopting approaches which have grown out of the considerable body of work related to the Scholarship of Teaching and Learning in Engineering Education. To date there has been relatively little work in this field in the context of Portuguese engineering education and most teaching tends to follow a fairly traditional knowledge transmission model in which the role of the learner is largely that of passive receptor.

Although there is no published work to date demonstrating the value of these techniques within the specific context of Portuguese engineering education, given the existence of a large and credible body of research, including longitudinal and meta-studies, showing the value of AL techniques in engineering education in other countries, particularly in the US (Springer et al, 1998; Felder et al, 1998; Prince, 2004; Paulson, 1999), we believe one can be confident of the qualitative benefits of employing these techniques in the Portuguese context.

The overall objectives were twofold:

- to motivate engineering faculty to introduce established AL techniques in their lectures (“theory classes” in the Portuguese system) over a three-year period;
- to cultivate a community of practice approach which will encourage the dissemination and development of this approach at institutional level and beyond.

The research question addressed in the present paper is: can the application of AL strategies place students in an active role in lecture-type classes in the Portuguese engineering education context?

2 Methodology

2.1 Active learning

> "*Learning is not a spectator sport. Students do not learn much just sitting in classes listening to teachers, memorizing prepackaged assignments, and spitting out answers. They must talk about what they are learning, write reflectively about it, relate it to past experiences, and apply it to their daily lives. They must make what they learn part of themselves*." (Chickering & Gamson, 1987).

To quote Christensen et al. in *Education for Judgment* (Christensen et al, 1991) "To teach is to engage students in learning." and our intention in this work was to help ourselves and our colleagues to develop our practice of pedagogies of engagement by applying AL techniques in our teaching. It should be said that it is not our aim to attempt to demonstrate unequivocally that AL techniques are as beneficial in the Portuguese engineering education context as they have been shown to be internationally, because the generation of valid, credible data on this aspect would imply a timescale, number of participating students and scale of project we are not in a position to undertake at this stage.

Active Learning has been defined as any strategy "that involves students in doing things and thinking about the things they are doing" (Chickering & Gamson, 1987) and this broad definition can be taken to include a very wide range of teaching and learning activities including collaborative and problem-based learning.

In this work, however, we follow Paulson (Paulson, 1999) in using the term more narrowly to refer to a number of techniques that can be incorporated in the lecture context so as to give students a more active role in their learning process.

We set out to introduce AL methods via a core group of lecturers, mostly new to this approach, who are teaching students at the Barreiro School of Engineering.

Assuming that engineering staff are often more comfortable with quantifiable results and a pragmatic approach, rather than one involving an immersion in unfamiliar education science theory, we have been developing a simple semi-quantitative tool, the LAMM, which uses in-classroom observation or post-class video observation to monitor the degree of student activity before and after the implementation of Active and Collaborative Learning techniques in their classes. This allows an individual lecturer or team to focus on the question of learner activity during class contact time and develop efficient techniques to increase it.

The academic year 2006-07 was the first year in which new ministry-approved Bologna Process courses were run in Portuguese higher education institutions. For the authors, involved in engineering education in Portugal, the general philosophy of Bologna presented an ideal opportunity to ally the competence-based and active and cooperative learning approaches.

In the teaching of engineering in Portugal, the classes are traditionally classified into theoretical and practical. The theoretical classes are devoted to transmission of the concepts needed to solve problems students will work on in practical classes. Thus, the lectures are often essentially expository with students in a passive role.

However, this approach suffers from some weaknesses. The duration of the theoretical class, the amount of new information that is presented by the teacher and the gap that exists between lecture and practice, compounded by the existence of content taught in other curriculum units, all contribute to students arriving at practical classes without the competences or practical grounding in the material necessary for autonomous work. So, the methodology and the objectives of the practical class are undermined as well as the learning, and this in turn is reflected in high failure and attrition rates.

One way to combat the above problem is through the application of Active Learning methodologies. The application of active learning in the classroom encourages student engagement through greater involvement in what is being taught.

Thus, the first year of the project has involved using self and peer observation of lectures to allow each participating lecturer in the pilot group (5 in all) to first of all establish a baseline level for the Learner Activity Index of students in his/her subject curriculum unit initially and then introduce tried and tested AL techniques with the intention of increasing levels of learner activity and participation. The in-class activities were adapted from those in two online activity banks (Paulson & Faust, 2008; Felder & Brent, 2006) containing around 30 different activities found to be useful in engineering courses in the United States, and included the following: Jig-saw

reading texts; Revision puzzles; In-Class Teams; Think-Pair-Share; Minute paper; Regular uses of students' names; The "One Minute Paper"; Muddiest (or Clearest) Point; Affective Response; Clarification Pauses; Wait Time; Discussion; show of hands voting; active review sessions, and student revision lists.

After one semester of activity we invited Richard Felder and Rebecca Brent to run a one and a half day workshop on AL techniques and effective teaching. This had 65 attendees including the focus group members and other faculty from ESTBarreiro and ISEL. The group is now starting its second year of this work that aims to build on this experience by involving more faculties at the original participating college and two other local Portuguese engineering colleges who have expressed interest in participating. In the final year we expect to broaden our community of practitioners to include more distant participants at national and international level. During the first year we have been operating our online community spaces in Portuguese but expect to evolve to a bilingual English-Portuguese environment at a later stage to facilitate international participation

2.2 ICT tools

The project team has used web-based video-conferencing and Web 2.0 tools for knowledge sharing and community building within the research team itself and this aspect is expected to be of increasing importance in collaboration with the dissemination partners in the later stages of the three-year project. To date the following ICT tools have been employed:

- video recording of lectures to a dedicated server followed by their analysis to determine Learner Activity Indices and Participation Parameters during the introduction of ACL techniques;
- use of a proprietary browser-based videoconferencing tool (Moonlight Conference) for synchronous meetings between faculty in the participating colleges;
- use of online groups (Google Groups) and wikis (pkWiki) for faculty Knowledge Sharing.

2.3 Development of the LAMM observation tool

The LAMM is a matrix (see next figures) that aims to allow an observer to register the behaviour of the majority of students (75%) of learners) present in the lecture into one of 7 categories on 2 minute intervals. The categories recorded and their relative weightings chosen are: all listening to lecturer or to another student (1); individual work (2); checking answers (2); pair-work (3); group-work (3); distracted or other non-classified behaviour (0).

LAMM

LAMM – Learner Activity Monitoring Matrix

Date: **Room:**
Class and Course:
Lecturer:
Timetable:
Observer:
Location: ESTBarreiro ISEL

Mins	Listening to lecturer or other student	Resolving exercises/problems (individual)	Checking/comparing answers	Pair discussion or other pair-work	Group work (x2)	Distracted	Other	Nº students
2						X		25
4	X							25
6	X							26
8		X						26
10		X						26
12			X					26
14			X					26
16				X				26
18				X				26
20	X							26
22	X							26
24	X							26
26	X							26
28	X							27
30	X							27
32	X							27
34	X							27
36		X						27
38		X						27
40			X					27
42				X				27
44				X				27
46			X					27
48					X			27
50					X			27
52					X			27
54					X			27
56		X						27
58		X						27
60		X						27
Weight	1	2	2	3	3	0	?	

Activity Index = 10x1 + 7x2 + 4x2 + 4x3 +4x3+ 1x0 = 56

Figure 1: Sample Learner Activity Monitoring Matrix for active learning activities class. Activity Index determination.

The higher weighting for collaborative activities reflects the evidence that suggests that peer learning results in higher learning gains and retention (Hake, 1998; MacManaway, 1970).

The Activity Index for a 1-hour portion of a lesson is calculated on the basis of these weightings. The observations cover the first 60 minutes of a scheduled lecture class, irrespective of the actual length of the class (usually 1.5 or 2 hours). An Activity Index is calculated by assigning a weighting of 1 to passive listening, 2 to individual work and 3 to pair or group work. Thus thirty recordings are made in each LAMM as shown in Figure 1. Consequently, Activity Index values of 30, 60 e 90 would represent exclusively listening, individual activity and group activity respectively.

In addition to the learner activity index calculation the LAMM has also been adapted to capture data on learner question and answer which is reflected in a Participation Parameter (included in Figure 2); this is calculated by registering:

- spontaneous learner questions/contributions (weighting of 1);
- group/class response to lecturer question (0.5);
- individually elicited student response (1).

LAMM

Participation Parameter

X - spontaneous learner contribution	Y - learners respond to individualised question from lecturer	Z - learners respond to whole-class question from lecturer
I	I	I
I	I	I
I	I	I
I	I	I
I		I
I		I
I		
I		
I		

PP = X +Y +Z x 0,5 = 9 + 4 + 6x0,5 = 16

Figure 2: Sample Learner Activity Monitoring Matrix for active learning activities class. Participation Parameter determination.

3 Activity Implementation and Results

3.1 Implementation

The active learning methodologies implementation described here were implemented in a Construction Processes I curriculum unit (4 hours per week). This is a one-semester subject of the second year degree course leading to a Portuguese B Eng in Civil Engineering.

Several in-class activities from two online activity banks (Paulson & Faust, 2007; Felder & Brent, 2007) containing around 30 different activities found to be useful in engineering courses in the United States, were adapted for use in this curriculum unit. From these lists a few activities were selected to be used in a variety of course contents, namely: In-Class Teams; Think-Pair-Share; Minute paper; Regular uses of students' names; Muddiest (or Clearest)

Point; Affective Response; Clarification Pauses; Wait Time; Discussion; show of hands voting; active review sessions, and student revision lists.

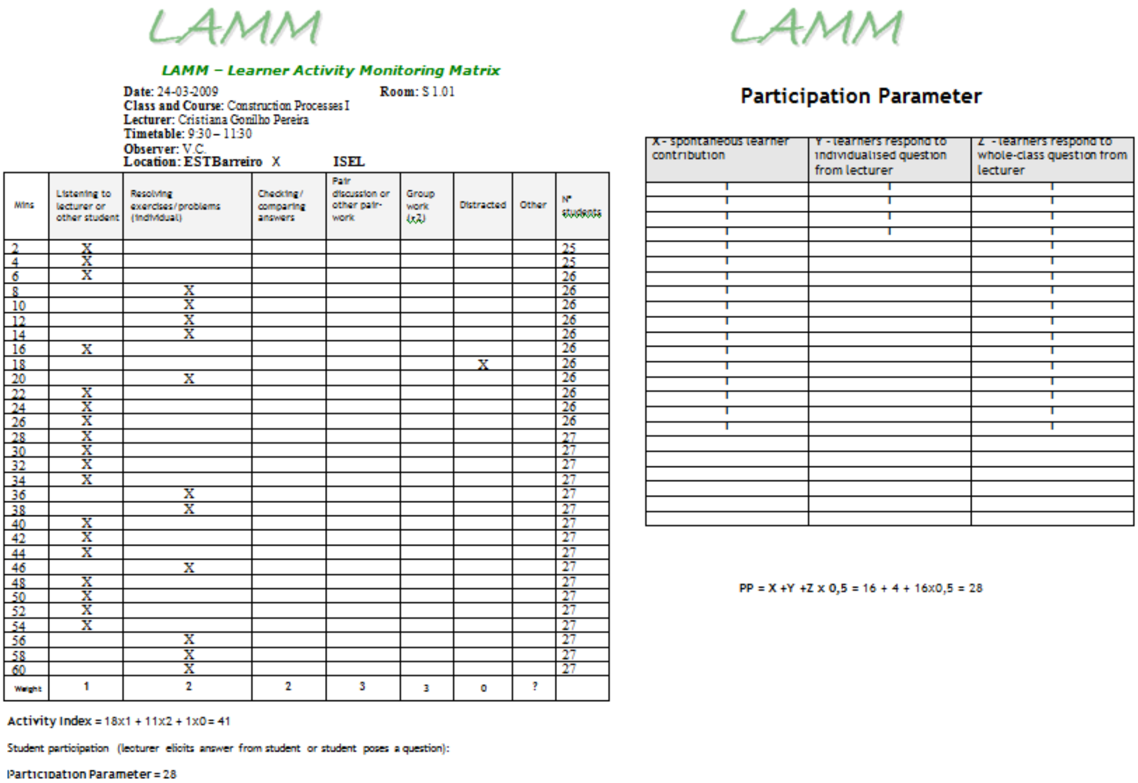
Following Felder's recommendation to "go for variety" (Felder & Brent, 2003) was the strategy adopted of interspersing more traditional exposition with a number of short learner activities, answering questions, solving problems, brainstorming, etc. and bearing in mind his maxim that "mixing things up keeps active learning from becoming as stale as straight lecturing" these normally represented an activity duration of 10 seconds to 2 minutes with interval between activities of 1 to15 minutes and working unit varying from 1 to 4 students. In practice, the instructor's perception was that the use of "In-Class Teams" became predictable and not attractive for students and concluded that the implementation of group activities with duration higher than 5 minutes became fructiferous.

Two classes were observed: Class 1 and Class 2, and the same activities were implemented in each one as shown in Table 1.

Table 1: Activities implemented in classroom

Activity Id.	Activity description
1	The assignment for the 2 hour class was to prepare two 15 minutes presentation about two topics. The students worked in groups of 3-4. The lecturer supervised all the working groups.
2	Supported by a PowerPoint presentation presented to the entire class, the students were asked to answer/solve different type of exercises during a two hour class, while the lecturer was explaining theoretical contents. Minute paper; Regular uses of students' names; Clarification Pauses; Wait Time; Discussion; and student revision lists activities were used with duration of 1-5 minutes.
3	The assignment for the 2 hour class was to, based on the lecturing material, fulfill a worksheet related to the topic under analysis. The best answers to each question were chosen among the different worksheets. The students worked in group of 3-4 elements. The lecturer was supervising the working groups.

Besides the teacher's perception related to the structured use of in-class AL, the effectiveness of the implementation and use of the techniques was monitored using the Learning Activity Monitor Matrix (LAMM) (Figure 3), as shown in Table 2 for both classes.


LAMM

LAMM – Learner Activity Monitoring Matrix

Date: 24-03-2009 Room: S 1.01
Class and Course: Construction Processes I
Lecturer: Cristiana Gonilho Pereira
Timetable: 9:30 – 11:30
Observer: V.C.
Location: ESTBarreiro X ISEL

Mins	Listening to lecturer or other student	Resolving exercises/problems (individual)	Checking/ comparing answers	Pair discussion or other pair-work	Group work (x2)	Distracted	Other	Nº students
2	X							25
4	X							25
6	X							26
8		X						26
10		X						26
12		X						26
14		X						26
16	X							26
18						X		26
20		X						26
22	X							26
24	X							26
26	X							26
28	X							27
30	X							27
32	X							27
34	X							27
36		X						27
38		X						27
40	X							27
42	X							27
44	X							27
46		X						27
48	X							27
50	X							27
52	X							27
54	X							27
56		X						27
58		X						27
60		X						27
Weight	1	2	2	3	3	0	?	

Activity Index = 18x1 + 11x2 + 1x0= 41

Student participation (lecturer elicits answer from student or student poses a question):

Participation Parameter = 28

LAMM

Participation Parameter

X - spontaneous learner contribution	Y - learners respond to individualised question from lecturer	Z - learners respond to whole-class question from lecturer

PP = X +Y +Z x 0,5 = 16 + 4 + 16x0,5 = 28

Figure 2: Learner Activity Monitoring Matrix of an observed class

Table 2 shows the Activity Index and Participation Parameter for 1 lecturer teaching the Construction Processes I curriculum unit over a period of three weeks. Ten classes were observed and different AL activities were

incorporated in order to identify if the LAMM, namely through the Activity Index and Participation Parameter, is representative of the activities developed in classroom.

Table 2: Activity Index and Participation Parameter of the observed classes

					Activity Index								**Participation Parameter**			
Class activities	Date	Time table	Class	N.º Students	Listening to lecturer or other student [min]	Resolving exercises/problems (individual) [min]	Checking/comparing answers [min]	Pair discussion or other pair-work [min]	Group work (>2) [min]	Distracted [min]	Other [min]	**AI**	Spontaneous learner contribution	Learners respond to individualized question from lecturer	Learners respond to whole-class question from lecturer	**PP**
1	10-Mar	9:30-11:30	1	24	12	0	0	0	48	0	0	**78**	2	5	6	**10**
	10-Mar	11:30-13:30	2	22	6	0	0	0	54	0	0	**84**	1	0	7	**5**
	11-Mar	8:30-10:30	2	15	4	0	0	0	54	2	0	**86**	0	9	0	**9**
	11-Mar	10:30-12:30	1	34	6	0	0	0	50	4	0	**81**	0	3	0	**3**
2	24-Mar	9:30-11:30	1	26	36	22	0	0	0	2	0	**41**	8	4	16	**20**
	24-Mar	11:30-13:30	2	22	42	18	0	0	0	0	0	**39**	6	16	8	**26**
	31-Mar	9:30-11:30	1	24	44	12	0	0	0	4	0	**34**	7	14	17	**30**
	31-Mar	11:30-13:30	2	20	52	8	0	0	0	0	0	**34**	16	12	21	**39**
3	1-Abr	8:30-10:30	2	13	2	0	0	0	54	4	0	**88**	9	0	3	**11**
	1-Abr	10:30-12:30	1	25	0	0	0	0	54	6	0	**81**	12	0	0	**12**

As can be concluded through the analysis of Table 2, despite the class and the number of students in class, activities involving group work for long periods present an Active Index higher than 80, namely for activity 1 and 3. On contrary, classes involving: Minute paper; Regular uses of students' names; Clarification Pauses; Wait Time; Discussion; among others, with duration of 1-5 minutes (activity 2) promote the students participation and the Participation Parameter increases to values around 30.

From the results obtained when the LAMM is used by different observers (Table 3), it can be concluded that different AI and PP may be obtained. In the same class, when two observers were registering the activities of the majority of the learners, a difference of 3 and 5% was obtained on the AI. In the case of the PP, there was also broad agreement between the observers.

Table 3: Influence of the observer on the LAMM results

Observer	Class	Date	Time table	N.º Students	Activity Index	Participation Parameter			
					AI	Spontaneous learner contribution	Learners respond to individualized question from lecturer	Leraners respond to whole-class question from lecturer	PP
VC	1	10-Mar	9:30-11:30	24	**78**	2	5	6	**10**
RC	1	10-Mar	9:30-11:30	24	**76**	2	7	7	**13**
VC	2	10-Mar	11:30-13:30	22	**84**	1	-	7	**5**
RC	2	10-Mar	11:30-13:30	22	**80**	1	1	6	**5**

4 Conclusions

The initial results presented for the use of Active Learning techniques in lecture classes of a curriculum unit in the second year of a civil engineering degree, show that this implementation brought about an increase in student engagement as measured by the LAMM semi-quantitative observation system.

The LAMM results are representative of the AL techniques used in classroom and the preliminary results suggest the data obtained are repeatable.

The LAMM observation system is currently in the process of validation to establish the consistency of Activity Index and Participation Parameters determination and to what extent it can distinguish between traditional and Active Learning centred teaching. The preliminary results reported here suggest that it could represent a fruitful line of development to support engineering faculty members involved in the introduction of innovative pedagogical practice within a traditional lecture-based structure.

Acknowledgments

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Improving Teamwork in a First Year Interdisciplinary Project

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Abstract

Engineering market needs are demanding for professionals able to integrate interdisciplinary teams. Being an agent or even leading these teams requires the demonstration of a different set of competencies including interpersonal communication, conflict management and time management. Furthermore, team members must anticipate teammates' needs, show commitment with team objectives, and to be reliable for assuring conclusion of tasks. Learning Engineering through interdisciplinary project approaches is one way to develop this set of competencies. Dealing with an open project puts students in a context where they have to develop those competencies to deliver project's desired results. Behind this context, usually, there are no explicit activities or instruments to develop teamwork competencies. This communication presents a workshop created with the objective to develop these competencies and the related evaluation results.

Keywords: teamwork; interdisciplinary project approaches; project-led education; engineering education.

1 Introduction

The implementation of the Bologna Declaration in Portugal has put in motion a deep reorganization in Higher Education, both in curricula and in teaching/learning models and practices. Subsequently there is a change of paradigm: the teaching one is replaced by the learning one, introducing active and participative methodologies in the teaching / learning process, in order to make it more meaningful for the students. The project approach in engineering education is one possible answer to these challenges. The methodology inherent to the Project-Led Education (PLE) aims, according to Powell & Weenk (2003), is the development of transversal competencies and it also requires to master technical competencies in each curriculum unit supporting the project. Later on both can be transferred and applied to the professional context. This is an active and collaborative learning methodology which can improve the efficiency and effectiveness of the teaching / learning process in direct articulation between theory and practice through a project that culminates in the presentation of a solution or product based on real-life situations. This is appropriate to the learning process in the perspective of Bologna process based on an active pedagogy focused on students and on the acquisition of competencies that stimulate the student-learner to question, to research, to explore.

Interdisciplinary open projects allow the materialization of a set of activities related to management and planning which only make sense in group. The project complexity requires an intense and prolonged contact: "Students teamwork in PLE will probably occupy something like 40 to 50 per cent of the student learning activity" - Powell & Weenk (2003, p. 33). This methodology also ensures the development of several transversal competencies related with teamwork such as project management, autonomy, and interpersonal communication. Mastering all these competencies increases the match between training and labour market needs - Mesquita *et al.* (2008) - increasing the quality of the processes of teaching / learning of engineering.

Over the past four years the Integrated Master's Degree of Industrial Engineering and Management (IEM) has been concentrating efforts and resources in the implementation of interdisciplinary project approach processes focused on the PLE methodology presented by Powell & Weenk (2003). PLE emphasis on teamwork promotes the constitution of different groups, each one monitored by a tutor and accompanied by the whole coordination team. Thus it is essential to assure the good functioning of the different teams in order to also assure the quality of the learning process. So there is an emergent need to answer to this challenge through the implementation of strategies, activities and tools contextually designed and built. The evaluation of the consecutive PLE editions allowed us to understand the significance of teamwork in the teaching/learning process - Lima *et al.* (2007), Fernandes *et al.* (2008).

Teamwork is a sensitive aspect of the whole process due to the PLE own dynamic and inherent conflicts: the management of interpersonal relationships, divergent ideas, opinions and attitudes, different schedules and priorities, need to establish consensus, and so on. The search for mechanisms which guarantee an efficient and effectiveness functioning is a way of promoting the development of a project of high quality. Consequently teamwork underlines a continuous interaction among the members of the team and their combined involvement in tasks, purposes, knowledge and goals of the project, makes learning process more active and cooperative.

The Project Led Education 2007/2008 process in the first year of the integrated Master's Degree of Industrial Engineering and Management allowed developing an intensive study regarding the teamwork in a learning project environment. Developing competencies of teamwork is one of the PLE main objectives, so it is important to understand the influence of the dynamics and practices of teamwork both in learning process and in 'transversal competencies' development intentionally enhanced by this approach. In this sense, there was an opportunity to create a learning support structure aiming to fulfil the needs experienced by the working groups in order to ensure the development of a range of learning competencies directly related to teamwork and project management. With the implementation of this structure, denominated Workshop TECO, it was intended to ensure a process of continuous training with regard to working in teams. Furthermore there was also the intention to contribute for the development of additional transversal competencies related to project approach practice, namely: collecting and processing information, creativity development, problem solving, interpersonal communication, conflict management and project management. The focus of interest in implementing the workshop is primarily to promote the effectiveness and efficiency of performance of the working groups in this process of active and collaborative learning. This communication will describe some of the fundamental aspects of the Workshop TECO, presenting an evaluation of teamwork learning results.

2 Improving Teamwork

In the context of the IEM 2007/08 first year PLE a set of six teams of 5 to 7 students each developed a proposal of a battery for electrical cars and the correspondent production system. This result was based on four project support courses that contributed in a multi and interdisciplinary way for project contents and students' technical competencies development. Students' teams worked together for a whole semester developing this project. This requires a direct, flexible and constant support to students based on an open communication environment. The previously referred Workshop TECO promoted the development of a set of actions under the learning dynamics of PLE towards the students and the students' teams. The implementation of this workshop has been based on three interconnected components: Teamwork Guide; Training activities and tools to support Project Management. These interconnected components can be summarised by the following items:

- Activities to show up to the students the importance of working together for the development of several transversal competences important to Industrial Engineering and Management profession. This was the main objective of the following actions: the development of a training session about teamwork in the first week; implementation of a Teamwork Guide with each team; analysis of a graph which reflects the transversal competences required by the employers in Industrial Engineering and Management area.
- To minimize problems developed in a teamwork context there were created two support sessions with each group, to identify their strengths and weaknesses. So, the teams reflected on their own performance, improving their identity during the process.
- The importance of the communication was emphasized by the teams in a meeting in the middle of the process. The feedback given by teachers and tutors was essential for the improvement of team performance. The quality of communication inside each team depends on their dynamics because there are teams that worked internally better than others. It was found that the quality of this communication is conditioned by a set of variables: geographical location, leading to unavailability and incompatibility of schedules. We observed that we have to give more emphasis on improvement of communication processes.
- Team performance was evaluated during the process, to perceive their needs, which helped to establish a team profile and to identify the dimensions to improve and the dimensions already consolidated.

3 Findings

Implementation of TECO workshop allowed the identification of some variables affecting the dynamics and practices of teamwork. These variables are directly linked with issues of organization of PLE processes, including

the theme and the role of curriculum units, the tutorial moments and the assessment. Furthermore, participation, involvement and interaction of the students at all stages of the process are perceived as highly important to achieve good learning results within this learning methodology.

The outcomes of the first edition of the workshop helped driving some interesting conclusions and even proposing some changes to future editions of the workshop TECO, increasing its relevance in the context of continuous improvement of PLE processes:

a) Promoting an intervention based on Project Management concepts with time management tools, communication and internal organization of the teams.
b) Assigning tutors a more active role with teamwork tools, according to the characteristics of the students' team.
c) Seeking strategies to encourage participation, involvement and interaction of the teams in the activities established.

The main objective for future editions will be consolidating Workshop TECO, giving it a lighter structure. The evolution of the concept of the workshop could increase the participation of the tutor in the process of developing teamwork competencies. In this intervention tutor will have training sessions with the group of students, focused on six attributes that clearly influence the dynamics and practices, determining the degree of an effective teamwork: (1) commitment, (2) interdependence, (3) interpersonal skills, (4) open communication and positive feedback, (5) appropriate team composition, and (6) commitment to team processes, leadership and accountability.

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The Different Roles of the Tutor in Design-based Learning

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Abstract

Design-based Learning (DBL) is the educational approach within the Eindhoven University of Technology (TU/e) (Wijnen, 2000) in which students work co-operatively and actively on multidisciplinary design projects guided by a tutor. In DBL the role of the tutor is essential as a facilitator of the learning process, as well as a subject matter specialist or as an assessor. However, the involvement of the tutor in supporting students depends not only on the character of the DBL projects but also on the level of competencies to be reached in each specific year of the Bachelor's program. This paper describes the experiences with the role of the tutor in Design-based Learning within the Mechanical Engineering department at TU/e. Throughout the paper the differences in the tutor's role are analyzed according to the nature of the students' group work. Conclusions on the ideal role for the tutor suitable for the Mechanical Engineering education are presented.

Keywords: design-based learning; role of the tutor; project work; collaborative learning.

1 Introduction

1.1 Problem-based Learning/Project-based Learning (PBL) and Design-based Learning (DBL): differences and similarities

PBL started in 1969 at McMaster University in Canada for the study of medicine. (Barrows, 1984). For already longer than four and three decades respectively PBL has been the educational model at Aalborg University in Denmark and Maastricht University in the Netherlands (Kolmos, 2006; Moust, van Berkel & Schmidt, 2005). This model has been successfully integrated in many educational programs i.e. Medicine, Law, Economics, Psychology, Sciences, and Liberal Arts with to certain extend adaptations in each program, such as incorporation of the element of project work in the domain of sciences. The positive experiences of PBL have been the starting point for Eindhoven University of Technology to adapt this concept to fit the engineering education which has a primary function on design.

Since 1997 Design-based Learning has become a crucial element of the educational philosophy within Eindhoven University of Technology. DBL has been introduced with the overall aim of improving quality of education. In order to achieve such a goal DBL is at the front of the curriculum change to provide educational programs with a more competence-based orientation; to strengthen the relation between education and research; to increase the coherence within the TU/e; and ultimately, to modernize the technical systems (Wijnen, 2000).

The underlying educational foundation of problem-based learning (PBL) and project-based learning inspired by the Universities of Aalborg and Maastricht was molded to give a particular flavor to the TU/e context. In doing so, a number of initiatives took place. With the support of experts from Maastricht University and by carrying out field visits to Aalborg University to broaden the scope, the DBL got finally its form. In this sense, the PBL model has gone through a transformation process to serve, therefore, the purposes of the engineering education which has a clear focus on design. The PBL objectives i.e. acquisition of knowledge and skills to be retrieved in the working place and the acquisition of problem-solving skills to be used in a professional setting (Perrenet, Bouhuijs & Smits, 2000) are to be found in the TU/e objectives as well. However, the pure PBL model has been tailor-made to meet the specific academic engineering profile of the Mechanical Engineering department. The PBL original concept was adapted into a DBL strategy to align the curriculum with the innovation trends in higher education towards a more collaborative and self-directed learning educational model. DBL became for the Mechanical Engineering department the educational concept with a strong emphasis on developing technical and scientific knowledge; on

acquiring abilities to conceive models and to solve multidisciplinary problems; and, to work in teams as well (Perrenet, Bouhuijs & Smits, 2000).

Although there has been substantial literature written on the similarities and differences between problem-based learning and project-based learning it becomes sometimes difficult to set the line to distinguish among one and another. These models are at times used in a combination and/or can play complementary roles. Differences can be blurred and can only be found in subtle variations based on the focus of the curriculum. Some of the similarities between PBL and the Danish project-based learning concept can be found in that both have similar characteristics i.e. problem orientation and interdisciplinary; open curriculum and experience-based learning; basic year and gradual specialization; and, work in groups (Kolmos, 1996).

One of the common elements to be easily recognized in PBL and project work is that they both have a strong accent in self-direction, collaboration and finally, in multi-disciplinary problem orientation. The emphasis lies on the learning process rather than in the teaching process. For both approaches the basic principle is to create authentic scenarios which mirror the real life and market situations aiming at reproducing the production activities by making use of the findings and ideas of the students to achieve the goals (http://pblmm.k12.ca.us/PBLGuide/PBL&PBL.htm). In all cases, the role of the tutor as a supervisor of the group activities is at the centre of this approach and his tasks are modified to respond to the processes, and complexity of demands in content expertise of problems and projects. These similarities can be found as well in DBL. However, the level of self-direction with project work is higher than with PBL since students have to manage their projects in terms of time and resources (Perrenet, Bouhuijs & Smits, 2000).

Essentially, the characteristics of PBL methodology, namely, the 'Seven Jump',(Moust, Bouhuijs & Schmidt, 1998, in Moust 2000), i.e. analyzing unclear terms and concepts; defining, consequently, the problem; brainstorming and carrying out a systematic analysis; formulating and executing, accordingly, own self-study assignments; and finally, reporting (see also next section), form the backbone of the PBL structure. These are also used, in an adapted formula, as the group working methodology of DBL. DBL makes a clear emphasis on the concept of design as a process in engineering education. In the PBL curriculum at Maastricht University, multidisciplinary courses take from six to eight weeks in which both subject-matter and skills are integrated around a central theme (Moust, van Berkel & Schmidt, 2005). Features particularly for design in DBL at the Mechanical Engineering department are analysis and synthesis with contributions from different disciplines, working in teams to create products, materials, processes, and systems.

When it comes to contextualize the DBL concept to Mechanical Engineering the alignment of DBL with the curriculum and the learning outcomes are one of the differences with PBL since DBL focuses on design, and more specifically, on engineering education. Another difference between project work groups and PBL groups is that the project groups (average eight students) are smaller than the PBL groups (average ten students)(Perrenet, Bouhuijs & Smits, 2000). The learning outcomes of DBL are based on a number of competence criteria designed for Bachelor's and Master Curricula by Meijers, van Overveld & Perrenet (2005). They define the features of a university graduate by seven areas of competence, namely: 1.Competent in one or more scientific disciplines; 2. Competent in doing research; 3. Competent in designing; 4. A scientific approach; 5. Basic intellectual skills; 5. Competent in co-operating and communicating; and finally, 6. Takes account of the temporal and social context. Within DBL most of the criteria for the areas of competence three and six and parts of the criteria in the other areas have to be reached. These are for example: the ability to integrate existing knowledge in a design; the ability to produce and execute a design plan; to have creative and synthetic skills with respect to a design problem; the ability to communicate in writing and verbally about the results of learning; the ability to work within an interdisciplinary team. Therefore, the character of the projects must also meet the six underlying educational DBL features: Professionalization; Activation; Co-operation; Creativity; Integration and Multidisciplinarity (Wijnen, 2000)

1.2 Position of DBL in the Mechanical Engineering curriculum

Design-based Learning has been specifically adjusted to meet the needs of the Mechanical Engineering curriculum. Analyzing, modelling, testing and application of project-related skills are the underpinning competencies for the mechanical engineering profile that students acquire in DBL projects.

A DBL project is a case study that takes from four to eight weeks which is often supported by different skills-training. In the first semester, for instance, students follow a training in how to work in a group (Moust, Bouhuijs & Schmidt, 1997), how to make a presentation and how to write a technical/academic report. But besides these process-skills they also get trained in different kinds of technical skills such as the basics of how to work with

different computer programs (Matlab, CAD, CAM, FEM) and other tools that they can choose to use to solve problems.

To develop a solid theoretical basis in the curriculum of the bachelors program of the Mechanical Engineering department students work for 60 percent of the time on courses. Parallel to the courses they work in groups of eight students on the DBL-projects for the other 40 percent of the time. Both the first and the second year have a total of 12 courses and eight DBL- projects, the structure of one semester is represented in Table 1. Some of the DBL-projects are programmed together with or directly after a related course, so students learn how to apply the knowledge they gained in the course in the practice of designing. But there are also projects that do not have directly related courses where students have to gain new knowledge to solve a design-problem.

Table 1: DBL in Mechanical Engineering curriculum

Semester			
Block		Block	
Course 1 (3 ECTS)		Course 1 (3 ECTS)	
Course 2 (3 ECTS)		Course 2 (3 ECTS)	
Course 3 (3 ECTS)		Course 3 (3 ECTS)	
DBL (3 ECTS)	DBL (3 ECTS)	DBL (3 ECTS)	DBL (3 ECTS)

The group composition in the first year of DBL remains the same for a whole semester. The students learn as a group how to work together (Belbin group dynamics). In the second year, students have to learn what their natural role is about and how they can balance this in a group. Likewise, they learn how to work in different groups. For example, a student who is a 'natural leader' will feel more comfortable in a group with hard workers only who listen to him rather than in a group where there are more students with the same type of character. The group composition changes in every project. The DBL group meetings take place twice a week. The duration of the meetings varies from two hours in the first year where they learn how to hold a meeting to one hour in the second year. The objective is to help the student to hold more efficient meetings.

The student and project guidance in DBL is divided in three stages. Firstly, there is a tutor who guides the group and supervises individually the student's progress against the achievement of the learning outcomes. Secondly, the project co-ordinator, who is the project owner, watches over the learning outcomes of the group. Lastly, there is for every year a year co-ordinator. The mission of the year co-ordinator is to assure that there is a balance between the projects. Among his tasks are to be mentioned: to guarantee the coordination among project co-ordinators, to arrange tutor trainings and tutor meetings and to solve problems with individual students and groups.

Though students go through the seven steps methodology (i.e. analyzing unclear terms and concepts; defining, consequently, the problem; brainstorming and carrying out a systematic analysis; formulating and executing, accordingly, own self-study assignments; and finally, reporting), there are some deviations of that planning steps model. While with PBL the learning activity begins with a problem and follows an inquiry model, the students within DBL follow a production model having in mind, as a starting point, a product. Students need to design the end product for which they also create a plan to manage the development of the project.

2 The role of the tutor in DBL at the Mechanical Engineering Department

There are two primary tasks for a tutor in DBL. Firstly, the responsibility of the tutor is to assure that the learning outcomes of the specific project as subset of the overall learning outcomes are being reached. Secondly, the tutor has a specific task as an assessor. The tutor holds the "assessor hat" for the individual assessment grades. This role is shared with the project co-ordinator who, eventually, grades the final product. The overall grade is composed of 50 percent for the deliverables (the same grade for all of the group members) and 50 percent for the group members individually. The group grades are given by the project co-ordinator and an individual grade is given by the tutor. However, it was identified that it will be almost unfeasible for a tutor to assess a student just by what (s)he shows during the DBL meetings. To solve this assessment problem a digital learning environment was created

by which students have to post their self-study outcomes. With this e-tool a tutor is able to judge the input and results of the individual students. In 2001 peer review was introduced within the DBL assessment set-up by which part of the individual grade is given by the students to each other. This was introduced as a respond to students' complaints on 'free-riders' within the group work (Visschers-Pleijers, Mulders & Van der Wouw 2001)

In the first year the students get a peer review training where they learn how to design assessment criteria, how to give constructive feedback and how to come up with an accurate grade. The individual assessment is done by peer review and it counts 25 percent of the individual grade. In the second year, peer review counts for 50 percent of the individual assessment. The three parts of the final grade are assessed by different parties, namely, the project co-ordinator, the tutor and the peer assessment system. In order to pass the DBL-project the grading of all three parties must be successfully passed. It is the task of the tutor to guide the peer review process, to create an open discussion about the collaboration in the group and to give constructive feedback to each of the group members not only after every meeting but also during the assessment procedure.

In addition to the two primary tasks already mentioned, it becomes essential to highlight that the tutor holds different roles in the three years of the Bachelor's program. The following roles can be defined:

- *The facilitator role:* the tutor is responsible for facilitating the learning process and assuring that it flows as expected. The tutor supports the group to reach a goal, to learn to work in teams and to help solve all problems encountered in the process so that the project goals can successfully be achieved. Encouraging communication during the process and creating a learning and reflective culture are some of the tasks of the facilitator.
- *The expert role:* the tutor provides content input where needed by asking motivating and challenging questions and by showing the students where they might find relevant literature.
- *The project manager role:* the tutor guides individual students and provides subject-matter input upon request of the student.

In the first year the role of the tutor takes a more process-oriented character since the complexity and level of difficulties of projects in the first years are less content demanding. The tutor embraces both the facilitator and the mentor role in coaching students in their new academic environment (Figure 1). To learn how to design students work on parts of the design cycle, namely, analyzing, modeling or testing and besides that they learn different basic skills in the skill trainings. The tutor, as a facilitator, supports students in the reflection of the application of knowledge into practical schemes. The tutors for the first year are the experienced (senior) tutors or Ph.D. students who themselves have studied following the DBL methodology. They are, therefore, acquainted with the DBL method, with the "ins-and-outs" of group problems, processes and assessment procedures.

It is also important to clarify that the tutor's role as a mentor must be seen completely separated from the tutor's role since the mentor tasks are related to the supervision and guidance in the study progress of the student. These tasks, therefore, must be regarded outside the boundaries of Design-based Learning. However, because the tutor and mentor in the first semester are the same person it influences the tutors' profile.

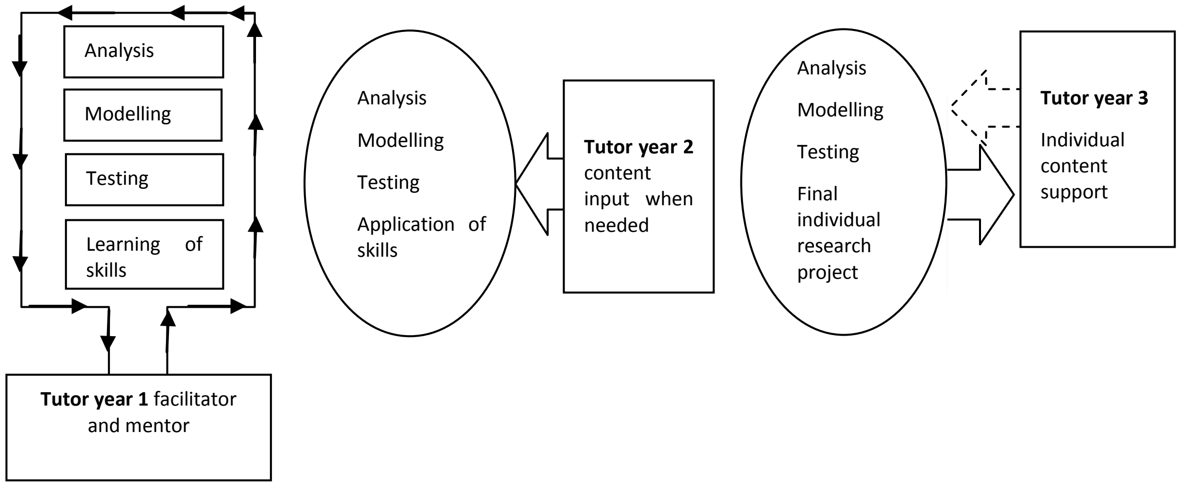

Figure 1: The tutor's role changes from facilitator and mentor to content expert and to project manager

In the second year, however, and due to the high demand in subject matter expertise the tutor holds "an expert hat" (Figure 1). In the project period students have to combine the competencies that they have learned in the

first year together with the expected learning outcomes determined for the second year. It requires a high level of application of both knowledge and skills. The different design steps are combined in one project and the skills learned in the first year can be applied. The tutor motivates students by asking questions and giving critical contributions. Furthermore, the tutor provides formative and summative input on the competences of the students related to the subject (i.e. analytical and critical skills; inventiveness; theoretical knowledge and practical skills) as well as to the process competences (i.e. role of group members) according to agreed upon criteria. During the second year the character of the DBL project requires the involvement of more content expertise. Therefore, tutors are those working in the same research group as the project co-ordinator, consequently, the tutors are Ph.D. students, post-docs, research assistants, and Master students who are specialized in the topic of the given DBL project.

On the contrary, in the third year of the Bachelor's program the tutor and the course co-ordinator are the same person and perform essentially the role of a project manager. DBL takes the form of a self-independent research project; the student has to apply in 'real-life' cases the analysis, modelling and testing phases in the design of a product. The student approaches the tutor for guidance whenever it is necessary. The tutor still holds the content expert role when requested but (s)he is not any longer the facilitator of the learning process (Figure 1). The student has already become a self- independent learner.

As it has been stated earlier, the tutor's role changes from facilitator of the learning process to content expert and to project manager. The experiences of DBL project implementation in the three years of the Bachelor's program have brought numerous lessons to be learned. These lessons will be described in section four. One of the aspects of these experiences is that the tutors' role must be accommodated to develop the specific competencies in each year Bachelor's program.

3 The Implicit Metacognitive Role of the Tutor

The DBL methodology applied by the Mechanical Engineering department accompanied by the different roles of the tutor in different moments has a clear objective to stimulate student learning. In this sense, the role of the tutor has another dimension when it comes to supporting students in learning to learn.

One of the primary tasks of the tutor is to guide and facilitate the process of learning to students by supporting them to integrate and apply the findings and information (Moust & Schmidt, 1994). Encouraging communication during the process and creating a learning and reflective culture are some of the tasks of the facilitator. The type of active learning strategies to support metacognitive processes are ample ranging from team working, self-study discussions, oral presentations, group-based concept map building, among others, which promote communication among peers and reflection on own experiences (Pascual & Uribe, 2006). The commonly use of guiding the students in this inquiry process and giving them the opportunity to re-orient themselves is by asking probing questions with the overall goal of challenging the students. Questions or 'nondirective comments' (Barrows, 1985; in Moust, 2000**)** such as "what do you think yourself about it? why do you think that it is fine like this?; or, does anybody have another opinion about it?" ; using suitable examples; or by confronting students with situations by playing the role of a devils advocate (Moust & Schmidt, 1994) are some possibilities used.

The underlying process factor engaged to the tutor's role in the first year at the Mechanical Engineering department is that the tutor act as catalyst of activating the learning environment in which the students need to produce knowledge. In this sense, their ability to use facilitation skills is a major feature in the quality of problem-based learning (Barrows, 1988, in Moust & Schmidt, 1994). In doing so, the tutor in the first year, as a facilitator, uses the Experiential Learning Cycle by David Kolb (Reese & Walkers, 2006) in an implicit manner. The experiential learning cycle is based on a four-step spiral (Figure 2) to help learners to gain insights in the learning process by reflecting on the four steps: experiencing, reflecting, generalizing and applying. The formula used by the tutor is based on asking questions to help student to go around the learning cycle to motivate their arguments instead of providing themselves the answers. The tutor might not follow the cycle in its original structure, however it uses it in such an adapted manner that allows the tutor to support students to learn. One of the ways to use it is that the tutor might go in several small loops and a number of times around the phases during group meetings so that students are supported to acquire self-directed skills since students learn how to analyze learning processes against learning outcomes, identify missing points to understand better concepts and topics, and, reflect on the processes in solving problems. By asking questions the tutor helps students to walk around the four phases. Likewise, the tutor facilitates the process of thinking about the problem statement, how the students can demonstrate that they have achieved the learning outcomes, but also, how they have learned and what they have learned during this process.

The tutor in the second year supervises that the knowledge of the topic is properly applied throughout the different phases of the project. Using the learning cycle the tutor adapts this model to inquire and assess how progress is being achieved and what results are reached becomes the priority of the tutor. Within the experiential learning cycle students operate more independently in the 'experiencing' and 'applying' parts while the expert tutor provides content support in the 'reflecting' and 'conceptualizing' parts of the cycle.

In the third year, however, the student has already become a self-independent learner, and (s)he is able to use the experiential learning cycle implicitly.

