INTERNATIONAL SYMPOSIUM ON PROJECT APPROACHES IN ENGINEERING EDUCATION

Aligning Engineering Education with Engineering Challenges

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Aligning Engineering Education with Engineering Challenges

Natascha van Hattum-Janssen
Rui M. Lima
Dinis Carvalho

Pavilhão Atlantico, Lisbon
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TITLE

Third International Symposium on Project Approaches in Engineering Education (PAEE'2011):
Aligning Engineering Education with Engineering Challenges

Editors
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Rui M. Lima
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University of Minho
and
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Welcome to PAEE'2011

It is an honour and a pleasure to welcome you to the Third International Symposium on Project Approaches in Engineering Education, part of the First World Engineering Education Flash Week in Lisbon. Our central theme for this edition is "Aligning Engineering Education with Engineering Challenges" and we aim to provide a forum for research and practical experiences on project approaches and the many aspects related to the preparation, implementation and reflection on learning through projects, as we are convinced that an interdisciplinary approach to learning for engineering students contributes to meeting current challenges for engineering education.

There will be many opportunities for interaction and discussion in the extensive programme. As in previous editions, a strong emphasis is on workshops in which you are challenged to discuss the theoretical foundations of Project Approaches in Engineering Education, different models of learning through projects and reflect on your own practice.

We are pleased to continue our cooperation with the SEFI Curriculum Development Working Group and we are happy to announce that we started to cooperate with ASIBEI, the Iberoamerican Association of Engineering Education Institutions. As the interest of Latin-American teachers in engineering education is increasing, we hope to contribute to innovation in engineering education in these countries as well and we warmly welcome the ASIBEI participants to PAEE2011, as well as the SEFI participants.

We look forward to an exciting weekend of sharing ideas and experiences with professionals in engineering education from around the world.

Natascha van Hattum-Janssen

Rui M. Lima

Dinis Carvalho

Chairs of PAEE'2011

SEFI Welcome Note

It is with great pleasure that the invitation received by the Curriculum Development Working Group (CDWG) of the European Society for Engineering Education (SEFI) to collaborate in the 3rd International Symposium on Project Approaches in Engineering Education has been accepted. I personally consider it an honour to send these lines to the participants in the Meeting.

The Curriculum Development Working Group (CDWG) is a forum for discussing on the development of Engineering Education in Europe, and it is formed by people highly involved in the innovation of engineering education. The Group is opened to teachers and managers of education, students, and employers of engineers. The CDWG focuses its activities on curriculum innovation, the advance of teaching and learning methods, quality and accreditation, and Faculty and teachers development.

We certainly support the organization of activities for the improvement of teachers and the increase of quality of engineering education. For that reason, a call for being actively involved in education and teaching as PAEE 2011 is certainly appreciated. Project Based Learning (PBL) is considered today as one of the most effective methods in Engineering Education in order to develop students´ competences and abilities which are everyday more and more demanded by employers operating in a global labour market. And last but not least, it is necessary to remark the relevance of team working as a necessary part in the training of students who are going to work as part of teams in companies anywhere in the world.

On the other hand, PAEE'2011 includes among the topics to be discussed some directly related to teachers´ activities such as the role of tutors, assessment of projects, and the preparation of teachers. In that line, workshop A1 is devoted to the theme of Teacher Professionalisation, while workshop C will deal with staff and students view of Project Management.

Finally, I would like to congratulate on behalf of SEFI CDWG the bright organization of PAEE'2011, and the contribution of both University of Minho and Lisbon Superior Engineering Institute, and I would also like to welcome the participants and wish the best success for all of them.