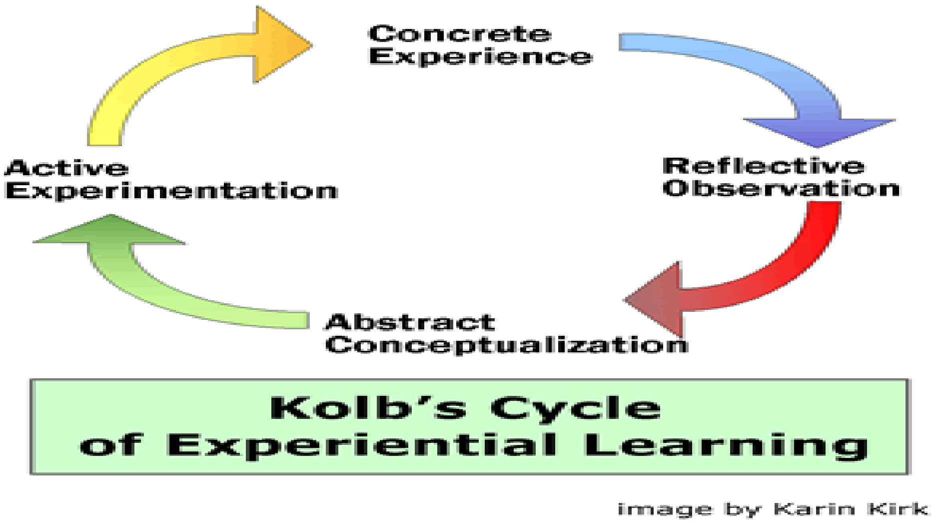

Figure 2: Experiential Learning Cycle (David Kolb)

The Experiential Learning Cycle provides a suitable platform to support learners to go through the experiences while undertaking the different steps of the design-based learning in group work. This model accompanied by the character of the seven step approach helps the student to go implicitly around the process of setting goals, selecting the appropriate strategy among a variety of possible choices; carrying out the planned scheme, and analyzing afterwards how the results of the implemented scheme went.

This brings also consequences for the need to design tailor-made training for the tutors according to the different levels of involvement either as a facilitator of the learning process, as a content expert and/or as an assessor. It is also important that students are aware of the change in the tutors' role.

The tutor training for the first year tutors is consisting of providing the tutor with the necessary skills to coach groups' meetings. In this sense, tutors become aware of their roles, i.e. expert, coach of the learning process, assessor, etc. (Delhoofen, 1996). They also learn strategies to motivate and encourage communication among students in project groups; to learn how to deal with 'critical situations' (i.e. group's problems; lack of progress in project assignments; students not committed to agreements, etc). The tutor's training for second year tutors is a combination of tutor's role and project content, the planning, and the assessment procedures as well.

4 The Dilemmas of the Role of the Tutor in DBL

It can be concluded that it is essential that the tutor' tasks are geared to enhance learning processes and content support when needed. However, there are a number of dilemmas that come up from the current practices at Mechanical Engineering department. A number of shortcomings, namely, the motivation of tutors linked to the time they have to spend devoted for group work; the financial constraints; as well as the low quality in students' report writing are some of the drawbacks encountered. These deficiencies can undermine the role the tutor has in group work. The already identified shortcomings and its potential impact on the tutor' role are at stake and, therefore, deserve serious considerations.

Experience shows that it becomes difficult to find suitable tutors for the first year of the Bachelors' program. The supervision of the DBL groups is regarded sometimes as a burden rather than a motivating function. The same counts for the tutors engaged to second year supervision of DBL groups. Therefore, the option of selecting Master students to hold the tutor's role has been introduced with the overall idea of surmounting the motivation problem.

The experience of introducing Master students for the first year tutor's position has been positive according to students' surveys from the Mechanical Engineering department. However, introducing Master students brings about two-fold type of consequences: firstly, there are financial implications of making such a decision. The same counts for the Ph.D. who are not faculty staff members but outside researchers at the service of an external research institution. They are volunteers and don't have education obligations as tutors. The management of the Mechanical Engineering department has to decide whether they are able to get this financial burden on its shoulders while for the faculty staff members the tutor tasks are part of their routine job.

Secondly, the introduction of 'less experienced tutors' can damage the image and credibility of the current tutor position. Consequently, to try to engage Master students as tutors may have a dangerous boomerang effect. The need to introduce a more academic seniority as tutors becomes an issue which demands careful attention at the Mechanical Engineering department. Considerations on selecting tutors who act as well as subject-matter specialist in the first year in combination with their process expertise can give an added value to the tutorship and, consequently, can be regarded as a valuable input to the students' learning process. Likewise, wrong interpretations of whether DBL could be considered a less important subject than a regular course will be avoided.

There are other types of considerations, in addition, in favour of having students as tutor's in DBL groups work. According to Schmidt, van der Arend, Kokx & Boon, (1995) the tutor's contribution depends in a great deal on the type of obstacles that students find while working in groups in problem-solving. However, teachers tend sometimes to avoid another role rather than the traditional one of teaching. Moreover, the traditional teaching in the form of lecturing doesn't respond to the problem-based approach since the emphasis lies on having students actively involved in seeking information to provide answers to the problems. In this sense, the alternative to academic staff having to fulfil the role of the tutor is to use the students who themselves have experienced problem-based learning. They are easily able to adapt themselves to the tutor's role, and are more sensitive to the groups' needs in terms of providing guidance, information and support.

There is substantial literature, likewise, on the impact of having staff tutors or student tutors on students' results in problem-based learning. Results on student's achievement in problem-based learning show benefits of using staff tutors (Schmidt et al, 1993b, in Moust & Schmidt, 1994). However, though the literature shows that problem-based learning is staff-intensive approach (Moust & Schmidt, 1994) there are also arguments to support that group work guided by student tutors can be as valuable as the staff members, i.e. student tutors compensate for the lack of content knowledge by giving more attention to learning difficulties of small-group tutorials. First at all, the learning environment and prior knowledge play a crucial role in the students' learning process. Having circumstances and cases when prior knowledge doesn't meet the needs of the students and the environment doesn't provide the necessary structure to the students, they tend to go back to the tutor looking for clear guidance. In this case, the students who are guided by subject-matter experts may benefit in a greater extend than those students who have a student tutor (Moust & Schmidt, 1994). However, to compensate their lack of content expertise student tutors spend more time in improving processes i.e. giving attention to learning problems, group motivation, a group dynamics.

Looking carefully at PBL experiences from literature, we can conclude that though PBL is a proved model to foster student-directed learning and process competencies. There are likewise a number of arguments which ask for some consideration for adjustment of this approach in the near future. These aspects are, namely, that students don't work following the seven steps method (Moust, Bouhuijs & Schmidt, 1998, in Moust 2000); they spend less time in seeking information, study only the compulsory literature, and report uncarefully (Moust, 2000). Though all above mentioned factors don't represent specifically the situation at the Mechanical Engineering department there are, however, common aspects such as the constraints identified in reporting requirements. This deficiency has been mainly identified in the students' reports of first and second year students.

Since the engineer profile for the XXI century must hold process competencies such as co-operation, communication skills and project management (Du & Kolmos, 2006) and not only content or technological competencies, the Mechanical Engineering department is currently facing a number of challenges that could be addressed by reinforcing the role of the tutor and, more specifically, by providing him with responsibilities to supervise the project reports' before hand.

5 Conclusions and Discussion

With the introduction of the Bachelor's curricula a more demanding engineering profile is being fostered at the Mechanical Engineering Department. This profile is contributing to model the future engineers from whom it is not only expected to have knowledge but also other type of process competencies such as problem solving, innovation, cooperation and communication among others (Du & Kolmos, 2006). Within this framework, the DBL as an educational concept is supporting the modeling of that profile. The role of the tutor, therefore, plays a crucial role in this scenario.

However, there are still some challenges in the current tutorship system at the Mechanical Engineering department. These challenges are summed up as follows: On one hand, we find 'motivation' as one of the fundamental problems that tutors are confronted with. On the other hand, we encounter that the expected targeted learning outcomes are not reached i.e. students' quality in report writing.

First of all, the unmotivated tutors are to be found more often in the first year than in the second one. Reasons to find unmotivated tutors, especially in the first year, are:

1. First year tutors are less involved in the subject that is given in the courses.

2. There is a lower level in collaboration between the tutors and the project co-ordinator. A consequence is that the learning outcomes of the specific project are not always as clear as expected.

The immediate consequence of having such a problem is that it becomes difficult to find suitable tutors.

It has been already discussed in this paper the positive and the negative aspects of the temporary solution of selecting Master students to hold the tutors' role. The risk of implementing such a solution is that the DBL projects can be regarded as less important parts of the curriculum than other courses.

Furthermore, due to the general character of the projects in the first year there are no research groups specialized in the first-year topics. The tutor's responsibilities are linked to the nature of the project which in this case are to be framed more in the process than in the content. They also have an extra responsibility as a mentor.

With regards to the second mentioned constraint of having unmotivated tutors, the relation between the tutors and the project co-ordinators plays a major role and deserves special attention. A potential solution could be that in the tutors in the first year will need to get their role reinforced. Reinforcement in this sense includes that the tutors get more responsibility in the supervision of the learning outcomes. Both the tutor and the project co-ordinator need to define more clearly the tasks by giving structure to the tutor's profile and criteria.

Another key element is the added value that can be given to the tutor's meetings. The tutorship meetings are aiming at reviewing tutors' experiences and giving answers to potential shortcomings found in the learning process with the students. To strengthen the value of these meetings a more clear agenda can be provided where careful attention is given to the project's learning outcomes. Moreover, to underline this process-orientation task and give an extra value to the relation with the project co-ordinator it would be essential to increase the collaboration between both so that the tutor holds a more relevant and well-defined specific function. In this sense, both the tutor and the project co-ordinator become a team. The latest counts also for the improvement of the relation of these two actors in the second year. Though in the second year the projects are linked to a research group and, therefore, the tutors are automatically more involved in the assessment process.

There are a number of considerations to provide tutorship with a more crucial role to try to undermine some of the above mentioned deficiencies. One of the discussions being held at this moment is that it is necessary to include the tutorship and coaching into the professionalization trajectory of the Ph.D. students. The tutor training can have, therefore, a broader scope and can engage as well the Ph.D. students. Consequently, tutorship as coaching can be included within their Personal Development Plan and curriculum vitae. This would be an ideal solution. However and due to the 'bad image' the tutorship holds at this moment this ideal situation is not included within the personal development.

Likewise, there are a variety of aspects which play a major role when it comes to meeting the standard requirement criteria for the students' reports. One of the main issues is that project co-ordinators find it difficult to give low grades. Reasons are to be found in that the assessment of projects focuses on process and less on content. Besides, and due to that the final grade is a group's grade, the belief is that the good students efforts count for the whole group when it comes to the group mark. Furthermore, experience learns that the requirements for a 'good report' are not always clear for the students.

At this moment, there are, however, some possibilities to make a step forward in the improvement of these shortcomings. The underlying effect is to emphasize collaboration among project co-ordinators to set clear criteria and norms for the definition of the expected quality in the reports as well as to identify the crucial phases in report presentation in the curriculum. There are, likewise, other types of implications. Tutors need to become more strict when it comes to the assessment of the reports just as the project co-ordinators do. To do so, the tutors will have to widen their role and gain more responsibilities within their tasks so that they will be able to provide feedback and advice on the structure to the students on report pitfalls. By doing so, the students gain a chance to improve the assessment.

Another discussion linked to the issue of giving lower marks to the group reports is the possibility of providing students with a chance to pass the learning outcome. The current situation is that the project co-ordinator sometimes spends more time in reviewing the reports than the students do in writing it. By becoming more strict in the report assessment this will be a measure to motivate students to take report writing as a more serious task.

At this moment there are numerous procedures that project co-ordinators use to assess a report. This represents to be an even more unclear aspect for the students to understand the different criteria used by the different teachers. The bottom message is therefore to create a more critical step-by-step set of guidelines which are also known and used by the tutors. Wherever project co-ordinators wish to include new or different rules these are to be stated in the norms and regulations framework and communicated properly with the tutors.

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A First Year and First Semester Project-Led Engineering Education Approach

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Abstract

This paper describes the organization model of a Project-Led Education (PLE) process carried out in the Industrial Management and Engineering (IME) programme at the University of Minho. It intends to analyse the PLE approach in the first year and first semester, according to the perceptions of the coordination team involved in the 2008/09 PLE edition. The emerging data from a group discussion with all coordination team members revealed a set of dimensions which allow a better understanding of the way the process is organized and how it could be improved. The constraints found were mainly three: first, teachers feel that in this process they have much more work than in traditional methodologies; second, some aspects of lack of suitable interdisciplinarity between subjects were identified; and finally some doubts in regard to learning outcomes were raised and some suggestions of individual activities were proposed. Therefore, a set of improvement changes will be presented in order to overcome some of the difficulties identified by faculty staff. These changes will be taken in account in the design of the next PLE edition (2009/10).

Keywords: interdisciplinary project approaches; engineering education; faculty staff perceptions.

1 Introduction

The current demands of the Bologna Process represent a change represent a process of change in curriculum design, as programs and course structures need to be revised and new teaching methods adopted, in order to focus learning on students. In the context of Engineering Education, Mills & Treagust (2003) have identified a set of critical issues that need to be addressed for significant changes in Engineering Education. These authors call attention to the following concerns:

- Engineering curricula are too focused on engineering science and technical courses without providing sufficient integration of these topics or relating them to industrial practice. Programs are content driven.
- Current programs do not provide sufficient design experiences to students.
- Graduates still lack communication skills and teamwork experience and programs need to incorporate more opportunities for students to develop these.
- Programs need to develop more awareness amongst students of the social, environmental, economic and legal issues that are part of the reality of modern engineering practice.
- Existing faculty lack practical experience, hence are not able to adequately relate theory to practice or provide design experiences. Present promotion systems reward research activities and not practical experience or teaching expertise.
- The existing teaching and learning strategies or culture in engineering programs is outdated and needs to become more student-centred. (Mills & Treagust, 2003:3)

Therefore, new educational methods and strategies are needed in order to engage students in the learning process and guarantee higher quality at undergraduate programs. Project-Led Education (PLE), for instance, is a teaching and learning approach which takes in account student-centred learning.

Motivated by this need for change, a group of teachers from the Production and Systems Department at the University of Minho has implemented a Project-Led Education (PLE) methodology in the Industrial Management and Engineering (IME) Masters Degree, during the past 5 years. Project-Led Education emphasizes team work, problem-solving and articulation between theory and practice by carrying out a project, based on a real situation linked with the students' future professional context, which culminates with the presentation of a solution /

product (Powell & Weenk, 2003). In Project-Led Education, students work together in teams to solve large-scale open-ended projects. The key features aim at fostering student-centeredness, teamwork, interdisciplinarity, linking theory to practice, development of critical thinking and competencies related to interpersonal communication and project management (de Graaff & Kolmos, 2003; Helle *et al*., 2006).

The PLE process implemented at the University of Minho, in the IME programme, involves teams of students from the first year and a coordination team composed by teachers, tutors and educational researchers. The project is developed during a semester and is based on project supporting courses (PSC).

This paper aims to describe the organization model of the Project-Led Education (PLE) process carried out in the first year and first semester of IME in 2008/09. An analysis of the coordination team perceptions and a set of improvements are also presented.

2 Organization Model

The characterization of PLE's organization model, presented in this paper, is based on the 2008/09 edition implemented in the first year of IME at University of Minho. The organization model description is structured according to the following aspects: stakeholders, i.e. students and faculty staff; courses; project.

2.1 Stakeholders

This project involved 38 students of first year of IME. Most of these students accessed to IME at University of Minho through national contest to higher education and a minority are transferred from other courses at the same university. Students who accessed by national contest have an average mark of 168.9, the minimum 158.4 and the maximum 188.0 (scale 0-200), and 29% of them entered in their first option. Their ages range between 18 and 23 years old. For the development of the project, the students were organized into 6 teams, varying from 5 to 7 members.

The coordination team of the first year, first semester 2008/09 included 12 members. Nine of these members are teachers that have different roles: 3 of them are lecturers and team tutors, 3 are only lecturers and finally 3 are only tutors. The coordination team also includes the course director and two educational researchers. There was an additional member, a teacher of a non supporting course that assisted to the all process and participated as an observer. Most of these members have been participating in different editions of this project and a large number of these also had training on Project-Led Education methodology.

2.2 Courses

The implementation of PLE in Integrated Master's Degree of (IME) is supported by the first four courses represented in Table 1. These are considered as project supporting courses (PSC) and the fifth course - Introduction to Economic Engineering (IEE) - in this table is a non-supporting course. The five courses of the semester represent a total of 30 ECTS (European Credits Transfer System), as indicated in Table 1.

Table 1: First year, first semester study plan of Industrial Management and Engineering.

Course	ECTS
Calculus C (CC)	6
Computers Programming I (CP1)	7
General Chemistry (GC)	5
Introduction to Industrial Engineering (IIE)	6
Introduction to Economic Engineering (IEE)	6

The Project was introduced as a value added to the learning process of the first year students. The technical competences acquired by the students come from specific courses' contents and from the interdisciplinary project. Additionally students develop transversal competences mainly through project activities: project management competences like time management and organization skills; team working competences such as responsibility, leadership and problem solving; writing and oral communication skills and, also, personal developing competences like critical thinking and creativity.

The linkage of interdisciplinary contents in an integrated way is supported by the Project. As the Figure 1 illustrates, each PSC had different contents included in the project, being CC, the course with minor participation. This means that some subject contents of each PSC was assessed by the contents included in the Project and specific contents not assessed in Project.

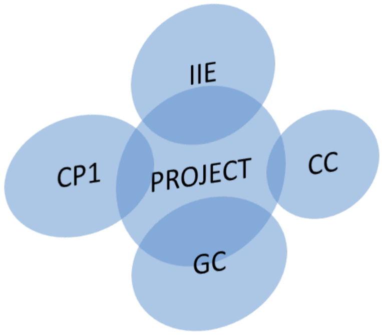

Figure 1: The four PSC involved in first year first semester IME PLE.

Student assessment in IME PLE courses is based on continuous assessment of the PSC specific contents and on project assessment. The final project grade has a 40% impact on students' final grade and continuous assessment 60%. Each PSC defines its own way of assessment based on small group tasks or work assignments and written tests. The criteria and the methods for the assessment of each PSC were, also, defined by the responsible teacher of each PSC. In the 2008/09 IME PLE edition, the number of assessment items (tasks and tests) defined by the teacher responsible for each PSC, is indicated in Table 2.

Table 2: Number of assessment items for PSCs.

PSC Assessment Item	PC1	IIE	GQ	CC
PSC Tests	4	2	2	2
PSC Tasks	1	6	2	3

2.3 Project 2008/09

This section describes the four main dimensions that are needed to understand the project carried out in the 2008/09 edition. These include the definition of the project theme, the start of the semester, the project process – since the beginning to the end and, finally, the assessment model.

2.3.1 Theme

Coordination team members are asked to freely suggest project themes at an early stage. Themes are then picked-up from the pool of ideas and subject to discussion during a coordination meeting. Themes are object of scrutiny by project supporting course (PSC) lecturers. This procedure contributes for validation of the eligibility and relevance of project contents within the context of each single PSC. A selected project theme normally emerges as a result of: a) adequacy to PSC contents (and vice-versa); b) coordination team members individual perceptions on the relevance of the project theme; and c) project holding adequate dimension for a full semester work by a team that can vary from 5 to 8 students. Therefore themes vary each year. After agreement on the project theme, all student teams work on such theme during the whole semester. The theme scope is normally wide enough to allow for significant diversity in both problem solving approaches and solutions.

The 2008-2009 first year first semester project intended to design and detail the: "Production of batteries for plug-in electric cars: specification of the battery system and the production system". The objectives of the project were:

1. Specification of the battery system for a plug-in electric car. This included: a) specification of relevant vehicle parameters; b) specification of the battery system: battery type, power, charge time, dimensions, weight, expected lifetime, environment impact, limitations of the chosen battery, etc., and c) electric vehicle autonomy.
2. Specification of the battery production system. This included: a) target market; b) monthly production; c) number of workers; d) suppliers; e) materials supply; f) Production management; g) equipments; h) layout; i) costs; j) proposals of eco-sustainable measures within the production system (such as rationalize de use of water, energy, materials, waste, etc.).

Teams were instructed to develop fully rigorous specifications. Their final work should show and prove the development of PSC-specific technical competencies. Students were informed of such PSC competencies in the beginning of the semester. The PLE approach intends to develop not only PSC-specific competencies but also soft skills, which are not well developed using traditional teaching approaches. Among these, there is a special emphasizes on teamwork skills; project management skills; communication skills and conflict management skills. The project development process also stimulates critical thinking and creativity while rewarding teams and individuals with initiative power.

Teams were introduced to the project theme by way of a short description on the relevance of cars for personal mobility, the global dependency on fossil fuels, the 2008 spotted energy crisis and consequent increase in fuels cost, the global phenomenon of climate change, and greenhouse gas emissions (GHG). Basic statistical data on Portuguese high dependency on energy imports (about 83%) were also given, showing the country's vulnerability to oil prices fluctuation. The Portuguese government holds a strategic agreement with Renault-Nissan group for the introduction of electric cars from 2011 onwards. This has set a high spotted relevance for electric cars thematic, and a renewed motivation to teams.

2.3.2 Start of the semester

For coordination team members the start of the semester begins two weeks before the start of classes. In the first meeting of the coordination team, everything has to be prepared: the session where the PLE project will be presented to students; PSC related issues, i.e. learning outcomes, week-by-week contents planning, assessment, etc.; the selection of the project theme, as described in section 2.3.1; detailed schedule of the first week of the PLE where student teams develop the pilot project, establish the project milestones and the evaluation system. Additionally, it is necessary to allocate some tasks: development of PLE supporting documents such as the students' project guide, the project description, the semester schedule, the first week plan and a short description of the pilot project and aims. Tasks allocation are discussed and agreed with all team members. Most coordination team members remain within the team year after year, except the Calculus C teacher. The first coordination team meeting usually includes a short balance on the previous year PLE run, in an attempt to refine the process.

The PLE presentation session is scheduled as the first event of the semester for the new students. This includes an introduction by the Course Director followed by the coordination team leader who presents PLE. This presentation launches the project theme, the overall project plan and the following PLE aspects: advantages and challenges of the PLE methodology; skills to develop in the course of the project; presentation of the members of the coordination team; tutor role; PSC classes plan; week schedule; monitoring project progress and milestones; assessment system. During this session the teams are formed and one tutor is allocated to each team. After the session, the students have the first meeting with the tutor. Each team is allocated a space (a permanent project room), a laptop computer, individual lockers and keys for the project room. Teams are afterwards instructed in teamwork and multimedia presentations. The teams then begin to develop the pilot project which they have to present in about a week time. The pilot project includes the construction of a Web Page (using a simple html editor) whose contents are the initial ideas and context for the project. This pilot project requires the development of many smaller tasks in a short timeframe. Therefore the teams have to organize themselves, split the tasks among team members, sequence them and assure that all runs smoothly to successfully accomplish the task. Therefore the pilot project works as a shortened experience of what will be the teams work during the full semester. At the end of week 2, the student teams have to come up with, and present, the project plan. At an early project development stage, teams have to be working and understanding the PLE methodology.

2.3.3 Process

The project plan has 19 weeks, with 9 to 17 hours of classes per week, one hour with tutor and 2 to 4 hours of additional support, in a total of 5 to 18 contact hours per week. The project schedule is presented in Figure 2. The figure also shows the 10 milestones of the project. After Christmas' holidays (week 14 and 15) there are no more classes and the teams concentrate their efforts in concluding the project work and some subject-related assessment activities.

Student-teacher hours	*Week 1*	*Week 2*	*Week 3*	*Week 4*	*Week 5*	*Week 6*	*Week 7*	*Week 8*	*Week 9*	*Week 10*	*Week 11*	*Week 12*	*Week 13*	*Week 14*	*Week 15*	*Week 16*	*Week 17*	*Week 18*	*Week 19*
Classes	4	17	17	17	17	17	17	17	17	17	13	13	17			<17	<17	<17	<17
Tutor	1	1	1	1	1	1	1	1	1	1	1	1	1			1	1	1	1
Total	5	18	18	18	18	18	18	18	18	18	14	14	18			<18	<18	<18	<18

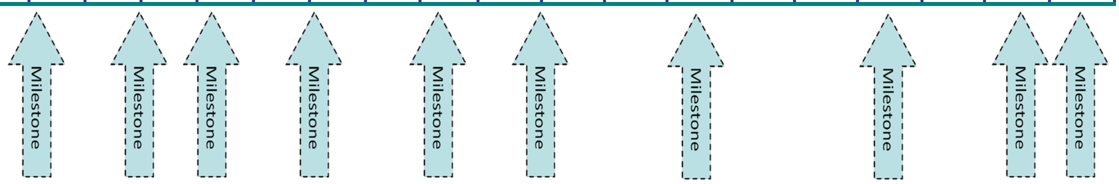

Figure 2: Project Aggregated Plan - classes' plan, tutor meetings and milestones

Project progress is monitored along the semester. Ten milestones enable the coordination team to acknowledge the team progress. In each milestone, teams are expected to deliver documents and/or presentations which are subject off scrutiny by some or all coordination team members. Teams underperforming are spotted and specifically tracked for project progress in following milestones. Table 3 presents all milestones, delivery times and expected deliverables.

Table 3: Milestones of the project.

Milestone	Date	Requisite
1	2008.10.02 2008.10.03 (Week 2)	18:00 – Pilot Project – Deliver a specification and a presentation file 14:10 – Pilot Project presentation
2	2008.10.10 (Week 3)	18:00 – Deliver a document (max. 2 pages) with the internal strategy to manage the team
3	2008.10.21 2008.10.22 (Week 5)	18:00 – First report delivery (max. 25 pages) 14:10 – Project progress presentation
4	2008.10.29 (Week 6)	14:10 – Extended tutorial
5	2008.11.18 2008.11.19 (Week 9)	18:00 – Intermediate report 14:10 – Formal presentation
6	2008.11.26 (Week 10)	14:10 – Extended tutorial
7	2008.12.19 (Week 13)	18:00 – Deliver a balance document (work done and future work)
8	2009.01.09 (Week 16)	18:00 – Preliminary version of the final report (max. 60 pages)
9	2009.01.23 (Week 18)	18:00 – Final report (max. 70 pages) + prototypes
10	2009.01.28 2009.01.29 (Week 19)	10:00 – Final exam (written test) 14:10 – Final presentation, discussion and poster delivery

On milestone 2, the team should deliver a document which describes the management strategy that the team will use to control the progress of the project. The coordination team uses that document to check if teams understand the meaning of team working and the eventual need to develop and explore strategies that will help bypass difficulties arising during the project. Extended tutorial – milestone 4 and 6 - is a special meeting, held twice in a semester, between each team and all the members of the coordination team. This meeting intends to give a more broad feedback on the work done by the team, and clarify any doubts relating the project that could persist within the team. The balance document – milestone 7 - helps teams to acknowledge their project status, i.e. what was already achieved and what remains to be done and when. The final exam - milestone 10 - is an individual exam on the respective project team contents. It is normally based on the project report delivered in milestone 9. This exam assesses the individual involvement and responsibility within each team. The project ends with a final presentation followed by discussion. The PLE has a final social activity which brings together students and teachers in an afternoon snack offered by the Course Director, to discard the stress accumulated during the semester.

A general model for engineering projects (Van den Kroonenberg, 1992) is included in the project guide. The model intends to aid the teams on identifying the project phase and serves as a general guideline for project phase contents, expected results and deadlines. The phases' description and expected deadlines are presented in the Table 4.

Table 4: Project phases, expected results and expected deadlines.

Phase	Expected Result	Expected Deadlines
Preliminary analysis	Context description; Problem definition; Objectives definition; Requisites identification and conditions.	Until week 2
Specification	Specifications; Alternatives list for the solution; Construction proposals.	Until week 8
Construction	Prototype, model, program construction.	Until week 12
Test/evaluation and e revision	Test, strengths and weaknesses identification and revision.	Until week 15
Implementation		Until week 19

2.3.4 Assessment

The IME PLE assessment has two major components: c_1 - continuous assessment of PSCs; c_2 - project assessment. The assessment weights of each component can vary yearly; in 2008/09 c_1 weighted 60% of the PSC final grade while c_2 weighted 40%, as previously referred. Early editions of IME PLE also used a 50/50 weight. The c_1 component includes work assignments and written tests. The c_2 component derives from the Project grade (team): Reports (60%), Prototypes (20%), Presentations and Final discussion (20%), which is transformed in an individual grade by multiplying the respective grade by: a) the peer assessment factor; and by the individual written test grade (20%). The assessment model was built in a way to help students regulate their own learning, however the authors identify that most project items are assessed only in a later phase of the project, although project related feedback is given extensively during the semester.

3 Coordination Team Perceptions

After completion of the IME based PLE semester, the coordination team members were asked to reflect on their experience. Few domains of analysis showed predominance over others. These domains included: staff workload; project theme and content integration; learning outcomes and the PLE methodology. In order to improve the IME PLE and students' learning outcomes, some of these aspects will be taken in account when preparing the next semester and will be discussed in the section 3.4.

3.1 Staff workload

From the discussion of coordination team members, the staff workload was one of the main concerns shared by most of the participants in PLE.

The single NSC teacher (IME PLE observer) stated "I never thought it would give so much work" and "You do not know the workload involved if you are not on it". She also referred to the high quantity of emails exchanged and the number of decisions that had to be taken.

The teacher of CC regrets that the respective course truly "awakened" to the PLE project in a later stage of the project. This teacher also indicates the "excessive PLE-related workload, both for students and teachers… especially in the final stage of the project", but he is positive about joining IME PLE next year and on the need for teacher stability to allow a successful contribution of the respective course on the IME PLE. He points out that the main advantage of the PLE is the integrated perspective that students acquire in regard to the PSC courses that make up a semester.

IIE teacher said that "it is possible to do the same with less effort" and that "…we need to be more efficient to reduce the coordination team workload". He spotted excessive use of coordination team meetings and identified some project issues that could have been discussed and decided through an alternative way of communication, reducing the number of meetings.

One tutor referred her difficulty to account the workload related to project coordination tasks. For her "what needs to be answered is: "Is the relation between staff effort and students' results positive?... is it worth it?"

Another tutor suggested that the "use of project tasks to assess PSCs" should be stimulated, and that "PSC teachers are not making it yet… resulting in an heavy workload both for PSC and Project". Another teacher agreed with this conclusion and added that "this is only possible if the PSC are well integrated within the project".

The GQ teacher spotted "many moments of heavy workload within IME PLE", but also "…assessment is readily done..." therefore valuing the new assessment model instead of traditional teaching, where assessment through written exams tends to be more spread over time.

3.2 Project theme and content integration

As said before, the selection of the project's theme is based on its pertinence and importance but, also, on its adequacy to PSC contents, especially GC. So, it is more or less expected that courses like CC had some difficulties in integrating the theme selected in the contents prepared for the semester. This was perceived by the coordination team members, in particular, IIE teacher referred "When we think about the Project theme, we think how we integrate GC and IIE and we do not think how we integrate CC, then the difficulties with integration arise."

This requires a continuous effort try to involve and readjust all program contents as one of the tutors noticed "Need to readjust the program contents: understand the project and look for the best possible way to integrate contents, even changing the syllabus or the contents order. It is a fundamental effort of the teachers. But this is a

difficult task, mainly when the teachers involved weren't responsible for the CU, like the NSC teacher (IME PLE observer), who admitted that "Initially I thought that I couldn't integrate the biggest part of the IEE contents but now, after what I have seen, I think I could." However, for this teacher it is difficult adapt the curriculum contents to the project: "I can't reformulate the syllabus contents, I can't teach *Costs*".

IIE teacher referred that these difficulties arose because the first year IME PLE didn't have an Integrated Project course. He says "We need one thing and the courses give another. An Integrated Project course is missing in the first year and I am increasingly convinced of that."

Other IIE teacher concludes that it is important to direct the project more "I think we have to define some concrete things in regard to the project. It could facilitate the content application. However, this change might put in risk one of the main characteristics of the project – be open."

3.3 Learning outcomes and the PLE methodology

The discussion involving students' learning process and outcomes in PLE is already a common theme amongst the coordination team meetings. However, in the 2008/09 PLE edition, one of the new participants in PLE processes, a teacher who played the single role of a tutor during the semester, expressed that her expectations in regard to students learning outcomes and the PLE methodology itself, hadn't changed. She believes that PLE brings some disadvantages for first year students "as they arrive to the University and have PLE right in the first semester, so they assume that University is this. They think that they will always work in teams and everything will be easy, that they don't have to get involved in the courses and that they will always get their way through by sticking to their teammates". She also referred that, in her opinion, "students seem not to get the message behind PLE" because, as she lectures these students later, in a course which takes place in the second semester, and verifies that "students seem not to be capable of transferring the knowledge and skills developed earlier, during PLE, to other different contexts. For instance, they should already know how to make a written report and I don't see them doing that successfully when I ask them to make one, for my course".

This point of view, however, was not shared by most of the coordination team members in the meeting. Many arguments and specific examples were given by other teachers and tutors, present at the meeting, in order to clarify that what actually might be happening in the second semester does not have necessarily to be related with PLE or even a consequence of its implementation. The coordinator of the semester stated that "when students reach the second semester, they become more relaxed. They are used to being under great pressure and, suddenly, they find themselves in a learning process which is less demanding, so they kind of sit back." Another teacher reinforced this idea saying that "it was the effect of worn-out."

Other teachers pointed out the positive outcomes which have been demonstrated by PLE students in previous years. The NSC teacher (IME PLE observer) was surprised by the quality of students' written reports and oral presentations. She said "I was quite amazed by their level of their autonomy during the discussion with the rest of the class." Besides this, one of the IIE teachers also called the attention for the opinion of some senior students, from the fifth year of IME, in regard to PLE students' performance, as he stated that "they were completely surprised by the quality of the presentations of first year students. They remembered their own first year at the university and they recognised that they didn´t make such outstanding presentations or master the courses contents with such a grasp as these students did."

3.4 Improvement changes

Coordination team members were also asked to propose improvement changes. Based on their fundamental reflections, a few items were identified. These items are presented and cross linked with domains of analysis in Table 5.

Staff workload reduction could be based on 4 items from this list. Item 1, reducing the number of staff meetings would, undoubtedly, contribute to this reduction. Considering the total number of meetings and the comparison with other PLE approaches, it was found possible to accomplish this goal without reduction of project results. Furthermore, as described by Alves *et al.* (2009), this reduction could also result from a lower number of attendees in each meeting.

Item 4 could contribute to the change of focus of assessment procedures. In case of implementation of this change proposal, courses' continuous assessment should be based mainly on project tasks instead of specific content assessment through tests. This should be bounded to a reduction on the number of continuous assessment tests (item 5) to maintain a balanced workload for students.

The reduction of the number of project reports is a consensus change (item 7). This should be replaced with something simpler like, for instance, the presentation of an argumentative strategy to sell the main project idea of the student's team.

Investing more time on the design and planning of the project, as well as identifying more detailed course requirements for each project phase (items 2 and 10) could facilitate the selection of the most appropriate project theme, as the interdisciplinarity between courses' contents could be explored more deeply between lecturers. This could result in more clear objectives and more adequate plans.

A clear interpretation from this list of items is the special focus on student learning and methodology improvement. Besides the positive results achieved by this project approach, in regard to student learning and competencies developed, the team of teachers is motivated to propose a few improvement changes. Most of the proposals are directly related to assessment and deliverables (items 3, 4, 5, 7, 8). It is a general perception from this team that learning is strongly influenced by deliverables and assessment activities. So, an improvement on the number and type of assessment elements could make a strong contribution for the improvement of student learning. Furthermore, some members of this team also believe that project requirements should be more detailed and clearer (item 10), which together with a better comprehension (item 6) of the project approach will be a benefit for students results. Finally, an increased level of interdisciplinarity is expected from the inclusion of the only NSC (item 9).

Table 5: List of improvement changes and relation with domains of analysis.

Improvement Changes	Staff Workload	Theme & Interdisciplinarity	Learning & PLE
1. Reducing the number of staff meetings	X		
2. Investing more time in planning		X	
3. Consider project milestones deliverables as elements of course's evaluation	X	X	X
4. Each curriculum unit should reduce one test	X		X
5. Students should make a better use of feedback			X
6. Each students' team should get a print copy of the Project Guide			X
7. One report less	X		X
8. Anticipate the first version of the final report			X
9. NSC included in the project.			X
10. Identify detailed course requirements for each project phase		X	X

It should be noticed that some of these suggestions can have a less positive effect on other domains. For example, investing more time in planning, preparing the theme and related contents can increase the teachers' workload. So, it is necessary to find ways of implementing these proposals that do not put in risk other aspects of PLE approach. For instance, in item 5 – students should make a better use of feedback – the students' teams can deliver a short essay indicating that the changes proposed by staff were included in the report. This essay should be designed in such a way that it would not be necessary for staff to read most of the report again.

4 Conclusion

This Project approach is continuously under evaluation aiming to monitor students learning progress. In the project edition described in this paper, the analysis of feedback from the coordination team resulted in the identification of a set of dimensions in regard to the constraints or doubts faced throughout the process. These dimensions include: staff workload, project theme and content integration, learning outcomes and the PLE methodology. For all these dimensions were presented improvement changes. Additionally, it is clear that the complexity of the organization model of PLE process is due to the several stakeholders and different courses which are involved. A strong level of coordination must be fostered amongst faculty staff in order to consider each of the views, interests and expectations of members involved in the process.

The proposals presented by the staff team will be considered in the beginning of the year 2009/10. On the first meeting of the staff team, issues related to the PLE process should be reviewed such as: How many meetings will we need to have? What are the alternatives in order to solve problems, without necessarily having to do a formal meeting? During the selection of the project theme, what is the role of each curricular unit in the project? At what time in the process project? What are the milestones that we have to change in the planning (one report less, one test less for each curriculum unit)?

In fact, it's also important to clarify the mission and goals of the PLE methodology with students. This could be assured by the tutor of each student team. Furthermore, it is important to find mechanisms which ensure that students and teams make a better use of feedback given.

The implementation of these improvement changes can result in other constraints or doubts to the PLE process. However, it is important make a critical analysis about the IME PLE process because it allows the establishment of action plans, essential for the achievement of better results.

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Active Learning as a Methodology for Motivating Team Work in Large Civil Engineering Classes

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Abstract

The renovation of teaching methodologies is leading to shifting perceptions of roles and responsibilities of both teachers and students concerning the way traditional and new materials are presented and learnt. While teachers strive to be creative and flexible and provide students with practical means for "self-teaching", students recognise the need for more responsibility and discipline. This paper describes a methodology for managing and motivating independent group work for students taking the Environmental Impact Assessment course included in the Civil Engineering programme at the University of Minho, either as a requirement or an elective. Though not agreeing on the overall level of difficulty of the course, the students were encouraged to complete their project assignments based on the critical analysis of real projects subject to EIA. The results indicate a significant move towards innovative approaches for motivating large classes of engineering students in a transdisciplinary context, through collaborative learning activities.

Keywords: civil engineering; active learning; independent work; self and peer-assessment.

1 Introduction

In recognising the generalised need for a more active approach to learning, the Bologna Declaration has driven a series of transformations designed to foster the deeper understanding of higher education topics by promoting newer approaches to teaching. The renovation of teaching methodologies is leading to a shift in perception of roles and responsibilities of both teachers and students, with regards to the way traditional and new materials are presented and learnt. While teachers are encouraged to be creative and flexible in their approaches and, above all, provide students with practical means for "self-teaching" through collaborative and active learning (Guedes *et al.*, 2007; Oakley *et al.*, 2004), students recognise the need for more responsibility and discipline on their part. By being allowed and encouraged to interact with their peers during and class time, posing questions and debating issues, students are able to benefit from an enhanced collaborative environment, where active learning takes a central role (Beichner *et al.*, 2007).

This appears to be a particularly adequate strategy for teaching large engineering classes whose students tend to favour more active approaches to learning, however diverse in learning styles and apprenticeship they may be (Felder & Silverman, 1988). These are particularly desired in engineering, where the call for more practical and tutorial approaches instead of the traditional lecture-types is largely preferred.

2 Scope

This paper describes a methodology for managing and motivating independent group work, using tutorial techniques for the practical sessions of the Environmental Impact Assessment (EIA) course included in the undergraduate Civil Engineering programme at the University of Minho.

3 Background

In the past, this second semester course was offered to fifth-year students as an elective course for which registration and attendance was traditionally kept to an average of 30 students. The small group of students lent itself to teaching and learning strategies centred on frequent instructor-mediated debates and discussions around the course's programme themes. The students were also required to conduct group projects around suggested topics and give a presentation at the end of the semester. The course was offered as an elective to fifth-year students for the last time in 2007-2008. Also in 2007-2008 and pursuant to the recommendations made by an

external and international evaluation panel, the course became a requirement for fourth-year students, a move that resulted in the need to teach, support and evaluate a universe of approximately 150 undergraduates. Already familiar with the challenges of teaching large classes, the authors were, nonetheless, faced with the challenge of re-designing a course that neither had taught before.

The complexity and all-encompassing nature of the subject further emphasised the necessity of a particularly well-organised and well-defined curriculum in terms of aim, content, teaching strategy and evaluation methodology. This was not a conventional engineering course in the sense that it did not necessarily require students to solve numerical problems or learn and apply calculation and design procedures. It mostly versed on concepts, laws and regulations, evaluation processes and documental procedures within the Portuguese system for EIA and SEA (Strategic Environmental Assessment), matters that are traditionally perceived as important but nonetheless dull, tedious, often frustrating, and not meeting the typical expectations of engineering students in what practical classes are concerned.

4 Methodology

The methodology described herein concerns the practical sessions of the course. The lecture classes followed a more traditional approach, where the instructor presented the learning subject using overhead presentations while encouraging the participation of the students and discussion of the topics under study.

4.1 Work assignment and monitoring

The course was organised in 2-hour long weekly lectures, for which attendance was recommended but not mandatory and 2-hour long weekly practical sessions, during which the students were required to work in groups of 3 to 5 elements and perform a series of tasks leading up to a final report for turning in at the end of the semester. The groups were required to conduct a critical analysis of one or more actual environmental impact assessment situations using case-file databases that are available to the public in institutional websites and offices. The goal was to expose the students to so-called “real-world” case studies by encouraging the research and review of relevant material and literature, namely documentation pertaining to complete EIA case-files as mandated by Portuguese regulations and guidelines. While providing a broad understanding of the field of study, the students were able to observe and discuss the limitations of bringing theory (regulations and guidelines) to practice (real projects).

The proposed approach brought a number of issues that were addressed early on during the planning stages of the course. Primarily, there was the imperative for providing project topics that would be adequately diverse so that work would not be replicated between different groups. Given the multidisciplinary nature of the field, each group was allowed to choose and rank, by order of preference, three thematic areas from a pre-determined list. Also, each group was given three options as to what type of study to conduct. Most groups were assigned their first or second preference of thematic area.

The need for an effective evaluation of each group’s ability to manage their own study and work effectively as a team led to a work progress monitoring plan, established to assist the instructors in this task. This monitoring plan included a series of progress meetings scheduled at predetermined dates and times within the class schedule, since the students were given the class time for conducting their research and writing and allowed to do so outside the assigned classroom. Each group sent a representative to meet with the instructor and deliver – along with any other written materials if and when requested – a written and oral progress report on the objectives accomplished thus far, goals to meet and tasks to be performed by the following meeting (Figure 1).

ENVIRONMENTAL IMPACT ASSESSMENT Practical Sessions: Group work monitoring School year: 2007 - 2008		
PROGRESS REPORT		
Date:	Group:	Representative:
Title:		
Accomplished objectives:		**Goals for the next work period:**
(…)		(...)
Difficulties:		**Other issues:**
(…)		(…)

Figure 1: Progress Report Template

Each group also reported on obstacles, difficulties and any other issues deemed important, for which they sought and obtained the instructor's advice and guidance. The role of group representative rotated among the team members and insure that the instructor talked to each student at least once during the semester (Figure 2).

ENVIRONMENTAL IMPACT ASSESSMENT

PRACTICAL SESSIONS: Progress meetings

School year: 2007 - 2008

GROUP ID	THEME / TITLE	ELEMENTS		(Date 1)	(Date 2)	(Date 3)	(Date 4)	(Date 5)
		(ID Number)	(Full Name)					
1.1								
1.2								

Figure 2: Progress Meetings Log

The instructor was also available during office hours, 2 hours per week and by appointment via e-mail for additional guidance to the groups that requested it. Thus designed, the practical sessions of the EIA course provided the time and space for the students to carry out independent work and devise working strategies that suited them best, while benefiting from guidance as needed. Exceptionally, the instructor presented a pre-scheduled class on an EIA software tool that was required as part of the work.

4.2 Evaluation

The final grade of the course resulted from a weighted average of the theoretical grade (worth 65%) – in the form of two written-tests administered during the semester at predefined dates and designed to appraise the theoretical knowledge derived from the lecture classes – and practical grade (worth 35%). The practical evaluation was amply supported by the regular monitoring of the work. The final reading and evaluation of the reports was aided by the knowledge on each project's history and team performance gathered throughout the semester.

Since it was necessary to evaluate each individual within the group, the authors resorted to a simplified form of self and peer-assessment to help differentiate between individual contributions and assign project grades. Accordingly, and upon submittal of the work, each student was required to email a private evaluation of his/her individual performance as well as an assessment of the remaining students in the group, in the form of percentage

contribution towards the total work effort. The final course grade was complemented by those obtained in the two written evaluation tests designed to appraise the theoretical knowledge derived from the lecture classes.

At the end of the semester, both students and teachers were also required to fill out an anonymous questionnaire as part of the Teaching/Learning Evaluation survey conducted by the University, in which both parties are given the opportunity to provide a quantified qualitative evaluation of the teaching and learning performances. The survey included a total of 37 parameters which were rated on a 6-point scale – 1 for "Strongly Disagree" through 6, for "Strongly Agree". This survey also included as self-assessment section. A list of 25 parameters and rating scale used for evaluating the teacher are presented in Appendix.

4.3 Resources

The progressive use of a wide and balanced variety of strategies for effective teaching and learning benefits from the support and is advanced by new electronic educational tools. Taking advantage of the existing resources, the authors decided to use the institutional e-learning platform (Blackboard Academic Suite®, BAS) in a variety of tasks such as sharing of class notes and study materials, and course managing tasks (posting of notices, rules and guidelines meeting schedules, etc.). The students were able to easily access the platform to view and obtain posted materials and also to post their own work for evaluation. The use of this additional interface proved to be a valuable enhancement to the authors' teaching and evaluation strategies. For instance, the availability of a "safe assignment" tool offered by the BAS platform allowed the teacher to verify plagiarised content in the submitted reports. Aware of this functionality, students were more likely to produce original text and carefully identify and list sources of information.

5 Results and Discussion

Of the 149 fourth-year students enrolled in the course, a total of 109 students in 26 groups actively participated and successfully completed the proposed practical assignment. Since the authors were also responsible for the elective course offered to fifth-year students (a total of 26 enrolled students, with 23 able to complete the project), the values in Figure 3 refer to the combined sets of students. Overall, they were able to demonstrate a satisfactory ability to carry out independent work and meet the goals set forth, with varying levels of enthusiasm and commitment to the duties and tasks assigned.

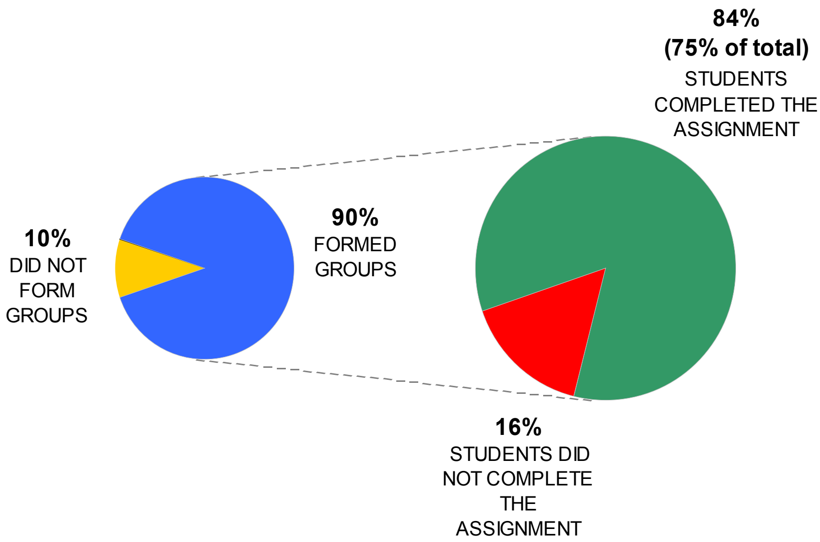

Figure 3: Student Participation

Fifth-year students were offered identical course requirements, class organization and practical methodology. In fact, both sets of students simultaneously attended the lectures and were offered the same course materials and notes. Fourth and fifth-year students were equally required to fill out the Teaching/Learning Evaluation survey for both lecture and practical classes. Since the methodology described herein concerns the practical sessions of the course, the results presented below exclude the students' assessment of the lecture sessions.

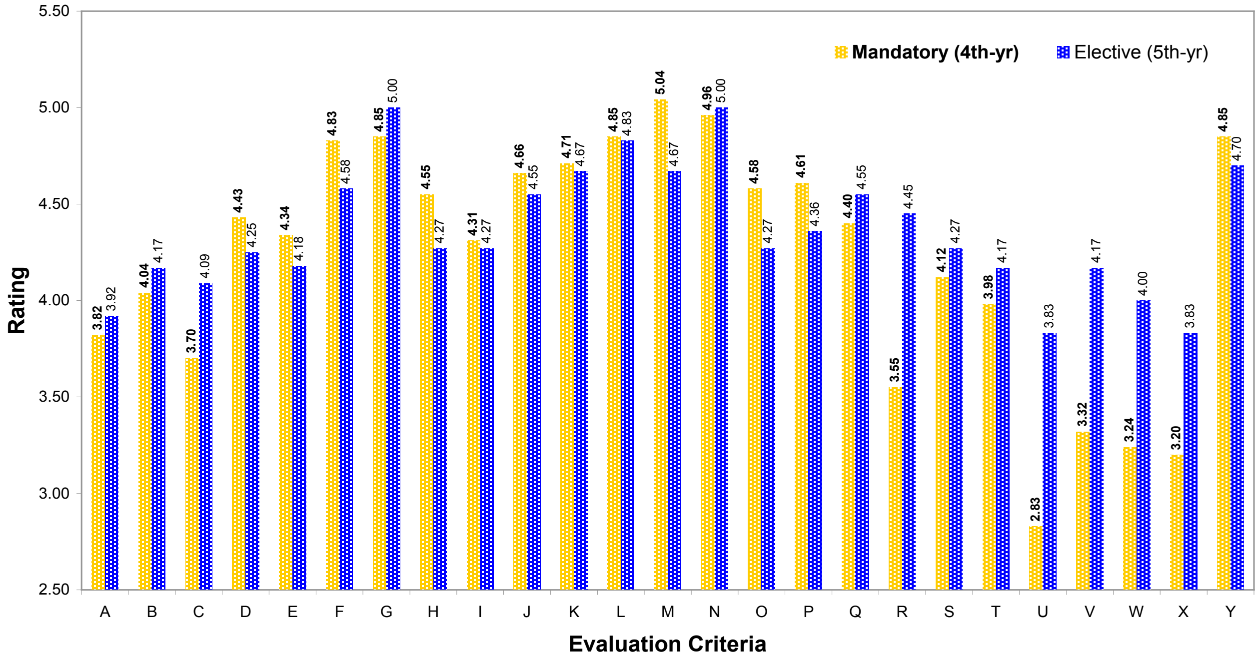

Figure 4: Teaching/Quality Evaluation Survey Ratings (Practical Sessions) by Fourth-Year Students (Mandatory) and Fifth-Year Students (Elective)

Overall, the ratings assigned by both groups of students are very similar and agree on most of the parameters, with few noteworthy exceptions. This is the case for parameter U, difficulty of the course. While both groups of students were least likely to agree with the level of difficulty, this was more evident for the students for whom the course was mandatory. In fact, fourth-year students assigned a full point less, corresponding to a total of 72% of disagreeing individuals. On the contrary, 67% of the fifth-years agreed with the degree of difficulty imposed. Likewise, the importance of the course (parameter W) received a lower rating from fourth-years. Not surprisingly, fifth-years were more likely to find the course more important. Fourth-year students were also more likely to disagree with the adequacy of the evaluation system (parameter R), assigning a significantly lower rating (a 0.9 difference) that their fifth-year colleagues. Fourth-year students were also less likely to agree with the work load demand (parameter V). In general, their assessment of the course warranted a 3.20 rating (parameter X), whereas the older students were a bit more agreeing, assigning a rating of 3.83.

These differences could be explained by two major distinctions between both sets of students. On one hand, fifth-year students were already familiar with both teachers, having had them in past courses. This may have allowed the older students to be feel more at ease and more focused on the subject because the teaching styles and personality traits of each teacher were already known. Fourth-years had little or no knowledge of the new teachers and thus, had the additional effort of getting to know them. However, the most important difference was the fact that fifth years chose to take the course, while fourth-years were given no such choice. This alone is a factor that could have led to some demotivation amongst the younger students, for not all of them were interested in pursuing the subject but were, nonetheless, required to do so. One may even speculate that this may have predisposed a significant number of students to agree on a poorer rating for certain aspects of the course.

The perception that the course was more difficult than expected was supported by feelings of anxiety regarding the lecture materials. When asked about these, the students admitted a lack of enthusiasm for the learning topics, describing them as complex and tedious. These observations were supported by feelings of bewilderment and incomprehension about the way the course was being managed this year, when "…it had been so differently done in the past". After being presented with the rationale for the new teaching approach, the students understood and accepted it but continued to have a difficult time letting go of their pre-conceived notions regarding how demanding they thought the course would be, an opinion built on conversations with older classmates that had successfully taken the course in previous years. These perceptions proved difficult to overcome emotionally, though intellectually it was clear to the students that they should not have expected identical approaches from different teachers (past and present), especially when the context of the course had changed as dramatically as it had. These feelings were expressed by both fourth and fifth-year students.

Consequently and regarding the written test performances, the students were neither thrilled nor thrilling. Their feelings of frustration and apprehension compounded by a fear of failing the class altogether (even before the written test grades were known) spilled into the practical sessions, hindering the motivation to go on working and get the job done. As a result, the scheduled progress meetings often became encouragement and pep talk sessions aimed at keeping the students focused and motivated. Despite the hardships, most groups persevered and managed to finish and submit the work, with satisfactory results.

Because the projects were centred on the analysis of case studies in light of topics covered in lecture, the practical sessions also served as a place for discussing some of the more theoretical aspects of the project, while assisting the students in cementing their knowledge of certain lecture materials. However, this was only carried out by some students that requested it, thus revealing more interest in the subject and more enthusiasm about their own project. The majority of the students, though given equal and ample opportunity to do so, both inside and outside the classroom, did not take advantage of this particular type of interaction with the teacher. In general and not surprisingly, groups that participated more and were more inquisitive about their work were also able to produce better reports. Nonetheless, the vast majority (94%) of the students easily obtained a passing grade on their projects.

In terms of the better-rated parameters, both sets of students selected concern and care about students, availability for answering questions and encouragement for expressing different ideas/questioning the teacher (parameters M, N and L, respectively). The vast majority (94% of the fourth and 100% of the fifth-year students) felt encouraged to express their points of view and in doing so, question the teacher in her own opinions and perceptions. An overwhelming majority (98% and 100%, respectively) felt there was concern and interest about them, an observation supported by the general perception of encouragement of participation in the course's activities (parameter K).

The overall results are encouraging and seem to agree with information obtained from casual and sporadic conversations with some students throughout the semester. The methodology was welcomed by the majority of them and when asked whether they would recommend it to classmates from the following school year, the majority would do so. The students mostly appreciated the freedom to manage their own work schedules though recognising that more effort and discipline was required on their part to remain focused and committed to the assignment. For the most part, the students were able to effectively accomplish the objectives as initially proposed. As for the peer-assessment, everyone seemed to have understood the purpose and importance of the task. Not surprisingly, the majority of the groups distributed equal effort percentages amongst their elements. Though this may have not corresponded exactly to an equal distribution of workload, it does seem to indicate a sense of *team unity*, particularly in groups where the effort was perceived – to the best of the instructor's knowledge – as having been unevenly shared.

6 Conclusions

The Environmental Impact Assessment course became a requirement for 149 fourth-year students in 2007-2008, while this was the last time the course was offered as an elective to 26 fifth-year students. The authors were responsible for the two courses and offered both sets of students the identical course requirements, methodology and access to the same learning materials. Because of their pre-existing motivation to attend the course, fifth-year students were less likely to give it a lower rating than their fourth-year classmates. Also, the previous acquaintance with the instructors might have increased the level of comfort of the older students, allowing them to more actively focus on the course and not as much on getting to know the teachers, their teaching styles and personalities. Nevertheless, there was a common sense of disenchantment with the course's level of difficulty and importance.

Regardless of the enduring lack of enthusiasm towards the course's more tedious topics and concepts, the students were able to overcome this obstacle by using active learning strategies in the form of a practical project that required the application of theoretical concepts derived from lecture. In this context, active learning functioned as a means to resist and balance demotivation and lack of interest towards particularly difficult aspects of the course's learning content.

Because the groups were entirely responsible for managing their work, there was an overall recognition of the need for disciplined and responsible approaches in order to complete the assignment in a timely manner and according to the proposed objectives. This was effectively accomplished by most individuals.

The opportunity to study and analyse real cases was referred as a particularly positive aspect of the methodology. The students were pleased with the fact that they were required to use and critically analyse actual procedural documents and regulations, favouring a broader understanding of the subject.

Despite the fact that the purpose of the peer and self-assessment exercise was followed by all the students, there is a need for additional reflexion. Though perceived as important and useful, it was not considered essential by students.

The methodology allowed for the regular interaction between teacher and students and monitoring of the work progress, which facilitated the final evaluation of the written reports. Additionally, it allowed the teacher to devote different levels of effort throughout the semester, with the more labour intensive moments at the beginning and end (initial planning and final evaluation). Consequently, and throughout the semester, the instructor was able to devote more time and effort to other activities, namely research, without compromising the quality of her guidance and availability to the students. This flexibility in schedule was both welcome and refreshing, leading to more focused and more productive moments in both areas of activity.

Overall, both instructors and students considered the implemented methodology to be positive and successful. Consequently, similar approaches are currently being applied to other courses of the 2008-2009 school year.

The experience described herein represents a significant move towards innovative and adequate approaches for handling and motivating large classes of engineering students in a transdisciplinary context, by encouraging active and collaborative learning activities and strategies. More importantly, it provided students with an opportunity to enhance their individual personal and professional abilities.

Appendix

Teaching/Learning Evaluation Survey Parameters	
A	Interest in the subject
B	Usefulness of learning
C	Understanding/Grasp of content
D	Classroom dynamics
E	Classroom organisation
F	Commitment to teaching
G	Meeting schedules and other activities
H	Clarity of subjects taught
I	Organisation and availability of study materials
J	Ease of producing class notes
K	Encouragement of students participation
L	Encouragement for expressing different ideas/questioning the teacher
M	Concern/care about students
N	Availability for answering questions
O	Comparison of different theories and existing models
P	Presentation of different points of view
Q	Usefulness of information regarding projects
R	Adequacy of evaluation system
S	Usefulness of projects and/or reading assignments
T	Number of projects and/or reading assignments
U	Level of difficulty of course
V	Work demand/load of course
W	Importance of the course
X	Global evaluation of the course
Y	Global evaluation of the teacher

Rating Scale	
1	Strongly disagree
2	Disagree
3	Somewhat disagree
4	Somewhat agree
5	Agree
6	Strongly agree

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Paper Session B2

Debating Teaching Attitudes for a Successful Learning Approach

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Abstract

This paper discusses the needs that should be fulfilled by both the teachers and the students for a successful learning process approach. It is based on the experience of teaching civil engineering students, both from the last years and also from 1st year, during the most recent years. Although the problems faced at teaching each student age are very different, the essence remains similar, and that is motivation for hard work. University students seem quite lost in the way to achieve their goals of success. It is one of the teacher's aims to give them back the joy of learning. Two learning/teaching experiences are presented and discussed in what concerns course planning, implementation, monitoring and assessment of pedagogic experiments. This paper describes all these problems and proposes possible solutions based on empirical evidence of teaching classes with team work in the course with more students in the University of Minho.

Keywords: team work; learning attitudes; pedagogic problems.

1 Introduction

The new process of adapting the courses to ECTS- European Credit Transfer and Accumulation System in order to fulfil the Bolonha Process arrived at a moment when many teachers were asking themselves what they could do in order to make the students more motivated to attend their classes. As mentioned by Powel in Pouzada (2002) the change of the methods of teaching to a method of cooperative learning work and by project highly contributes to solve problems of motivation, of innovation needs and the internationalization of courses. We do believe that this process, if well carried out, can be an answer to many existing problems. In times of change, many questions come up and induce reflection.

The adoption of the ECTS based on students work should not be taken as a formal change. For each curriculum unit, a number of ECTS was assigned that is based on the time that a student should allocate to achieve the required learning outcomes. The time allocated for each curriculum unit is a sum of the time spent in class, plus independent study and assessment. The change of theoretical and practical lectures into class time associated with independent time is an essential change since it allows a more effective teaching, being the teacher an inducer of knowledge and no more a transmitter of knowledge. This change should promote, on one hand, pro-activeness of the students to become more interested during the lectures, as they participate with their work and are more likely to put questions about the subject. On the other hand, they should be more aware of what is expected of them to do. The teacher now plays the role of motivating the students to learn by themselves. This new behaviour of leadership implies a profound knowledge of the human behaviour as described in Daniels (1994) but only some university teachers have been attending courses on methods of teaching/learning and applying those new techniques in their classes. The same applies to the students that should be aware of the time that they are expected to spend in independent study and this has to be well planed, so in this moment of change, students should be provided with short courses or manuals to help them cope with what is expected of them to do.

A recent study on Portuguese higher education students mentions the need to obtain a diploma and a successful career as the main motivation reasons to be at University. Nowadays, on one side more persons wish to have a degree course, and on the other side, the syllabus from the secondary school have changed a lot in the last years, and we cannot forget the fast technology evolution. All these factors are very much responsible for a wider choice of activities and ways to do things that may bring fuzziness into the choice of aims by our students. Motivation for hard work is difficult to achieve in modern times. In order to better understand this difficulty we must be aware of student motivations. They have to make too many choices, they have to decide in each moment what is best to do in order to fulfil the objectives they proposed for themselves. In this context of multiple demands, University

students seem quite lost in the way to achieve their goals of success. It is one of the teacher's aims to give them back the joy of learning in a safe and stimulating environment as defended by Erlauder (2005).

It has been shown that the students are more interested, nowadays, in getting a degree than in getting knowledge. Therefore the question "How do we get the students to learn what we want them to?" arises. Thomas Shuell said in 1986: "what the student does is actually more important in determining what is learned than what the teacher does." So how can the teacher induce the student to work in order to achieve the intended outcomes? By lecturing about those outcomes? No, in a lecture the student simply listens and takes notes, with various levels of understanding. Then, the role of the teacher is to facilitate student learning. This role is carried out by both, the teacher's attitude and the way the curricula is presented. The next section discusses the teaching attitudes and afterwards in the paper, it is analysed how the curricula can be developed.

2 Teaching Attitudes in order to Activate Students

Assuming that the teacher is the leader in the classroom, there follows the consequent idea that he must behave like that. As referred in Warren Bennis (1997) the qualities of leaders are, among others, the ones that: focus on people, inspire trust, have long-term perspective, innovate, ask what and why, develop, show originality, challenge the status-quo, have an eye on the horizon, be their own person. This implies that it is not the aim of this paper to give instructions for teachers to act as leaders; the basic goal is rather to discuss some general points that can improve the students' behaviour and, consequently, help them to be more responsible for their learning. The way in which a teacher applies these concepts is the one that is best suited to himself.

Daniels (1994) claims that behaviour is a function of its consequences. Many times we ask what happened before some behaviour has occurred when we should ask what occurs normally after that behaviour. When analyzing a performance problem it is necessary to determine if is a motivational problem (won't do) or a skill problem (can't do). Practically, to manage a behaviour it is needed a precise specification of what we want to improve, the development of a baseline of current performance against which we can measure progress, and then a precise intervention and the evaluation of its impact on performance.

At a first glance, it could be said that everything we do produces a consequence for us, therefore it is natural that: i) if we obtain something we like, we repeat it; ii) if we do not get what we like, we stop. But this is not so easily catalogued in i) and ii), because consequences change the rate or frequency of a behaviour. In order to obtain desirable behaviours from students, it is relevant to know that the behaviour consequences can be classified as: Positive reinforcement (if it increases the rate of the behaviour because we get something we want), Negative reinforcement (if it increases the rate of the behaviour because we want to avoid something we don't like), Positive punishment (if it decreases the rate of the behaviour because we get something we don't want) and Negative punishment (if it decreases the rate of the behaviour because we don't get something we want).

Since behaviour and consequences always come together we must understand how the first influence the others and vice-versa. The first step to understand behaviour is to know what have been the consequences experienced after that behaviour in previous times. The ABC (antecedent-behaviour-consequence) Analysis is a simple method for systematically analysing the antecedent and consequence influencing behaviour.

In ABC Analyses, consequences are classified in three dimensions: 1. Positive or negative. This dimension answers the question, "Is the consequence positive or negative from the perspective of the performer?" 2. Immediate or future. Here we want to know, "Does the consequence occur as the behaviour is happening (immediate) or some time later (future)?" 3. Certain or Uncertain. This dimension expresses the probability that the performer will actually experience the consequence.

The behaviour that occurs is the one in which the performer considers the consequence to be positive, immediate and certain. For example, in a very simple behavioural attitude, if a student is playing a game in the mobile phone, while in class, it is because the consequence is certain and immediate - he is enjoying himself now. If instead of working - as he should be doing – he is playing, it is because the consequence of better performance in the future due to hard work is considered as uncertain. So, in order to change this type of behaviour, one action could be to announce beforehand that all the students with this behaviour will have the gadget confiscated. Then this threat would be considered negative, certain and immediate, therefore the students will not play but, most probably, they also will not work as desirable (negative reinforcement). Other type of action could be simply ignore that behaviour and find an activity that the student considers enjoyable (positive reinforcement).

To be able to make a good ABC analysis is an indirect measure of empathy because in order to do so, it is necessary to classify the consequences through the eyes of the performer. Since a consequence considered certain will determine the behaviour the leader should be considered as trustfully, i. e., the change of behaviour in the long term depends on how it is possible to pair antecedents with consequences. In other words, to be trusted all you have to do (consequence) is what you say you are going to do (antecedent). In fact, trust can be constructed every moment and it is very important in the relationship of the teacher with the students in the class. Once trust is established, people will give you the benefit of the doubt even if you make a mistake. If you are not trusted, they will not believe you even when you tell the truth.

In order to facilitate successful performance, it is important to understand and accurately measure leadership performance. As explained in George (2000) the mood of the leader influences the behaviour of the group, i. e., positive mood leaders transmit their mood to the group and the group tends to perform better and more consistent than those in which the leader is in a negative mood. A positive mood leader tends to give positive reinforcements and thus the response of the group is of better quality.

The first day of class is very important in order to define group's mood. The teacher's attitude in believing that the course will be well succeeded within a team work is a positive attitude. Working as a team will be the key to success, but there are pre-conditions: it is not a team if 1) the students work and the teacher is not there to guide, 2) the teacher guides and the students won't follow. A team means that all members work together in order to pursue a goal. As a leader, the teacher should have the ability to understand and manage the moods and emotions in the self and others, i. e., to master the emotional intelligence. If the leader allows the student's behaviour to influence his own behaviour, he loses the leadership and puts at risk the aimed goal. This is the case when a teacher is not able to control himself when a class is misbehaving. Most probably, the students do not understand what is expected of them to do and it is certain that their behaviour is going to have that consequence. Also, in the first day, the limits of behaviours should be discussed and defined, living no place for misunderstandings. This discussion also sets the tone for class dynamics.

There seems to be a need for university teachers to do team work deeper than the actual coordination of assessment moments (Felder, 2003) and have pedagogic support when planning learning activities and schedules. In fact, the normal teacher will not provide a new leadership in terms of individual student or team learning due to his (her) own lack of time and preparation. This is especially true in courses with many students where organization and dedication are crucial for any successful attempt to shift learning paradigms. The motivation task, alike for team learning or project approach, as the student is induced to learn by him (her)self and by sharing knowledge with other colleagues, is difficult to manage by teachers without technical support, pedagogic expertise and even more, without time to question present teaching attitudes. University teachers still work in a very lonely way and this lack of team work among them endangers the success of the Bolonha Process (Lourenço et al., 2007).

Each of us has a social personality as well as a learning personality that is different from everyone else. Our learning personality is the combination of natural talent, personal interest, current opportunity, social environment, character, motivation and how the brain processes information.

People, whose learning personality is in harmony with their social environment, are considered highly intelligent. People, whose learning personality is out of harmony with their social environment, are considered to have low intelligence.

The formal education helps intellectuals discover and develop their natural talent. The system does not do the same for non intellectuals. These students are labelled failures because they cannot perform like intellectuals. On the other hand, put these students in a social environment that is in harmony with their natural talent, suddenly, they become highly intelligent and excel.

Albeit social environments and talents can be divided into hundreds of categories, for comprehension´s sake four straightforward categories were established as can be seen in Table 1. The last one aggregates the varying others that do not fit into academic/intellectual, arts/artistic, mechanical/technical, physical/dexterity environments/talents.

In fact, an intellectual learning personality relates to superior motivation with academic subjects, because these students enjoy learning. They are highly motivated and their high grades reinforce their self-motivation to learn but they must feel challenges from the learning system. We agree that this is a strong component of university students learning types.

Teaching Engineering students, in particular, civil engineering, implies a relevant percentage of students with mechanical talent and skills, that is having a technical learning personality. These students take risk and learn by trial and error and so they should be allowed to experiment, in order to discover their true capabilities. Project work seems especially catered for their needs

Table 1: Perceived Intelligence in Different Environments

Learning Type/Talent	Social environments				
	Academic	Arts	Mechanical	Physical	Other
Intellectual	HIGH	Moderate to Low	Moderate to Low	Low	Low
Artistic	Moderate to Low	HIGH	Moderate to Low	Low	Low
Technical	Low	Moderate to Low	HIGH	Moderate	Low
Dexterity	Low	Moderate to Low	Moderate	HIGH	Low
Other	Low	Low	Low	Low	HIGH

Source: http://www.motivation-tools.com/youth/project_education.html, accessed at 2009.04.22

Another relevant learning type is the dexterity learning personality that relates to the need to know "why," otherwise, the information is rejected. While the artistic talent if strongly dominant does not seem to fit in the engineering world, there will be some percentage of students in this set, apart from others who are not so easy to classify.

Here, another conceptual approach to learning should be introduced that is “constructive alignment”. This concept by John Biggs starts with the notion that the learner constructs his or her own learning through relevant learning activities. The teacher should be aware that the key aspect is that all components in the teaching system - the curriculum and its intended outcomes, the teaching methods used, the assessment tasks - are aligned to each other. All are tuned to learning activities addressing the desired learning outcomes. Then, if this occurs, the learner finds it difficult to escape without learning appropriately.

In brief, instead of controlling the performance of students, close supervising teachers should lead in such a way that they will condition students to assume responsibility.

3 Course Planning

The importance of course planning is increasing in the new Bolonha format compared to the previous format as students are supposed to learn in more independent ways, having the number and time duration of classes diminished. This section addresses the issue of course planning for two subjects, one in the first year – Mathematics -and the other – Urban Planning - on the fourth year of the Civil Engineering degree.

Course planning is an essential task, it needs the definition of the course objectives, of teaching and learning activities and of assessment methodologies. Explicitness of objectives gives the guidelines for both the teachers and the students in terms of learning outcomes. Assessment and learning tools have to be in tune with the objectives that should themselves contain statements which suggest the kind of behaviour the students will be required to demonstrate in order to show that those objectives have been achieved (Newble & Cannon, 1995).

It is also important to define if the teachers will only deal with behaviour concerning knowledge or also skills or even attitudinal. The knowledge behaviour incorporates six levels, according to the taxonomy of Bloom, from knowledge, comprehension, application, analysis, synthesis to evaluation or three subdivisions, recall of information, understanding and problem-solving, as recommended by Newble & Cannon.

The objectives should be derived from a careful analysis of the subject matter, what the lecturers know about students (knowledge, skills and attitudes) and about the subject (Newble & Cannon, 1995). Methods to achieve these objectives can be lecturing, small group teaching, practical teaching direct observation with feedback, preceptor system, independent work, field-work, peer teaching and a variety of simulation techniques.

The planning of a mathematical course for the engineering first year students takes into account the fact that they feel some times very disappointed since they do not understand the reason to learn mathematics. First year lecturers know how mathematics is important either in life in general as in an engineering course, but is not by telling that to a student that makes them more interested in the subject. The question now arises on how to motivate them to hard work in something they don't feel as important. The mathematical concepts taught in first year are designed to train and develop proper thinking and to give the basis knowledge for later appliance. Sometimes, it is very difficult to find direct applications to subjects since their application requires a deeper knowledge of different subjects. To teach the mathematical bases trough project base education seems difficult because of the given problems and as well because of the extended course subject. The solution to the problem seems to be active learning.

In active knowledge construction, knowledge is constructed with the activities the student does and not what the teacher does. In this process the teacher's task is to help students construct understandings instead of transmitting them. Content thus evolves cumulatively over the long term, having "horizontal" interconnections with other topics and subjects, and "vertical" interconnections with previous and subsequent learning in the same topic. The process of teaching is to help the learner undertake activities that involve progressive understanding of the meanings. The process is multidimensional, not linear: it is to intrigue the gourmet, not to sate the glutton (Biggs, 1994).

The horizontal and vertical connections of each subject enforces a well planed course, implying discussion with the teachers of the other subjects. These discussions need to take place in a systematic way, which has not been the case due to lack of time of the teachers involved.

In the experience carried out in the linear algebra and analytical geometry, the subjects were presented in a bloom taxonomy order. With this we mean that the presentation of the subjects is not done in a sequential order, as is usually founded in referential books. To start the students occupied to master the calculations, with exercises that prepare them to discover some properties. Then the curiosity to understand deeper the subjects is established and then properties and applications follow. The study to analyse, apply and relate the knowledge of different subjects is a natural step to carry out. This order is not completely linear, since we can not forget that each student is an individual with special type of learning. Nevertheless, not all of them are happy with basic learning and those who are should be pushed into a deeper understanding of the topics.

The assessments are planned in such a way that subjects are common to more than one assessment, but in a different level of knowledge. As said before the topics are aligned in the bloom taxonomy therefore, in the first assessment is mainly calculations of different procedures and some understanding. The next assessment comprises understanding and some problem solving, leaving to the third the interconnection between the topics. In this way, the student will master all the topics, since all the topics will be tested more than once, being the most important topics tested in all the three assessments at different levels of knowledge.

The other course unit, Urban Planning, previously a fifth year subject of the Civil Engineering degree, was passed to the fourth year, due to Bolonha re-arrangements. Also, due to this fact, the number of contact hours decreased and students start this subject without one subject that used to be taught in the previous year. In short, the course needed re-planning in order to cater for these shifts.

The planning of the new course took into account the lesser knowledge, the lesser age of the students and the lesser contact hours. The course keeps theoretical classes that appeal essentially to the most motivated hard working students with passive learning attitudes albeit the classes are structured around an interactive critical questioning but given at an auditorium. In the practical classes, students work in project based activities. In the last two academic years, the project had to be more closed and pedagogical exercises were introduced. This means that the project was pre-defined and the methods were pre-established, whereas previously the problem was partially defined and the methods were partially established in a partially open project.

Education that is based on projects is highly motivating and is man's natural learning process. The Project Based Education concept is based on what interests and motivates the student. Because the instructor cannot customize lesson plans for each student, he must implement student responsibility. It becomes the student's responsibility to develop the research project as well as a plan of action. The teacher acts as a coach or facilitator. This means that the teacher takes an interest in students' projects instead of students having to take an interest in topics handed down by the teachers.

Today's education system is based on academics and tests are used to gauge progress. A high percent of students are in tune with the current system, but there will always be the 30% who cannot associate classroom instruction

with the real world. This is especially true for students with creative minds that are searching for alternatives. Project based education would solve this problem.

Projects require a goal where students must search for a method, acquire skills and knowledge, accept failure and bounce back from it, and keep trying until the goal is achieved. They learn through experiences and more important, they learn how to research and apply knowledge. Success is measured by the complexity of the project and the ability to finish it. This type of education motivates one to learn more about the world we live in while creating a lifetime love to learn as projects are learning tools that are motivated by curiosity.

A team of 5 to 8 members agree on a common interest project. With teams, the opportunity to share knowledge has a powerful influence on team members. It motivates others to find ways to contribute information or skills. When things go wrong, strong team members can support and encourage the weaker ones. Support from associates is a powerful force and peer pressure can motivate all to excel.

Projects make it possible to offer a wide variety of subjects, determined by the interest of the students. It becomes the students' responsibility to develop the project with available resources, not the teacher. But projects require a plan, which includes ways to acquire needed knowledge and skills.

4 Implementation of Student Activities

The solution to the problem on how to increase motivation for hard and independent work in the learning process depends naturally on the age of the students and also on their personal aims. The first case study presented here comes from the experience of teaching math subjects to first year students. The behaviour problems faced with these students are more concerned with motivational problems than with skill problems, since being the first courses in university the bases are not in general the problem. In fact, these freshmore are not used to, or motivated to, work hard within a relaxed not closely supervised environment.

Furthermore, they are not prepared to cooperative learning, in most of the cases. Teaching the basic mathematical concepts is particularly difficult since the student does not see the immediate application of those concepts. Although this is a fact, our experience has shown that introducing the concepts with some application to their future life and the mathematical theoretic in a way that can solve the problems at stake in a more efficient way has fostered a higher motivation in the student. But that is not enough, per se.

As referred before, it is what the student does that define what the student learns, thus the classes are carried out with the teacher behaving as a conductor defining the times that a topic should be mastered. The methodologies advised in Felder (2006) are very important to this kind of behaviour. In sum, what Felder advises is to propose to the students a simple question that they try to answer in class in groups of two or three and after a few minutes all the class discusses what the solution to the question is. To follow this methodology the classes are no longer divided in theoretic and theoretical–practical, they are just contact classes. In contact time a topic is launched and questions are proposed in order the student start to understand the topic at different levels of knowledge.

In order to get them acquired to cooperative learning that is very used in classes, they are induced to discuss the problems presented between themselves, in groups of two or three, and then discuss the result to the class. Explaining the problems to each other is highly encouraged in almost every class. This method keeps the student active in class and forces him to work together with other students. In this way the classes became more appealing and the student realises the benefit of working together, leaving the students to follow this behaviour outside class and to study along the course.

In first class the intended learning outcomes will be explained in a brief way, since it is difficult to fully understand what is not yet known. But presenting the outcomes in the bloom taxonomy, allows the students to realise what is expected from them, which is more than just learning procedures and memorize a few formulae. In order to reinforce this idea, the classes are carried out with student activities that make them experiment the high level of knowledge that is expected from them.

The alignment of classes is such that the easiest concepts for doing calculations were the first to be introduced. Since these calculations were easy to learn, the students started to be motivated, and then it was not difficult to move them to deeper thinking procedures in order to apply the acquired knowledge to different situations. It is already possible to conclude that this kind of step by step approach fostered a better apprehension of concepts.

The basic procedures in the first part of the course are presented with applications to the future life as civil engineers in order to motivate them and to build their confidence. After being able to master the procedures they

can come to apply those procedures into problems, deciding case by case which procedures are more appropriate to the situation under study. In this way, it is expected that the student be able to connect and associate the subjects taught.

The activities proposed during class are group activities in order to encourage them to do cooperative and team work. Several times, explanations are given to a group and then these students are asked to explain to other groups of students. This procedure is especially important when dealing with large classes, when it is impossible that the teacher reaches all the groups. Obviously, when and if doubts still persist the teacher has to find time to explain. In the end of the class, the students are prepared to single out and discuss the important points. Then, new activities to deepen the knowledge in the subject are proposed to the student to be carried out during their independent time study. These activities can be either performed alone or in group as more advisable.

Maintaining the student active in class improves their knowledge, since it is what they do that determines what they learn. Discussing the subjects between themselves improves their thinking in a relaxed way, as they are less afraid to make mistakes with their peers. Immediate positive reinforcements are more likely to happen since they discover that they are capable of discussing with each other. In consequence, they feel more prepared to do the assessments since they work in problems alike. This means that the levels of knowledge that they are expected to acquire are the ones that they train during lecture time and independent study.

Turning now to a description of the activities undertaken at the 4th year subject, Urban Planning, under practical classes as mentioned in the last section, they evolve around simulation scenarios and urbanisation proposals for an existing area not far away from the University. The difficulties presented by the selected area vary from year to year but the level has been decreased in order to cater for the lesser knowledge of present-day students which are no longer fifth year students. The average number of students per team continues to be eight students which has probably to be lowered to six members but the total amount of students per class has not yet allowed this down sizing.

Students have to make a diagnosis for the area which is discussed and framed by topics. Each topic is dealt upon choice by each team of students and after a given time, topic analyses are exchanged between all teams so that all students can make a global diagnosis of present situation. This sharing activity allows interaction between teams and indeed a better overall performance as sector analyses could reach a detailed level that will help more effectively team work at the time of making proposals.

The joint field trip, the open possibilities for choice, all concurs to motivate the majority of the students. Intermediate oral and visual presentations foster the adequate level of progress for the vast majority of the teams, enabling healthy competition and critical evaluations.

In former years, the level attained by the sketched proposals was good, in general, with some of them reaching professional status. This high level resulted from the joint work by many students while in the real world, professionals are many times working isolated and subject to plot property constraints. Some old students talk about their proposals being better than the ones that actually took place on those sites and this message is carried over the years.

But with the lesser age and knowledge of present students, the quality of the proposals has naturally come down. So, the challenge now, is while keeping the freedom of choice and action of the students so that they can enjoy the work they are carrying out makes a compromise with the obvious student limitations.

In brief, both subjects portray engagement in constructive in addition to receptive activities. Constructive activities involve (Biggs, 1989):

- a positive motivational context, hopefully intrinsic but at least one involving a felt need-to-know and a aware emotional climate;
- a high degree of learner activity, both task-related and reflective;
- interaction with others, both at the peer level with other students, and hierarchically, within "scaffolding" provided by an expert tutor;
- a well-structured knowledge base, that provides the longitude or depth for conceptual development and the breadth, for conceptual enrichment.

5 Discussion of Results Obtained

Assuming that learning with responsibility is the future, as society is becoming too complex for authority control to be efficient, it is obvious that leadership cannot comprehend, let alone implement, the wide variety of alternatives available. This is valid for the world at large and also for the academic circles. People with hands-on involvement are the best ones to explore ways to be efficient, but the system has to be organized to allow students to take responsibility. Likewise teachers have to give up control and find increasing ways to delegate responsibility to students.

In attempting to do so, it is important to highlight what are outdated beliefs as the ones that all university students can learn in a passive environment as a significant part of them cannot. And so, the old assumption that academics must be mastered before other opportunity is offered is not universal as some people learn by doing. Putting a diploma on a pedestal, thinking that it is the most important tool to present to the market has been a constant in the Portuguese society. But this obliterates the importance of attitudes, namely the relevance of displaying more positive self-esteem and a commitment to action in the real world.

This paper presented course planning and implementation of student activities for two courses of the civil engineering degree – Mathematics and Urban Planning. Despite different approaches, the basic conceptual framework of learning has strong similarities in the sense that it is attempted in both to delegate learning responsibility to students. And both courses do not undertake the last degree of responsibility which is allowing students to assess their performance.

Peer-assessment of experiments has not been carried out formally as in previous times in another subject (Van Hattum & Lourenço, 2006, 2008). Lack of pedagogic support, mostly and in part, lack of time, explain this fault. Likewise, the questions remain: How do we know how well the student has done the applying? By getting them to write an exam paper on application? The answer is negative, as what is important is to check how well they have applied the principle in the case study, perhaps in a different situation. “Exam” is only one sort of assessment task and not one best suited to assessing many high level outcomes. Frequently, the most important outcomes are about behaving differently, making informed decisions. In fact, many times given exams most easily assess how well students remember what they have been told or what they have read. But they do not provide evidence on how the students can use the topic to inform their behaviour.

In sum, the achievements obtained in the mathematics and urban planning courses were to get them acquainted to cooperative learning. In the first course, students are induced to discuss the problems presented by the lecturer between themselves, in groups of two or three, and then discuss the result to the class. In the second course unit, students find problems in team work and they come with these problems to the lecturer when they cannot solve them.

A first monitoring and reporting of the learning processes of fourth and fifth year civil engineering students show surprising results in team learning evaluation. In fact, evidence from 4th year students have recently achieved problematic results in many subjects where team learning or group work has been introduced for a long time in the corresponding subjects. The reasons can be many, among them the reduction of lecturing hours and “laissez faire” attitudes from students as well as the overwork schedules and busily dispersed activities faced by university teachers at this turning point times. These reasons are similar to others described by students at Porto University, even at other courses not involved with engineering studies.

Nevertheless, more lasting outcomes can only be assessed in the next years and in other subjects if students are able to apply the acquired knowledge and the proactive attitudes.

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Improving Collaborative and Communication Skills with a Multinational Project Course Unit

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Abstract

Our society is experiencing sudden changes in the way people and institutions produce and manage value. Modern economy is highly dependent on technology requiring engineers to excel in collaborative and communication skills at an international setting. However these competences are not addressed in the generality of engineering curricula. A set of curricular activities involving students from different countries, collaborating to complete projects, might improve both students' enthusiasm and their teamwork and communication skills. Under the frame of the Erasmus Multilateral projects we intend to evaluate the benefits of a multinational project course unit on improving students' teamwork and communication skills at an international level. Depending on the outputs of this initial pilot project we expect to set this course on a permanent basis from 2011 on.

Keywords: curricular development; collaborative learning; international course unit.

1 Introduction

Recent results from the European Association for Education in Electrical and Information Engineering network (EAEEIE 2008) point out that students complain about a big gap between what students would like to know and what is taught at school related to the ability to work in an international context.

Our society is experiencing sudden changes in the way people and institutions produce and manage value. These changes are in part due to the growing ease with which people can collaborate nowadays. Many successful cases of peer-to-peer models of organization arise and assume leading positions in world economy. Take the cases of Linux, Wikipedia, InnoCentive and the Human Genome Project, for instance (Tapscott, D., William, A., 2006). People are evolving and interacting inside heterogeneous teams composed by members from many different cultural groups with distinct skills and backgrounds but these issues are not generally addressed by engineering courses curricula.

Modern economy and society, being highly dependent on technology, require complex problem solving and communication skills in technical subjects (Wieman, 2008). In such a demanding and culturally diverse environment as the professional world is today, it is essential to promote the development of team work and communication skills at an international and intercultural level.

Presently, there is an increasing need for the establishment of international and multidisciplinary teams. These teams, either spontaneously or explicitly generated, are capable of conceiving and developing successful products to be distributed worldwide. Therefore, we consider being of extreme importance to start promoting this type of work as early as possible in students' academic activities. Leading future engineers at an early stage of their higher education to be involved in an academic multinational project where they will need to interact and communicate at distance with their team, and work together to fulfil a common target, will certainly be challenging and enriching both for students and teachers involved. Furthermore, it will provide students with the communication and cooperation skills essential to survive in the international world market, which are not other way addressed by general engineering curricula.

Students' motivation and enthusiasm is another fundamental aspect requiring our attention. There is a big gap between the environments where students perform schoolwork and other activities. General activities involving students outside the academy are much more engaging and immediately rewarding than academic tasks. This gap suddenly got larger with the advent of the web and mass collaboration. This is probably one of the reasons behind students' lack of enthusiasm and motivation for schoolwork (Karsenti, 1999).

We believe that a set of tools and curricular activities involving students from different countries, collaborating to complete projects that generate relevant outputs to the community, might improve both students' enthusiasm and their teamwork and communication skills. That is the mission of the Multinational Undergraduate Team Work project (MUTW).

The MUTW methodology is devoted to create and manage international teams of students who will collaborate in order to develop a solution for a given engineering problem.

2 Multinational Undergraduate Team Work

MUTW courses are developed by a group of higher education institutions working as a team to solve some engineering problem. It is intended that final-year-undergraduate students from the different partner institutions are engaged in developing a common project. Each partner will be responsible for the development of a part of the final product.

Final-year-undergraduate students from the partner institutions are the target of our project. By the end of their graduation, students have to develop, within a generic project course unit, a system that requires the integration of the technical skills acquired during their undergraduate course. For students enrolling, MUTW's work-load will replace that course unit. The work developed within the MUTW will correspond to around 20 ECTS (ECTS 2008), and will take place during the spring semester. The MUTW is expected to greatly contribute to develop other skills besides the technical skills aimed to be developed at the project discipline within the regular local scope.

This project is strongly related to the development of software products. Partner institutions should have software design and development in their curricula. In the future, we intend to enlarge the project and apply it to other engineering fields; however, we believe that, at this initial stage while still realizing MUTW potential, a broader scope might not be executable.

Partner institutions organize themselves in work teams. Partners within each team should ideally be geographically spread. Work teams are constituted by two final-year-undergraduate students from each partner institution. For each academic year the consortium agrees on a software project which should be of interest to the community. This software project will be developed by the international work teams.

The software project must be designed in a modular way; each member of each work team will be assigned a given module. Distinct modules should be equivalent in terms of the workload they require. This is to guarantee that the tasks assigned to distinct team members have similar workloads. Once the planned product has been developed, the whole multinational team gathers face-to-face to present the final product and justify the options taken.

During the software project development period (spring semester), partners will communicate and discuss technical issues – mainly those related to modular integration – within their work team or globally at the consortium level, using some groupware platform. Two face-to-face meetings involving all partners will take place each year. The first will be at the beginning of the spring semester. This first meeting aims at presenting the software project to the enrolled students, introducing students to each other, and at presenting them to base competencies. Two seminars are to be organised for this purpose. The second meeting, taking place at the end of the spring semester, will be dedicated to evaluation. In this last meeting, teams present their solutions and students are evaluated.

Besides the software project assignment-related tasks, partners will be engaged in management tasks including the management of the groupware platform, formalization of the methodology, financial control, dissemination, seminars preparation, MUTW web site, designing evaluation questionnaires, among others.

2.1 Goals and impact

Having the mentioned aspects into account, MUTW intends to accomplish the following:

Aims

- Prepare students for an emerging economy based on active (mass)collaboration.
- Increase students' enthusiasm and motivation for schoolwork.