Urbano Domínguez

University of Valladolid, Spain

Chairperson of SEFI CDWG

ASIBEI Welcome Note

The agreement established between ASIBEI (Ibero-American Association of Engineering Education Institutions) and PAEE (Project Approaches in Engineering Education) for the development of their activities during WEE 2011 event (First World Engineering Education Flash Week), will be a stimulus for the participation on both forums (ASIBEI Conference and PAEE Symposium). Effectively, there is a common identity and a complementary action in those meetings. ASIBEI, whose members are representatives of engineering higher education institutions from almost all the Ibero-American countries, focuses its activities on the general development of engineering education in those countries, and the PAEE Symposium focuses its activity in the improvement of engineering education using active learning, particularly the Project Based Learning, which is considered today one of the most effective methods in engineering education. In common they have the purpose to contribute for a better engineering education.

So I would like to welcome all the participants of the PAEE Symposium, that, I wish and believe, will be a great success and I invite you all to attend the ASIBEI Conference and contribute with your inputs to the discussion of important themes like international mobility, social responsibility or sustainability. I am sure that the conference will be very interesting for those people who are fully involved in engineering education issues.

Finally, it is our purpose that the agreement between ASIBEI and PAEE will stay effective after the WEE 2011, in order to contribute for the growing and development of both organizations.

Armando Pires

President of ASIBEI

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Programme

	October 1	Location
09:00	Registration Opening and Welcome	*Lobby* *Business Centre Auditorium*
10:00	Keynote Speaker **Wim Weenk**	*Business Centre Auditorium*
10:45	*Coffee break*	
11:00	Paper Session A1 Paper session A2 Paper Session A3	*Business Centre Room 1* *Business Centre Room 2* *Business Centre Room 3*
12:30	*Lunch*	
14:00	Workshop A1 Workshop A2	*Business Centre Room 1* *Business Centre Room 2*
15:15	Paper Session B1 Paper session B2 Paper Session B3	*Business Centre Room 1* *Business Centre Room 2* *Business Centre Room 3*
16:30	*Coffee break*	
16:45	Workshop B	*Start in Business Centre Auditorium*
18:00	Plenary Session	*Business Centre Auditorium*
	Social Programme Dinner	*Treaty of Lisbon Hall*

	October 2	Location
09:30	Keynote Speaker **Alex Stojcevski**	*Business Centre Auditorium*
10:15	PAEE'2011 Student Best Project Award	*Business Centre Auditorium*
10:45	*Coffee break*	
11:00	Paper Session C1 Paper session C2 Paper Session C3	*Business Centre Room 1* *Business Centre Room 2* *Business Centre Room 3*
12:30	*Lunch*	
14:00	Workshop C	*Start in Business Centre Auditorium*
15:30	*Coffee break*	
15:45	Plenary Session	*Business Centre Auditorium*
16:15	Closing Session	*Business Centre Auditorium*