Objectives

1. Conceive, apply and evaluate a methodology to design and manage collaborative assignments to be developed by teams of students from distinct institutions geographically spread.
2. Promote communication and cooperation skills at an international level by engaging final-year-undergraduate students in a multinational team to work on and develop a common software product of interest to the community.
3. Promote creativity, competitiveness and the growth of an entrepreneurial spirit essential in the present job market.
4. Improve the quality and increase the volume of multilateral cooperation between higher education institutions while reinforcing the contribution of higher education to create innovative projects.

2.2 Evaluation

These objectives will be evaluated by:

- The quality of the software product produced by students. This might be measured by the final evaluation of students' performance on the project, and by the number of partners that apply the software products generated by the project; this evaluates objective 1,
- Reviews and discussion of papers presented at higher education international conferences; this evaluates objective 1,
- Evaluation of students' performance on the teaching modules (Communication and Open Source, see section 3.1.2 and 4.1 – WP2); this evaluates objective 2,
- Comparing students' answers to a questionnaire that will be filled in by the enrolled students in two moments: when they apply and at the end of the project; this evaluates objectives 2 and 3,
- Analyzing the number of students applying for the project; although this project does not guarantee financial return or employment perspectives for students, as the majority of similar offers from industrial players do, this number is expected to increase in due time; this evaluates objectives 3 and 4.

2.3 Envisaged impact

We envisage a significant impact at:

- Improving students' and teachers' awareness of international multicultural projects
- Improving students' communication skills by promoting and reinforcing intercultural dialogue
- Improving students' team work abilities
- Increasing students' motivation and making learning more attractive
- Making the European higher education area more visible and attractive
- Promoting high performance, innovation and multinational dimension in systems and practices in the field
- Supporting the development of innovative ICT-based content, services, pedagogies and practices
- Helping promote creativity, competitiveness and the growth of an entrepreneurial spirit
- Reinforcing the contribution of higher education to process of innovation
- Improving the quality and increasing the volume of multilateral cooperation between higher institutions in Europe
- Promoting the European spirit

3 MUTW Methodology

The MUTW methodology is devoted to create and manage international teams of students who will collaborate in order to develop a software system.

These teams are set up for a semester with the purpose of developing and presenting a solution to a given engineering problem. The problem specifications, its architecture, its main building modules and interfaces will be briefly described by the consortium. At this stage, only the central rules are provided; students have to interact and cooperate during the project development in order to get to know the other necessary rules. At the end of the project all modules must be integrated and the fully operational system will be presented.

Each team member will be responsible for:

- developing a part of the whole solution,
- justifying their technical options as an integrating part of the whole solution proposed by the team,

- collaborating whenever needed with other team members, either from their own team or from another MUTW team, to guarantee that problems are solved in due time, and that all parts integrate a unique final solution.

The team as a whole must:

- guarantee that all parts integrate well to produce a unique coherent solution for the problem,
- produce a unique report describing the full solution,
- present the full solution to the project jury.

The project jury will be composed by a teacher from each partner institution. Students will be evaluated in the following items:

- proposed solution and technical options taken,
- feedback provided by the supervisor teachers,
- report describing the solution,
- presentation,
- preliminary seminars' evaluation.

Partner institutions are responsible for:

- selecting students for the team,
- defining a supervisor,
- following, guiding and evaluating students.

3.1 Calendar

For each academic year a new software project, of relevance to the community, will be specified by the consortium. The project will be developed during the academic year, according to the following plan.

3.1.1 Fall semester (assignment preparation and specification)

Partners agree and prepare assignment specifications.

M1 (meeting in November) – define the assignment final proposal, including global objectives and technical specifications; assign partners' tasks and compute required effort (ECTS, number of students); define deliverables; define milestones including regular meetings' place and date.

3.1.2 Spring semester (assignment realization)

Students apply for the project and each partner selects a group of students to perform its task until mid February.

M2 (meeting in February) – consortium meeting with teachers and students to get acquainted with project details, specifications for each task and responsibilities of each partner, and also to put students in contact with each other. During this meeting students will attend two teaching seminars. One on *Communication and Presentation Skills* and another on *Open Source Projects* (around 4 hours' workload each). The aim of these seminars is to introduce students to each other while learning basic rules of oral communication, project presentation, open source projects and licensing. Students will be evaluated on each seminar. The assignments and the evaluation of these seminars should be performed by work groups within each project team.

In teams, partners discuss and agree upon open issues, develop and exchange each others' modules to test integration.

M3 (meeting in July) – a 3 to 4-day face-to-face meeting to put it all together at a partners' site, demonstrate results and evaluate. Students must prepare a unique presentation for the system as a whole, which should integrate and coordinate all the partners' tasks together. The aim of this presentation is to present the functionalities of the whole system while describing each partner's contribution. Following the presentation, there will be a discussion period, during which the project team must justify the options taken. The jury will be composed by at least one teacher from each partner institution.

M4 (at the end of meeting M3, last day, after evaluation) – define next year's assignment: general specifications and architecture.

3.2 Project deliverables

The main outputs we expect to deliver from MUTW are:

- a white book describing future curricular activities within the scope of MUTW,
- a software product with interest to the community delivered by each year's teams.

Besides these main outputs, other deliverables are expected to be produced:

- a manual on Communication and Presentation based on the seminars to be held each year on this subject,
- a manual on Open Source Projects based on the seminars to be held each year on this subjects,
- an e-learning course on Communication and Presentation based on the seminars to be held each year on this subject,
- an e-learning course on Open Source Projects based on the seminars to be held each year on this subject,
- one or two papers to be presented at international higher education conferences to disseminate the spirit and the results of the MUTW project.

3.3 Expected difficulties

The multinational and multicultural facet of MUTW poses several problems that do not arise in local environments.

Academic school calendars will hardly match within each international team. This fact poses several difficulties, in particular, to schedule meetings M2 and M3.

Students enrolling the project must be fully dedicated to it during the periods of meetings M2 (3 days in late February) and M3 (4 days in July). During these periods students would be out of their local school environment and will not be able to attend classes or respond to any local requirement.

Students are not used to collaborate at such an extent as required by the MUTW project. This might generate difficulties when integrating modules and when preparing the final report and presentation requiring additional effort and attention from supervisors.

4 Operationalization of MUTW

The MUTW project consortium includes 11 partners from 10 countries all over Europe.

Given the high number of partners, on the one hand, and the need to have students working in smaller teams, on the other hand, we have organized ourselves in two groups. Partners for each group have been selected to achieve geographical spreading throughout Europe in each group.

The following teams have been formed:

Orange team

- Belgium, Gent, KaHo (Katholieke Hogeschool) Sint-Lieven
- Bulgaria, Veliko Turnovo, St. Cyril and St. Methodius University
- Greece, Heraklion, Technological Educational Institute of Crete
- Iceland, Reykjavík, University of Iceland
- Portugal, Porto, Instituto Superior de Engenharia do Porto
- United Kingdom, Glasgow, Glasgow Caledonian University

Blue team

- Bulgaria, Sofia, Faculty of Telecommunication, TU-Sofia
- Espana, Vigo, Universiade de Vigo
- Oesterreich, Dornbirn, University of Applied Sciences
- Sweden, Gävle, University of Gävle
- Turkey, Ízmir, Ege University

4.1 Work packages and responsibilities

MUTW partners organize themselves in workgroups that will be responsible for the execution of certain work packages related to project dissemination and management and student supervision.

The following work packages have been defined:

WP1 – Student Project: This is MUTW's core work package. MUTW editions to be developed aim to prove that the core ideas are workable and feasible before going further, and to evaluate its potential to improve students' cooperative and communication skills, adding a relevant international flavour to their undergraduate experience.

This work package involves all partners in the specification of students' projects. One teacher and two students per partner will be involved each year to develop the project, with a total of 22 teachers and 44 students involved.

WP2 – Base Competences: The purpose of this work package is to provide students with base information on core competences given MUTW goals. Two core areas have been identified: communicating with peers in an international setting and open source projects. Information on these competences is to be provided through two seminars. One on communication and presentation, addressing written and oral communication, and another on open source addressing subjects related to open source software projects, such as, version control and licensing. These seminars will not be restricted to MUTW students; any student in partner institutions can assist them. We intend to broadcast these seminars on the web so local promotion is needed and brings additional visibility to the project.

WP3 – Student Groupware Platform: The aim of this work package is to help geographically dispersed students work together towards one specific goal. Groupware systems streamline communications and facilitate the sharing of data among all team members. It provides a centralized location for data storage and synchronization, and provides a means by which groups can collaborate efficiently regarding the data.

WP4 – Project Meetings: Project meetings are fundamental milestones used to present results and to discuss MUTW core issues. These are the only moments for partners to get together and discuss project ideas and progress.

Each year there will be four meetings: one on November (M1) to decide on the final specification of next edition student's project; one on February (M2) to have students to know each other and to attend base competences seminars; another one on July (M3) to evaluate students and a last one (M4) to evaluate project results and to decide or adjust what follows. M3 and M4 will be organized together, one after the other. Each meeting will be organized by one partner; all partners will participate in it.

WP5 – Methodology: The goal of this work package is to define a methodology that can be deployed by multinational groups of partners to setup curricular units aimed at improving students' communication and collaboration skills. A first draft of this methodology will be set and applied on the first year editions of MUTW course. This will be refined from first year results and evaluation. This refined version will then be applied to MUTW's second year editions. A final revision will be made, once we have second year results and global evaluation, to formalize a final MUTW methodology.

WP6 – Web Site: This is a fundamental work package concerning our long term goals. The project website will probably be its most visible face, assuming a fundamental status in dissemination and exploration. The goal of the website is to provide key actors and general public interested in European higher education with a centralized source of information on the MUTW project and other related initiatives. It should be a reference for us to direct interested agents and should be appealing to attract new partners to join MUTW.

WP7 – Dissemination: We believe that MUTW may bring huge benefits to students. These beliefs raise intrinsic motivations inside the consortium, so promoting MUTW is becoming a continuous effort that goes much further than single dissemination tasks. We promote our ideas and intentions in every chance we have, in all our contacts at international and national level. This work package is just one more chance to promote MUTW in a formal way.

Formal dissemination, during project time period, includes four local promotion actions and presenting a paper on an international conference to discuss first year results. Second year and global results will be discussed in a workshop that we intend to organize but that lies outside the time frame for this project.

WP8 – Exploitation: We intend to put MUTW into action as a permanent curricular unit in European higher education arena. This ambitious goal needs evidence proving MUTW merits. Providing this evidence is the first step. Forwarding this evidence to key actors is the second step. Both these are to be achieved with current project. From this point of view we may consider that the full project is about exploitation; from a more restricted point of view, exploitation relates to the second step previously stated, that is, to persuade key

actors, based on facts from previous experience, that MUTW brings a fresh new twist to engineering project course units.

WP9 – Evaluation Questionnaires: Evaluation questionnaires are an essential tool to realize to what extent is MUTW contributing to improve students' skills. Designing the questionnaire in itself and the most adequate methodology to apply it in order to evaluate MUTW objectives requires competences that are not available within MUTW partners. Education psychologists will be subcontracted to help on these tasks.

This questionnaire will provide information to evaluate objectives related to improving students' communication and cooperation skills at an international level and promoting creativity, competitiveness and the growth of an entrepreneurial spirit. Relevant information will be retrieved by comparing students' answers to the questionnaire they will fill in two distinct moments: when applying and at the end of their MUTW course.

Data retrieved from the questionnaires will be analyzed by partners with the help of education psychologists to realize objectives fulfilment at the end of the first year and at the end of the project.

WP10 – External Evaluation: Consortium members will probably get so deeply involved that they will hardly make impartial judgments on MUTW. To prevent this negative effect and to get a clear view of MUTW added value we will subcontract external evaluators. These evaluators will comment on results and suggest recommendations.

WP11 – Project Management: Overall project management and financial control are the main purposes of this work package.

WP12 – Reporting: Reporting project status and achievements is required to inform key actors and the European Commission, as imposed by funding obligations. This work package will satisfy both these needs by delivering an intermediate report by the end of first year and a final report by the end of second year.

4.2 Student's projects

Students' projects must have visibility to compete with attractive industrial proposals. We will have to compete for students with industrial partners that offer internships to students.

For the first edition of MUTW an open source Erasmus Site offering support for Erasmus students and institutions is proposed. This software system will be composed of several modules, such as: finding equivalent curricula given a specific set of requirements, following up Erasmus students during their Erasmus period, managing an academic and cultural agenda.

5 Conclusive Remarks

We believe the MUTW project to be an interesting innovative curricular development that might be valuable for students, providing them the chance to improve several skills that are not addressed in the regular engineering courses curricula.

Previous experiences with Erasmus students led us to conclude that students enrolling in a period of studies abroad evolve their personality, promote their contacts' network and acquire skills that are much harder, if not impossible, to get by students that do not take these opportunities. MUTW may extend these opportunities to a broader number of students and at a lower cost since there is no need for long periods abroad.

However, there are still costs involved that might be prohibitive if no external funds are available. In the case that the first editions prove to be valuable, sustainability issues must be addressed. It might be feasible to continue with MUTW, after the conclusion of this project, provided some conditions are met: if there are a number of institutions, either in the current consortium or not, that agree to include a MUTW course in their curricula, on a permanent basis, and if this group finds a way to support required expenses (especially travel and subsistence). These expenses can be either funded by Erasmus or some other international or national wide programme or else partners agree supporting these expenses. Partners might also find some external sponsorship.

This MUTW proposal has been submitted to the European Commission on the scope of the Life Long Learning Programme and we hope to get the required funds to prove the benefits of such an experience on improving students' personal, academic and professional skills as required by modern society.

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Learning Industrial Management and Engineering in Interaction with Industry

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Abstract

This paper describes learning aspects of Industrial Management and Engineering based on projects developed with industrial organizations. The particular project under study in this work is based on the Project-Led Education (PLE) concept and was implemented in the first semester of the fourth year of 2008/09 in the Industrial Management and Engineering (IME) master degree course (1st and 2nd cycle of Engineering Education) at University of Minho, Portugal. An evaluation of the process is presented, based on the perceptions of three types of actors: students, teachers and some of the involved companies. From the developed analysis, some themes have emerged - these are described and discussed. Some of the fundamental drawbacks of the process can be related with the lack of time dedicated to the different components of the project. In this paper, an alternative approach is designed and presented to improve the project outcomes.

Keywords: interdisciplinary project approaches; interaction with industry; engineering education.

1 Introduction

Along the last years, teachers from the 1st and 4th year of the Integrated Masters Course on Industrial and Management Engineering (IME) at University of Minho have been implementing an innovative learning/teaching methodology based on interdisciplinary projects: the Project-Led Education (PLE) methodology - Lima *et al.* (2007); Fernandes *et al.* (2008).

The adoption of this methodology is justified by the challenges arising from the Bologna Process and from the consequent encouragement of University of Minho' Rectory for the introduction of active learning experiences. On 2004/2005 a group of teachers involved in the disciplines of the 1st year of IME, has developed and implemented a PLE pilot experience aiming not only to increase the student's motivation, but also to improve the quality of their professional profile.

The PLE methodology, as described by Powell & Weenk (2003), emphasizes team work, problem-solving and articulation between theory and practice by carrying out a project, based on a real situation articulated with the students' future professional context, which culminates with the presentation of a solution/product. The PLE implementation in IME has the following main objectives: implement student-centred learning processes, promote team work, develop initiative and creativity, develop communication skills, develop critical thinking and finally, link interdisciplinary contents in an integrated way.

More specifically, in the 4th year of IME, it is intended that the students establish contact with an industrial company (selected by themselves), analyze the correspondent production system and, subsequently, present a set of consistent proposals to improve that production system. The project is complex, its solution is not unique and it should be challenging, both for students and teachers. The competences that students will acquire result mostly from the specific competences acquired on the disciplines involved in the project. Moreover, it is also expected the acquisition of relevant transversal competences, which are inherent to the development of a multidisciplinary project by a team of students.

The main objective of this paper is to develop and present an evaluation of the process, based on the perceptions of the involved actors: students, teachers and some of the involved companies. Based on some of the fundamental difficulties identified, an alternative approach is designed and presented to improve the project outcomes.

2 Process Characterization

All courses of the 1st semester of 4th year of IME are Project-Supporting Courses (PSC): "Integrated Production Management" (GIP – courses' portuguese acronyms), "Production Information Systems" (SIP), "Simulation" (SIM), "Complements of Quality Engineering and Management" (CEGQ), "Decision Models" (MD) and “Integrated Project I "(PI). All of these courses have 5 ECTS (European Credit Transfer and Accumulation System) - ECTS-EC (2009). At the University of Minho each ECTS correspond to 28 hours of student workload, summing up to 1680 hours for an academic year.

The project has involved 35 students, 9 teachers - 4 of them also as tutors -, 2 educational researchers and 4 companies. The students' ages range between 23 and 30 years old and almost all of them are full time students, with the exception of 5 which are worker students.

A significant part of the students has already participated in a PLE edition, namely in the 1st year - 2nd semester of IME in 2005/2006. For these students, the process of PLE organisation and functioning, which is associated to the discipline of Integrated Project I, is already familiar.

In terms of the interdisciplinary project, students' evaluation implies different assessment components involving distinct moments and functions along the project' duration. Two main components are defined: a quantitative component and a formative component (which has also some quantitative aspects). Teachers of each PSC are responsible for the first component, which covers, mainly, the technical competences defined for the correspondent discipline. Usually this component is evaluated near the semester's end, through written tests and exams. The second evaluation component involves the students' participation on several predefined milestones during the entire project (e.g. formal presentations, tutorial sessions and progress reports). This component represents a fundamental formative role for students and has a significant impact on their performance because it provides almost continuous feedback about not only the project' progress, but also about the evolution of students' learning process. This is in fact a distinctive characteristic of interdisciplinary project-based approaches, that emphasizes the formative aspect as a privileged evaluation issue by considering and valorising the formative process itself. Students are exposed to a multitude of situations during the project and, mainly based on teachers' feedback, they are able to continuously assess their own formative process.

The practices involved on the assessment of the formative component have implications not only on students' role, necessarily active and reflexive, but also on the roles of their teachers and tutors - Flores & Veiga Simão (2007). Particularly, the tutor should provide orientation and support along the students' learning process, trying to facilitate knowledge attainment and promoting both individual and team autonomy - Alves *et al.* (2007).

3 Integrating Industry Aspects with Interdisciplinary Project Methodology

All courses have to change, adapting their contents and pedagogical methods, in order to integrate with each other. Furthermore, courses should also adapt themselves to specific requirements imposed by decisions of students' teams, related to the project development. Based on the perceptions of different actors, this work presents an evaluation of the integration of learning content through the development of a project involving industry organizations. These requirements showed to be both time and customized content dependent.

The interdisciplinary project methodology approach implemented on this case study is characterized by the influence of the interaction with an industrial organization. Nevertheless, the process organisation is strongly guided by academic requirements and evaluation models. This mixed approach between academic requirements and the interaction with an industrial organization influence the way the teams of students deal with both learning and industry aspects. So, the industrial interaction is characterised by a few visits to the industrial organisations. This approach creates a low level intensity model of interaction that should be evaluated. So, an evaluation of the methodology and of the relation with industry requirements, and associated restrictions, is developed.

3.1 Students' perceptions

At the end of the project, a workshop was held with students in order to build a view on their expectations and perceptions about PLE. This workshop involved three different groups that discussed separately three issues related to PLE, for an hour, namely: a) the role of PSCs; b) the PLE as a learning methodology; c) teamwork. It was expected that the main difficulties were identified and some proposals made to improve the next PLE editions. Then, each group presented the results in order to initiate a global discussion about each subject. Eighteen

students participated in this workshop and it was developed by the coordinator teacher and two educational researchers.

From the workshop conclusions three dimensions emerged: tutorial support and orientation during the project; role of companies that were involved into the project; motivation facilitated by industrial interaction.

3.1.1 Tutorial support and orientation

For students, the tutorial support and orientation is quite important for the team performance. In some cases, the tutor is perceived as one member of the team. Students specially appreciated in the tutor role the demonstrated availability and interest by the team problems and difficulties. However, they also consider that tutor should be more active in the team motivation, for example, and should have more knowledge about the project contents. It was given particular importance to the fact that all students' teams should have same conditions about their tutor. Some teams felt a truly lack in the monitoring process by their tutor. Other students´ teams described the tutor action as decisive at certain times of the process, to the decisions that the team had to take or to alert the team on any issue that was not being successful.

The main questions arising from this discussion requiring a deeper analysis are:

- Students' perceptions about the role of the tutor are matching with the role of the tutor that is expected in PLE methodology?
- Could it be possible to give the tutor more responsibilities on teamwork competencies development?

3.1.2 Companies' role in PLE

About this dimension, students reinforced two difficulties: one is each student's team had to deal with different companies; and another is the companies had some difficulties to fully understand the learning concept and to cope with PLE requirements. This affected the communication between students and companies members and their expectations – what students' team hoped from the company and what company hoped from the students' team.

From students' perception analysis there were three main suggestions to overcome these difficulties: 1) Students' teams should spend more time in the companies during the project development and not limited to irregular visits. Students also consider the importance that PSC teachers go to the companies allowing a higher involvement and contact; 2) Coordination team must select the companies which will develop the project throughout the semester and not leave this issue to the students' teams. Selected companies must demonstrate interest, availability and openness, to ensure a high interaction between students and company; 3) before the start of the semester, the coordination team should explain clearly to the companies which are involved their role in all process, ensuring a good coordination in the project development. This is important to also ensure that the suggestions aren't insignificant or useless for the company. The quality and usefulness of the project results to the company should be factors take into account in the final assessment.

In fact, students believe that only one semester is not enough to develop the proposals achieved based on the problems indentified and analyzed over time. The development of the project is often dependent on the PSC's contents, which intensifies the difficulties related to relevance and consistency of proposals submitted by the students' teams. To overcome this issue students suggests that, at the end of the semester, should be given more time to the students' teams to review the consistency of their proposals and conclusions because the knowledge achieved by PSC should enable that.

3.1.3 Motivation and learning

In the workshop final discussion were also raised some issues that motivated the students during the project. This motivation was enhanced by the opportunity given to students to be in direct contact with companies which are closely related to their professional area. Students feel that gained perception on the industrial organization facilitates the learning of PSC contents. Students ensure that in the context of real companies they perceive the applicability of the contents easier, and also that the comprehension about the way the industrial organization operates allowed to apprehend some of the PSCs' conceptual knowledge.

3.2 Staff perceptions

After the project was concluded, a group interview was held to faculty staff involved in the Integrated Project I with the overall goal to discuss the process and outcomes achieved. Two significant themes emerged from the discussion. One focused on the relationship between course outcomes and industry requirements and, the second,

was related to student assessment and individual achievement. These themes will be discussed on the following sections.

3.2.1 Linkage between course outcomes and industry requirements

The need for students to achieve the course outcomes and, at the meantime, also provide appropriate solutions for the problems identified within the companies they are studying, is not an easy goal to accomplish. Lecturers recognize the importance of university and industry interaction for effective student learning, as projects supply a contextualized learning environment which encourages student motivation. Students are challenged to use prior knowledge to figure out new solutions and develop a project that gives sense to the concepts learned.

> Students deal with a real problem, which makes learning more attractive and motivating. There is no predefined work guidelines, students must find solutions for problems which they identify in interaction with real industrial contexts.
>
> Lecturer A

> In my course, students presented more creative solutions than in previous years.
>
> Lecturer B

> With the project, students were able to develop deep level learning, as they were able to understand and apply the concepts taught in previous years to real situations.
>
> Lecturer C

However, some difficulties arise from this process. Teachers argue that it is difficult to manage industry requirements with the academic nature of the project developed. In fact, students are encouraged to apply course contents in the project but this integration is not always clear or possible in some cases. Since the project has to be completed in one semester, time is quite short for students to characterise the industry context, identify existing problems and define actions to improve the production system. This emphasis on the projects' goals and the need to keep up with the integration of the courses' content, may sometimes inhibit students from adopting a more creative or innovative approach on the proposals that they present.

> More than half of the course's program was not applied in the project. Since all teams worked with different companies, sometimes it was easier to apply certain concepts in one company better than on the other. This also happens because the project is open-ended. If it was not, it would be easier to integrate and connect contents from different courses.
>
> Lecturer D

> In my opinion, students do quite little in the beginning of the semester, mostly the basic things. Later on, when they get to the more interesting part of the program, they don´t have enough time to invest on the creative solutions, as they are too busy, at this stage, with delivering the project's final report. This is a great disadvantage of the process. (...)
>
> Also, in regard to students' projects, I think that they were at a very surface level and most of the proposals presented by students were of no use for the companies. They were not very innovative. I think we have to increase the demand of projects.
>
> Lecturer E

> What company B expected from students was to have an outside view as a result of their work and not necessarily an innovative solution to improve their production system.
>
> Lecturer C

> We have to be careful with the expectations that we might be creating in industries, when students develop projects there. For instance, in the beginning, when we had the first meetings with each company, we mentioned that students were going to look at quality and generic referencing bill of materials, and what happened at the end was that none of the groups brought anything new to this company. I even heard a few comments from the representatives saying that they were expecting more from fourth year engineering students.
>
> Lecturer E

> Company B was pretty satisfied with the outcomes achieved. They also suggested that students should spend more time at the company. However, if we look at students' schedule, we notice that they do not have available time to do this. It would be necessary to arrange a specific day and hour on students' timetable for them to stay at the company for a longer period of time.

Lecturer C

> If we decide to make the project less open-ended, maybe faculty staff could previously meet and discuss with the companies what students are able to do and not do in the scope of the project. This could facilitate a better preparation of the companies to accept the projects' conditions. However, this has a disadvantage for faculty staff which is the increase of their workload.

Lecturer A

3.2.2 Student achievement and assessment practices

In regard to student assessment in PLE, most teachers are concerned with students' final grades and individual accountability. They recognize that it is difficult to assess students individually when students work in teams. To overcome this difficulty, teachers often use tests to assess students in regard to their course's contents. Peer assessment processes are also part of PLE's assessment model but these are carried out with the overall goal to assess students' transversal skills, such as teamwork, time management, critical thinking, leadership, initiative, etc.

> Last year, I didn't determine an individual component of assessment. I gave 17 (in a scale up to 20) to students who deserved to fail the course. This year, I changed the assessment method. I gave students a practical test and 11 students failed! This means that these 11 students did nothing in regard to Simulation course on the project work. I can't avoid that some students are engaged in some courses and that others are not.

Lecturer A

Student engagement is also a key issue that project work fosters. As the following teachers' quotations confirm, some students seem to go further than what is expected of them, exceeding the stated learning outcomes for a specific course and getting deeply engaged on that same course. However, it appears to be difficult for students to develop this level of detail for all courses so, inevitably, course tasks and assignments are divided amongst teammates. This, sometimes, leads to some students being more specialized at specific courses than others.

> I'm a bit concerned with the level of learning or effort that we require students to achieve. I think we ask too much of them. What happens is that the successful students go too much in detail. But I am afraid that if all students were deeply engaged in all the six courses of the semester, this would not be feasible, neither for students, nor for teachers. The available time is not enough. (...)

Lecturer C

> In regard to Simulation course, what I notice is that the good students get better prepared. That is, this approach to learning benefits successful students because it allows them to learn deeper. However, I still can't avoid that a number of students do not complete this course with success.

Lecturer A

3.3 Perceptions of representatives of companies

Besides the faculty staff perceptions described and analysed in the previous section, the opinion of the companies involved in the project is, obviously, another fundamental aspect to be considered in the analysis of this PLE process. This section presents the perceptions of two of the four companies where the projects were developed. That information was gathered by the two educational researchers, through interviews with representatives of the companies. Some specific questions have been previously prepared, and thus the initial debate in both interviews was about the same topics. However, after this common part, the discussion at each interview took, naturally, different directions. From the entire set of discussed issues, four main themes emerged: importance of projects in cooperation with industry, performance of the students' teams, limitations and problems of the adopted organizational model, and, suggestions for improvement. The following subsections will address each one of these themes.

3.3.1 Importance of projects in cooperation with industry

In general terms the companies acknowledge the importance of the cooperation between university and industry. Projects involving students' teams and companies are recognized as a potentially good approach to promote that cooperation. Both companies have pointed out the importance of these projects not only for themselves but also for the students.

The persons in our company have a "contaminated" vision of the manufacturing system, acquired along the years, and are no longer able to figure out some problems and/or inefficiencies. The vision from someone from the outside – in this case the teams of students - is very important for us.

Company A

These projects are fundamental to the students because they have to deal with “real life” problems. This is their first contact with the professional environment and the acquired experience will allow an easier integration in the labour market when they finish the graduation.

Company A

With this kind of projects, students have the opportunity to observe/analyse manufacturing processes and to talk to the company’s employees, allowing thus the approximation to the industrial reality. Besides that, the academic contents that can be effectively applied are identified and that may result in relevant improvements for us.

Company B

Students realize that the ability to take decisions based on large amounts of information is an essential competence demanded by the company.

Company B

3.3.2 Performance of students’ teams

The feedback provided by the companies about the performance of students’ teams has addressed several aspects, namely, the expectations created within the companies, the attitude of the students’ teams during the project and the results obtained. Both positive and negative perceptions were pointed out.

We are quite curious about the way that some items of the work plan proposed by the students’ team, after the initial visits, are going to be developed.

Company B

The work proposal of the students’ team is very interesting for the company, because identifies problems on some of our procedures (which were stable for us).

Company A

The attitude of the students’ group was very professional. However, some conclusions presented in the final report have not been well achieved.

Company A

We would like to emphasize the professional behaviour of the students’ team and we are impressed with the results of the project. The number of visits was small and we were not expecting an output with this quality.

Company B

The development of a particular aspect (quality area) was too superficial and, consequently, the correspondent results were not significant. This happened because the interaction between us (company and students) was not enough, resulting in a deficient work proposal (for the quality area).

Company A

The most important result of this project was the diagnosis of our production system, performed by persons from the outside (students).

Company A

3.3.3 Limitations and problems of the adopted organizational model

The analysis of the companies’ perceptions about the organizational model adopted to implement this project in cooperation with industry, has led to the identification of a major concern: the amount of time spent by students in the companies. Both companies explicitly mention that students do not spend enough time in their facilities (however both recognize that sometimes are not available to receive the students). This deficient interaction has negative implications namely, in the validation of the work plans proposed and, consequently, in the projects’ development.

The time spent in the company by the students' team was not sufficient to carry out the intended analysis. We were supposed to have a meeting every week, but, too often (due to several reasons), this was not possible.

Company A

Sometimes, instead of a general view, a more detailed focus on a specific problem would be preferable for the company. With this organizational model, students still spend too much time in the classroom.

Company B

During the visits the students' team gathers a lot of information to analyse later, at the university. However that analysis has, usually, several misunderstandings because the team is working at the university and, thus, the interaction with us is very inefficient (or is not even possible).

Company B

In some occasions we had to cancel the meetings at the company and this has a negative impact in the development of the project. Sometimes the students' team was not able to attend the meeting due to exams, reports and other academic tasks. In other cases we were not available to receive the students (e.g. due to external audits).

Company B

3.3.4 Suggestions for improvement

As expected, the companies' suggestions are aligned with the major concern described in the previous subsection, proposing that more time should be allocated to direct interaction with students. Additionally, other improvement proposals were indicated, including one to extend the duration of the project.

Students should spend much more time in the company. The identification of the problems, and the definition of objectives and work proposal, should be made in close cooperation with us.

Company B

The number of hours that students spend in the company should be monitored. Approximately in the middle of the semester, the team of students should make a presentation of the project's status.

Company B

The university could ensure the continuity of certain projects in the next semester, with the same students' teams. With such kind of approach, the probability of effective implementation of some improvement proposals is much higher. If the company cannot take any profit from work that students are doing, then the work does not make sense.

Company A

The university should become more "practical", aligning with the industry's needs. Academic projects, with no immediate results, do not motivate the companies. The cooperation between university and industry must be improved and it is fundamental for companies' survival. At the very beginning of the courses, students should have direct contacts with the industry.

Company B

Universities could provide consulting services to the companies.

Company A

4 Alternative Approach

The analysis of perceptions from students, teachers and companies gave a clear indication about the need to create time slots dedicated to different components of the project. Although this approach could induce some lack of integration it would allow exclusive dedication to those components. In this way, students would have time slots completely dedicated to project work without CUs interference. Companies would have students in the company for dedicated time periods in order to give them some predefined tasks and have time to discuss their objectives and outcomes. Teachers would gain time to explore some specific contents more deeply and also the potential to have better project results.

Any project approach must consider the ECTS structure of the first semester of the fourth year of IME. This semester has five PSCs plus one dedicated course to the project, each with 5 ECTS. In the alternative approach proposal, the workload is aggregated in time slots instead of a fragmented distribution all over the semester. So, in this alternative approach the project course is completely dedicated to the project work and should be scheduled in final weeks.

For the time allocated to the company, an initial visit should be considered for the characterization, identification of problems and definition of objectives. Later on, teams should return to the company for discussion of ideas, fine tune their proposals and show their results.

PSCs give content foundations for the project work and should be mainly allocated to the first part of the semester. This phase should include three fundamental parts. The first part should be focused on preparing the first visit to the company. The second part will be dedicated to the development of specific learning competencies. Depending on the PSC, this can be, and should be if possible, based on project work also. This part must include all continuous assessment activities. Finally, the third part of PSCs will include the necessary complementary assessment activities if necessary.

Figure 1 illustrates the project's components load for an alternative approach. This load is represented in a 20 week planning horizon. In this alternative approach weeks 1 (one) to 4 are completely dedicated to PSCs contents and to the preparation of the first week in the company. Week 5 will be completely occupied in the company. Week 6 will have some load dedicated to a residual visit do the company to clarify some necessary aspects and a residual load dedicated to the project. This low level load dedicated to the project will carry on just to week 14 with the objective of keeping the project going on. Any PSC exclusive time can also be used for project work if it is congruent with PSC's expected learning outcomes. Weeks 15 to 18 will be dedicated to project work and for visits to the company. It is expected that students' teams develop most of the project during this time and deliver the first version of a complete report. Final version of the report will be delivered later on during week 19. In week 20, teams should make the final presentation.

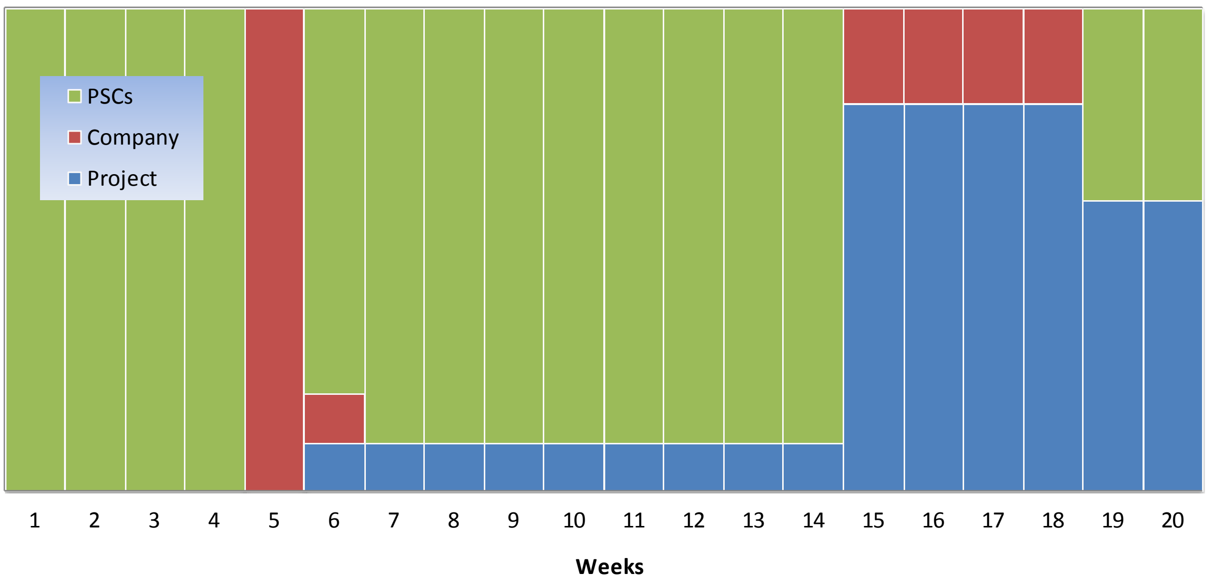

Figure 1: A Generic Load of Project Components within the Alternative Approach

5 Conclusion

Developing learning models based on the interaction with external entities can bring an outside relevant agent to the learning process that could motivate the students. Nevertheless, this presents some difficulties that must be analysed. In particular, developing competencies of industrial management and engineering with an open interdisciplinary project based on the interaction with industrial organizations can raise some challenging issues. These organizations have to manage the time to deal with external actors, allow them to have access to their facilities, give them access to some of their information, discuss their objectives and finally assess their results. Despite all challenges, involved actors have a large predominant positive opinion about the learning and

interaction aspects that are enhanced by interdisciplinary projects and the relation with *live* industrial organizations.

The evaluation of the project approach developed in the first semester of 4th year of IME in interaction with industrial organizations, based on the involved actors' perceptions, allowed to identify some of the fundamental advantages and difficulties of this process.

Students highlighted tutors supporting as one of the major issues on their process development. According to them this support helps them to understand alternative paths and taking decisions. Different teams identified companies simultaneously as having a positive impact on motivation and learning, and also as being one factor of disturbance on project development. Students' teams must deal with companies own rhythm and getting information on time could be sometimes a challenging issue.

From the analysis of teachers' perceptions a clear view on the different expectations raised up. Some teachers expected highly innovative approaches to be applied to the industrial organizations and believed that companies were expecting that also. Other teachers referred that companies were not expecting that level of results and the quality of the final project proposals were considered innovative for the company and exceeded expectations. Learning results and assessment are two fundamental domains of continuous discussion and there is a need to clarify aspects such as: distribution of competencies among students' team members; individual assessment; balance of students' workload.

For companies this type of projects can help to develop the cooperation between the industry and the university. From the point of view of the developed project, companies pointed out the professional behaviour of students' teams all over the semester. They considered important to get an outside view that even identified some processes and organizational issues that could be improved. Some of students' proposals were considered as starting points for future improvements.

Students, teachers and companies' representatives referred that in some occasions the interaction needed to be more intensive. Furthermore, students perceive the need to get dedicated time slots for some project activities. Based, mainly, on these analysis a proposal for project improvement was designed. If implemented, this proposal will allow students to interact with companies for one whole week in the beginning of the semester for characterization and diagnosis purpose. Later on, students will have time slots solely dedicated to project activities, with no courses' interference, that will include, again, the interaction with companies.

Engineering faculty must find ways to approach industrial organizations and these types of projects can help to show what type of work could be addressed in this interaction, both by Engineers recently graduated and by researchers.

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Practices of Socio-Environmental Responsibility Teaching in Engineering Courses

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Abstract

This article is based on review of literature on socio-environmental responsibility, sustainability and engineering teaching. The aim is to highlight a new practice in the teaching of engineering to achieve sustainability, in face of the importance of the education in enabling the people to better lead the development on a sustainable way and deal with the social and environmental responsibility of people's decisions. Within the context of the Decade of Education for Sustainable Development (2005 to 2014) of the United Nations and towards the many educational approaches which are being tested, a new idea, the teaching of socio-environmental responsibility is an outlook to face the current challenges and build a more sustainable world. Finally, it is concluded that it is necessary clarity on the teaching methodology and content, so that social responsibility would not have simply decorative purposes in the curricular grid.

Keywords: socio-environmental responsibility; engineering teaching; education.

1 Introdução

No Brasil e em várias partes do mundo, a partir da realização da Conferência das Nações Unidas sobre o Meio Ambiente e Desenvolvimento – Eco Rio 92, um novo conceito que está em evolução, a Educação para o Desenvolvimento Sustentável – ESD, tem sido amplamente discutido. Esse novo paradigma de educação, segundo os envolvidos não deve ser restrita e ainda deve ser conduzida de forma inter-transdisciplinar em todos os programas e instituições de ensino.

Essa nova perspectiva de educação deverá promover o entendimento do significado da sustentabilidade, sendo assim o ensino superior é fundamental se nós quisermos alcançar um desenvolvimento sustentável. Para Broman et al (2002), a engenharia deve ser considerada como uma das principais disciplinas de transformação para uma sociedade sustentável.

A engenharia por definição já está voltada para a melhoria das condições da existência humana, por meio do desenvolvimento e aplicação de tecnologia. A engenharia, por muitos anos, foi considerada como sendo uma disciplina que formou profissionais meramente tecnologistas, não preocupados com as implicações decorrentes de sua atuação. No entanto, a falta de engajamento com as questões complexas, como as modificações na sociedade e no meio ambiente, indubitavelmente se deu devido a esse tipo de formação.

Assim, uma nova forma de ensino de engenharia se torna necessário, onde os profissionais formados não sejam somente técnicos e altamente especializados, mas que também numa formação humanística ampla (SENAI-IEL, 2006) sejam capaz de lidar com os impactos sociais e ambientais decorrentes de suas decisões. Além disso, de acordo com Cruickshank (2004), eles devem ser capazes de tomar melhores decisões, sempre conduzindo os vários aspectos das questões sócio-econômicos e ambientais relacionados a sua atividade.

A educação sendo uma forma de intervenção no mundo (FREIRE, 1996), e a universidade mediante a sua função formadora desempenha um papel essencial na preparação dos futuros profissionais e conseqüentemente na organização que estes se inserirem. Disso provavelmente decorrerá o que Alledi e Quelhas (2004) ponderaram, as organizações no ambiente de negócios globalizado terão de um diferencial competitivo como conhecimentos e atitudes baseadas nos princípios do desenvolvimento sustentável, englobando a responsabilidade sócio-ambiental, transparência, ética empresarial e genuíno interesse pelo ser humano.

Este artigo aborda sobre as práticas de ensino de responsabilidade sócio-ambiental em cursos de engenharia. Para que isso fosse alcançado, foi realizada uma pesquisa exploratória, por meio de uma revisão de literatura sobre

engenharia, sustentabilidade, responsabilidade social e em estudo de caso de disciplina em universidade pública brasileira.

2 Contextualização da Educação e Sustentabilidade

Desde a apresentação do relatório de Brundtland, muitas controvérsias tem havido na interpretação do que vem a ser desenvolvimento sustentável e sustentabilidade, entretanto para Meppem & Gill (1998) o "Desenvolvimento Sustentável é uma orientação política da sustentabilidade". Como esses conceitos ainda estão em evolução, a sustentabilidade pode ser considerada como o objetivo e o desenvolvimento sustentável como o processo para se alcançá-lo (DIESENDORF, 2000; CLIFT, 2000 apud SIKDAR, 2003). No entanto, a distinção entre essas duas expressões passa a ser irrelevante, se considerarmos que elas são a única opção razoável que temos para se buscar a longo prazo (RASKIN et al., 1998).

Para Orr (2002), um dos maiores desafios da sustentabilidade é a educação, preocupação que foi considerada no capítulo 36 da Agenda 21, intitulado "Promoção do Ensino, da Conscientização e do Treinamento", considerando-a fundamental para se alcançar o desenvolvimento sustentável e melhorar a capacidade das pessoas em conduzir as questões de meio ambiente e de desenvolvimento.

No Encontro Mundial sobre Desenvolvimento Sustentável que ficou conhecido como Rio +10 reafirmou-se o compromisso e foi o marco da utilização dos três pilares do desenvolvimento sustentável: economia, social e meio ambiente. Deste evento originou a declaração que recomendou à Assembléia Geral das Nações Unidas a DESD – "Decade of Education for Sustainable Development" ou Década da Educação para o Desenvolvimento Sustentável, um processo de aprendizagem surgido da necessidade de um suporte para se promover o Desenvolvimento Sustentável (WSSD, 2002).

A DESD ocorrerá de 2005 a 2014 e será conduzida pela UNESCO, sendo que para Calder (2005), este é o momento certo para se dedicar uma década à educação para o desenvolvimento sustentável, e uma excelente oportunidade para que sejam formadas lideranças para a implementação de Agenda 21. Ainda segundo este autor, ela tem como foco integrar as disciplinas da grade curricular dos cursos de engenharia, transformando o processo de formação do engenheiro em oportunidade de desenvolvimento de consciência com abordagem sistêmica.

3 O Ensino de Responsabilidade Sócio-ambiental em Engenharia

No ano de 1990, lideranças universitárias se reuniram na França e criaram uma iniciativa específica na educação, que ficou conhecida como Declaração de Talloires, onde foi definido o desenvolvimento sustentável e ficou estabelecido que este fosse promovido na educação de nível superior. Mais tarde na Espanha, no ano de 2006, uma outra reunião deu origem a Declaração de Barcelona, onde se sugeriu um novo perfil para os engenheiros que a sociedade precisa. Ainda solicitou que o ensino superior considere uma formação holística para os engenheiros, incluindo os aspectos sociais e éticos.

A engenharia é uma disciplina que, por definição, sempre buscou a melhoria da existência humana e desempenha um papel importante em atender as satisfações e aspirações de hoje e de amanhã (VANEGAS, 2006), por isso deve ser uma das maiores prioridades, a integração total da sustentabilidade nos currículos dos cursos de engenharia (GLAVIC, 2006). Além disso, para que essa nova perspectiva de engenharia aconteça, torna-se necessário a contextualização da formação do profissional na sustentabilidade, pois a engenharia não pode ser separada do contexto na qual a atividade é conduzida (JOHNSTON et al., 1996).

Como um processo transformativo (WALS & CORCORAN, 2006), o ensino de responsabilidade sócio-ambiental é fundamental para que isto ocorra, sendo que na opinião de Conlon citado em Zandvoort (2008), para se preparar profissionais para a responsabilidade social torna-se necessário que haja um estudo amplo e critico da engenharia e das dimensões política e social da mesma. Embora neste mesmo artigo na p. 134, o autor pondera que não está claro o que responsabilidade social demanda e o que significa para o currículo dos profissionais, estarem preparados adequadamente para a responsabilidade social.

Nas escolas de negócios e universidades da Espanha, desde os anos 70, tem se ensinado responsabilidade social como prática empresarial, denominado Responsabilidade Social Empresarial – RSE ou "Corporate Social Responsibility - CSR" (MELÉ, 2004) e que é definido pelo Conselho Empresarial Mundial para o Desenvolvimento Sustentável, como "o comportamento ético de uma empresa em prol da sociedade" ou "atuar responsavelmente no relacionamento com outras partes interessadas no negócio, não apenas com os acionistas" (WBCSD, 1998).

A CSR é referida às questões éticas e morais relacionadas com o comportamento e a tomada de decisão corporativa, tais como as relacionadas à proteção ambiental, gestão de recursos humanos, saúde e segurança ocupacional, relações com a comunidade local e relacionamento com fornecedores e clientes (Castelo e Lima, 2006).

A Ética, transparência, sustentabilidade e responsabilidade social não são conceitos aplicáveis somente às organizações. Segundo a Comissão de Normas dos Estados Unidos, ser ética, transparente e responsável virou não só diferencial competitivo para a organização, como também questão fundamental para os graduandos em engenharia em busca de desenvolvimento profissional.

Mesmo sendo complexo devido à definição dos conceitos, responsabilidade social e sustentabilidade, o desenvolvimento de novas práticas de ensino, principalmente em engenharia, tem ocorrido. Vários cursos de engenharia nas universidades brasileiras já têm apresentado algumas mudanças, mesmo estando os cursos de engenharia ainda vinculados à estrutura curricular formatada nas décadas de 50 e 60 (SCHNAID et al., 2001). De acordo com esses autores, os envolvidos no ensino de engenharia devem apresentar novas soluções nas variadas e algumas novas áreas de engenharia.

4 Estudo de Caso: o Ensino da Disciplina Gestão Estratégica Empresarial no Curso de Engenharia da UFF

4.1 Histórico

A abordagem da ética, da cultura organizacional, dos aspectos e metodologias inovadoras e participativas foi sendo incluída nas atividades em sala de aula e em projetos de pesquisa envolvendo outros docentes e discentes, em disciplinas oferecidas tanto em nível de graduação quanto na de pós-graduação. Tal abordagem de gestão com foco sistêmico no ensino de diversas disciplinas, como Controle da Qualidade e Planejamento e Controle da Produção no curso de graduação em Engenharia, despertaram interesses dos alunos para projetos finais de graduação nos cursos de Engenharia da UFF.

Esses interesses motivaram o desenvolvimento da disciplina de Gestão Estratégica Empresarial, com foco em responsabilidade social e ambiental, produção mais limpa e estratégia empresarial direcionada ao equilíbrio entre meio ambiente, desenvolvimento social e econômico nos critérios de tomada de decisão.

4.2 A disciplina gestão estratégica empresarial

Nos últimos quatro anos a disciplina vem contando semestralmente, período letivo tradicional nas universidades brasileiras, com 60 a 70 graduandos matriculados, atendendo além dos graduandos em engenharia quanto à demanda de alunos de outros cursos. Ela tem como objetivo, alinhar e atualizar o conhecimento dos alunos de graduação, apresentando princípios estratégicos de sustentabilidade, bem como dar suporte para aprimorar a capacidade de formular e implementar as Políticas de Gestão Empresarial para a excelência, considerando inclusive os aspectos estratégicos.

A disciplina é lecionada por meio de aulas expositivas e atividades em sala de aula, provocando a interatividade, o desenvolvimento de atributos de oratória e preparação de apresentações em powerpoint, direcionadas para os seguintes temas:

- O que é sustentabilidade?
- Evolução e histórico dos conceitos da sustentabilidade;
- O que é Responsabilidade Socioambiental e as ferramentas de utilização pelas empresas?
- Liderança, gestão de pessoas e segurança e saúde ocupacional;
- Gestão pela qualidade total, ferramentas de qualidade, critérios do PNQ e sistemas de gestão, conforme as Normas ISO 9000, 14000, 18000..., que é utilizado como tema do 1° seminário;
- Gestão ambiental empresarial e indicadores de desempenho socioambientais, como o GRI, Indicadores Ethos e outros exemplos;
- Produção mais Limpa: neste aspecto os alunos são levados tanto a compreender os princípios das metodologias tradicionais de implantação da produção mais limpa, como também aplicam tais conceitos em estudo de caso.

O docente e o monitor juntos, com o objetivo de tornar mais atraente a disciplina, em 2004, produziu um conteúdo composto de artigos, textos e apresentações sobre os temas ministrados e distribuído na forma digital em CD-Rom e por intermédio de e-group específico da disciplina, sendo que o conteúdo deste CD-Rom é atualizado semestralmente, e hoje conta com aproximadamente 1500 artigos, organizados em áreas do conhecimento para facilitar a pesquisa dos alunos. Com isso, pretende-se que ao final do curso o aluno tenha a habilidade de identificar os fatores ambientais, de segurança e sociais, os fatores internos das organizações, como pontos fracos e fortes, e o modelo/metodologia de gestão mais apropriado ao negócio.

4.3 Resultados alcançados

Ao longo de aproximadamente cinco anos, a disciplina tem se mantido com demanda espontânea, ou seja, optativa para alguns cursos e eletiva para outros. Os alunos têm demonstrado grande interesse por esses temas, além de um genuíno interesse pelo meio ambiente, pelas questões éticas na condução das empresas, na humanização dos ambientes e postos de trabalho e no desenvolvimento de uma nova abordagem na condução dos sistemas produtivos. Desta forma, os projetos finais de graduação tem tratado desde o desenvolvimento de ferramentas para gestão, como indicadores, modelos de implantação da responsabilidade socioambiental empresarial, até o desenvolvimento de modelos de gestão para organizações não governamentais e de intervenções sociais através de projetos de responsabilidade social.

O número de projetos finais de graduação em engenharia nas temáticas relativas a sustentabilidade tem crescido, além de despertar o interesse nos alunos para a pós-graduação dedicada à temática. Como títulos dos trabalhos apresentados no Seminário Final da disciplina, Estudos de Caso em Sistemas de Gestão, evidenciamos:

- Sistema de Gestão Integrada – Grupo Gerdau
- Sistema de Gestão Integrado - CPFL Paulista
- Sistema de Gestão Integrado – TRANSPETRO
- Sistema de Gestão da Qualidade – RJZ Cyrela
- Sistema de Gestão da Qualidade – TENDA
- Sistema de Gestão da Qualidade – AMPLA
- Sistema de Gestão da Qualidade - Mil Arquitetura e Consultoria S/C Ltda
- Sistema de Gestão da Qualidade – Forship Engenharia Ltda
- Sistema de Gestão Ambiental – Kyocera

Como ponderou Paulo Freire (1996), "a transformação de um anteprojeto em projeto é decorrente da atuação". Sendo assim, somente nesta disciplina tem se trabalhado os tópicos como o planejamento e controle do produto, logística da cadeia de suprimentos e sistemas de gestão dos recursos naturais, tendo como enfoque em conteúdos mais específicos, como Analise de Ciclo de Vida de Produtos, Logística Reversa, Produção mais Limpa e Ecoeficiência, Sistemas de Gestão Ambiental e Certificação, e outros.

Durante esse tempo, essa proposta evoluiu bastante, sendo que também alunos de doutorado e mestrado, tanto acadêmico como profissional, têm inserido o conceito da gestão do desenvolvimento sócioambiental empresarial como temas na problematização das pesquisas.

4.4 Próximos passos

O desenvolvimento das metodologias, que abordam a produção mais limpa e a responsabilidade socioambiental indica uma ênfase na ecoeficiência no sistema produtivo, nos princípios estratégicos de gestão participativa, como a investigação apreciativa. A atualização constante do conteúdo da disciplina Gestão Estratégica Empresarial e a continuada busca de inovação nas dinâmicas de ensino são uma indicação para práticas de ensino que motivem os alunos e despertem as intenções de pesquisa.

O foco da disciplina Gestão Estratégica Empresarial não é ensinar Planejamento Estratégico, mas desenvolver o sentido de pesquisa como o essencial atributo de qualquer profissional graduado, onde ele não deve confiar em conhecimentos prontos, mas sim estar em constante movimento de pesquisa, de curiosidade com o novo, com a instigante e permanente busca de auto-aperfeiçoamento.

O próximo passo é desenvolver experimentos mais sofisticados e documentados sobre a implantação de produção mais limpa assim como pesquisa de opinião junto aos engenheiros envolvidos em projetos associados à sustentabilidade.

5 Conclusão e Sugestão para Novas Pesquisas

Como a educação para o desenvolvimento sustentável requer que se conduzam igualmente os três pilares: meio ambiente, sociedade e economia, o ensino de responsabilidade social em cursos de engenharia, se torna fundamental, pois coloca a dimensão social em discussão, já no processo inicial de formação desse profissional.

Para que novas soluções no ensino de engenharia, como cursos de responsabilidade sócio-ambiental e sustentabilidade não tenham uma mera função decorativa na grade curricular, torna-se necessário que se defina com maior clareza a metodologia e conteúdo dos cursos propostos.

Considerando os resultados da pesquisa, pode-se definir que a finalidade do ensino da sustentabilidade e da responsabilidade social na graduação em engenharia é o de promover o bem-estar dos diversos públicos impactados pela atuação do Engenheiro.

Igualmente a busca por experiências nacionais e internacionais com foco no ensino de técnicas e metodologias inovadoras direcionadas à sustentabilidade organizacional, é tema para futuras pesquisas, abordando-se a forma de ensinar e de permanentemente adicionar valor aos cursos de formação de engenheiros.

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An Holistic Project Experience in Environmental Engineering Education

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Abstract

This paper presents and discusses a teaching experience conducted with third-year Environmental Engineering students at University Fernando Pessoa (UFP). This experience was planned in order to break with the classic compartmentalization of knowledge among different courses. Students were involved in an interdisciplinary research project with inputs from four different courses. The final evaluation of this project is supposed to reflect students' skills in applying knowledge acquired from different courses within an interdisciplinary context. The project consists in studying actual and planned projects of small-scale hydroelectric power plants, considering hydrologic processes, energy production, environmental impacts, water quality analysis, relevant legislation and its integration, with the objective of reaching conclusions about the costs and benefits of real projects. Regular assessments of the ongoing project are encouraging, showing that students improved significantly their knowledge on the relevant themes and trained their complex thinking capabilities. This was also an opportunity for teachers to start changing their approach towards interdisplinarity with more appreciation for professional skills demonstrated by students than by specific knowledge related to specific courses.

Keywords: learning through project approaches; holistic thinking; engineering education.

1 Introduction

Much of present day scientific understanding of the world was established three centuries ago by Bacon, Descartes and Newton and is based on the mechanistic paradigm. This implies the analysis, i.e., the division of the study object in parts and, later on, their synthesis into a whole. For this reason, it is also known as reductionism. This mechanistic-reductionistic view implies that fractioning reality is essential for learning, and became an inspiring paradigm for education over the last centuries. The systemic view of nature emerged as an alternative at the beginning of the XX century, criticising some of the assumptions of the mechanistic view, emphasising the difficulty of understanding a system when it is separated in its constituents and these are studied out of their context. The emergence of this new paradigm was probably related to the advances of Physics, when it became clear that nature is more than a complex machine, as viewed by Descartes, and where stochasticity and chaos may play an important role. The Systems Theory, of Ludwig von Bertalanffy (van Bertalanffy, 1969), and the paradigm of Complexity, of Edgar Morin (Morin, 1990, 1999), are relatively recent examples of views in direct opposition to reductionism. The former states that the study of a system should be focused on the whole and on the interactions between their constituents, instead of on the fractioning of reality. The latter emphasizes complexity, chaos and trans-disciplinarity. However, in spite of these emergent paradigms, higher education is still mostly based on reductionism. Teaching remains a highly compartmentalized activity, with interdisciplinarity and holistic approaches depending mostly on individual initiatives rather than on mandatory prerequisites in higher education. The recent reform of higher education within European Union countries, known as the Bologna Process, is a good opportunity to discuss new teaching paradigms.

In Engineering Education, the holistic approach and 'system thinking' has particular relevance in preparing the future graduate engineers for the range of roles they will find themselves in their professional path, and this preparation cannot be achieved with discipline-specific approaches (Spinks, Silburn & Birchall, 2006). In fact, the importance of engineering graduates as 'integrators' and 'holistic systems thinkers' has already been stated by several authors and studies (see, for example, Harrison, Macpherson & Williams (2007); Spinks, Silburn & Birchall (2006); Kellam, Maher & Peters (2008); NAE (2005)).

An efficient way of developing integrated system design skills is to involve engineering students in designing realistic interdisciplinary projects (Harrison, Macpherson & Williams, 2007). Learning through project approaches has also other important outcomes, like the development of problem solving skills and application of theory to real problems, both frequently referred as specific gaps of recently graduated engineering professionals

(Spinks, Silburn & Birchall, 2006). A recent study revealed that engineering students identify project work as the most important element of their education in terms of their subsequent professional experience (Nair, Patil & Mertova, 2009; Spinks, Silburn & Birchall, 2006). In the words of John Cowan, teaching is the purposeful creation of situations from which motivated learners should not be able to escape without learning or developing (Cowan, 2006), and learning through project approaches is definitely one of these situations.

The objective of this paper is to present and discuss a simple holistic methodology that is being tested with third-year Environmental Engineering students at University Fernando Pessoa (UFP). The general idea is to stimulate students for the need to improve their understanding of different subjects from the need to solve some environmental problem. The problem is selected to be related with as many courses of the semester as possible and a workshop is organized with students and teachers, where the latter present their views of the problem. From these presentations, it is expectable that questions arise among the students, related to the different courses of the semester. This should work as a stimulus for students to fill in the gaps by attending the mentioned courses. An interdisciplinary work is defined for the students, based on the problem discussed during the workshop. During the semester, students have to develop the different parts of the project under the advising of teachers lecturing different courses and, periodically, workshops are organized where the former present and discuss their progresses. Therefore, students have to deal constantly with interdisciplinary and end up learning the different courses with the objective of solving some practical problem. Instead of learning different courses and integrating later acquired knowledge to solve some practical issue – reductionistic approach – students departure from the problem and analyse the interactions between their constituents, from different courses – holistic approach. At the end of the semester, works are evaluated by different teachers, considering the way different subjects, corresponding to different courses, were approached by students.

2 Methodology

This project was planned to be tested with the students of the 3rd year of the first cycle of studies in Environmental Engineering at UFP. The project is currently ongoing and will have the duration of one semester. The project title is *Environmental Impact Assessment of Available and Ongoing Projects of Small-scale Hydroelectric Power Plants* (SSHPP).

The courses involved are

- Energy and Environment,
- Environmental Impact Assessment (EIA),
- Hydrology and Water Quality, and
- Water and Waste Water Treatment.

The main objective proposed is to train the complex thinking capabilities of the students through the analysis of several aspects of this specific problem, with the purpose of drawing relevant conclusions about the costs and benefits of real projects and propose mitigation measures for the identified environmental impacts.

The specific objectives drawn by the team of teachers involved are:

- Understanding the processes involved in the implementation and operation of SSHPPs;
- Drawing an environmental impact assessment plan for the Project;
- Evaluating environmental impacts from data analysis and other sources;
- Integrating relevant legislation in the analysis;
- Formation of a reasoned opinion on the subject.

The processes involved in the implementation and operation of SSHPP were discussed in detail in a starting workshop involving students and teachers and thereafter in each course. Bibliographic research was encouraged by both reading and analysing scientific papers and engineering handbooks. The renewable energy production was compared to other non-renewable coal-fired power plants, quantifying savings in CO_2 emissions and other pollutants like sulphur dioxide, nitric oxides, carbon monoxide and particles (PM10). Analysis of the weight in the national energy balance of produced energy by renewable resources in general, and SSHPP in particular, was performed. Discussions on the processes involved in hydrology and water quality issues was also followed, focusing stream flow, ecosystem and water quality alteration, inducing the need for quantification. Based on the analysis performed in the previous topics, a plan for development of an environmental impact assessment study was designed based on the collection of the necessary information available in books, internet (raw data), scientific papers, and in loco, regarding water quality, hydrology and biotic quality indexes. All this work was

supported by field visits, in which water samples were collected for analysis, both in site and in laboratory, of the water chemical and biological quality along the river stretches where the power plant is or where it will be built. Students also contacted local authorities to obtain information on the planned SSHPP. The work has been overviewed within the scope of national legislation on each specific field.

At this point, each course had already developed the necessary skills for acquisition and analysis of information for evaluating an Environmental Impact Assessment. A workshop was organized between all the students and teachers involved in the process to present the work developed to date, in order to discuss and analyse the interactions between the different approaches and integrate them into one single holistic work. This workshop resulted in an evaluation of the work produced so far and of the skills acquired by students, based on their presentations. Reinforcement of initially proposed guidelines and orientations were suggested for proceeding with the work. An in depth analysis of the whole process will be carried out at the end of the semester.

3 Discussion

Edgar Morin proposed seven knowledge types that should be included in the future education and may be summarized as follows: (i) Epistemology; (ii) Integration and complexity; (iii) Human condition; (iv) Earth citizenship; (v) Uncertainty and stochasticity, (vi) Mutual understanding and (vii) Ethics (Morin, 1999). These seven knowledge types are in opposition to the traditional curricula with a clear separation between Philosophy and Science and between natural and social sciences, inherited from Descartes, with the separation between the subject (human) and the object of study. The study of Epistemology implies a critical assessment of Science through Philosophy. The idea of integration and complexity contradicts reductionism, emphasizing the need to approach the study of reality in all its complex interactions and feedbacks, integrating knowledge from different fields. The study of human condition is based on the assumption that each human being has its own complex identity and a common identity with all other human beings. The study of earth citizenship emphasises the need to accept this as the main citizenship shared by all humans. The ideas of uncertainty and stochasticity emphasize the importance of randomness in nature and the need for humans to be able to handle unpredictable outcomes. Mutual understanding and ethics are important to educate people to relate with each other.

Thinking about classic curricula in engineering it is hard to recognize some of the knowledge types listed above. Emphasis is generally on physical and biological sciences that are studied on a fragmented way. Certainly, it is easier to organize curricula under this “reductionist model” and to allocate teaching effort to different specialists. It seems also reasonable to assume that this model gave way to important progresses in science and technology over the last three centuries. However, it is also clear that it is not a perfect model. Over the last years it became evident the need for integrative approaches in many branches of knowledge. For example, the intense discussion about sustainable development over the last two decades led to the understanding that this kind of development depends on some sort of equilibrium between environmental, economical and social issues, bringing together natural and social sciences. Another example may be the carrying capacity concept, with its roots in Ecology and presently employed as a multidimensional concept across several disciplines, and a central one towards sustainable development. The emergence of Human Ecology is yet another example of interdisciplinarity, merging natural and social sciences (Steiner et al., 2002).

The results of a recent survey conducted at University Fernando Pessoa, where students of Environmental Engineering were asked to identify links between different courses, suggests that several courses giving generic basis are viewed by students as poorly linked with more specialized ones. Apparently, this is not a problem of course contents not including common concepts useful for another subjects, but a result of different languages used by specialists in different areas. In any case, it results in the breakdown of knowledge and in the difficulty of students to merge it into a coherent whole. To circumvent this “fragmentation” one may choose to make some adjustments in teaching methods such as coordinating efforts between different teachers to guarantee a clear cross-over of concepts and examples between different courses emphasising commonalities and differences.

It is important to emphasize that, projects such as the one described herein may be viewed just as an intermediate step between the “business as usual” in higher education and a possible new paradigm that, probably, will imply a complete reorganization of university curricula, not just as the one resulting from the Bologna Process, with a strong emphasis on the acquisition of professional skills, but on a completely different teaching model. Perhaps a possible way to integrate some of Morin’s proposals would be to organize knowledge on a more logic manner, where the transition between different themes would follow a natural “path”. For example, if curricula are organized by large interdisciplinary themes, the fields treated normally under different subjects such as Physics, Biology, etc. would be studied simultaneously in a truly interdisciplinary way and in line with the paradigm of

complexity, emphasizing the multidimensional nature of reality. This approach would, at the same time, emphasize commonalities and differences across studied phenomena. In Environmental Engineering some possible “nuclear” themes could be: Energy, Transfer Processes, Environmental compartments (such as Atmosphere, Hydrosphere, Lithosphere), Pollution Prevention and Control Technology, etc. Within each nuclear theme, Physical, Chemical, Biological and Ecological processes, relevant legislation, social, economic and political issues could be discussed with the participation of several teachers. It would be important to coordinate matters in such a way as to have students learning Maths, Physics, Chemistry, etc., as a function of their needs to understand some of the issues discussed within the nuclear themes. For example, the study of biogeochemical cycles (typically within the scope of Ecology) is a good opportunity to study redox reactions (Chemistry) and, at the same time, to use differential equations to describe temporal dynamics of relevant variables (Maths and Calculus). Furthermore, seminars could be organized on a regular basis to integrate the various nuclear themes. Certainly, such a teaching model would require larger coordination efforts between faculty staff. However, at the same time, it would promote interaction between teachers during the planning of the whole process, with potential feedbacks towards their research interests.

Probably, the emphasis on skills and learning outcomes in the Bologna Process, is a sign of some general feeling that classic curricula did not prepare students for the present day needs of society. Within this scope, several projects have been conducted in the European Union to develop a common framework of comparable and compatible qualifications, either in general terms, like the Dublin descriptors (JQI, 2004) and the Tuning Project (Tuning Educational Structures in Europe, 2007), as well as in specific areas, like the EUR-ACE framework for accreditation of engineering programmes (EUR-ACE, 2006).

The Dublin descriptors aim to define the expectations of achievements and abilities associated with the end of a Bologna cycle. According to these descriptors, at the end of a first cycle of studies the students are expected to (JQI, 2004):

- demonstrate knowledge and understanding;
- apply their knowledge and understanding with a professional approach, devising and sustaining arguments and solving problems within their field of study;
- have the ability to gather and interpret relevant data to make judgments that include reflection on relevant social, scientific or ethical issues;
- be able to communicate information, ideas, problems and solutions;
- possess the learning skills necessary to continue their studies with a high degree of autonomy.

The authors believe that the project described in this paper has given a relevant contribution for the students involved to achieve the skills listed above. In fact, the achievement of most of these qualifications is only possible with an interdisciplinary and holistic approach.

The Tuning Project aims to define points of reference, convergence and common understanding for higher education in Europe (Tuning Educational Structures in Europe, 2007). According to this project, the competences expected to be developed in Higher Education Programs are divided in three categories: instrumental, interpersonal and systemic:

- Instrumental competences are those having an instrumental function, including cognitive abilities, methodological capacities, technological and linguistic skills. This category includes competences like capacity for analysis and synthesis, capacity for organization and planning, oral and written communication skills, information management skills, problem solving and decision-making.
- Interpersonal competences are those intended to facilitate processes of social interaction and co-operation. Competences typically included here are critical and self-critical abilities, team work and ethical commitment.
- Systemic competences, considered an upper level of the two basic categories described above, are those skills and abilities combining understanding, sensibility and knowledge that allows one to see how the parts of a whole relate and come together. This category includes the capacity for applying knowledge in practice, research skills, ability to work autonomously, project design and management and initiative and entrepreneurial spirit.

Although the project under discussion in this paper will develop instrumental and interpersonal competencies of the students involved, it is on the systemic competences that the major contribution is expected.

Specifically in the field of Engineering Education, the EUR-ACE framework for accreditation of engineering programmes which to a large extent was influenced by TUNING, intends to build a reference framework to ensure the suitability of programmes to serve as entry routes to the engineering profession (Feyo de Azevedo, 2009). From the six fundamental outcomes expected from an Engineering program, as described in EUR-ACE (EUR-ACE, 2006), the project described in this paper is believed to give a relevant contribution to the following:

- Knowledge and understanding - Graduates should demonstrate their knowledge and understanding of their engineering specialisation, and also of the wider context of engineering.
- Engineering analysis - Graduates should be able to solve engineering problems consistent with their level of knowledge and understanding.
- Investigations - Graduates should be able to use appropriate methods to pursue research or other detailed investigations of technical issues.
- Engineering practice - Graduates should be able to apply their knowledge and understanding to developing practical skills for solving problems, conducting investigations, and designing engineering devices and processes.
- Transferable skills for first cycle graduates – team work, communication skills, awareness of the impact of engineering solutions in a societal and environmental context.

Being in the scope of an Environmental Engineering program, the interdisciplinary project here discussed was planned to focus specific areas considered fundamental for the Portuguese Association of Environmental Engineers (APEA, www.apea.pt), namely:

- Energy Planning;
- Environmental Impact Assessment;
- Environmental Quality monitoring and control;
- Environmental Risk Analysis
- Natural Resources management;
- Water, soil and air pollution management and control.

A global discussion of the aspects of the interdisciplinary project here described will only be possible after its conclusion. Further analysis of the whole process is essential to define the extent to which students have fulfilled the objectives proposed and attained the learning outcomes expected. It is also important to formally assess the students' perception of this process, in order to identify improvement opportunities. A full in depth analysis focusing these issues will be carried out at the end of the ongoing semester.

There are plans to extend the methodology described above to 1st and 2nd year students, in line with the idea of exposing students to complex systems thinking throughout the curriculum as suggested by Kellam, Maher & Peters (2008).

4 Conclusions

The utilization of methods such as the one described in this paper, where students are challenged to conduct an interdisciplinary work, may help to integrate otherwise dispersed concepts of different courses. Although this is still an ongoing project, "intermediate" workshops involving students and teachers, where the former presented their working progresses, suggest that students are enthusiastic about the work and improved several professional skills, such as specific knowledge about the issues under study, communication capabilities, autonomy in searching for data, and maturity in the way different project alternatives are analysed and discussed.

Interestingly, this project was also useful for teachers, who started with a typical reductionist view of the whole process, trying to guarantee that the project would allow them to evaluate student's knowledge about their particular subjects and tending to transform the project more into a sum of parts then into a coherent whole.

Finally, it was agreed that specific knowledge/skills of each course should be evaluated within the scope of the course classes, whereas this interdisciplinary project should emphasize integration and complex thinking capabilities, contributing only partly to the scores obtained at each course.

The project here described is believed to be a relevant contribution for the students to achieve the skills and qualifications commonly accepted as essential for first cycle graduates in the European Higher Education context, both in general terms as well as specifically for engineering programs.

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Possibilities of Project-Based Study in Aviation Engineer Training

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Abstract

The present paper concentrates on possibilities of project-based study in aviation engineer training. The paper is based on the example of Estonian Aviation Academy which prepares specialists for the aviation of the Estonian Republic. Engineers are trained in the following professional fields: Air Traffic Management (incl. communication and navigation systems), Aircraft Piloting (pilot-engineers), Aviation Management (incl. aircraft maintenance).

Keywords: engineer education; project-based learning; aviation engineer.

1 Introduction

Estonian Aviation Academy (EAVA; till 01.09.2008 Tartu Aviation College)) was founded in 1995 with the purpose of training aviation specialists for the Republic of Estonia.

A peculiarity of EAVA is that there are not many members of full-time teaching personnel. The majority of the instructors are experienced specialists of Estonian and foreign aviation enterprises and institutions of higher education working at the Academy on contractual basis. This guarantees the permanent high quality of the teaching process and its compliance with the requirements of the International Civil Aviation Organization (ICAO), the Joint Aviation Authorities (JAA), the European Aviation Safety Agency (EASA) and the European Commission (EC). This, in its turn, guarantees good opportunities at Estonian and European labour markets for the graduates. Quality assurance is given special attention at the Academy and for this purpose the post of quality manager has been created. The full course lasts four years. The major specialities taught at Estonian Aviation Academy are listed below: Air Traffic Management (Air Traffic Service; Management of Communication and Navigation Systems); Aircraft Piloting (Aeroplane Piloting, Helicopter Piloting); Aviation Management (Aviation Company Management; Aircraft Maintenance; Maintenance of Aerodrome Equipment and Systems). In the form of Open Studies aviation specialists (and also people interested in aviation) can obtain a diploma of professional higher education in the area of Aviation Administration and a Master's degree in Human Factors and Systems Safety.

2 Description of Curriculum

At present the Academy is developing new curricula for all specialities. The curricula and the subject programmes will be based on the learning outcomes. New directions in education presume new didactic methods and approaches for making the teaching process more learner-centred. One of the didactic methods enhancing better stimulation of the student's mental activity in learning is project-based study.

The curriculum consists of four modules:

- basic engineering studies,
- basic aviation studies,
- professional studies
- speciality studies.

Basic engineering studies are carried out at the University of Tartu. The duration of the module is three semesters, during which higher mathematics, physics, engineering graphics, applied mechanics, electro-engineering, and other general engineering subjects are provided. An essential part in the curriculum is given to the English language, which is taught also in the three following modules.

Basic aviation studies are conducted at the Academy, and at this phase students already learn about practical work in aviation. Among other subjects, the curriculum also includes humanities.

The professional studies (two semesters) of different specialities take place at different institutions – the University of Tartu (Aviation Data Communication and Information Processing Systems), Tallinn University of Technology (Management of Navigation and Surveillance Equipment) or the Aviation Academy.

Speciality studies are carried out at Estonian and foreign aviation enterprises and at the Academy.

3 Project-Based Study

Project-based study has been introduced in speciality studies laboratory works. It enables to make use of the following advantages:

- acquiring knowledge through creative activity;
- being learner-centred;
- integrating subjects of different study modules;
- enabling to study essential speciality problems occurring in working situations.

Compared to traditional laboratory works, project-based learning takes more time but in conclusion this method guarantees greater efficiency in acquiring a given speciality than the traditional methods.

Figure 1: Computer aided experiment in the laboratory of communication and navigation systems

In designing a project for study purposes, two main objectives should be observed:

1) the speciality objective the students have to achieve as the result of the project;
2) the didactic objective which determines the knowledge and skills the students acquire as the outcome of being part of the project.

The process of going through the project, the experience learnt from it is far more important from the point of view of learning than the final result towards which the students are moving in the course of the project. In case of this method the teacher is not directing the students' line of thought but creates the conditions necessary for learning, ensures availability of the information and helps to form a creative environment favourable for learning.

A method similar to project-based learning is problem study that was introduced several years ago in several countries, including Estonia. Problem study is also learner-centred but its precondition is that the teacher initially plans different problem situations the learner has to perceive (recognize a problem is existing), solve and later check the solution. But project-based study has an advantage: the problems need not be planned in advance, they appear themselves in the course of the work. Such cropped up problem situations are similar to the reality that the students will encounter in their future profession. There is no special need to direct students, in most cases they direct their activity independently. The work is carried out in small groups which enables to develop interaction and culture of cooperation.

Project-based study gives the opportunity to realize various didactic principles in the process of learning. Especially favourable conditions are created for realizing interdisciplinary ties. During the process students make use of and integrate the knowledge and skills acquired in different subjects. In addition to technical knowledge also speciality foreign language is learnt. Reading and writing skills form one of the essential facets developed by project-based study.

4 Project-Based Study in EAVA

Estonian Aviation Academy has introduced project-based approach in the subjects “Data Transmission” and “Radio Measuring in Aviation” – in these courses the traditional laboratory work has been partly replaced by the new method.

The traditional laboratory work methodology required directing the student’s activity according to an instruction. The student had to carry out the work according to a certain algorithm. According to the project-based methodology the students involved are presented the technical task of the project or concrete targets and conditions (possibilities): a list of the laboratory measuring instruments, study models, communication and multi-media equipment and software. The materials are available on the web-page of the communication and navigation systems laboratory. The results are given in a multi-media presentation.

An example of a task might be the simulation of a signal of the VOR radio beacon or the automatic landing system ILS with the help of the given measuring instruments and study models.

In the laboratory of communication and navigation systems there are used industrial models of communication systems and their nodes: the duplex radio communication systems and fiber optic communication system for both analog and digital communication. The models for laboratory works enable to study the construction of different waveband receivers and transmitters, analog and digital processing of signals. The laboratory is using computer connected Rohde-Schwarz measuring equipment which is also used by the future employers of the aviation engineers: the signal generator SM300, the dual arbitrary generator AM300, the spectrum analyzers FS300 and FSH3, the HAMEG digital oscilloscope HMO3522. Using this equipment enables to control the experiment by computer and the same computer will record the results of the experiment and process the results statistically. It is not difficult to add the necessary oscillograms and characteristics to the digital report – this reduces the amount of the students’ routine activity in the laboratory.

The duration of the project depends on the task set, the working time in the laboratory is four academic hours per week. The average project lasts from two to four weeks. At the initial stage the students familiarize themselves with the tasks and preliminary data they have received from the supervisor and then design the activities to achieve the required result. At first it may be done individually, after that follows group work or brainstorm for planning further activity. The action plan is coordinated with the supervisor. Within the group, the activity of each member is agreed in a way that the distribution of work is equal regarding routine and creative activity.

The laboratory working positions have been equipped with the multimedia Microlink computers with processors Intel ® Core ™2 Duo CPU E8400 (CPU speed 3GHz). Each computer has two 24-inch monitors. The large screen monitors enable the project team members to observe and actively control the experiment or get the necessary information for the tasks. The computers have the *NI Lab View* licence.

5 Conclusion

Our experience has shown that the project-based method in laboratory works significantly enables to raise the efficiency of the study process. Evidently the main reason for this is the improvement of the students’ motivation. The students prefer using materials from real working situations (‘Living Documents’) to traditional academic instructions. The role of mental activity is significantly greater than before as the old algorithm of action was determined by the laboratory work instruction. Now the students themselves control the process, discussing the activities with each other, often using the form of brainstorm. In conclusion it can be said that the project-based study method has justified itself and it is planned to take it into use also in the other study laboratories of the Academy. At the same time the authors of the present paper are fully aware that for a more precise evaluation of the given method and its effect on the study process a pedagogical experiment is needed. In the course of this experiment the results of two groups of students should be compared to each other: an experimental group where the project-based method is used and a group using the traditional method of laboratory works. It has been

planned to carry out a pertinent experiment like this together with the pedagogical researchers of the University of Tartu.

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Special Paper Session C

A Project Based Learning Case Study Development of a Didactic Equipment for Groundwater Flow Problems

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Abstract

This paper describes a project based learning exercise whose objective has been the development of a didactic setup for small scale seepage studies.

Keywords: groundwater flow; didactic laboratory equipment; project based learning.

1 Introduction

Seepage or groundwater flow is one of the topics covered in the Soil Mechanics course that is part of the curriculum of 4th year Civil Engineering students at FEUP (Matos Fernandes, 2006). Experience has repeatedly proved that students show some difficulty in mastering the basic concepts, mostly because of their lack of feeling for the underlying physics. The reason for this may reside in the fact that the development and training of student sensitivity is primarily oriented for mechanical and structural problems. To make this point one may add that in years 1 to 4 of Civil Engineering at FEUP students have two semesters of Mechanics, of Strength of Materials, of Structural Analysis and of Concrete Structures, which are considered by many the "spinal column" of the course. This mechanical emphasis scenario is probably shared by most Civil Engineering schools elsewhere. In order to help overcome student difficulties with seepage the availability of an experimental didactic apparatus was considered of paramount importance, particularly for providing a clear visualization of the phenomena involved, given that "seeing is believing". The development of one laboratory equipment for small scale study of seepage problems has therefore become the theme of the Master thesis of the second author (Ferreira, 2008) and is described in this paper from the point of view of an example of project based learning.

2 Equipment Description

This project had two major constraints that imposed careful planning:

- Time – the deadline for submission of the thesis had to be met.
- Money – the total funding made available by FEUP was 2000€ and could not be exceeded.

The first step has been a thorough market search for this type of laboratory equipment which has led to over a dozen manufacturer Internet sites. Seven have been selected for full scrutiny and comparison of the technical specifications of their equipment: Armfield Ltd. (UK); Cussons Technology (UK); Edibon Internacional (Spain); EHF (South Korea); GUNT Gerätebau,GmbH (Germany); Hampden Engineering Corporation (USA); TQ Education and Training Ltd. (UK). This has helped to identify the major features and facilities provided by commercially available products. And it also gave a good idea of the saving that could be achieved by opting for "in house" development. At this stage a preliminary definition was made of the dimensions and overall conception of the equipment. It was also decided to adopt clear acrylic as the material to be used for the main tank, in order to provide maximum visibility for the users.

The second step has been a round of visits to several laboratories at the Chemical, Civil and Mechanical Engineering Departments, complemented by contacts with other laboratories of the University of Porto. The objective has been to become familiar with the pros and cons of the use of acrylic in laboratory equipment.

The experimental apparatus has three main components (Figure 1):

- The main acrylic tank.
- The support structure.
- The hydraulic closed circuit.

Figure 1: Frontal view of the equipment

2.1 Main tank

The main tank is 2000 mm long, 585 mm high and 200 mm wide (internal dimensions), with 12 mm wall thickness. Up to three overflow pipes and two walls may be installed, all being height adjustable (Figure 2).

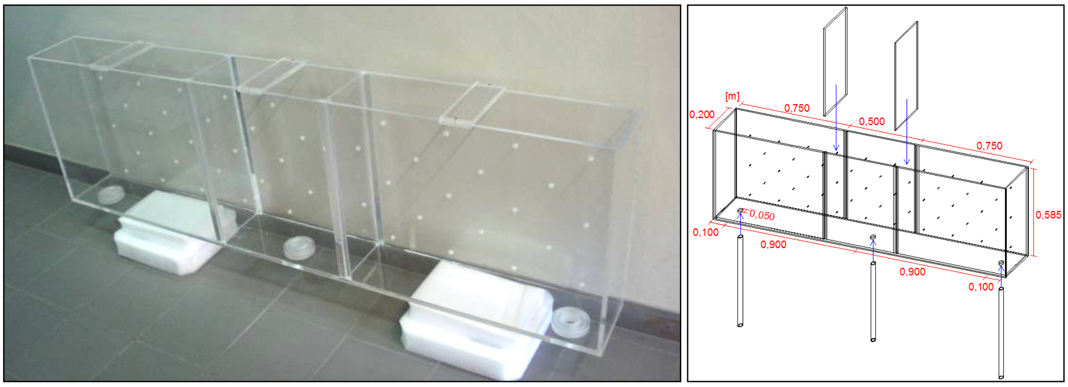

Figure 2: Main tank

The overflow pipes have 50 mm external diameter and 3 mm wall thickness. Each overflow pipe slides through a cylindrical part protruding downwards from the base of the tank. This part is threaded on the outer surface onto which is fastened a specially designed round nut provided with an O-ring for water tightness (Figure 3 left). The overflow is connected to a flexible pipe that returns water to the sump tanks. Each 8 mm thick height adjustable wall runs in two vertical notches and is held in position by two C-shaped parts that are tightened with an Allen screw to the wall vertical edges and rest on the top of the notch, preventing the wall from sliding down under its own weight (Figure 3 right).

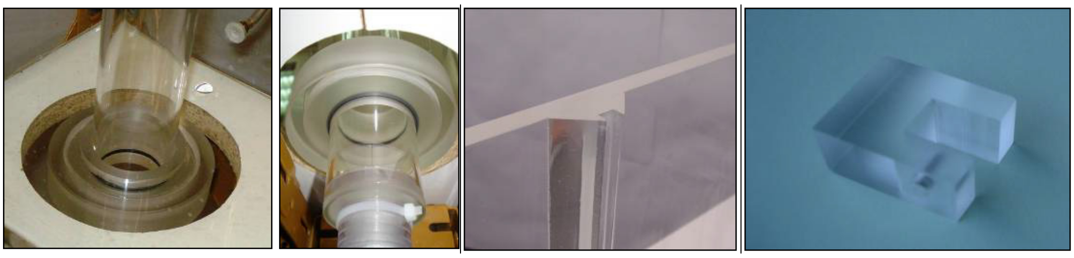

Figure 3: Overflow pipe above and below the tank base; wall notch; C-shaped wall holding part

The back wall of the main tank has 48 pressure taps. Each one is protected by a nylon mesh that prevents ingress of soil grains (Figure 4). The transparent PVC piezometer tubes have 6 mm external diameter and 1 mm wall thickness. It was decided to adopt a vertical tube layout in order to minimize the tube length and to provide a better visual correlation between the pressure measurements and the corresponding location. The tops of the piezometric tubes are held in groups of two or three by a device that is clamped to the top of the tank back wall (Figure 4 right).

Figure 4: Pressure tap: protective nylon mesh; coupling brass part; pipe top holding device

2.2 Support structure

The tank support structure has to fulfil several functions:

- Carry the main tank holding it securely in place (note that the tank total weight with saturated granular soil may reach 300 kg in some experiments).
- Lodge the sump tanks and the other elements of the hydraulic circuit.
- Provide mobility inside the laboratory to this self-contained experimental unit.

The tank support structure has therefore been carefully conceived (Figure 5). It has been assembled reusing steel perforated angles recovered from the FEUP deposit of obsolete or broken down items, which provided a very significant saving. After a good coat of paint the end result was a very nice laboratory trolley (Figure 5). Six castors have been fitted, each with 125 kg load bearing capacity. The corner ones have brakes. The total height of the support structure is 1.45 m.

Figure 5: Support structure

2.3 Hydraulic circuit

The hydraulic circuit corresponding to the experimental setup shown in Figure 1 (seepage under a double walled cofferdam) is represented in Figure 6.

The electric submersible pump (4) sends water from the left sump tank (2) along the flexible inlet hoses (8 and 9) to the left and right lateral zones of the acrylic tank (1), where the overflow pipes (10 and 12) keep the water level constant. Water seeps through the soil under the two walls into the central zone where the overflow pipe (11) drains it to the sump tank via the outlet hose. The combined capacity of the sump tanks is 200 litres. The two-tank solution has been adopted since it provides an easier fitting into the lower shelf of the support structure.

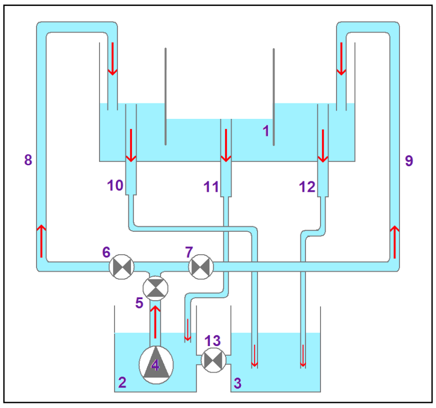

Figure 6: Hydraulic circuit

The inlet and outlet hoses are PVC tubes with 30 mm external diameter and 2.5 mm wall thickness.

The 300-watt power submersible pump of Figure 7 is housed inside the left blue plastic sump tank and has a float switch. The flow rate is adjusted by operating the main valve (5). The secondary valves (6 and 7) regulate the flow distribution to either end of the tank. The pump can suck impurities up to 5 mm and has a maximum delivery capacity of 7000 l/h.

The pump electric cable is plugged into a socket provided with an On-Off switch.

Figure 7: Submersible pump; electric cable and switch

3 Didactic Applications

The equipment can be used to perform numerous practical experiments whose objective is to make students aware of the qualitative and quantitative aspects of the physics of flow through porous media, with emphasis on situations relevant for Civil Engineering.

Such experiments may include:

- Verification of Darcy's law.
- Construction of flow nets and visualization of flow lines.
- Seepage into a trench or a cofferdam.
- Seepage underneath a sheet pile wall.
- Seepage through an earth dam with or without a toe drain.
- Demonstration of hydraulic instability phenomena (piping and quick sand condition, heave).
- Analysis of uplift pressure.
- Comparison of experimental results with analytical or numerical solutions.

3.1 Application example – seepage underneath a sheet pile wall

Figure 8 illustrates the experimental layout and dimensions considered for this case study.

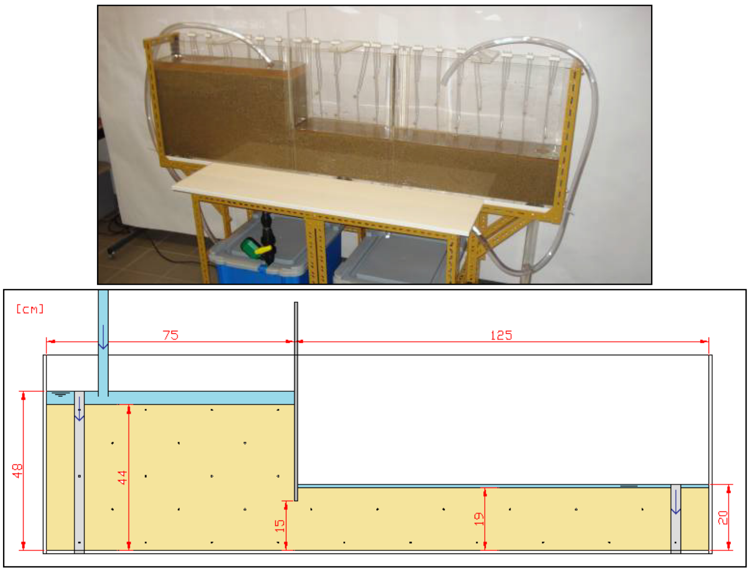

Figure 8: Seepage under a sheet pile wall

The experimental study has been complemented with a finite element analysis whose mesh is shown in Figure 9.

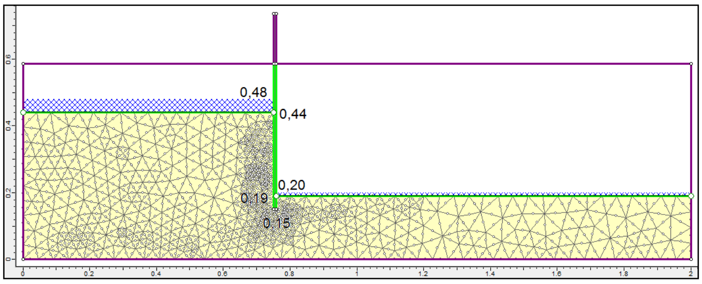

Figure 9: Finite element mesh

The flow net diagram obtained numerically is depicted in Figure 10.

Two flow lines have been visualized experimentally by dye injection and there is good agreement with those determined by the numerical model (Figure 11).

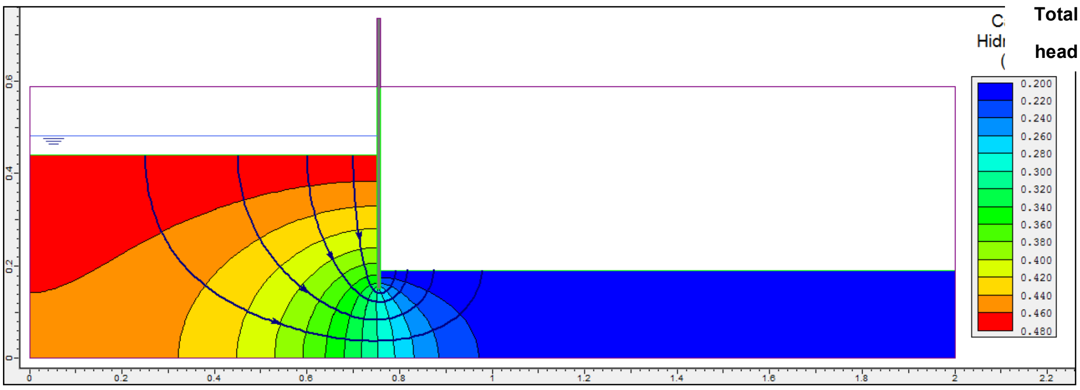

Figure 10: Flow net diagram for the case study of seepage under sheet piling

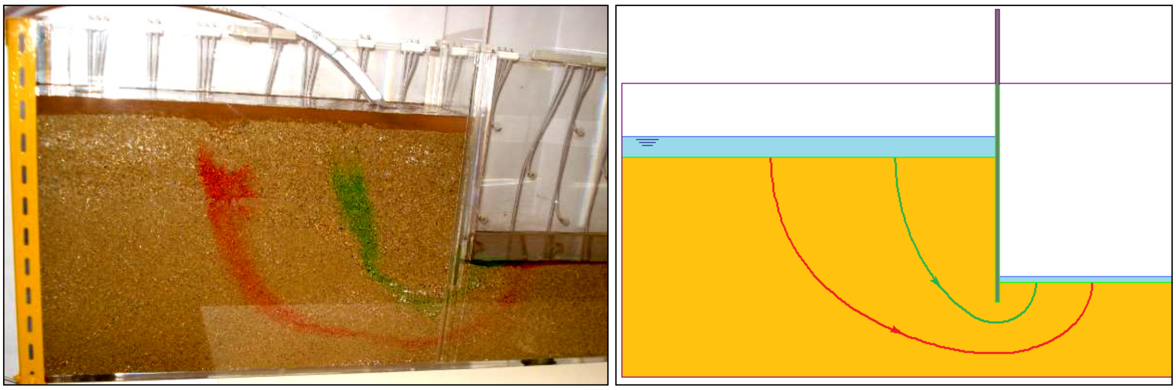

Figure 11: Flow lines obtained experimentally (left) and numerically (right)

On the back wall of the main tank several red vertical scales are affixed (see Figure 12) whose zero coincides with the bottom of the tank. By measuring with reference to these scales the level of the water in each piezometer tube one gets the so called total head, which is the sum of the elevation of the pressure tap and the height of the water column inside the piezometer tube. The total head values measured in the experimental apparatus are shown in Figure 12. Note that this figure shows the view of the back wall, with water seeping from right to left

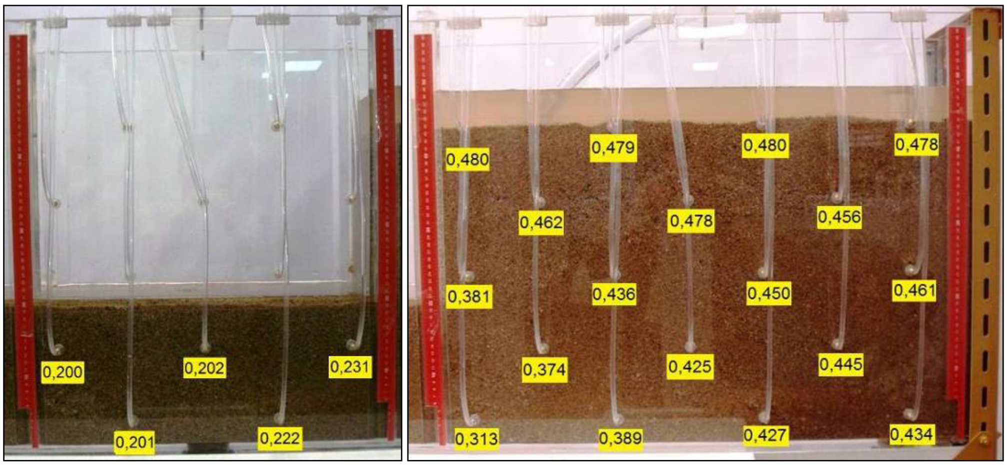

Figure 12: Experimental values of the total head

The total head has also been computed numerically at the location of the pressure taps. The values obtained are shown in Figure 13. In this frontal view water is seeping from left to right. The experimental and numerical values are in good agreement, differing on average by only 3%.

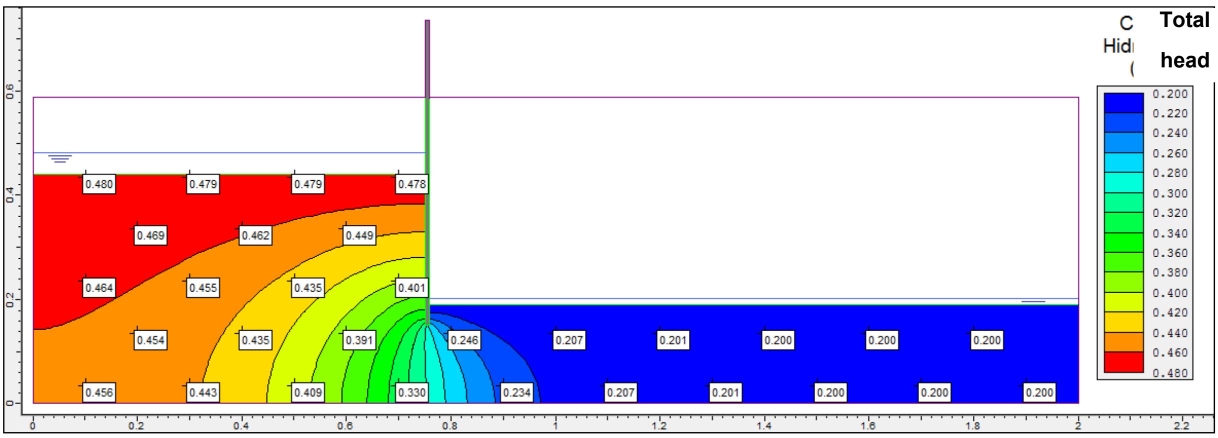

Figure 13: Numerical values of the total head

4 Final Remarks

The work has been completed on schedule and the thesis has been successfully submitted. The total cost was kept 7% below the budget. A commercial equipment of this type would have been five to six times more expensive. The Geotechnical Laboratory is now in possession of a new experimental equipment that will be most valuable for the education of future Civil Engineers in years to come.

The development of this experimental setup has been a very comprehensive instance of project based learning performed by an individual student. It has called for the practical application of knowledge from structural, geotechnical and hydraulic engineering. It demanded the combined skills of a designer, a mechanic, a carpenter, a plumber, an electrician, a laboratory technician, a photographer and a numerical analyst. It has required initiative, engineering judgement, creative thinking, manual skills, persistence and determination. It has involved market and internet searching, interaction with several suppliers of parts and a substantial amount of inventiveness. And last but not the least, the whole task had to be condensed into a well structured and illustrated document, complemented with a public multimedia presentation synthesizing and highlighting the multiple and remarkable achievements. A very wide range of skills has been trained and perfected in the whole process. The final result has been extremely rewarding for both authors in personal, academic and professional terms.

Acknowledgment

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Thinking Over b-Learning Strategy: The MIPO Model Approach

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Abstract

This article describes the main research results in a new methodology, in which the stages and strategies of the technology integration process are identified and described. A set of principles and recommendations are therefore presented. The MIPO model described in this paper is a result of the effort made regarding the understanding of the main success features of good practices, in the web environment, integrated in the information systems/information technology context. The initial model has been created, based on experiences and literature review. After that, it was tested in the information and technology system units at higher school and also adapted as a result of four cycles of an action-research work combined with a case study research. The information, concepts and procedures presented here give support to teachers and instructors, instructional designers and planning teams – anyone who wants to develop effective b-learning instructions.

Keywords: e-learning; b-learning; instructional design; higher education.

1 Introduction

Nowadays, we deal with a growing offer of educational technology solutions and a constant pressure to use them. It is important to analyze carefully the best pedagogical approaches, in order to explore properly the technologies available. The fact of making computers merely available in classrooms does not promote the knowledge construction. Our higher institutions continue to use the traditional education schema which promotes an environment based on providing information (European ODL Liaison Committee, 2004). Whenever an institution adopts an LMS (Learning Management System), it does not ensure the integration of WEB technologies on the educational process.

Throughout the study presented in this paper, we had the opportunity to deal with many different experiences on the e-learning domain. Many times, the changes occur in the technologies and without any methodological or pedagogical support. For instance, whenever printed documents are replaced by digital contents, using the same communication schema (emitter-receiver) but with more sophisticated tools.

All technologies should be viewed as work tools and not as an end itself. The selection of the learning strategy, in order to achieve the defined goals, is more important than choosing a tool itself. We believe that the existence of a model that supports the complex management process of blended-learning (b-learning) may promote the systematization, the usefulness and the organization of the web classroom integration. The MIPO model (integration model by objectives) presented in this paper intends to be a dynamic and flexible structure that offers a large set of orientations in order to conduct a combined learning process.

The literature review added by personal experience resulted in a new conceptual model (MIPO model) which helps tutors to integrate web technology in the teaching-learning process. This holistic model intends to align on-line strategies with learning objectives.

The rare data found regarding the higher education and namely the information system area conducted to the development of a general model, transversal to different areas of knowledge.

Considering the support offered by the ADDIE model (McGriff, 2000) (Kruse, 2006) and the advantages of aligning objectives and evaluations, the MIPO model suggests a progress in 5 phases (learning environment analysis, instruction design, instruction development, unit implementation and model evaluation) and also adds a dynamic and interactive adaptation, in order to reach defined objectives.

In 2006, we planned a research process that intended to validate the MIPO model created. The initial model was tested and validated on the information and technology system units at higher education. This model was adjusted as a result of four cycles of an action-research work combined with a case study research.

As an instruction model, the MIPO model intends to be a guide for the definition of management procedures, planning, developing and implementation of teaching-learning processes using web technologies. It enhances the designing of creative strategies that promotes the motivation and the accomplishment of objectives. The main concern is about the pedagogical/educational dimension of the learning management systems when comparing with the technical and administrative/management dimensions.

The MIPO model was applied and adjusted in four cycles of an action research, according to the following schedule:

- 1st semester of 2006/07 school year: application of MIPO model I, getting as a result the MIPO II;
- 2st semester of 2006/07 school year: application of MIPO model II, getting as a result the MIPO III;
- 1st semester of 2007/08 school year: application of MIPO model IIII, getting as a result the same model MIPO III, named by MIPO;
- 2st semester of 2007/08 school year: application of MIPO model by four teachers, getting the final validation of the MIPO model;

Each cycle included four phases: planning, action, evaluation and analysis. During the four cycles of the action research we intended to validate the MIPO model, considering its performance and implication on the learning results. All cycles involved units about the information systems area, lectured at ISCAP, in the enterprise communication course. The last interaction of the action research process, the MIPO model was validated by four teachers from four classes of the information and communication technologies subject, set in the enterprise communication course. Two classes were studying during the day and the other two were studying in the evening. All teachers attested the performance of the MIPO model to guide the b-learning process. The data was collected by semi-structured interviews, questionnaires, direct observations and documental analysis.

Unlike the majority of e-learning models proposed (Laurillard, 2006) (Schofield *et al.*, 2006) (Klein *et al.*, 2003) that describe general procedures, the MIPO model gives a special emphasize to the activities design strategies and is targeted to the blended-learning systems, at the higher education.

2 MIPO Model

The MIPO model proposes the integration of web technologies by learning objectives and relates, in a systemic view, the elements that come up from the literature review and that were validated both in a research and in a practical context. The expression "Integration by objectives" enhances the importance of the integration of web technologies on the educational context, supported by the learning objectives defined to the unit and to the course. This orientation intends to avoid the promotion of online activities without causing any advantages in reaching learning objectives. Despite their importance, the lack of time demands the main concern on the developing activities, in order to reach one or more course and unit objectives.

Based on the ADDIE model (Analysis, Design, Development, Implementation, Evaluation) (McGriff, 2000) and on the activity theory (Engestrom, 2001) the MIPO model added the main tasks to perform in each phase and also a dynamic, flexible and constant adjustment to the needs that come up and are specific of each combined learning process. According to this, we should follow, interactively and dynamically the following phases: learning environment analysis, instruction design, instruction development, unit implementation and model evaluation, as presented below:

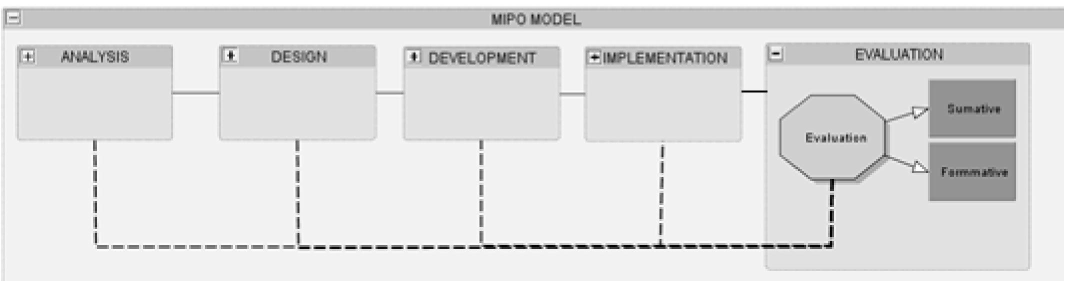

Figure 1: Global vision of MIPO model

2.1 Phase I – Learning environment analysis

According to the MIPO model, the first phase of the integration process is the analysis of the system. Teacher acts as an architect, who before starting a project, analyses contextual requirements. Later, the results are reflected on the space organization, that is, on the instruction design.

At this stage, we analyze elements such as the identification of context, learners' features, instruction needs, available contents, prerequisites and tools:

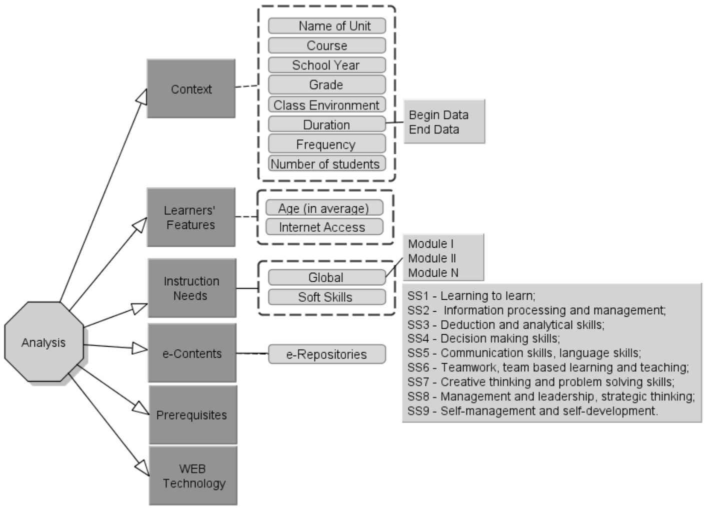

Figure 2: Analysis phase of MIPO mode

2.1.1 Context

The context describes the environment where learning will take place, namely by identifying the unit (e. g. Information technologies), the course (e.g. enterprise communication), the school year (e. g. 2008/09), the grade (e. g. 1st), the class environment (e. g. classroom equipped with computers connected to the Internet), the duration (e. g. 44 hours) making reference to begin and end date (e. g. 01-10-2008 to 23-01-2009), frequency (e. g. 3 classes per week) and number of students enrolled (e. g. 30 students).

2.1.2 Learner's features

The identification of age (in average) helps to obtain important indicators on students' motivation and personal objectives.

The students, who are in average 18 years old, are, in general, motivated to the online learning. However, many times they show difficulty in describing their personal objectives and expectations, when enrolling both in a course and in a unit. On the contrary, the older students that usually enroll in evening classes, show more difficulty in using the web tools but are also motivated. These students have more ability to describe their personal objectives when enrolling both in a course and in a unit, probably due to their professional experiences. In general, students enrolled in day courses are more competitive and prefer activities that use learning games. Despite the interest shown by evening students in this kind of activities, they also appreciate the recreation of an enterprise environment.

The identification of students' previous experiences and abilities to work in certain environments as defended by (Kemp *et al.*, 1998) is an important fact and may be obtained on the face-to-face classes.

The easy access by students to the Internet is crucial to the learning success on a blended-learning environment. If it does not happen, the process of web integration is at risk. Hence, it is useful to make an online inquiry at the beginning of the course to determine the kind of access students have. The research developed revealed that students' access to internet through broadband has been increasing.

2.1.3 Instruction needs

The objectives specification, global to the unit and transversal to the course, should guide the learning paths definition and lead the creation of contents modules. Global objectives are detailed afterwards, at the design phase, in order to develop targeted learning actions. At this stage, the definition of contents modules according to the global objectives, scaffolds the whole learning process. Parallel to the definition of the global learning objectives, it is important to determine which transversal objectives (also named soft skills) are defined to the course.

2.1.4 Available e-contents identification (e-repositories)

The e-contents analysis is the identification of available resources that may support the teaching-learning process and help reaching the defined objectives.

2.1.5 Prerequisites

The process of prerequisites identification establishes a platform, in order to ensure the same level of previous knowledge among all participants (Allen, 2007). It is crucial to clarify and spread the unit prerequisites. We may use the self-learning and constant support in order to help students that do not satisfy the prerequisites. Students should be hold responsible for the importance of long life learning. The lack of prerequisites might give rise to doubts on the learning strategies success.

If, for example, students are asked to create a document in the MS Word based in a study result, and if they are not able to use that specific application, the success of the activity may be threatened. These students will need more time and monitoring from the teacher so that they become able to make an effective and qualified participation.

2.1.6 WEB technology

The analysis of Web technologies corresponds to the identification of the available web environments, which may be used during the instruction process. This may be the learning management system made available by the institution such as the moodle or other web environments as the *yahoogroups*, *wikispace*, *google groups*, *blogspot*, etc. These last are not specifically oriented to the learning environment. As a result, they may demand the use of other complementary tools, such as *quizstar* to make tests available online. One of the advantages of using a LMS, when comparing with other online environments, is based on the multiplicity of educational tools gathered in a single place made available by itself.

2.2 Phase II - Instruction design

The system analysis supports the instruction design which, according to the MIPO model, includes the specification of objectives, the evaluation methodologies, the definition of contents sequences and learning strategies, as presented below:

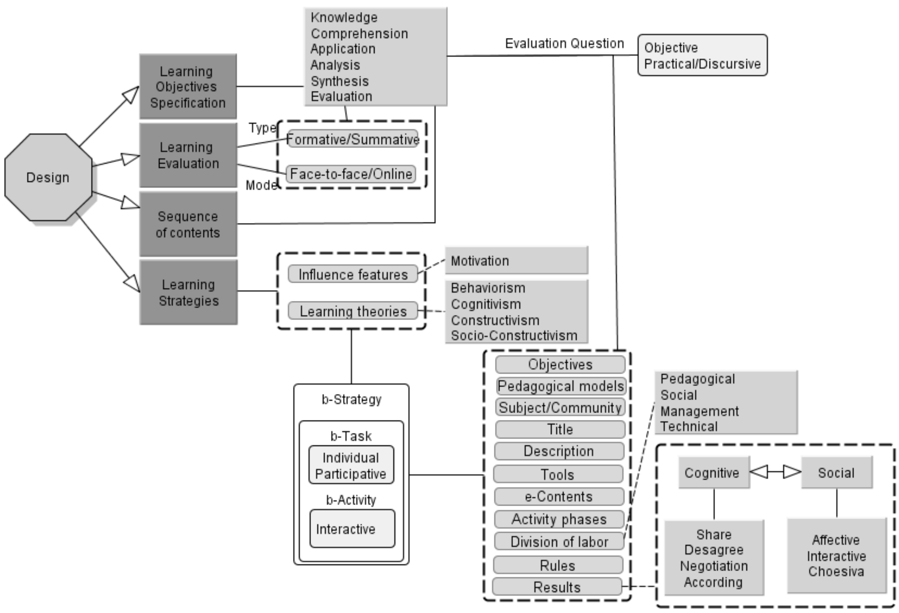

Figure 3: The design phase of MIPO model

2.2.1 Specification of learning Objectives

The learning objectives specification process conducts the development of an important guide to be used both by teacher and students.

If students do not understand what is expected from them, they will not be able to have success in their learning. The use of a taxonomy may facilitate the process. Bloom (Bloom *et al.*, 1975) suggests a taxonomy of learning objectives sorted out in six levels: Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation. The intention is to display the different behaviors, starting from the simplest to the more complex one. Any taxonomy may be used if it helps to promote the referred understanding.

It is important to establish a balance between the level of demand and the time available for the study of the unit. The highest level of knowledge demands more time and teacher support.

2.2.2 Learning evaluation process

According to MIPO model, after defining the objectives, we should design the evaluation process. Making decisions about what to evaluate is useful to understand clearly the learning objectives. The design of the evaluation process has the objective of making clear the way how students will demonstrate their knowledge.

Evaluation can be classified in two main groups: formative and summative. In the summative way, the evaluation occurs at the end of the instruction. In the formative way, the evaluation occurs during the instruction process and it consists in a continuous collection of learning thoughts (Born, 2003). The contextual importance of formative and summative evaluation conducts the decision about the use of the evaluation modes such as: face-to-face, online - with or without supervision.

The nature of the questions to ask and the standards to the success should be based on learning objectives and spread around the entire class. These procedures scaffold the students' understanding. The specification of evaluation modes to each learning objective may facilitate the alignment and leads to the later activity design.

2.2.3 Sequence of contents

According to the MIPO model, after defining objectives and designing learning objectives, we should establish the sequence of contents. This organization avoids the specification of learning objectives based on the contents. This scenario usually results in sentences such as "understand the content A" and in a lowest level of knowledge (first or second Bloom level). Despite the importance of these levels, if the learning objectives consist in achieving a higher critical thinking level, it is important to explicit it on the objectives definition associated to analysis, synthesis and evaluation.

2.2.4 Learning strategies

A combined instruction strategy design (blended-strategy or simply b-strategy) demands the biggest effort of all. In the MIPO model, the design of a b-strategy includes a set of learning individual tasks (for instance an online test) or participative tasks (for instance the building of a repository of assignments) and interactive activities (for instance an interactive game of learning). These tasks and activities are more or less complex and intend to promote the learning in a semi-online environment (b-task or b-activities).

2.2.5 Influence features

A b-strategy design should consider the results of the context analysis done in the previous phase. Time available, students' age, class dimension, the course, the grade, etc. are elements that need to be considered. Motivation comes up as a crucial element that influences the way people participate on learning activities and develops self-regulation, time and task management.

Many authors defend that we should provide students cooperation, use active learning and contextualized activities, and consider the learning objectives.

Learning activities that are more demanding in terms of objectives, also demand more monitoring to students and more time to assimilate.

The complexity and the time available for students to develop the b-strategy are crucial elements that influence the number and quality of participations.

If a certain activity is too complex, students may try to discover the solution, but after a period of time they may give up. Otherwise, if the activity is too simple, students are not motivated to participate because they feel that they will not learn.

At the same time, the time available for the development of the activity is also crucial to get students engagement. If students feel that they are not able to participate in a short period of time, many times, they give up, even before starting. Unlike, if students feel that they have too much time they direct their effort to other things.

This process may become more sustainable if we add other features such as: establishing frequent contact with students, providing correct time to achieve objectives, communicating to students the great expectations and respecting differences.

Students' motivation and general principles for the learning success are, according to the MIPO model, important features to consider on the design strategy phase. Nevertheless, learning something new or developing a deep study on a subject is not a linear process. The way as we learn, individual learning styles (Kolb, 1984) (Felder & Brent, 2006) and multiple intelligences (Gardner, 2000) characterize the singularity of the learning process. In this sense, we should consider these features when we are designing instructions.

Features as culture, motivation, emotional feelings, previous experiences and personality are also important. Whenever possible, teachers should give value to diversity responding to students preferences, but never forgetting the learning objectives. We should also consider pedagogical models in order to scaffold interactions (McGriff, 2000) (Kemp *et al.*, 1998).

Summarizing, we identified the following main learning influence features: Contextual analysis results; Time definition; b-Strategy complexity; Nature of subject in study; Personality, ways and individual learning styles; Previous experiences, knowledge and culture.

2.2.6 Learning theories

The learning strategies designed may be based on influence features, learning styles, multiple intelligences but also learning theories. Today's theoretical design approaches can be seen as a derivation of behaviorism, cognitivism and constructivism viewpoints (Allen, 2007).

Students' participation in small online tasks (b-tasks), either individual or participative helps the construction of knowledge scaffold. This fact allows a better participation on b-activities with more complex demands.

The choice of the pedagogical model should consider the moment of learning. At the beginning of the subject study, it is important to make sure that students are getting the basic knowledge. Then, it is important to consolidate it and promote the self-learning based on previous experiences. At the end, it is important to promote a deep learning by social interaction. This path should be aligned with learning objectives. In this context, learning may be achieved by defining behaviorist b-tasks, based on the repetition, mainly to assimilate concepts. These tasks correspond to the implementation of individual objective questions. In order to go from a short term memory to a long term memory, the knowledge understanding may be promoted by using individual or participative questions and by implementing practical or discursive b-tasks. The use of synchronous and asynchronous communication available in the internet and identified in the previous analysis phase helps the implementation of interactive b-activities supported in the socio-constructivist approach.

The choice of a pedagogical model does not have to be exclusive. On the contrary, it may be combined in different moments of the learning process.

2.2.7 b-strategy of learning

The *b-strategy* instruction design includes the definition of b-taks and b-activities which, while considering the influence factors and pedagogical models leads to the reaching of the objectives defined and should be aligned with the evaluation questions (objectives or practical/discursive). In the instruction design, it is important to make sure that we are promoting different activities that cover all objectives defined and that we are in fact helping students to prepare themselves to answer the evaluation questions.

A b-task is mainly individual, but may include the participative type when an individual work has the objective of reaching a common goal. Unlike b-tasks, the b-activities are interactive and have as a main objective to help students to reach the high level of complexity of objectives associated with analysis, synthesis and evaluation ability according to the bloom taxonomy. A b-activity differs from a b-task mainly due to the collaborative nature

applying the socio-constructivist approach. Usually a b-activity demands more time to design and to develop and also demands the definition of participants' roles. The b-activity phase definition helps to sort out the individual work.

B-strategies (that include b-activities and b-tasks) should be aligned with course objectives in order to facilitate the organization and procedures and also ensure that all the contents of the program are covered.

The design of a b-strategy is the main step in the MIPO model and demands more time and creativity. It is characterized by: Objectives (specific and soft skills) and pedagogical models, Subjects/ Community, Title and general description, Tools, e-Contents, Activity phases, Division of labor, Rules, Results

The building of a database with different b-tasks/b-activities in order to achieve different objectives will sustain the re-use in future editions.

2.3 Phase III – Development

The development stage is based on the previous phases of analysis and design. The purpose of this phase is to generate the lesson plans and lesson materials. During this phase, one will develop instruction lessons and all media and support documentation that will be used. This may include hardware and software. Materials and procedures development must be based on the instruction strategy. For each lecture, it is important to develop or adapt material, develop presentations, organize lessons, seek for cooperation and represent it on the e-learning platform.

The following tasks should be performed on the development phase:

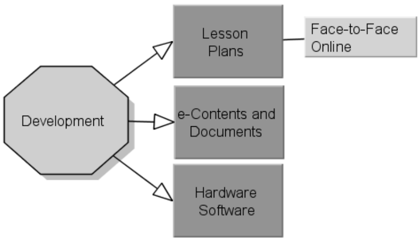

Figure 4: Development tasks

In the development phase the design of the lesson plan is important. It includes the identification of online and offline activities and also the alignment between objectives and program. This phase may include the planning of the messages that will be used during the application of the b-strategy. It is also important to adapt the existing e-contents to a particular context.

2.4 Fase IV – Implementation

The implementation phase refers to the delivery of the course. The purpose of this phase is to promote an effective and efficient delivery of instruction. This phase must encourage learner's understanding of contents. It is important to provide a good support in order to achieve the objectives defined.

The following tasks should be performed on the implementation phase:

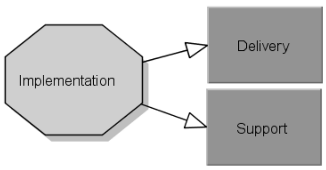

Figure 5: Implementation tasks

Face-to-face sessions are useful to the presentation, accomplishment and clarification of doubts about the activity.

2.5 Fase V – Model evaluation

The evaluation phase measures the effectiveness and efficiency of instruction. Evaluation should occur throughout the entire design process, within the phases, between the phases and after implementation. The constant evaluation allows the adjustment to a particular context.

On the formative evaluation we should answer questions such as “do the b-tasks and b-activities cover all learning objectives?”; “are there activities that are not covering any objectives?”; “do students have all the necessary information?” etc.

The summative evaluation is made at the end of the process and the results should be used on further course editions.

3 Conclusion

In the higher education context, besides everything that has been said about the use of e-learning technologies, we attested the idea defended by the European committee (European ODL Liaison Committee, 2004): Our higher institutions continue to use the traditional education schema promoting an environment that is based on providing information. This scenario constitutes the best option for many students, teachers and institutions. When an institution adopts an LMS (Learning Management System), it does not ensure the integration of WEB technologies on the educational process.

Updated technologies help the construction of a huge set of learning strategies and methods options, as large as our imagination. All technologies should be viewed as work tools and not as an end itself. More important than choosing a tool is the selection of the learning strategy, in order to achieve the defined goals.

However, during this study we had the opportunity to deal with many different experiences on the e-learning domain. Many times the changes occur on the technologies and without any methodological or pedagogical support. For instance, whenever printed documents are replaced by digital contents, using the same communication schema (emitter-receiver) but with more sophisticated tools.

Updated technologies give support to the construction of such a huge set of learning strategies and methods’ options that can be as large as our imagination. All technologies should be viewed as work tools and not as an end itself. More important than choosing a tool is the selection of the learning strategy, in order to achieve the defined goals.

We believe that the existence of a model that supports the complex management process of blended-learning (b-learning) may promote the systematization, the usefulness and the organization of the web classroom integration. The MIPO model intends to be a dynamic and flexible structure that offers a large set of orientations in order to conduct a combined learning process.

Unlike the majority of e-learning models proposed (Laurillard, 2006) (Schofield *et al.*, 2006) (Klein *et al.*, 2003) that describe general procedures, the MIPO model gives a special emphasize to the activities design strategies and is targeted to the blended-learning systems, at the higher education. This model results from the evaluation and analysis of various pedagogical approaches and helps the instruction design beyond the traditional classroom environment. A profitable use of technologies on higher education demands individual and collective behavior changes. The implementation success always depends on the teacher’s will.

The theory associated to MIPO model was generated by inductive methods in which generalizations were extracted from specific observations. This model may be tested by other researchers who by a deductive method may foresee new data.

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Innovation on Supporting Material for B-Learning Purposes

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Abstract

The present e-book has been conceived and designed in a Task Based Learning (TBL) approach. In TBL the tasks are central to the learning activity and students may also be developing a remarkable range of different skills, which is aligned with Bologna goals. Concepts are normally presented and described in books. In the present e-book, contrarily to what is traditionally used for presenting concepts, they are mainly treated by exploring dedicated experiments. Those are entirely described and so, reproducible in any lab but it is also possible to reach experiments at Faculdade de Engenharia da Universidade do Porto (FEUP), remotely available and specially developed for this purpose. The option for a TBL instead of a PBL (Project Based Learning) approach is related with the present teaching/learning activity with large classes. The e-book is written in portuguese language but it also has a version in English. So, being useful for native students it is also suitable for students in general or in a mobility process. In fact, switching into the lingua franca version is very simple, and so just a “click” is required if the Portuguese speaking user desires to be familiar with the technical subject terminology for later searching, for example.

Keywords: electronic book; measurement; metrology; hands-on; project based learning; remote labs; virtual labs.

1 The Innovation

This work reports on a novel use of Information and Communication Technologies for composing an electronic book on the measurement field. The bi-lingual e-book “Laboratórios de Instrumentação para Medição/Laboratories of Instrumentation for Measurement” (URL - http://www.sensorsportal.com/HTML/DIGEST/E_19.htm) deals with concepts, methods, procedures and hands-on activity and it combines sketches, figures, animations, videos and remote and virtual labs on the measurement area, integrating many types of multimedia within the written material. The complete electronic format used is inspired in the Confucian wisdom, “what I hear, I forget; what I see, I may remember; what I experience, I know for life”, Confúcio (451 A.C.).

2 The Pedagogy

The educational objectives of the present work, in terms of Bloom’s taxonomy principles, are:

- to convey metrology concepts and terminology;
- to offer a basic background in laboratory and industrial measurement principles’, metrology and procedures;
- to practice the evaluation of error analysis and measurements;
- to promote ‘hands-on’ laboratory activity;
- to develop the students’ capacity in analyzing, interpreting, criticizing and reporting results;
- to encourage student initiative and imagination;
- to make students familiar with new technologies for remote access;
- to reinforce students teamwork skills, personal responsibility, self-organizing and conflict-solving capabilities;
- to improve students autonomy according with Bologna recommendations;
- to provide student self-assessment of his/her mastering of subjects by proposing open-ended questions based on the given materials.
- to intensify active/collaborative/cooperative learning activities;
- to attempt to teach how to learn.

3 The Technology

This e-book is in a PDF format, maybe the most popular format. In fact all platforms are able to gain access and read PDF formatting. It requires the Acrobat Reader but this software is usually available in the computers and, if not, it's freely downloaded. PDF is also really good at preserving the appearance of a document and for printing out the pages of the e-book. The reader may add his own notes.

The e-book has also flash applications that allow the "interaction with the contents"; these ones are imbibed in html page and so a browser is required.

The remote experiments accessed through the e-book are integrated in a Moodle platform and they are using a web server based on LabVIEW, a video server and a booking system developed as an extension of the Moodle platform.

4 Conclusion

The present e-book has been tested with undergraduate mechanical engineering students as well as with postgraduate students from other different fields of sciences and engineering, either as a text book or in a b-learning bases.

A dedicated questionnaire has been made. Students have referred the work as a valuable conceptual learning material, as a very good support for training hands-on activities, thinking critically, analyzing, evaluating, predicting and solving problems in an innovative and autonomous way. They considered this e-book as a good support to relate information to their own experiences and previous knowledge, to promote understanding and even to help long-term retention. The access to online experiments has also been considered of interest by the possibilities offered, especially due to the flexible 24-hour a day, seven days a week, and by providing contact with the new technology.

From the pedagogical point of view this work won the E-learning in Practice 1st place in "Supporting Materials for On-line Learning" category of the 5th Competition within the International Conference ICETA 2008, Slovakia. It had also the 1st place Multimedia Contents category in Prémio ZON Multimedia, Criatividade em Multimédia, December 2008, Portugal.

A long way of 5,000 years, since clay tablets up to the "electronic book", tells us the evolution of the book. And it has been always the same: "*Any new technology is an evolutionary and biological mutation opening doors to perception and new spheres of action to mankind*", Marshall McLuhan (1911-1980).

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PAEE Students' Project Award

Sustainable Engineering Student Project on Biomass Based Carbon Capture

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Abstract

The Sustainable Global Technologies study programme at TKK teaches critical thinking and practical tools needed for taking sustainable development into consideration in engineering. Project course for Master's degree students gives students a possibility to analyse and find creative solutions real-life cases. This paper presents a student project on biomass based carbon capture through anila stove technology.

Keywords: sustainable development; student project; carbon capture; anila stove; project-based learning.

1 Introduction

"It is our collective and individual responsibility to protect and nurture the global family, to support its weaker members and to preserve and tend to the environment in which we all live."

This Dalai Lama's famous quote captures what should be the essence of contemporary engineering education. Today, engineering students graduate to a world with 1.4 billion people living in extreme poverty, greenhouse gas emissions drastically exceeding the sustainable level, and to a world where technological advancement is giving more possibilities than ever to those few with skills and access. Dealing with global warming consequences, possible extinction of fossil fuels and global epidemics might all occur during present day's students' lifetime. Thus, preparing students to cope with this unequal and unsustainable situation is a challenging, but an essential task.

Helsinki University of Technology (TKK) has responded to this challenge with a multidisciplinary study programme Sustainable Global Technologies. The programme started in 2006 to increase awareness, education and research in the fields of sustainability, development and technology. The programme consists of 20 ECTS worth of courses, encompassing both theory and practise. The study programme is offered for Master's level students finalising their studies from diverse engineering and architecture backgrounds as well as visiting students from other universities. In addition, the course embraces foreign exchange students to enrich the global discussion.

The study programme culminates to a semester-length project course featuring real-life challenges. This spring, there were five interdisciplinary project groups, each consisting of 4-7 student members. The groups worked with very diverse topics: evaluation of hydropower potential for sustainable development in Romania, master plan study in Amman in Jordan, sustainable voice and Internet access for rural communities in developing countries, urban design project for Taipei river area, and biomass based carbon capture in Kenya, in which the author of this paper took part in. Each project group was supported by mentors from a company or organisation. The mentors offered guidance as well as set requirements for the final result.

2 Project Overview

Since the energy crises in the 1970s, replacing three stone stoves with more efficient substitutes to reduce the need for fuelwood, the consumption of local wood resources, and air pollution has become a popular means to improve the living conditions of the poor in developing countries (Barnes & Floor 1999, pp. 120-121). However, the prevailing energy acquisition through inefficient small-scale wood combustion, the imminent deterioration of soil fertility and the decrease of arable land are still among the many problems affecting the everyday life of rural people in developing countries (Mahiri and Howorth, 2001; Mbugua, 2001; Barnes and Floor, 1999). After the introduction of market-based greenhouse gas emission reduction mechanisms, like the Clean Development Mechanism (CDM), the opportunities for the developing countries in climate change mitigation have been actively discussed.

The anila stove is a technology appropriate for daily cooking and heating. As a by-product, biomass is converted into further exploitable char via pyrolytic process. The biochar can be used in agriculture to create soils with high organic matter contents and exceptionally good fertility (Glaser et al. 2002). In addition, adding the charcoal into the soil sequesters carbon, as biomass to energy conversion adds no additional greenhouse gases to the atmosphere.

Figure 1: The project work included, among other things, drawing the blueprints and building and testing the model stove

The work of the anila stove team took place in mainly three phases. A comprehensive project plan was developed in the first phase. The second phase consisted of drawing the blueprints and building a model stove, which was tested in the third phase. The experiences from the stove building and testing were compiled with extensive desk research for the course final result, a feasibility study on the anila stove.

3 Project Learning from Student Perspective

According to a review on project-based learning research by Thomas (2000, s. 7), learning is enhanced in situations that resemble real-life, and when problem solving skills are needed. In addition, learning that has occurred in projects is more flexible and easier to apply into different situations. As engineers often work in changing situations where creative application of theoretical knowledge is a requirement for success, engineering curricula should be planned accordingly.

Project-based learning is a great tool for practising the application of theoretical knowledge. Besides, projects encourage students towards creative thinking: instead of aiming for pre-defined answers, ground for innovative ideas is enabled. Furthermore, many students choose engineering for its connection with practical work. Thus, project-based learning can be more motivating for those students, and so produce better learning results.

In the Sustainable Global Technologies course, learning took many forms. Besides immersing into the latest academic research on the topic, the project required practical application of the knowledge gained. Specifically, building and testing of the stove helped understanding the path from design to the actual product.

In addition to the academic contents, the course provided the students with an environment to practise many transversal skills. The students worked independently in small teams, that allowed practising team-work and leadership skills. The teams presented both their project plans as well as final reports for public evaluation and commenting by the peer students and mentors from companies and other organisations. In addition, the teams had to design and organise a workshop for the other students. This enabled the students to practise workshop-leading and presentation skills, as well as to face public evaluation.

Finally, probably the most important feature of the course, from a student perspective, was to conduct the project for a real organisation with a real need. The project assignment required critical evaluation over the proposed project and creative problem-solving skills. The end results needed to be carefully matched with the needs from the mentoring organization.

Project-based learning reminds the students about the overall objective of education. The point is not in studying the materials by heart and without critical thinking. Instead, projects connect the theories with real life. Through project-based learning, the students gain knowledge and tools to understand and act in the real world.

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Temporal Analysis of Macrobentic Fauna Associated with Salt Marsh, Cananéia (São Paulo, Brazil)

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Abstract

This paper shows itself as a practice from the discipline "Ecologia de Ambientes Aquáticos" based on teaching by projects, introducing analyses and arguments from a fieldwork accomplished in Cananéia, south-eastern, Brazil. The main objective of this fieldwork is to make a temporal analysis of the fauna, associated with the local ecosystem vegetation, from 1998 to 2008, evaluating the possible impacts caused by anthropic actions on the region. This procedure was evaluated under the perspective of the fieldwork analysis as well as survey data, the conclusion of the project and its elaboration, shown at the class work.

Keywords: teaching by projects; fieldwork; temporal analysis.

1 Introdução

A disciplina "Ecologia de Ambientes Aquáticos", do Curso de Ciências Biológicas da Universidade Presbiteriana Mackenzie (São Paulo, Brasil) vem sendo oferecida baseada no ensino calcado em projetos, em busca de uma máxima interface teoria-prática, que vem se mostrando uma condição dinâmica no processo ensino-aprendizagem.

A partir de um grande eixo temático de um Estudo de Campo na Cidade de Cananéia (São Paulo, Brasil): "Análise de solos, água e vegetação", numa região de baixo índice de desenvolvimento humano (IDH) do Estado de São Paulo, aos alunos é sugerido o desenvolvimento de um estudo aplicado. A escolha do enfoque do desenvolvimento do trabalho fica à critério de afinidade de cada aluno, ou grupo de alunos. Estes grupos foram formados livremente diante da afinidade dos alunos com cada eixo temático e divididos pelos diferentes ambientes da cidade, conforme sua análise exige. Dentre os temas discutidos, chegou-se aos seguintes selecionados: Ambientes Lóticos (rios), Bacia Oceânica, Manguezais, Marismas, Floresta Tropical e Restinga.

Dentro destas grandes linhas temáticas, foram sugeridos "cortes", com a finalidade de direcionar os trabalhos para assuntos mais específicos (menos abrangentes), tais como: Estudo de Impacto Ambiental, Levantamento de Espécies, Levantamento de Taxas de Poluição, Comparações Temporais de Ecossistemas, Divisão Demográfica de Espécies Animais e Vegetais.

Os grupos de levantamento de fauna e flora se dividiram na mata local (Restinga Alta e Média) e Mata Atlântica, grupos de estudos de Impacto Ambiental se dividiram em Análise de Água Oceânica, Análise de Água Estuarina e de Corpos Lóticos. Outros grupos como de Comparações Temporais de Ecossistemas se dividiram de forma que cada um analisasse um determinado ecossistema (como Marisma, Bacia Oceânica e Mata Atlântica).

Uma adequada fundamentação teórica foi requerida para cada eixo temático trabalhado, mediante revisão bibliográfica, para que houvesse suporte à pesquisa de campo. A partir dessa fundamentação, havia ainda a possibilidade de os alunos proporem modificações na temática, mediante argumentação justificada.

No presente trabalho é relatada a experiência com uma análise temporal sobre associações da fauna macrobêntica à marismas (ecossistemas estuarinos de transição) da referida região de Cananéia, de modo a abranger um período de tempo em que o Estado de São Paulo revelou um desenvolvimento vertiginoso - de 1988 a 2008 - em suas diversas regiões . E frente a esta proposta, será realizada uma análise quanto à metodologia e realização do

ensino baseado em projetos, que segundo Machado (2000), se estabelece de maneira investigativa e dinâmica no ensino.

2 Problemática

Marismas são sistemas estuarinos típicos do ecossistema litorâneo tropical e subtropical que se desenvolvem na zona entre marés, localizando-se, geralmente, na desembocadura dos rios. São também classificados como ecótonos ou ambientes de transição entre o ecossistema terrestre e o ecossistema estuarino costeiro (Macedo, 2003), caracterizados por uma vegetação herbácea de grande importância na produção primária estuarina.

Revelam adaptação às condições peculiares do solo, constantemente submetido a estresses hídrico e salino, de modo que a vegetação e a fauna associada são adaptados a grandes mudanças nas condições de salinidade, regime das marés e extremos de temperatura.

A região entre marés da zona estuarina de Cananéia está colonizada pela espécie vegetal Spartina alterniflora (Flynn et al; 2007), de grande importância na produção de matéria orgânica, constituindo base da teia para vários organismos estuarinos ou costeiros e ainda utilizada na forma de detrito enriquecido por biomassa bacteriana (Costa et al; 2004). Ela é ainda utilizada como área de reprodução, berçário e moradia para diversas espécies de crustáceos, poliquetas, gastrópodes, assumindo grande importância na alimentação da ictiofauna (peixes) local, que pode se alimentar na maré alta (Flynn et al; 1998).

Com isso, as marismas têm grande importância na estabilidade do ecossistema estuarino, suscitando preservação contra os impactos ambientais que possam comprometê-las, o que significa prejuízo da fauna aquática e terrestre a ela associada. Para isso se requer o emprego de indicadores, tal como a fauna macrobêntica associada à Spartina.

Macroinvertebrados bentônicos são organismos que habitam o fundo de ecossistemas aquáticos durante pelo menos parte de seu ciclo de vida, associados aos mais diversos tipos de substratos, tanto orgânicos (folhiço, macrófitas aquáticas), quanto inorgânicos - cascalhos, areias, rochas etc (Rosenberg & Resh,1993). Sua utilização como bioindicadores é usual por possuírem hábito sedentário, sendo, por isso, representativos da área em que foram coletados. Além disso, apresentam ciclos de vida curtos em relação aos ciclos de outros organismos presentes do ecossistema em questão, refletindo, de maneira mais rápida, as modificações ambientais. Adicionalmente, vivem e se alimentam dentro ou próximos aos sedimentos, onde as toxinas tendem a se acumular. As comunidades de macroinvertebrados bentônicos apresentam elevada diversidade biológica, ou seja, diferentes respostas às mudanças ambientais. Por serem componentes dos ecossistemas aquáticos que formam um elo entre os produtores primários, são consumidos por diversas espécies e apresentam papel fundamental no ciclo da matéria orgânica.

Tal estudo remete à aliança entre teoria e prática, fator que possibilita uma ampla visão na construção do conhecimento e no processo de elaboração e reelaboração de hipóteses como sugere Freire (1996), bem como uma compreensão objetiva e crítica do tema trabalhado.

A análise temporal da marisma, suas associações com fauna, bem como sua posterior discussão de um possível impacto ambiental local (apontado por esse ecossistema) se mostram uma rede de diferentes informações que permite uma interface de conhecimentos, atendendo aos objetivos pretendidos na disciplina.

3 Objetivo

A análise efetuada objetivou estabelecer possíveis impactos ambientais no ecossistema estudado, no período compreendido de 1998 a 2008, decorrentes do desenvolvimento regional. Os resultados obtidos e sua discussão servirão de suporte à avaliação da disciplina ''Ecologia de Ambientes Aquáticos''.

O presente trabalho pretender analisar e discutir a metodologia do ensino calcado em projetos sob as seguintes perspectivas: desenvolvimento do processo ensino-aprendizagem na realização das atividades sugeridas na disciplina, forma como ocorre a aliança entre teoria e prática, integração entre professor-aluno, como se dá a avaliação e os "produtos finais" da disciplina.

4 Desenvolvimento Metodológico

Foram realizadas coletas na Ponta do Rosal, no mar interno do estuário da Ilha de Cananéia, em três diferentes situações: duas ao nível do mar, duas ao nível da restinga e duas em uma distância média entre aquelas, totalizando 6 amostras distintas.

As amostras foram retiradas com o auxilio de um Corer aprofundado 15 cm no substrato;com um auxílio de uma pá, este material foi colocado em embalagem própria para a posterior identificação em laboratório. Analisou-se a fauna com respeito à sua composição específica, nº total de indivíduos e diversidade, relacionando-a ao tamanho médio das plantas e à condição físico-química do solo. A avaliação temporal das possíveis modificações no período 1988-2008 empregou os registros publicados por Flynn et al (1996).

Era desejada a comunicação entre grupos que poderia ocorrer de forma livre, com possibilidades de trocas de informações sob os ambientes de transição entre cada ecossistema estudado, procedimentos de coleta, materiais de pesquisa e outras informações pertinentes ao trabalho.

Os grupos, que foram divididos livremente, formados de seis à oito integrantes, possuíam temáticas específicas – como anteriormente descrito na introdução deste trabalho- e deveriam desenvolver, após a saída de campo, um trabalho com apresentação escrita e oral mediante avaliação do professor.

Diante desta avaliação foram analisados: a metodologia para realização de coleta e levantamento de dados, a transversalidade entre grupos (comunicação com outros trabalhos da disciplina, seja ela realizada por citações na apresentação ou por levantamento de dados e comparações), a relevância do assunto para o contexto da disciplina e a discussão em cima dos dados obtidos (pressupondo diferentes hipóteses geradas para uma análise de cada caso).

Durante todo desenvolvimento metodológico, desde coleta de material até as apresentações dos trabalhos, os alunos tiveram possibilidades de consultas à diferentes fontes bibliográficas e especialistas em cada assunto, sugeridos pelo professor.

5 Resultados

Algumas alterações na fauna macrobêntica puderam ser identificadas no período analisado (1998 - 2008). Dados anteriores apontam algumas espécies como bioindicadoras, como é o caso da Pagurus sp. e também Euritrium limosum. A análise dessa fauna associada à Spartina alterniflora demonstrou que, mesmo sendo uma vegetação submetida a um considerável estresse salino e hídrico (Cunha, 2007), há uma interação da fauna e da flora de recíproca importância, em que a flora fornece substrato fixatório e alimentação e a fauna permite uma rizosfera oxidada (ou aeração do substrato).

Houve diferentes perspectivas e levantamentos dos temas inicialmente sugeridos e as hipóteses levantadas pelos grupos, em diversas ocasiões, se mostraram complementares e/ou plurais. Foi constantemente observada e requerida a união e discussão de dados entre os grupos, tal interligação que as temáticas de cada grupo de alunos apresentavam.

A consulta de bibliografias e especialistas permitiu que alguns dos trabalhos fossem publicados, com posteriores meios de continuação da pesquisa.

6 Discussão e Conclusões

Devido a uma baixa quantidade amostral, optou-se por analisar espécies incomuns em levantamentos de anos anteriores, visto que, possuindo pouca quantidade de material, seria arriscado afirmar que uma espécie comum a este habitat estivesse em escassez no outro. Assim, direcionou-se a atenção a novas espécies macrobênticas associadas à marisma, o que levou a ponderar que estas espécies continuam mantendo, aparentemente, uma comunidade semelhante à existente àquela de antigos levantamentos, em relação à diversidade, riqueza e composição específica. Isso permite evidenciar níveis de alterações baixos nas características ambientais deste sistema quando colocado em paralelo a dados anteriores, provavelmente em decorrência de Cananéia vir apresentando um significativo programa de conservação ambiental, com iniciativas sociais e governamentais, a despeito de seu baixo índice de desenvolvimento, o que, por si só, acaba representando certa condição de preservação nem sempre verificada em regiões bem desenvolvidas.

Tais interpretações dos dados levantados permitem uma análise bem estruturada do ensino mediante projetos. Os alunos, durante a realização do trabalho cumpriram algumas etapas que privilegiavam a interface da teoria, previamente veiculada pelo professor e o processo empírico das análises. Com oportunidades de coleta, triagem de material, seleção de dados a serem utilizados e informações de outros trabalhos realizados pelos colegas da disciplina, os alunos se encontraram em condições suficientes de elaborar hipóteses e explicações para suas diferentes análises, assim como era prevista na avaliação da disciplina.

Essa análise in loco, de todos os conceitos previamente trabalhados, permite não apenas o desenvolvimento de uma pesquisa aplicada, mas também a formulação e discussão de hipóteses diante das problemáticas em questão. Observa-se assim o aprendizado ocorrendo em diversos planos, de maneira engajada e dinâmica, como sugere Machado (2000).

Os resultados obtidos atingiram o objetivo principal da disciplina, ao terem propiciado adequada associação ensino-aprendizagem mediante trabalho por projeto, tendo possibilitado uma elevada integração aluno-professor e uma desejável associação entre prática e teoria, visto que envolveram transversalidade de temas entre os grupos, além de envolverem os alunos em diversas etapas do trabalho científico aplicado: levantamento de dados, coleta de material, metodologia de pesquisa, formulação de hipóteses com respaldo teórico, confecção de um relatório com os relatos de todas estas análises, procedimentos e discussões e apresentação do produto final de cada grupos aos colegas.

Freire (1996), afirma que na educação deve haver troca, onde alunos e professor estão sempre reelaborando o “como fazer” e criando uma condição autônoma do ensino e da aprendizagem, fato observado com clareza nas produções escritas e orais dos alunos bem como na interação entre os grupos, por meio de trocas de informações e citações com os devidos créditos nas apresentações, o que evidencia a pluralidade e transversalidade dos trabalhos realizados.

Diante de situações onde diferentes eixos temáticos se encontram em pontos adjacentes da proposta do projeto, o professor teve a oportunidade de estabelecer um vínculo entre as muitas áreas de estudo da Ecologia. Isto demonstra a forma que o ensino calcado em projetos faz o elo entre as diversas formas de conhecimento e habilidades, tanto do professor quanto do aluno.

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The Importance of Interdisciplinary Projects in the Learning Process: a Case Study

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Abstract

This article describes a first experience of work in an Integrative Project of the second cycle from the first year of the Master Program in Systems Engineering. This experience was also a first contact with the active learning method. The motivation to write this article was to describe a positive balance of the work done in this Project in spite of the difficulty felt, due to the exigency of a more proactive behaviour, unusual in the traditional teaching methods and teamwork. The author of this article is a student of the cited Masters. In this experience he concludes that besides the knowledge acquired, there are several advantages in the active learning projects like the acquisition of technical and transversal skills of great importance. As such, there were highlighted the positive points and suggested points to develop.

Keywords: integrative project; active learning; learning by project.

1 Introdução

No contexto desta experiência, o Projecto Integrador (PI) visa promover a aprendizagem activa, através de um projecto que relaciona conteúdos de áreas distintas. Neste sentido, a aprendizagem activa é de elevada importância pois implica a assimilação de conteúdos por parte dos alunos através das suas próprias iniciativas, responsabilizando-os pelos seus progressos (Niemi, 2001). Paralelamente, espera-se que os alunos que executam trabalhos seguindo esta abordagem, adquiram não só conhecimentos científicos, mas também competências transversais. Carvalho, Lima e Fernandes (2008) concluíram na análise a um projecto multidisciplinar, que os alunos adquiriram competências técnicas devido à sua aplicação prática, e, desenvolveram competências interpessoais (gestão de equipa, resolução de conflitos) e outras (inovação, empreendorismo).

Na universidade onde decorreu esta experiência, a aprendizagem por projecto é comum em praticamente todos os cursos de Licenciatura e Mestrado do Concelho de Cursos de Engenharia (van Hattum-Janssen & Vasconcelos, 2007), o que demonstra uma preocupação crescente por parte dos docentes na mudança do paradigma educacional, motivada fortemente com o surgimento do processo de reestruturação europeu de Bolonha (Carvalho & Lima, 2006).

Este tipo de abordagem contribui grandemente para a aprendizagem activa. É mais uma iniciativa de aprendizagem activa desenvolvida na Universidade do Minho, que tem promovido novos projectos no sentido de melhorar a qualidade de ensino (Carvalho & Lima, 2006).

2 Contexto do Projecto Integrador

O projecto integrador (PI) é um módulo da unidade curricular de Engenharia de Sistemas do Mestrado em Engenharia de Sistemas. Este mestrado faz parte da oferta formativa da Escola de Engenharia da Universidade do Minho. O PI que este artigo aborda, integra dois módulos pertencentes à mesma unidade curricular: o módulo de Gestão da Produção e o módulo de Simulação. Simulação é um módulo que aborda a descrição, classificação e planeamento de modelos de simulação, bem como a filosofia de fluxo de processos e a implementação de experiências de simulação, utilizando para isso, recorrentemente, o software *ARENA*. Em Gestão da Produção, são leccionados importantes conceitos de sistemas de produção, abordando temas como a gestão de projectos e o planeamento e programação da produção. O projecto integrador surge com o principal objectivo de aplicar os conceitos abordados em cada módulo isoladamente, articulando-os entre si num trabalho integrado que garante a aplicação prática dos conceitos. O projecto descrito foi a primeira experiência de projecto integrador em que o autor participou, envolvido numa equipa de três elementos. Até então, apenas tinham sido realizados trabalhos no âmbito de uma única área de conhecimento.

3 Descrição do Trabalho Desenvolvido

O enunciado do projecto a desenvolver para o PI foi fornecido pelos docentes às equipas de alunos, e consistia, de forma genérica, em modelar um sistema fabril em que os produtos se encontram em produção modular a partir de vários componentes. Os produtos são assimilados em linhas de montagem enquanto que os componentes são fabricados em máquinas distribuídas numa oficina de produção. Pretendia-se configurar esse sistema e o seu modo operatório de forma a conseguir custos aceitáveis de acordo com pressupostos e restrições que constavam do enunciado do projecto. Adicionalmente foi requerida uma codificação de um algoritmo de escalonamento de produção. Os alunos foram convidados a formular a sua solução, apresentando um protótipo do sistema de produção em *Arena* e a codificação do algoritmo de escalonamento da produção que decidiram implementar. Foi dada autonomia aos alunos para irem além do enunciado, promovendo o espírito de iniciativa e de empreendorismo destes. Desta forma, foi possível desenvolver propostas inovadoras, integrando conhecimentos dos dois módulos.

Foi dada liberdade aos alunos para escolherem os colegas com quem queriam efectuar o trabalho. O autor deste artigo optou por formar grupo de trabalho com dois colegas do referido mestrado. Ficou estabelecido entre estes alunos reunirem-se alguns dias da semana, com frequência variável, para realizarem algum trabalho em equipa. No fim de cada reunião, era acordado o que cada elemento poderia fazer isoladamente, de forma a adiantar algum trabalho para que as reuniões envolvessem também discussão e avaliação do que tinha sido feito, e o que ainda poderia ser desenvolvido.

4 Resultados do Modelo de Aprendizagem

A apreciação que se faz da aprendizagem por projecto é positiva. De facto, o que se aprendeu na execução do projecto foi superior em relação a uma avaliação tradicional, em que teriam sido assimilados, isoladamente, conteúdos de módulos diferentes. Não obstante das dificuldades sentidas pelo trabalho ser em equipa (conflitos de opinião e interesse, dificuldade na divisão de tarefas), existem aspectos positivos ao realizar este tipo de trabalho em equipas pequenas em detrimento de o realizar individualmente, pois dentro de uma equipa os colegas corrigem-se mutuamente, convergindo opiniões no sentido de conseguir apresentar um bom trabalho. Neste sentido, apresentar o resultado do trabalho desenvolvido perante um painél de avaliadores, inspira responsabilidade e rigor, pois é necessário preparar o que se vai dizer de modo a que a exposição seja clara e sucinta, odedecendo a uma duração imposta. Conclui-se portanto que o PI consegue assim o seu objectivo, conseguindo dotar os alunos de um espírito de trabalho em equipa e de competências transversais. Para o autor deste artigo, a principal vantagem do projecto integrador centra-se nas competências transversais desenvolvidas, pois conseguiu desenvolver competências ao nível da escrita de relatórios e leitura de artigos científicos. Também conseguiu desenvolver a sua assertividade, o seu espírito de equipa e a sua capacidade de gerir conflitos. Sugere-se, por fim, o planeamento de várias avaliações durante o período de execução de projectos integradores por parte dos docente e que essas avaliações incidam no trabalho desenvolvido, promovendo a discussão sobre os pontos a desenvolver. Paralelamente, os alunos também puderiam avaliar os seus colegas de equipa, sobre o trabalho desenvolvido e sobre as competências adquiridas.

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Interdisciplinary Projects as a Tool for the Development of Transversal Competencies

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Abstract

This paper illustrates a project approach to engineering education proposed within the discipline Integration Project with main focus on project management, interdisciplinarity and the development of soft skills. The Integration Project is an optional discipline of the University of Brasilia (UnB) mechanical engineering graduation course and has for its objective the solving of real engineering problems by heterogeneous groups of students. The following work shows how one of these groups had to develop and create a hydraulic device to pump water from cisterns of the poor semi-arid regions of Brazil and how it had to organize itself like a real micro-company following strictly the reality of the labour market.

Keywords: engineering education; project interdisciplinarity.

1 Introdução

O cenário atual do ensino de engenharia não está ligado apenas ao domínio de habilidades específicas desta área, tais como resolução de equações diferenciais ou o conhecimento de leis e normas técnicas. Cada vez mais, aliados a essas competências específicas, a formação do estudante de engenharia exige que ele se adapte a diversos outros requisitos demandados pelo mercado de trabalho.

O que se verifica atualmente é que existe uma divergência grande entre o perfil de formação dos alunos recém-formados nos cursos de Engenharia e aquele demandado pelo mercado de trabalho. Assim, esse profissional recém egresso acaba tendo que se adaptar a funções para as quais não foi preparado na graduação.

Pela falta de contato com os desafios de áreas correlatas à sua formação, mas essenciais para o domínio completo das competências exigidas no exercício das atividades de engenheiro, o profissional acaba apenas se “encaixando” em alguma atividade correlata, mas sem exercer plenamente o seu potencial e, em conseqüência, aquelas atividades que o poderiam realizar profissionalmente.

Dessa forma, fica nítida a importância de se fomentar o desenvolvimento das competências transversais, quais sejam, aquelas que complementarão e diferenciarão o aluno recém-formado, a fim de melhor dotá-lo de recursos e ferramentas que o habilitem a um bom e pleno desempenho profissional. Por esse motivo, faz-se necessária a inserção de novas abordagens metodológicas nas faculdades de Engenharia, a fim de melhor preparar os futuros engenheiros.

2 Projeto Integrador

A disciplina *Projeto Integrador* do curso de Engenharia Mecânica da Universidade de Brasília foi introduzida no primeiro período de 2007. Ela surgiu como resultado dos trabalhos de uma comissão de reforma curricular instituída pela Faculdade de Tecnologia. O Departamento de Engenharia Mecânica tomou a iniciativa de colocar em prática experiências curriculares envolvendo atividades do tipo “ensino baseado em projetos”. Tais atividades foram propostas como recursos essenciais para complementar a formação do futuro profissional, seja por contextualizar conhecimentos adquiridos em disciplinas teóricas, possibilitar abordagem de aspectos sociais, econômicos e ambientais sob a forma de temas transversais ou por simular situações vivenciadas no ambiente de trabalho. Pressupôs-se ser uma forma dos estudantes se beneficiarem de um meio de aprendizagem propício ao desenvolvimento de habilidades e competências usualmente pouco frequentes em disciplinas tradicionais (Comissão de reformulação curricular do ENM, 2008).

3 Projeto DiBoA

A disponibilidade de recursos hídricos constitui a principal condição sustentável para a fixação do homem nas áreas rurais de clima semi-árido. Neste contexto, um programa de captação de águas pluviais foi estabelecido pelo governo brasileiro no qual um sistema de calhas coleta a água proveniente das chuvas para as cisternas, onde é armazenada para a utilização durante os longos períodos de estiagem. Com o propósito de se utilizar técnicas mais adequadas de recuperação dessa água, foi proposto o projeto e construção de um dispositivo de bombeamento. O dispositivo projetado deveria atender a certos requisitos a fim de torná-lo um produto viável a seu público alvo. O processo de confecção e manutenção da bomba deveria ser simples, de baixo custo e capaz de ser realizado pela própria população local. Frente a estes desafios, competências relacionadas à solução de problemas e práticas de engenharia verde e sustentável também puderam ser exploradas.

A fim de aumentar ainda mais o realismo da experiência, as equipes formadas a critério dos professores, se assemelhavam a pequenas empresas. Os membros tinham de assinar um termo de compromisso produzido com o consentimento de todo o grupo, onde se estabeleciam os deveres, regras e punições referentes ao não cumprimento destas. Havia a possibilidade de um membro ser "demitido" e este deveria tentar persuadir integrantes de outro grupo a aceitarem seu ingresso, do contrário, seria reprovado na disciplina. Os alunos possuíam total liberdade para redigir os documentos pertinentes às diretrizes do projeto e deveriam escolher um representante ou gerente de equipe.

O andamento do projeto era monitorado pelos professores através de apresentações orais, realizadas pelas equipes, denominadas pontos de controle. Os estudantes eram então avaliados quanto aos aspectos técnicos - como a análise coerente das condições de contorno e a viabilidade do projeto em termos de recursos - e não-técnicos como a comunicação verbal e não-verbal, a capacidade individual de liderança e a gerência do projeto como um todo.

Ao final das apresentações, os estudantes eram alertados quanto a deficiências nestes objetos de avaliação e recebiam orientações para sanar tais dificuldades. Deveriam também preencher individualmente um formulário avaliando as competências transversais de cada integrante do grupo. Dois outros questionários foram entregues, um no início e outro no final do projeto com o objetivo de analisar comparativamente cada membro da equipe e notar como foi sua evolução nos principais pontos trabalhados pelo Projeto Integrador.

A gerência de pessoas e de conflitos também foi muito explorada, uma vez que se tratava de um grupo relativamente heterogêneo. Divergência de idéias a respeito da elaboração de documentos, especialmente do relatório final, acarretaram em uma discussão um pouco mais séria entre dois membros da equipe. A questão foi resolvida através do diálogo e houve um crescimento observado em todos os componentes do grupo quanto à postura diante de problemas relacionados a interações interpessoais, visto que o grupo esteve exposto a situações desta natureza.

4 Conclusão

O projeto citado buscou aliar a área da engenharia às outras dimensões relevantes para o projeto. Este alcançou as metas propostas estipuladas e detalhadas no decorrer do planejamento, observando as condições de contorno e restrições inerentes às dimensões social, econômica, ambiental, entre outras. Com a participação no projeto, os alunos puderam desenvolver habilidades e competências pouco freqüentes no ambiente acadêmico de Engenharia. Foi possível desenvolver habilidades relacionadas à oratória e a boa execução de uma apresentação formal. Os estudantes tiveram que se atentar quanto à postura e o tom de voz empregado nas apresentações. Em nível mais profundo, os alunos eram estimulados a superar crenças limitantes relacionadas à baixa autoconfiança e autocontrole, que os impediam de desenvolver de forma plena capacidades de liderança, comunicação entre outras. Foram também desenvolvidas competências transversais relacionadas ao trabalho em grupo, uma vez que nas reuniões era necessária a capacidade de expor e defender uma idéia perante os demais membros, ser sutil ao criticar uma idéia alheia, gerenciar conflitos, realizar tarefas em prazos determinados e tomar decisões importantes para a concretização do projeto.

Pode-se então afirmar que o *Projeto Integrador,* enquanto atividade interdisciplinar, constitui uma ferramenta fundamental para o aprimoramento e fomentação das competências transversais, imprescindíveis no contexto atual da prática de engenharia.

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Project-based Learning: Analysis of the Experience of a Group

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Abstract

In this article we present a balance of two project-based teaching/education editions that occurred along the academic route of a students' group from the Integrated Master of Engineering and Industrial Management. With this article the group want to make known this kind of teach, focusing some advantages relatively to the traditional teaching methods. Beyond these advantages, the group presents some less positive points, with the intention to allow the constant improvement of this type of projects.

Keywords: evaluation; project-led education.

1 Introdução

O Mestrado Integrado em Engenharia e Gestão Industrial (MIEGI), com o auxílio dos seus docentes, tem vindo a tentar implementar novas formas de ensino/aprendizagem com a finalidade de preparar melhor os profissionais que forma. Esses novos processos de ensino/aprendizagem baseiam-se, essencialmente, numa educação apoiada em projectos (PLE - Project Led Education), segundo um modelo de aprendizagem activa e que vai de encontro ao espírito da Declaração de Bolonha.

2 Descrição do Projecto

Segundo Powell & Weenk (2003), a aprendizagem baseada em projectos consiste numa metodologia que privilegia o trabalho em equipa, a resolução de problemas interdisciplinares e a conjugação dos conhecimentos teóricos com a sua aplicação prática. O principal objectivo deste tipo de ensino cinge-se à realização de um trabalho que culmina com a apresentação de soluções para problemas reais. O Grupo, no seu percurso académico, participou em dois tipos de projectos: o primeiro visava a apresentação de um sistema de produção através da aplicação dos conhecimentos adquiridos em várias UC´s e o segundo, na análise e melhoria de um sistema produtivo real de uma empresa seleccionada pelo grupo. As competências que os alunos adquirem com a participação neste tipo de projectos interdisciplinares correspondem essencialmente às competências específicas que estes devem adquirir aquando da realização das várias unidades curriculares integradas no projecto. Além destas competências, os alunos também desenvolvem igualmente competências transversais, como por exemplo, capacidade de decisão, espírito crítico, entre outras.
Como em qualquer outro método de ensino, a aprendizagem baseada em projectos apresenta vantagens e desvantagens. Segundo o grupo, uma das vantagens está relacionada com a aplicação dos conhecimentos teóricos, adquiridos nas unidades curriculares, no contexto industrial. O trabalho em equipa também constitui outra vantagem deste tipo de aprendizagem, uma vez que obriga o grupo a viver situações que se podem verificar num futuro contexto profissional. Neste sentido, aprende-se a resolver possíveis conflitos entre os elementos da equipa de trabalho, a tomar decisões que possam influenciar elementos em particular, entre outros pontos. No entanto, nem tudo se resume a pontos positivos. O facto de nem todos os elementos desenvolverem as mesmas capacidades perante os desafios que surgem é um problema que o grupo tem de ser capaz de ultrapassar. Isto deve-se ao facto de o tempo para desenvolver este tipo de projectos ser normalmente limitado, o que leva o grupo a distribuir actividades específicas pelos diferentes elementos de modo a conseguir abranger o maior número de requisitos possíveis. Outra desvantagem é o esforço adicional que é requerido relativamente aos modelos tradicionais de ensino.

Para que haja sucesso num projecto deste tipo, em que estão envolvidas várias unidades curriculares, é fundamental que estas se encontrem bem integradas com o tema de trabalho. No entanto, isto nem sempre se verifica, pois existem unidades curriculares cujos conteúdos leccionados não se enquadram com a realidade do trabalho. Este tipo de situações já originou, em certos casos, alguma desmotivação dentro do grupo uma vez que

obriga a um esforço suplementar de modo a responder positivamente aos requisitos impostos pela unidade curricular. Apesar de, numa fase inicial, existir uma compartimentação do conhecimento derivado da divisão de conteúdos em UC´s, esta tende a desaparecer quando os alunos adquirem competências através de projectos de aprendizagem cooperativa, a qual prevê a integração de diferentes conteúdos (Lima *et al*, 2005).

A equipa de coordenação inclui os docentes que leccionam as várias UC´s, bem como, os tutores dos vários grupos. Esta é fundamental para a orientação, aconselhamento e desenvolvimento de um projecto de sucesso. Uma característica inerente a este tipo de trabalho, no entender do grupo, é a elevada proximidade existente entre os docentes e os alunos. No sentido de orientar o grupo o elemento que tem maior relevância é o tutor. Nos dois projectos realizados pelo grupo existiu uma diferença acentuada no papel desempenhado pelo tutor. No primeiro o tutor acompanhou exaustivamente o desenrolar do projecto, orientando e estimulando o grupo a superar-se constantemente. Já no segundo projecto, o tutor esteve bastante ausente pelo que, em certos momentos, o grupo teve dificuldade em definir um caminho a seguir. Segundo o grupo, outro aspecto negativo deste segundo projecto foi o facto de o tutor não se encontrar enquadrado com o objectivo do trabalho. Na opinião do grupo, isto verificou-se pelo facto de o tutor destacado para nos acompanhar não leccionar nenhuma UC que integrasse o projecto.

Quanto à organização interna do grupo, os vários papéis normalmente definidos neste tipo de projectos (secretário, líder, gestor de tempo, etc.) nunca tiveram verdadeira importância no seio do grupo. Com o passar do tempo, surgiu naturalmente um líder. Isto deveu-se ao facto de um dos elementos se destacar dos outros no que diz respeito a tomada de decisões, organização da informação, entre outros aspectos.

Uma vez que este projecto é realizado pelos vários elementos do grupo, é necessário atribuir a nota mais justa e apropriada a cada um dos elementos, de forma a diferenciar a nota individual de acordo com o desempenho de cada um. Para conseguirmos esta diferenciação foi necessário atribuir um factor de correcção da nota individual, através da avaliação de cada elemento do grupo de acordo com a Tabela 1.

Tabela 1: Avaliação de pares

Escala de 1 a 10	Peso Percentual (%)							
Notas dadas ao elemento		1	2	3	4	5	6	7
Critérios de Avaliação								
Pontualidade	10							
Assiduidade	15							
Nível de esforço no trabalho	35							
Sugestões de soluções	15							
Relacionamento Interpessoal	10							
Cumprimento de prazos	15							
Total	100							

A classificação de cada um dos tópicos é feita numa escala de 0 a 10 e cada um tem o peso percentual que se pode observar na tabela. A definição dos pesos percentuais foi feita pelo grupo, sendo que o factor que mais peso tem é o do Nível de Esforço no Trabalho. Por outro lado, os factores que menos importância têm no desempenho do projecto são a Pontualidade e o Relacionamento Interpessoal.

A avaliação é feita ao longo do semestre, definindo-se as datas de avaliação após cada ponto importante do projecto, como por exemplo, uma apresentação. Em cada sessão de avaliação é pedido ao elemento que está a ser avaliado que saia da sala, de forma a permitir uma discussão entre os restantes elementos sem que este interfira. Isto acontece porque se esse elemento estiver presente poderá constantemente levantar entraves na sua avaliação levando a que esta se prolongue por demasiado tempo. No entanto, esse elemento tem a oportunidade de comentar a sua avaliação e, no caso de bem fundamentado, tem a possibilidade de, em conjunto com o grupo, alterar a sua nota. Há a salientar que após as avaliações alguns elementos do grupo não reagiam muito bem às notas que lhe haviam sido atribuídos. Nestes casos, os restantes elementos tentavam elucidá-los relativamente aos motivos pelas quais mereceram aquela nota. O grupo acha que esta avaliação se adequa mais a este tipo de trabalhos em comparação com a avaliação usada no primeiro trabalho realizado pelo grupo. No primeiro projecto a grande diferença na avaliação estava relacionada com o facto de cada elemento fazer a avaliação dos outros elementos individualmente, o que não é muito justo, uma vez que nem todos os elementos têm conhecimento sobre o trabalho realizado.

3 Conclusão

Sobre este novo método de ensino, a opinião do grupo é muito favorável. Para além de ser muito mais cativante relativamente ao método de ensino tradicional, ajuda-nos a perceber melhor a matéria das várias unidades curriculares, uma vez que esta é aplicada (não ficamos só pela teoria). Relativamente à avaliação neste tipo de projectos, o grupo conseguiu evoluir neste aspecto (de um projecto para outro). O modelo de avaliação utilizado no segundo projecto é bastante vantajoso, pois a nota atribuída a determinado elemento é discutida entre todos os elementos do grupo (excepto o elemento que está a ser avaliado). Esta discussão faz com que a nota atribuída seja mais justa, uma vez que durante o debate podem surgir questões que nem todos os elementos se recordam. O trabalho em equipa, quer no caso do ensino, quer no caso profissional, possibilita o desenvolvimento de trabalhos com melhor qualidade na medida em que os diferentes elementos possuem diferentes capacidades e que no fim essas capacidades se complementam. Este aspecto faz com que todos os elementos adquiram outro tipo de capacidades, o que traz vantagens para todas as partes.

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Analysis of Participation in the Innovation and Entrepreneurship Integrated Project

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Abstract

This paper has the intent of describing how the project PIEI (Integrated Project on Entrepreneurship and Innovation) is organized, how students are assessed, describing how it came to integration between them, describing the experience and why this project is so successful. The main objective of the Integrated Project on Entrepreneurship and Innovation (PIEI) is through the certainty of a multidisciplinary team to promote the integration of different areas, allowing participating students to develop technical skills (for integration with other courses, and units directly involved with curriculum activities) and cross-linking of an integrated interdisciplinary content, acquiring skills of other professions, the professional relationship is an important aspect, particularly in conflict management, time management and task assignment. Through this project the students were also able to develop skills related to the curriculum units directly involved in the project.

In general we can make a positive assessment of participation in PIEI, where there was a good multidisciplinary integration, providing the interaction with students from other courses, acquiring knowledge of different engineering domains. It is believed that, such projects should be repeated with new students, new subjects and new businesses.

Keywords: project-led education; project approaches in engineering education; multidisciplinarity.

1 Introdução

Este artigo foca a organização e a participação no Projecto Integrado em Empreendedorismo e Inovação (PIEI). São descritos os objectivos do projecto, o seu funcionamento, a forma como o projecto se encontra organizado, a descrição do método de avaliação e dos diferentes pontos de avaliação dos alunos, o tipo de organização dos grupos e a sua constituição, a interdisciplinaridade inerente e alguns exemplos da integração dos elementos do grupo. Por último, será feita uma avaliação da participação neste tipo de projecto, salientado a importância que este trouxe na vida académica e pessoal dos alunos.

2 Novas Metodologias de Ensino/Aprendizagem

Neste ponto serão referidos alguns exemplos de ensino tendo por base um projecto que integre diferentes áreas. O PLE (“*Project Led Education*”) é um exemplo de integração das várias unidades curriculares, dadas num semestre, num projecto, onde os alunos tem como principal objecto unir o conhecimento apreendido nestas unidades e desta forma realizar um projecto em que apresentam propostas de melhorias para qualquer que seja o tema do projecto.

Outro exemplo deste tipo de ensino é o PBLE (Project Based Learning in Engineering). O PBLE é um método de ensino de Engenharia baseado em projecto, em vigor em três universidades do Reino Unido (University of Nottingham, Loughborough University e Nottingham Trent University). Os temas propostos no PBLE são vários e tocam as diversas áreas da engenharia. Podem, no entanto, ser mais específicos, envolvendo apenas uma área de saber como construção, ou produção industrial, onde apenas integram estes grupos alunos de licenciatura relacionados com essas áreas. Nos temas mais amplos, e consequentemente mais aliciantes e motivadores para os participantes, envolvem diversos cursos, Engenharia Mecânica, Engenharia de Produção, Engenharia Electrónica e

Engenharia Civil, ou áreas de saber muito distintas como um projecto multidisciplinar envolvendo os cursos de Línguas Modernas e Engenharia Civil [1].

A organização e funcionamento do PBLE é muito semelhante ao PIEI, cada grupo é constituído por cinco a dez elementos, número considerado ideal nesta abordagem de ensino. Existe um professor encarregado de orientar cada grupo - tutor académico – e quando o projecto se interliga com a indústria, atribuí-se também um tutor industrial. Para facilitar a organização do grupo a cada elemento incumbe-se uma tarefa diferente em cada semana. O método de avaliação assenta numa componente individual, onde se avalia o contributo efectivo de cada elemento, e numa componente global, onde se qualifica o trabalho desenvolvido pelo grupo, através de apresentações orais públicas, relatórios e tutoriais no decorrer do projecto [2].

Invariavelmente, as impressões deixadas pelos alunos participantes no PBLE são positivas, podendo-se destacar as seguintes: desenvolvimento de diversas competências transversais de Engenharia como a autonomia e capacidade de resolver problemas, e o desenvolvimento da capacidade de comunicação, espírito de equipa, gestão e organização de tarefas.

3 Projecto Integrado em Empreendedorismo e Inovação - PIEI

O Projecto Integrado em Empreendedorismo e Inovação (PIEI) resulta do incentivo à introdução de novas metodologias de Ensino/Aprendizagem, no espírito da Declaração de Bolonha e da Aprendizagem Activa ("*Active Learning*"). A filosofia do PIEI é influenciada em projectos tipo *Project Led Education* (PLE) onde alguns dos objectivos são fomentar o trabalho em equipa, desenvolver o espírito de iniciativa e criatividade, assim como as capacidades de comunicação e o espírito crítico sendo o principal objectivo do PIEI relacionar conteúdos interdisciplinares de forma integrada melhorando a qualidade e as competências profissionais dos seus Engenheiros. Neste projecto os alunos devem desenvolver as competências de aprendizagem das unidades curriculares directamente envolvidas no projecto, promovendo a aprendizagem centrada no aluno e não no professor [3].

3.1 Objectivos

O PIEI propõe-se desenvolver competências técnicas – inscritas nas áreas específicas dos Cursos de Engenharia – e transversais – requeridas pelos contextos de trabalho reais – suscitando nos futuros profissionais da Engenharia a adopção de uma atitude empreendedora, iniciativa, capacidade de decisão, capacidade de trabalhar em grupo e liderança. O empreendedorismo é entendido como uma proposta que adopta metodologias e estratégias de ensino-aprendizagem que favoreçam e incentivem atitudes como: autonomia, iniciativa, criatividade, liderança, diálogo, participação, desenvolvimento de projectos, resolução de problemas, inovação e boa utilização de informação e dos recursos.

3.2 Constituição dos grupos

Os grupos do PIEI do ano lectivo de 2008/2009 (2ª edição) são compostos pelos alunos a frequentar o 1º semestre do quarto ano, dos cursos Mestrado Integrado em Engenharia Mecânica (MIEM), Mestrado Integrado em Engenharia e Gestão Industrial (MIEGI), Mestrado Integrado em Engenharia de Polímeros (MIEP) e Mestrado Integrado em Engenharia Electrónica Industrial e Computadores (MIEEIC) e cada grupo é composto por dois elementos de cada curso. O grupo é composto por oito elementos e por um tutor. De referir que os elementos do grupo, vindo dos diferentes cursos, conheceram-se na reunião de apresentação da iniciativa.

A maioria dos grupos tiveram reuniões semanais onde eram abordados e discutidos os temas e tarefas a realizar, sendo, no fim, anotadas as decisões tomadas. Na Figura 1 pode visualizar-se um esquema representativo da integração do PIEI.

Cada grupo definiu a sua organização interna. Alguns optaram por uma organização hierárquica, com Líder, Presidente, outros com um líder rotativo, ou seja, liderança foi exercida por todos os elementos do grupo em períodos definidos. Os membros do grupo decidiram não implementar esta metodologia. Assim, todas as decisões eram discutidas abertamente e votadas, como numa democracia, todos os elementos do grupo contribuíram com igual peso nas decisões tomadas. A distribuição de tarefas era realizada voluntariamente, de acordo com as competências dos elementos do grupo. O grupo não encontrou, ao longo do projecto, dificuldades na utilização deste método. Foi também o único grupo, participante no PIEI, a atribuir notas iguais a todos os elementos do grupo, visto que ninguém se desviou dos objectivos definidos no início do projecto.

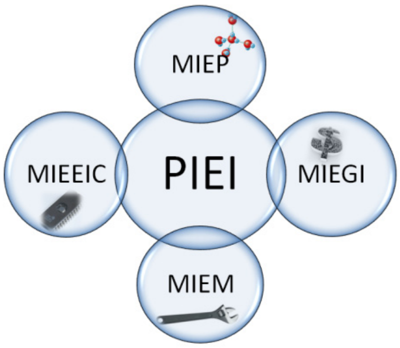

Figura 1: Esquema que representa a integração no projecto

3.3 Descrição do projecto

Nesta segunda edição do PIEI, o objectivo de estudo do projecto foi o protótipo de bomba de combustível P5000 desenvolvido pela Petrotec, empresa no ramo assistência ao ramo petrolífero. O Projecto proposto foi complexo, não tendo uma solução única e foi motivador, tanto para os alunos como para os docentes que coordenaram e deram apoio ao projecto.

Os objectivos específicos a este projecto foram a apresentação de propostas de melhoria para o produto e para o sistema de produção da empresa. Estas propostas de melhoria tiveram de ser convenientemente justificadas, de acordo com critérios de avaliação definidos no desenrolar do processo. Os quatro grupos de alunos tiveram como missão criar um produto novo, ou melhorar o existente, assim como apresentar melhorias para o sistema produtivo e verificar qual o impacto económico que estas propostas viriam a ter na empresa caso fossem implementadas. Os quatro grupos foram concorrentes no mesmo projecto havendo no final uma equipa vencedora. Apenas fazem parte deste projecto alunos interessados e seleccionados pelos directores de cada um dos Mestrados Integrados. Este factor foi preponderante no projecto, pois como o trabalho era de elevada exigência, era necessário que os alunos estivessem altamente motivados e que demonstrassem boa capacidade de trabalho. A equipa docente e o facto de se estar a trabalhar directamente com uma empresa contribuíram para a motivação e o empenho dos alunos.

3.4 Avaliação

O número de ECTS (*European Credit Transfer and Accumulation System*) envolvido no projecto difere de curso para curso. Em MIEGI o projecto valia 12,5 ECTS, englobando as unidades curriculares Projecto Integrado I, Sistemas de Informação para a Produção, Simulação e Gestão Integrada da Produção. Em MIEP este projecto corresponde à Unidade Curricular Integradora VII correspondendo 7 ECTS, em MIEEIC a participação no PIEI dava equivalência às unidades curriculares Projecto I e Projecto 2 correspondendo desta forma a 10 ECTS, finalmente ao curso de MIEM foram atribuídos 10 ECTS que equivalem às unidades curriculares de Teoria do Projecto Mecânico e Unidade Curricular Integradora VII.

A nota final do projecto dependeu de avaliações de vários itens em diferentes fases do projecto, denominados por pontos de controlo, a saber, as avaliações das três apresentações realizadas ao longo do projecto (20% da nota do projecto), avaliação do Relatório Preliminar (30% da nota do projecto), a avaliação do Relatório Final (30%) e a avaliação dos Protótipos realizados (30%). Esta nota do projecto multiplicado por um factor denominado por factor de correcção resultou a nota individual de cada elemento do grupo no projecto. O factor de correcção resulta da avaliação individual realizada por todos os elementos do grupo, que consistia na auto-avaliação e na avaliação dos restantes elementos do grupo. Os pontos de avaliação eram a presença nas reuniões, o nível de esforço no trabalho, a sugestão de soluções, contributos originais, o relacionamento interpessoal e o cumprimento de prazos.

4 Experiência de Interdisciplinaridade

A interdisciplinaridade é um factor de enriquecimento académico e pessoal para os alunos, dado que ao longo da sua vida académica não é espectável trabalharem em grupo com alunos de outros cursos. A iniciativa PIEI tem como um dos objectivos preencher esta lacuna. Ao promover essa integração e cooperação entre cursos, de onde surgem ideias inovadoras, e há uma partilha de conhecimento e experiências que em muito contribuem para a qualidade dos futuros Engenheiros.

Como exemplo de integração dos diferentes cursos no grupo, encontram-se nas várias propostas de melhoria da bomba P5000 apresentadas. Este envolvimento permitiu por exemplo, projectar uma linha de produção automática e apresentar um possível programa para a automatização e controlo da linha, esta proposta foi realizada pelo envolvimento dos cursos de MIEGI e MIEEIC. Outro exemplo da integração foi o desenvolvimento da tina de derrame de combustível para a Bomba P5000, o desenvolvimento desta peça envolveu elementos dos cursos de MIEM, MIEP e MIEEIC, tendo sido realizado o dimensionamento integrado nas peças envolventes, foi possível reduzir o custo à peça com a utilização de materiais poliméricos na sua construção e integrou-se ainda um sensor, de maneira a garantir a segurança dos utilizadores.

5 Conclusão

Fazendo um balanço da experiência PIEI, pode referir-se como um ponto positivo o conjunto de potencialidades e desafios que se colocam aos alunos, durante o desenvolvimento do projecto. A aplicação prática dos conteúdos e a proximidade com a realidade profissional contribuem para uma elevada motivação e empenho dos alunos durante o projecto. As principais dificuldades sentidas pelos alunos durante o processo relacionam-se, sobretudo, com a gestão do projecto, sendo os grandes desafios a este nível a coordenação dos horários, o cumprimento de prazos e na organização e planeamento das tarefas do projecto. Estas dificuldades que naturalmente acontecem durante a concretização do projecto exigem estratégias para as ultrapassar. Entender estas dificuldades como desafios e saber como superá-los constitui um momento importante de aprendizagem.

Um factor importante de referir, para além da interdisciplinaridade e da integração, é o facto de os elementos constituintes do grupo, na sua maioria, não se conhecerem, o que reflecte, e muito, o mundo do trabalho que o aluno finalista irá enfrentar. Pois no mundo de trabalho será necessário trabalhar com pessoas de diferentes áreas. A realização deste tipo de projectos permite a integração de uma equipa multidisciplinar e a consequente oportunidade de interagir com alunos de outros cursos, adquirindo conhecimentos de outras áreas profissionais que não a própria.

Este projecto possibilitou testar as capacidades dos alunos de percepção de diferentes áreas e descobrir a sua importância, dando uma noção do trabalho em equipa e com elementos de áreas distintas, com linguagens técnicas próprias.

Em termos gerais pode-se fazer um balanço positivo desta participação no PIEI, onde existiu uma boa integração multidisciplinar, proporcionando a interacção com alunos de outros cursos, adquirindo conhecimentos de outras áreas profissionais. Pensa-se que, se possível, deve ser uma experiência a repetir com novos alunos, novos temas e novas empresas.

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PLE Contribution for the Acquisition of New Concepts

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Abstract

Teaching methodologies have been changing since the beginning of the Bologna Process. The "Project Led Education" methodology aim to put students in the centre of the learning process. This methodology is based on a project implementation that integrates courses' contents and promotes autonomous exploration of concepts and their practical applications. Our project ended in a proposal for a production system improvement.

This paper talks about a company that has problems in producing in time and maintaining low stock levels. A promising alternative would be the utilization of a Kanban System to guarantee a Just-in-time production and ensure costumers satisfaction, solving some problems like Lead times and wastes. It was suggested a Generic Kanban System adapted to the company, since the huge diversity of products does not allow the utilization of regular specific Kanbans.

The presentation of this improvement proposal is accompanied by the description of the explored concepts and its discovery origin.

Keywords: project-led education; Kanban.

1 Introdução

A procura por parte das empresas, serem cada vez mais competitivas, faz com que cada vez mais surja a necessidade de se trabalhar de forma a reduzir todos os desperdícios, havendo uma grande preocupação com o nivelamento de stocks da empresa.

1.1 PLE – Project Led Education

A metodologia PLE consiste no ensino baseado em projectos e permite a interiorização de competências transversais a todos os alunos que passam por esta forma de ensino. O Curso de Mestrado Integrado em Engenharia e Gestão Industrial ministrado na Universidade do Minho, é um dos pioneiros no ensino baseado na metodologia PLE e conforme a estruturação curricular do curso é obrigatória a realização de um projecto, em ambiente empresarial, pelos alunos inscritos nas unidades curriculares do 1º semestre do 4º ano, e a nota final obtida no Projecto tem um peso relevante em todas as unidades curriculares deste semestre.

No ano lectivo de 2008/2009 o projecto PLE teve como principal objectivo a apresentação de propostas de melhoria para o sistema produtivo de uma empresa. Cada grupo ficou responsável por seleccionar uma empresa e efectuar o contacto com esta, informando-a dos objectivos pretendidos bem como a eventual disponibilidade para acolher este projecto em parceria com a Universidade do Minho.

1.2 Selecção da empresa

Na fase inicial do semestre, o objectivo consistia na selecção de uma empresa. Foi elaborada uma lista de empresas com as quais o grupo teria interesse em estabelecer um contacto para desenvolver o projecto. A remodelação do sistema produtivo e a indisponibilidade dos seus responsáveis foram os principais motivos que levaram as empresas a rejeitarem a solicitação do grupo, tornando esta fase um obstáculo ao desenvolvimento do PLE. A tentativa de gestão deste obstáculo, permitiu o desenvolvimento de uma capacidade interpessoal no que diz respeito a gestão de respostas negativas por parte das empresas. A participação do tutor nesta fase, revelou-se determinante para a selecção da empresa com a qual o grupo iria a desenvolver o projecto.

A empresa seleccionada enquadra-se no sector metalúrgico e metalomecânico. Fundada em 1940 e situada em Braga. A ETMA dedica-se ao fabrico de torneados estampados e parafusos. Estes produtos são destinados a vários sectores nomeadamente a indústria eléctrica e electrónica, a indústria automóvel, construção civil, mobiliária e indústria do gás, empresas localizadas por toda a Europa. Há no entanto, três clientes que correspondem a 70% da produção da ETMA. São eles a Vulcano, Shneider Electrics e GE Power Controls.

1.3 O objectivo do grupo

As primeiras visitas à empresa, foram essenciais para transmitir os principais objectivos do PLE, nomeadamente as competências que o grupo planeava adquirir com esta experiência, e o proveito que a empresa poderia obter. O principal objectivo do PLE era apresentar uma proposta de melhoria no sistema produtivo da ETMA que fosse real, e que a empresa pudesse usufruir e aplicar da melhor forma no seu ambiente industrial.

O contacto mantido com funcionários da ETMA, na fase inicial deste projecto, permitiu desde logo identificar alguns problemas. Para a sua solução, a empresa propôs o estudo de um sistema de Kanbans convencionais, seguindo o exemplo da Vulcano (o seu principal cliente), que fosse capaz de resolver grande parte dos problemas que a empresa atravessava.

Desde logo o grupo aceitou a proposta de estudo, mesmo com a intuição de que no sistema produtivo da ETMA, a implementação de Kanbans convencionais não seria viável uma vez que o ambiente industrial da empresa não cumpria os requisitos básicos da implementação desta ferramenta. No entanto, o grupo seguiu em frente com o desafio, mantendo a ambição de procurar uma solução baseada em Kanbans mas adaptada ao sistema produtivo da empresa, que fosse capaz de resolver grande parte dos seus problemas.

1.4 Organização do grupo

O projecto foi realizado por uma equipa de seis elementos com o apoio de um tutor que monitorizava e acompanhava o desenrolar do trabalho.

No início do semestre, estabeleceram-se diferentes cargos para garantir um eficiente funcionamento do grupo. Um dos cargos que se destacou foi o "Presidente", que actuava como líder do grupo tendo como principais funções a planificação das reuniões e a distribuição das tarefas. As tarefas eram traduzidas para post-it e afectas ao elemento que as devia realizar. O prazo de entrega de cada tarefa dependia da complexidade e da dificuldade afecta à mesma.

Os elementos do grupo usaram diferentes meios de comunicação e métodos de recolha de informação, quer dos conteúdos das disciplinas quer dos dados fornecidos pela empresa, para cumprir as diferentes tarefas estabelecidas.

Estabeleceu-se diferentes critérios para avaliar o trabalho e a motivação de cada elemento do grupo. Essas avaliações foram realizadas cinco vezes ao longo do semestre. Quando ocorriam problemas, devido a divergências de opiniões, o grupo reunia-se e resolvia em conjunto essas dificuldades.

A iniciativa, a criatividade e a comunicação oral e escrita de cada elemento do grupo foram essenciais para desenvolver o projecto PLE.

2 Proposta de Melhoria para o Sistema Produtivo da ETMA

Os Kanbans geralmente são usados em ambientes com pouca diversidade de produtos e com uma procura estável, porém esta empresa possui um rol muito alargado de produtos e a procura é muito diversificada, o que dificulta a implementação de um modelo de Kanbans tradicional. Neste sentido foi explorado o conceito de Kanbans leccionado ao longo do percurso académico de modo a encontrar uma possível solução que fosse de encontro ao pretendido pela empresa.

2.1 Percurso de desenvolvimento de conceitos

O actual sistema produtivo da empresa foi analisado in loco, juntamente com opiniões de funcionários intervenientes no processo produtivo. Desde logo, foram identificados diversos problemas que se pretendiam ver resolvidos com a introdução de Kanbans no sistema produtivo (Tabela 1).

Tabela 1: Problemas da empresa

Problema	Descrição
Desperdício de Óleos	No solo e na limalha
Elevados Prazos de Entrega	Habitualmente, 2 ou 3 dias
Máquinas Paradas	A afectação dos recursos depende da solicitação do produto no mercado
Serviço de Manutenção do ERP	Pouca disponibilidade para suprir necessidades de apoio
Elevados Setups	Elevados tempos de mudanças de ferramentas nas máquinas
Elevados Stock	Elevados níveis de stock de matérias-primas e produtos finais
Codificação de Artigos	Elevado número de códigos

O conceito de Kanbans foi referenciado pela primeira vez na unidade curricular EEPS (Elementos de Engenharia de Produção e Sistemas), leccionada no 2º semestre do 1º ano, sendo posteriormente mais desenvolvido nas unidades curriculares de OSP1 e OSP2 (Organização de Sistemas de Produção 1 e 2) que fazem parte do plano curricular do 1º e 2º semestre do 3º ano.

A informação adquirida sobre esta ferramenta de Lean Manufacturing (Carvalho, D., 2000; Courtois, A. Et al., 2007), nas unidades curriculares anteriormente referidas, desde logo permitiu identificar inúmeras incompatibilidades com o sistema produtivo da ETMA, entre as quais elevada diversidade de produtos.

Surgiu então a necessidade de saber mais sobre esta ferramenta. A consulta de literatura relacionada com este tema permitiu identificar um novo conceito de Kanbans designado de Kanbans Genéricos (Courtois A. Et al., 2007), que não limita a sua aplicação pela diversidade de produtos produzidos. O grupo decidiu explorar a introdução de Kanbans Genéricos, tendo em conta o sistema produtivo da empresa. A elevada quantidade de informação referente aos produtos levou o grupo a limitar o seu estudo através de uma análise ABC (Alves, A., 2008), que permitiu identificar o tipo de produto mais representativo da empresa. A análise ABC foi leccionada em IO2 (Investigação Operacional 2) e OSP2 respectivamente no 1º e 2º semestre do 3º ano.

Paralelamente ao desenvolvimento dos conceitos referenciados, foram desenvolvidos conceitos leccionados nas unidades curriculares do 1º semestre 4º ano com vista a satisfação integral dos objectivos do PLE e ao mesmo tempo ir de encontro aos objectivos da empresa.

2.1.1 Estudo de funcionamento dos Kanbans

O conceito de Kanbans tradicionais e o novo conceito que surge na literatura (Courtois, 2007; Pinto, 2006; Silva, 2007) diferem principalmente no fluxo de Kanbans. As imagens que se seguem (Figura 1 e Figura 2) pretendem traduzir essa diferença.

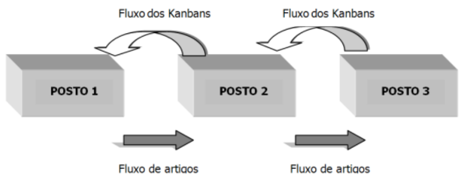

Figura 1: Sistema de Kanbans tradicionais (Courtois A. Et al., 2007)

Com um sistema de Kanbans tradicionais (Figura 1) implementado numa linha de produção, a ordem de produção de um posto é dada pela produção de um lote no posto seguinte. Neste sistema quando um posto de trabalho executa o processamento de um lote de produção com um Kanban associado, este posto envia o Kanban para o posto anterior dando-lhe uma ordem para produzir, puxando assim a produção do posto anterior. Deste modo os Kanbans tradicionais aplicam-se em sistemas de produção do tipo pull, devido a toda a produção ser puxada pela produção do posto seguinte (Silva, 2007).

Os Kanbans específicos revelam uma enorme utilidade no nivelamento de stocks intermédios, porém são mais referenciados para sistemas em que a procura seja relativamente estável e com pouca variabilidade de artigos, como esta empresa é detentora de um enorme rol de produtos e com procura algo instável a aplicação de Kanbans tornar-se-á mais difícil (Lima, 2008).

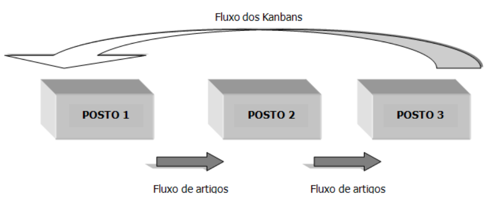

Figura 2: Sistema de Kanbans genéricos (Courtois A. Et al., 2007)

Os Kanbans genéricos (Figura 2) lidam mais facilmente com uma quantidade de artigos elevada e utiliza o método CONWIP que significa um WIP constante, ou seja, onde haja um nivelamento das entidades em processo de fabrico, este tipo de Kanbans tem como principal obstáculo o facto de exigir uma capacidade semelhante dos vários postos de trabalho. Num sistema de Kanbans genéricos sempre que dá entrada no sistema uma ordem de produção, esta é enviada para o primeiro posto de trabalho, onde este sempre que o número de Kanbans, do

sistema, não ultrapasse o número que se definiu é processado dentro entrada numa “fila de espera” do posto seguinte aguardando para ser processado quando todos os contentores de Kanbans que estavam antes na fila sejam processado, sendo assim este modelo de Kanbans segue a regra FIFO, onde o primeiro Kanban a chegar a fila de espera é o primeiro a ser processado, tendo de aguardar pelos outros que já lá estão. Pelo facto do número de Kanbans do sistema ser limitado, há um equilíbrio do WIP (Courtois, 2007).

O conceito de Kanbans na visão do grupo limitava-se aos Kanbans específicos juntamente com os requisitos que esta ferramenta arrasta e só poderia ser implementado em ambientes que cumprissem os requisitos mínimos desta ferramenta, mais concretamente, a reduzida variedade de artigos. O desenvolvimento deste projecto, permitiu não só encontrar um novo conceito de Kanbans nunca antes leccionado nas unidades curriculares do curso, mas também desenvolver uma forma de os adaptar e implementar num ambiente industrial com requisitos completamente distintos.

Os Kanbans genéricos foram muito úteis, uma vez que a atenção do grupo direccionou-se para a possível implementação desta ferramenta, juntamente com outros conceitos adquiridos nas unidades curriculares do 1º Semestre do 4º ano para as quais estava direccionado o projecto em geral.

2.1.2 Análise dos produtos a serem processados com Kanbans.

Depois de se decidir a possibilidade de adaptar os Kanbans genéricos para serem aplicados na empresa, o primeiro passo a ser realizado foi a análise dos roteiros de fabrico dos parafusos. Com esta análise, foi possível identificar os tipos de parafusos que apresentavam roteiros diferentes, e quais as operação que tinham em comum.

Esta análise permitiu identificar que muitos dos parafusos apenas diferem no acabamento, ou seja, parafusos aos quais são atribuídos códigos diferentes apresentam como variante apenas o tipo de acabamento. Esta variabilidade de produtos implica a exclusão da operação de acabamento no sistema de Kanbans.

O dimensionamento de um Supermercado, para os parafusos imediatamente antes da operação de acabamento permite reduzir consideravelmente o tamanho de stock.

A Figura 3 apresenta os diferentes roteiros de fabrico dos parafusos identificados pelo grupo.

No seguimento desta proposta foi necessário dimensionar o supermercado identificando, assim, os tipos de parafusos que devem permanecer no Supermercado e em que quantidade.

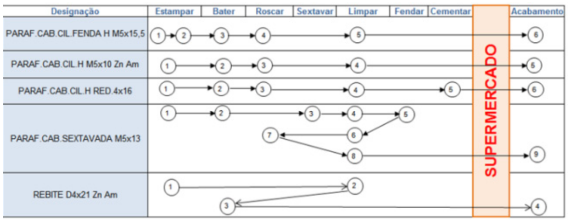

Figura 3: Roteiro de fabrico dos parafusos

Da análise ABC (Alves, 2008) identificou-se, que os parafusos da classe A devem ser mantidos permanentemente no Supermercado. Os parafusos identificados na classe B podem ou não existir em Supermercado. Os parafusos que formam a classe C apenas deverão ser produzidos quando a previsão da procura assim o indicar, ou seja, conforme um PDP. Estes parafusos apenas são lançados para a operação do acabamento quando surgir uma ordem de produção dos clientes, de modo a manter um stock relativamente baixo de semi-produtos e produtos acabados.

Nesta fase, foi adquirido o conceito de “Supermercado” nunca antes leccionado nas unidades curriculares. Este conceito foi adquirido na interacção com outro grupo PLE, ao qual estava atribuída uma empresa que pratica este conceito, permitindo ao grupo identificar que a implementação de um Supermercado em pareceria com os Kanbans genéricos poderia melhorar o desempenho da empresa no sentido da diminuição de stock.

2.2 Modelo de Kanbans para a empresa.

O sistema de Kanbans proposto para a empresa, como já foi referido, surge a partir do conceito dos Kanbans genéricos. Existe um número definido de Kanbans dentro do supermercado e sempre que surge uma encomenda o lote de parafusos associados aos Kanbans necessários para satisfazer as encomendas é enviado para o acabamento ficando o contentor vazio. Este contentor vazio segue para o inicio da linha de produção representando uma ordem de produção Deste modo, o sistema geral é considerado Pull, pois a produção é puxada

pelos contentores vazios enviados pelo supermercado. Dentro da linha produtiva o sistema é Push e segue a regra FIFO (Silva, 2008).

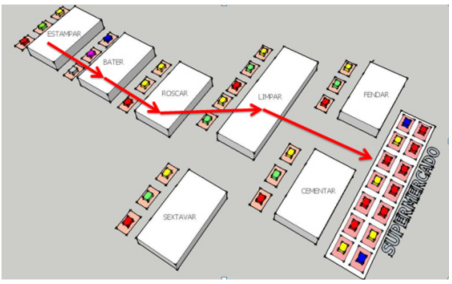

Figura 4: Modelo de Kanbans proposto para a empresa

A Figura 4 representa a proposta do dimensionamento do sistema de Kanbans para a empresa. São apresentadas todas as operações e o roteiro de fabrico mais comum para os parafusos. Porém, como se verifica na imagem e de acordo com o método CONWIP (Carvalho, 2002; Carvalho, 2006), o número de Kanbans entre os postos de trabalho é constante. No entanto, tendo em conta a tendência do operário para aliviar o seu posto de trabalho, foi decidido não limitar o número de Kanbans entre postos de trabalho. O número de entidades em processamento é assim limitado e controlado apenas pelo número de Kanbans total dentro do sistema.

3 Resultados

Uma vez projectado o sistema de Kanbans foi utilizado o software Rockwell ARENA v10.0, explorado na unidade curricular de Simulação, com o intuito de observar o funcionamento do sistema e, posteriormente dimensiona-lo no que concerne ao número de recursos a afectar à produção e o tamanho do lote (e, consequentemente, o tamanho do Kanban).

Das diversas simulações realizadas, três destas permitiam a satisfação da procura. Nomeadamente a duplicação dos recursos de bater e limpar com um lote de 3.000 unidades, um lote de 5.500 unidades e a duplicação do recurso de limpar com um lote de 4.750. Qualquer um dos 3 dimensionamentos apresentados permite uma considerável redução do tamanho dos lotes para um mínimo entre 3.000 e 5.500 unidades, sendo que, actualmente, a dimensão do lote pode variar entre 25.000 unidades e 1.000.000 de unidades.

A decisão de entre os três dimensionamentos possíveis foi realizada com recurso a modelos de decisão leccionados na unidade curricular com o mesmo nome, uma das intervenientes no projecto. Deste modo foi possível identificar a alternativa mais benéfica para a empresa quer a nível de custos, quer a nível de tempos de produção.

O tamanho dos lotes dimensionados com o sistema de Kanbans projectado permite uma "considerável" redução dos níveis de stock tanto de produtos finais como de matérias-primas, permitindo uma satisfação das encomendas Just-in-time. Os dimensionamentos apresentados contribuem, também, para o elevado nível de serviço aos clientes, permitindo assegurar prazos de entrega.

4 Conclusão

Este trabalho vem contribuir com o desenvolvimento economicamente viável de uma possível solução para um problema que bastantes empresas encontram, o cumprimento dos prazos de entrega com baixos stocks quando há uma grande variedade de artigos. Os resultados aqui apresentados não repercutirão a solução por completo deste problema, porém tem como intuito colaborar e demonstrar uma potencial e promissora aplicabilidade dos Kanbans genéricos.

Os Kanbans genéricos são um conceito novo para o grupo, conceito este que resulta da pesquisa literária e interacção a diferentes níveis, o que permitiu ao grupo adquirir novos conhecimentos e consolidar conhecimentos já adquiridos, nas disciplinas leccionadas, sobre Kanbans.

Estes resultados foram atingidos em consequência da organização PLE que pretende uma integração coerente entre conteúdos programáticos das unidades curriculares com o contributo da componente prática relacionada com o contributo da empresa, dos conhecimentos adquiridos das unidades curriculares anteriores e conceitos explorados de forma autónoma.

O Projecto PLE tem inerente a ele próprio, o desenvolvimento de algumas competências transversais desenvolvido no seio do próprio grupo (comunicação, gestão de tempos, objectivos, entre outros), da interacção do grupo com outros grupos (aquisição de conhecimentos, troca de informação e experiências, etc.) e da relação do grupo com os docentes (discussão de ideias, fundamentação de conceitos, etc.).

Do contacto mantido com a empresa, surge uma nova interacção, Empresa-Grupo, que se manifestou numa postura diferente, numa realidade não tanto académica, mas mais direccionada para o ambiente profissional. Esta experiência contribuiu para a assimilação integral dos conceitos estudados no percurso académico, bem como a aquisição de novos conceitos.

Em suma, o desenvolvimento deste projecto em pareceria directa com uma empresa, é uma mais-valia para o nosso percurso tanto académico como profissional.

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Radio-Frequency Integrated Circuit for a Remote-Controlled Car

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Abstract

The project aims the development of an integrated circuit designed for a wireless application. The project is supervised by two Professors and led by a PhD student. Although the team is large in number, the students are not experienced with this type of work. Any project for wireless systems requires the comprehension of multidisciplinary aspects and reasonable technical experience. However, the project has been partitioned in a way that the contribution of each student can be integrated within the system, to constitute very well-defined functions.

Keywords: multidisciplinary projects; system integration.

Nowadays wireless communications are almost ubiquitous in society. It can be found in every type of modern handheld devices. The interest for wireless devices has increased exponentially since last decade. Today's students are becoming much more aware of the huge capabilities that wireless communications can really offer. However, in terms of the development of a real wireless device, the technical issues involved are undeniably very complex. Therefore, it is quite hard to understand the main concepts and technical details behind typical wireless applications, such as mobile phones or even wireless network cards of common laptops.

The project presented here aims the development of an integrated circuit (a chip, as popularly known) particularly designed for a wireless application. The initiative mainly addresses the design of microelectronics communication circuits, which requires deep technical background. The project is supervised by two Professors of the faculty and led by a PhD student. The project is being funded by the LIDERA program of the University of Porto (LIDERA, University of Porto, 2009). The team is mainly constituted by undergraduate students of the Integrated Masters in Electrical and Computer Engineering, from the first till the fifth year of the degree. Although the team is large in number, the students are not experienced with this type of work. Any project for wireless systems requires the comprehension of multidisciplinary aspects and reasonable technical experience. However, the project has been partitioned in a way that the contribution of each student can be integrated within the system, to constitute very well-defined functions. Actually, the system topology proposed in this project is a modern receiver architecture mostly used in short-communication standards like Bluetooth, which allows the students to better understand current technologies.

The main goal here is the design of a receiver chip. The target application chosen by the students is the implementation of the chip in a remote car. The chip is to be fabricated in a European foundry. For the meantime, the students have already designed most of the circuits that constitute the system. They are now starting to draw the on-chip components for fabrication. This involves the drawing of very small structures, e.g. transistors with 350-nm minimum length and other devices up to just some hundreds of microns.

This work is part of an extracurricular activity. In the poster that we propose, we would like to include some of the most advanced results of the ongoing project, together with the work methodology adopted for such complex project.

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Interdisciplinary Project-based Learning: Organizational Dynamics of a Work Team

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Abstract

The introduction of new educational policies in the academic environment changed practical teaching and learning methodologies by the University of Minho. This paper describes the organization and management model for the working team, developed by a group of students of the Integrated Masters in Industrial Management Engineering in PLE -Project Led Education. This organization model is based on three main points: attribution of tasks (stabled or rotary) for each one of the elements of the work group; introduction to a liberal policy defining the schedule and work place for each person, as well as using an interpersonal evaluation methodology to be done to the elements during the project. The primitive objectives that were in the basis of the methodology are allowing the intervenients to obtain technical abilities connected to the curricular unites involved in the project and transversal abilities, such as: management capability, team work spirit and leadership capability. The organizational model revealed to be efficient in the team functioning as well as in acquiring knowledge. Nevertheless, the need to do some adjustments was found at the level of defining the tasks and its rotation, for a better team performance.

Keywords: learning based on interdisciplinary projects; project-led education (PLE); team work; transversal competencies.

1 Introdução

Uma das directrizes chave do acordo de Bolonha baseia-se na necessidade de alterar os processos de ensino/aprendizagem existentes para metodologias mais activas. Estas proporcionam um maior enfoque no aluno, dando a este um papel central, autónomo e activo nos processos de aprendizagem.

Seguindo esta ordem de ideias, Powell & Weenk (2003) definem a Aprendizagem Baseada em Projectos (PLE – "Project Led Education") como:

"…team-based student activity related to learning and to solving large-scale open-ended projects. Each project is usually supported by several theory based lecture courses linked by a theme that labels the curriculum unit. A team of students tackles the project, provides a solution, and delivers by an agreed delivery time (a deadline) a ´team product´, such as a prototype and a team report.(…) In this way, the students learn to master the competencies specified in the curriculum (knowledge, skills and attitudes) within the context of professional practice."

Esta metodologia foca-se no aluno e na sua aprendizagem, possibilitando que este adquira não só competências técnicas relativas às unidades curriculares envolvidas no projecto, como competências transversais ("*soft skills*") tais como: capacidades de comunicação, organização e relacionamento interpessoal, desenvolvimento de espírito crítico e de iniciativa, etc. (Fernandes *et al*, 2007).

As "*soft skills*" representam, nos dias de hoje, um peso cada vez mais relevante no *curriculum* de qualquer candidato a uma empresa. Seguindo essa ordem de ideias, o presente artigo pretende descrever um modelo de organização do trabalho em equipa inserida num projecto PLE e enunciar as suas vantagens na aquisição equitativa de competências técnicas por parte dos elementos.

2 Caracterização da Experiência

2.1 Meio envolvente

Atendendo à necessidade de potenciar a qualidade dos futuros profissionais que forma, o Departamento de Produção e Sistemas da Universidade do Minho tem vindo a implementar, ao longo dos últimos anos, metodologias de ensino mais activas. Exemplo disso é a aprendizagem baseada em projectos interdisciplinares (PLE – Project Led Education) desenvolvida ao longo do 1º semestre do 4º ano do Mestrado Integrado em Engenharia e Gestão Industrial leccionado no ano lectivo de 2008/2009.

Este projecto, além de ser interdisciplinar - as seis unidades curriculares (UC's) do semestre estiveram directamente envolvidas - compreendia uma parceria com algumas empresas industriais. Propiciou-se desta forma que os alunos experienciassem um contacto directo com a realidade que os espera como futuros profissionais, permitindo também potencializar o desenvolvimento de competências de aprendizagem das UC's integradas neste mesmo projecto. Estas unidades curriculares foram: Gestão Integrada da Produção, Complementos de Engenharia e Gestão da Qualidade, Modelos de Decisão, Sistemas de Informação para a produção, Simulação e Projecto Integrado I.

O projecto apresentava como objectivo central a análise do sistema de produção de uma empresa e uma consequente apresentação de propostas de melhoria. De forma a atingir este objectivo principal, existia um conjunto de outros pressupostos que deveriam ser conseguidos para que o sucesso do projecto fosse alcançado. Alguns desses pressupostos passavam pela caracterização e classificação da estrutura organizacional da empresa, identificação das principais funções de planeamento e controlo da produção ou caracterização dos pontos menos fortes existentes na organização. (Equipa coordenação MIEGI41_PLE, 2008).

2.2 Formação da equipa e selecção da empresa

A primeira fase para a realização de qualquer trabalho em equipa passa pela selecção dos elementos que a irão constituir.

Atendendo ao conhecimento interpessoal já existente e ao desejo de formar uma equipa eficiente e madura, foram seleccionados sete elementos (dois do sexo feminino e cinco do sexo masculino). É de salientar que a caracterização do grupo formado primou pela multiplicidade. Isto é, o intervalo de idades encontrava-se entre os 21 e os 33 anos, havendo cinco estudantes a tempo inteiro e dois trabalhadores-estudantes, sendo que quatro dos elementos envolvidos se encontravam a realizar, em simultâneo, unidades curriculares de outros anos lectivos. Além disso, o meio envolvente inerente a cada elemento também era dissemelhante fazendo com que cada um apresentasse personalidade e cultura pessoal diferentes.

Após o grupo de trabalho estar definido, os esforços concentraram-se na selecção da empresa que serviu de base ao projecto. Para esta selecção foram estabelecidos alguns requisitos. Procurou-se encontrar uma empresa onde fossem aplicadas muitas das técnicas abordadas nas unidades curriculares, quer do 4º ano quer de anos anteriores. Outro dos factores que condicionou esta selecção esteve relacionado com a facilidade de comunicação entre o grupo de trabalho e a empresa, onde se incluía a possibilidade de a visitar regularmente.

3 Modelo Organizacional da Equipa

Após a constituição da equipa de trabalho e selecção da empresa, tornou-se necessário estabelecer algumas regras que promovessem o bom funcionamento do trabalho e do grupo. Para isso, foi criado um modelo organizacional para o trabalho em equipa tendo como principais objectivos: a motivação dos elementos do grupo em torno do projecto, a distribuição equitativa de tarefas e conhecimentos, a organização da comunicação, a evolução sustentada do projecto atendendo ao seu objectivo a às expectativas da equipa e ainda potenciação do capital humano.

3.1 Definição de cargos

Neste modelo foram criados dois tipos de cargos: os fixos e os rotativos. Os cargos fixos eram destinados a um porta-voz interno (comunicação Grupo – Universidade), a um porta-voz externo (comunicação Grupo – Empresa) e ainda a cada um dos responsáveis pelas diferentes unidades curriculares (UC's). Os cargos rotativos eram destinados a um líder e a um colaborador para cada uma das UC's.

Os cargos fixos surgem com o intuito de garantir a estabilidade do projecto ao longo do tempo. A cada um dos elementos do grupo foi atribuída a responsabilidade de uma unidade curricular até à finalização do projecto, com

excepção da unidade curricular Projecto Integrado I que foi coordenada por dois elementos (um ligado à coordenação global do projecto e outro aliado ao cumprimento das normas académicas). Esta atribuição de responsabilidades visou garantir uma linha orientadora para cada uma das UC's ao longo do projecto, para além de minimizar o risco de perda de informação (normalmente associado à rotatividade dos elementos pelas várias UC's). As principais funções alocadas ao cargo de responsável da UC foram: a elaboração do plano de trabalho para a UC em questão, o seu acompanhamento e a sua coordenação ao longo do projecto.

A comunicação como ponto essencial para sucesso de um projecto, foram seleccionados, dentro da equipa de trabalho, dois interlocutores (Porta-vozes). O principal objectivo destes cargos foi a criação de canais únicos de comunicação, entre o grupo e os vários intervenientes externos. Dessa forma, procurou-se reduzir a duplicação de informação e o facto desta poder proporcionar diferentes interpretações por parte dos diversos elementos do grupo. O porta-voz interno esteve responsável pelo contacto com os docentes, enquanto o porta-voz externo providenciou a informação da empresa necessária ao projecto.

Relativamente aos cargos rotativos, estes foram criados com o intuito de fomentar a aquisição equitativa de conhecimentos, permitir uma distribuição justa de tarefas e ainda possibilitar o desenvolvimento de competências de liderança.

De forma a permitir aos elementos da equipa uma aquisição equitativa de conhecimentos definiu-se que cada elemento passaria duas vezes por cada unidade curricular – sob a forma de colaborador da UC. Atendendo ao número de passagens e à janela temporal do projecto (16 semanas), o período de permanência em cada UC fixou-se em duas semanas. Após este período, executava-se uma rotação que consistia na passagem de um cargo rotativo para outro cargo rotativo por parte de cada um dos elementos da equipa de trabalho.

A principal função associada ao cargo de colaborador da UC era a execução do trabalho planeado para o espaço temporal em causa, enquanto o líder organizava as reuniões, redigia a acta informal das mesmas e fazia a gestão de conflitos. Na Figura 1 podemos encontrar a organização, nos instantes T (semana 1 e 2) e T+1 (semana 3 e 4).

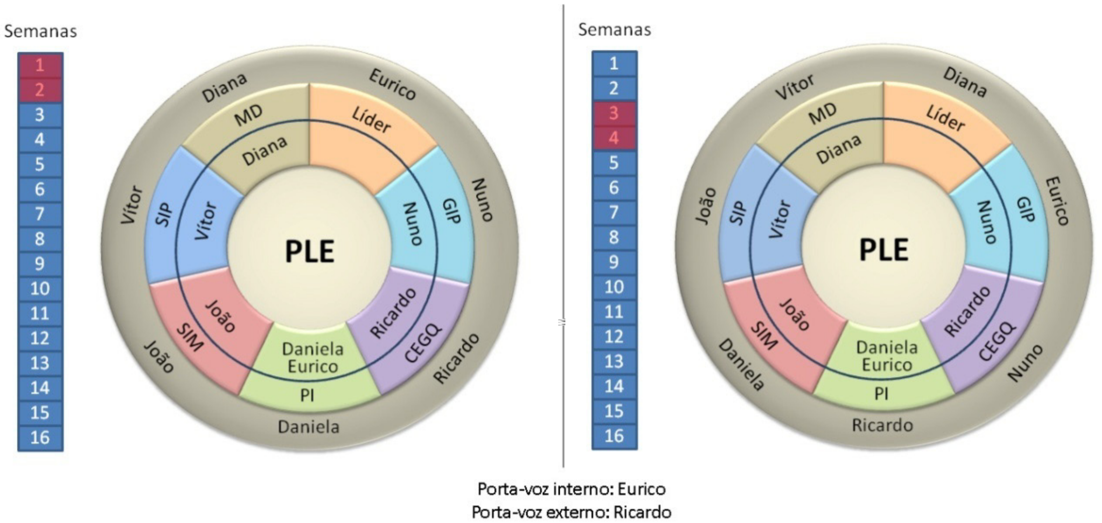

Figura 1: Esquema Organizacional adoptado

No círculo interno (multicolor), estão alocadas as várias pessoas aos cargos fixos que desempenham. Como é possível verificar, estes cargos não sofrem alterações ao longo do tempo. A mesma pessoa está sempre associada ao mesmo cargo. Já no círculo externo (unicolor), é possível verificar que ocorrem alterações ao longo do tempo. Este círculo, representativo dos cargos temporários, vai evoluindo no sentido dos ponteiros do relógio, permitindo que cada elemento passe pelos diferentes cargos rotativos – colaborador de determinada UC e líder - ao longo de todo o projecto.

3.2 Gestão de tempo

Outra das premissas definidas pelo grupo foi " Máxima liberdade, máxima responsabilidade". Isto é, cada elemento definia o seu local e horário de trabalho. Na sequência desta decisão tornou-se necessário definir reuniões semanais (tutoriais e de grupo) de maneira a analisar e avaliar o estado do projecto e ainda definir o trabalho futuro. Cada elemento, para além da carga horária relativa às unidades curriculares e ao

acompanhamento tutorial, necessitou de encontrar disponibilidade para efectuar visitas regulares à empresa, de forma a compreender, *in loco*, o seu modo de funcionamento.

Relativamente às visitas à empresa, numa primeira fase definiu-se que o grupo faria uma deslocação semanal a esta, com a presença de todos os elementos. Após as primeiras visitas, decidiu-se que a melhor solução seria dividir o grupo em dois subgrupos, sendo que cada um destes visitava a empresa semanalmente. Desta forma, a obtenção da informação tornava-se mais concisa e poderia ser feita com maior frequência.

3.3 Avaliação dos elementos da equipa

Para concluir a forma de organização do grupo, e de certa forma controlá-la, foi necessário definir alguns critérios de avaliação. O projecto em causa abrangeu duas vertentes distintas de avaliação. Uma delas esteve sob total responsabilidade da equipa de coordenação do projecto, estando a outra a cargo do grupo de trabalho.

A avaliação realizada pela equipa de coordenação teve como principal objectivo classificar o grupo em termos de trabalho desenvolvido no âmbito do projecto, para diferentes períodos de tempo. Estas avaliações compreendiam vários pontos de controlo, sendo que cada um deles apresentava um peso percentual específico para a nota final do projecto.

A avaliação adoptada pelo grupo teve como principal objectivo motivar todos os elementos em torno do projecto. Para tal, foram definidos quatro pontos de controlo interno. Os três primeiros constituíam avaliações meramente qualitativas, com o intuito de os elementos poderem reforçar a dedicação ao projecto. O último ponto de avaliação, para além de uma apreciação qualitativa, englobava também uma classificação numérica individual. Esta classificação seria igual para todos os elementos, exceptuando o caso em que o grupo decidisse valorizar ou penalizar um ou mais elementos.

4 Conclusão

Considera-se que o primeiro grande objectivo do grupo foi alcançado, permitindo que o grupo funcionasse como uma verdadeira equipa. Este funcionamento foi facilitado pela adopção do modelo de organização descrito anteriormente. Todavia, surgiram alguns entraves que dificultaram a adopção desta metodologia.

A conjugação de horários entre todos os elementos e o próprio acompanhamento do projecto não foram totalmente conciliáveis. O grupo de trabalho passava assim por algumas dificuldades quando pretendia receber *feedback* dos docentes, sendo que estes acabavam por não conseguir ter uma visão totalmente detalhada do trabalho que ia sendo desenvolvido.

Em termos da atribuição dos cargos definidos pelo grupo, estes revelaram-se de grande utilidade para o bom funcionamento da equipa de trabalho. Para os cargos de responsável por determinada UC, verificou-se que surgiu alguma variabilidade em termos de planeamento de trabalho. Esta variabilidade resultou pelo facto de, para algumas UC's, o conteúdo programático abordado inicialmente não apresentar aplicabilidade para o projecto. Esta situação reflectiu-se do mesmo modo no cargo de colaborador para a mesma UC.

No que diz respeito ao porta-voz interno, apesar de numa fase inicial se ter definido este elemento como único interlocutor entre o grupo e o corpo docente, com a evolução do projecto os responsáveis por cada UC foram tendo necessidade de contactar directamente com os docentes, passando a coadjuvar o porta-voz.

A liberdade de trabalho disponibilizada aos elementos funcionou bem ao longo do semestre, apesar de ter sido crítica em momentos onde vários pontos de controlo coincidiam, pois dificultou a coordenação e finalização de algumas tarefas.

A metodologia de avaliação adoptada possibilitou um bom ambiente entre os elementos da equipa de trabalho, evitando situações de conflito, de competição e promovendo o espírito de equipa. Os três primeiros pontos de avaliação fomentaram nos elementos a capacidade de opinar construtivamente sobre o trabalho desenvolvido pelos restantes colegas, como também a capacidade de aceitar a opinião dos mesmos. No final do trabalho, o grupo acabou por valorizar três elementos da equipa. O modelo organizacional revelou-se como um pilar importante para o bom resultado obtido pela equipa de trabalho.

Em suma, o modelo criado funcionou bem sendo os seus objectivos atingidos. Relativamente à aquisição equitativa de conhecimentos foi, em geral, atingida pelos vários elementos - apesar de alguns terem alcançado tal objectivo com maior distinção que outros.

Após a experiência vivida, o grupo sugere alguns reajustes ao modelo apresentado. Nos pontos de controlo específicos, definidos pela equipa docente, não deverá haver rotatividade de cargos, devendo o responsável por cada UC ser simultaneamente o colaborador da mesma nessas alturas. O cargo de porta-voz interno deve ser eliminado, ficando a comunicação interna a cargo do responsável pela coordenação global do projecto e pelo responsável de cada uma das UC's.

Desta forma, espera-se que este documento sirva de orientação para futuros grupos de trabalho envolvidos em projectos do mesmo cariz.

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The Role of Local BEST Group Porto in Extra-Curricular Activities Organisation

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Abstract

Students' lives are essentially focused in curricula studies provided and accredited by an education institution. However, nowadays recently graduated students need to be able to overcome challenges and acquire new skills and competencies, to work in a global based industrial and economical world. In all disciplines of engineering education, there is a need for a greater dimension, a dimension that can be complemented by learning by doing and here extra-curricular activities can play valuable role. BEST, Board of European Students of Technology, is a European students' organization striving to provide complementary education and career support to technology students throughout Europe. The organization is composed by 82 Local BEST Groups, one of them in Porto. This article, focusing on the activity of Local BEST Group Porto intends to present the extra-curricular activities provided by this group, and how these activities can help the involved students to develop new skills and competences that still aren't taught on technologic courses.

Keywords: students association; extra-curricular activities.

1 Introduction

Students' lives are essentially focused in curricula studies provided and accredited by an education institution. However, learning goes beyond what is taught in a classroom. Graduated students need to be able to overcome challenges, acquire new skills and competencies to work in a global based industrial and economical world. In all disciplines of engineering education, there is a need for a greater dimension, a dimension that can be complemented by *learning by doing* and here the extra-curricula activities can play valuable role (Hantal, O. (2007)).

Extra-curricula activities appeared to complement curricula instruction. Students have the need to create and involve themselves into students' organisations and learn by contributing voluntarily to a better society and develop themselves. These non-credited educational activities, which can be related or not to the field of studies are conducted during the students' free time and can stimulate the development of soft skills and competencies useful for the students' personal development (Hantal, O. (2007)).

2 BEST

BEST, Board of European Students of Technology is a constantly growing non-profit and non-political organisation. Since 1989 we provide communication, co-operation and exchange possibilities for students all over Europe. Local BEST Group Porto is one of the 81 Local BEST Groups in almost 30 European countries. We work to help European students of technology to become more internationally minded, by reaching a better understanding of European cultures and developing capacities to work on an international basis. Therefore we create opportunities for the students to meet and learn through our academic courses organised in close cooperation with educational institutions, engineering competitions and days on technology (BEST website (2009)).

3 Extra-curricular Activities

Through this article we intend to present our work, why our contribution towards extra-curricula activities is valuable and why we think it's relevant for students' development. We intend to present three projects organised by BEST Porto local Group:

3.1 Engineering competitions

The Engineering Competition is an event organised by BEST Porto for the students of the engineering and Science schools. This event creates a challenge for the participants, who have to build a prototype, using only basic and simple materials. The prototype has to fulfil specific parameters and is submitted to an evaluation by the judges. Some examples of prototypes built in these competitions are pasta bridges; lighthouses and hybrid vehicles. The teams during these competitions can only succeed through good teamwork, team and resource management (such as time or material).

There are several types of Engineering Competitions that BEST organizes. In the last one organized by BEST Porto, the participants had twenty-four hours to create the prototype. During these twenty-fours it was up to the team to decide how they will use the time and how will they work. This competition was very demanding physically and psychologically and the teams really had to work very well among them, and manage the effort, in order to avoid too much tiredness. This competition gave the possibility for the two winning teams to participate in the national competition and dispute the place for the European finals in Ghent.

Through these competitions we intend to allow the students to solve practical problems in a quick, spontaneous and effective way, to help them practice what they learn in theory and to help them improve their soft skills and team work.

3.2 BEST days on technology

BEST days on technology was conceived so that the students of the engineering faculty of the university of Porto could interact with themes and realities that aren't a part of the regular majors in engineering and that are important for a quality education perfectly adapted to the reality of the business world. The event tries to create a discussion area about problems, projects, new ideas and themes in the engineering and technology field.

3.3 BEST academic courses

Throughout the year BEST organises different academic courses where students from member universities get the opportunity to increase their international experience, establish contacts, improve their English and learn about an engineering theme. Each BEST Course is attended by 20 European engineering students. BEST courses enable students to learn in a multicultural environment in a different university permitting them to develop a broader vision on different engineering topics

4 Teamwork in BEST

As in any student association, members of BEST Porto have to learn and develop how to work in teams.

The projects and events organized by BEST Porto require a big range of knowledge and skills that no student can provide by himself. These projects require a multiplicity of people with different backgrounds and knowledge in order for it to develop at its full potential. Although all the members have a common background: technology, each person is different and each person has its own way of working. Working in BEST allows people to discover those differences and allows them to explore those differences in order to make them an advantage in the project. Members learn how to lead a team; how to communicate their ideas and how to understand other people's views, in order to reach a common goal: the success of the project and personal development.

This process allows BEST Porto events and projects to grow richer: they convey the best ideas and abilities of the members.

5 Conclusion

To conclude, we intend to describe our vision why and how students should be encouraged to involve in extra-curricula activities, the self-assessment of extra-curricula activities implying that the student understands the importance and the relevance of these activities to his/her personal development and knows how to value the acquired skills and competencies and discuss the importance of ECTS assignment to extra-curricula activities.

In the same time, the students' behaviour and pro-activeness has to be taken into consideration: there are some that only attend lectures and other that are active members in various extra-curricula activities. These students recognise the potential of such activities, where they learn how to solve challenging and real problems, using skills and knowledge acquired. Some of these activities are thought to be very useful in promoting international

cooperation, in spreading a new mentality that companies are looking for, so that students can actually get better internships or first jobs (Hantal, O. (2007)).

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Social Programme

City Tour: Historic Centre of Guimarães

The symposium's social programme includes a city tour to the historic centre of Guimarães, on Tuesday July 21st 2009, from 19h00 to 20h00. A guided visit will be provided to the most notable sites, such as the Guimarães Castle, Dukes of Bragança Palace, "Bosque da Colina Sagrada" (Sacred Hill Forest), Church of Santos Passos, Alberto Sampaio Museum, Santiago Square, etc.

Photo: Guimarães Castle.
http://en.guimaraesturismo.com/files/3/multimedias/20090415153231636987.JPG

Symposium Dinner: Pousada de Santa Marinha, Guimarães.

The Symposium Dinner will be held at the Pousada de Santa Marinha, Guimarães, on Tuesday evening (20h30). The majestic Pousada de Santa Marinha is located near the historical centre of Guimarães. It is a former XII Century Augustin Monastery, which after being rebuilt and restored, received the National Architectural Prize in 1985.

This historic luxury hotel has unique charming points, like the superb gardens, to be counted among the best Portuguese's gardens, a magnificent stone staircase and an artificial lake can be found among the trees. The rich Portuguese glazed tiles, the cloisters, the terraces over the city will, together with the magnificent cuisine and wines, make you wish to stay for a very long time.

Photo: Pousada de Santa Marinha, Guimarães.
http://www.pousadas.pt/historicalhotels/EN/pousadas/Portugal/Norte/SantaMarinha/home/

General Information and Services

Conference Venue

All conference sessions will be held at the University of Minho. The Opening Reception will be held at the University of Minho, School of Engineering Building. The Symposium Dinner will be held at the Pousada de Santa Marinha, on Tuesday, 21 July. Transportation from the city centre will be provided to the Pousada and back to the University.

Registration

Registration will be open 21st July at 08:30, room EE0.19 (new Building of the School of Engineering of University of Minho).

Guest Program

Guests may also attend the Symposium Dinner. Tickets are available at the registration desk. Contact the PAEE secretariat or members of the organizing committee for more detailed information.

Meals

Coffee breaks will be provided during the Symposium as listed in the program. Lunch is also included in the registration fee and will take place at the University canteen, from 12:30 to 14:00.

Internet and computers

Computers will be available for internet access, as well as Wireless (EDUROAM) internet connectivity.

Computers and multimedia projectors will be available during presentation sessions.

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