Paper Sessions

Session Facilitators	Paper Number	Authors - Title	Language	Session
Natascha van Hattum-Janssen	1	Leila Vilela, Reinaldo Campos, Mauro Speranza and Nival Almeida. From methodology hands-on to problem-based learning: experiences and prospects of an unconventional introduction to engineering	English	A1
	5	José M Esbrí, Pablo Higueras, Willians Llanos and Alba Martíenz-Coronado. Project-based practicum experience in the Almadén School of Mines (UCLM, Spain): the case of Mining and the Environment.	English	A1
	11	Lise Jensen and Christin Lindholm. The Blurred Line Between Failure and Success in Student–Industry Projects	English	A1
	25	Natascha Van Hattum-Janssen and João Miguel Fernandes. Peer-assessment in projects: an analysis of qualitative feedback	English	A1
	30	Raul Ricardo Diaz Contreras. Engineering in México, present and future	English	A1
	65	Francisco Moreira, Diana Mesquita and Natascha Van Hattum-Janssen. The importance of the project theme in project-based learning: a study of student and teacher perceptions	English	A1
Rui Sousa	4	Dianne Magalhaes Viana, Daniela Favaro Garrossini, Ana Carolina Kalume Maranhão, Maria De Fátima Souza E Silva and Humberto Abdalla Junior. Uma Experiência de Aprendizagem Colaborativa Interdisciplinar no Desenvolvimento de um Veículo Elétrico na Universidade de Brasília	Portuguese	A2
	26	Maria de Fátima Souza e Silva and Rudi Henri Van Els. Disciplinas de projeto e a integração do ensino, pesquisa e extensão: um estudo de caso a partir do desenvolvimento de uma plataforma experimental de veícuo elétrico.	Portuguese	A2
	41	Ricardo Fragelli and Fábio Mendes. Batalha Naval dos Extremos Locais: Jogos de Aprendizagem para o Ensino dos Cálculos	Portuguese	A2
	42	Ricardo Fragelli and Mendeli Vainstein. O Labirinto do Rato Cego: Aprendizagem Baseada em Projeto em Algoritmos e Programação de Computadores	Portuguese	A2
	43	Ricardo Fragelli. Uso de Objetos de Aprendizagem Interativos, Adaptativos e Multiformes como Apoio ao Ensino Presencial	Portuguese	A2
	23	Ana Lucia Manrique, Ely Antonio Tadeu Dirani and Luiz Campos. Aprendizagem Baseada em Problemas e o uso de mapas conceituais	Portuguese	A2
Sonia Gomez Puente	8	María Felipa Cañas Cano. El Trabajo en equipo y su relación con la motivación del estudiante de Ingeniería Industrial y de Sistemas	Spanish	A3
	13	Elfriede Victoria Inga Huamán. Proyecto Ecológico y Entornos Virtuales Web 2.0	Spanish	A3
	24	Javier Páez, Carmen García, Miguel Angel Álvarez, Juan Jose Herrero and Francisco Aparicio. La experiencia de la participación en el equipo UPM racing para el desarrollo de la competencia de resolución de problemas en equipos multidisciplinares	Spanish	A3
	55	Diego Vergara Rodríguez, Manuel Pablo Rubio, Miguel Lorenzo Fernández and Ana Ramos Gavilán. Nuevas herramientas docentes interdisciplinares: mecánica de medios continuos y expresión grafica	Spanish	A3
	71	Rosa María González-Tirados and Cristina Núñez Del Rio. Ser profesor-tutor en el marco de los estudios universitarios de Ingeniería: análisis descriptivo de las necesidades formativas.	Spanish	A3
	22	Javier Fernandez, Marisol Valencia and Diego Zapata. Una propuesta de desarrollo del area de formacion en optimización en Ingeniería Industrial: hacia la vinculación del curriculo con la investigación	Spanish	A3

Session Facilitators	Paper Number	Authors - Title	Language	Session
Rui M. Lima	2	María Fenollera, Pilar Pazos and Itziar Goicoechea. Learning assessment based on active training methods for competence in education using engineering projects	English	B1
	12	Pilar Pazos, Maria Fenollera and Miren Itziar Goicoechea Castaño. Planning, Communication and Management tools for project-based learning using virtual teams	English	B1
	3	Igor Safyannikov, Alyona Zakharova and Evgeniya Vehter. Model of project and design competences development in conditions of multilevel system of technical education	English	B1
	57	Gilbert Ravalli and Alex Stojcevski. Students' Judgment in Initial Phases of Industry Projects	English	B1
	58	Natália Almeida, Camila Carrer, José Dinis Carvalho and Rui M. Lima. A Project Management Guide Proposal for Engineering Students' Teams	English	B1
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	67	Mauricio Duque and Diana Guayacundo. Estrategias de aprendizaje activo y cambio conceptual en circuitos eléctricos a nivel de pregrado	Spanish	B2
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	28	Claudio Cameselle and Susana Gouveia. Collaborative work in projects for laboratory teaching in chemical and environmental engineering	English	B3
	40	Eric Costa, Sara Bragança, Celina P. Leão and Dinis Carvalho. Project-based Learning in Industrial Environment from the perspective of students, teachers and company	English	B3

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	47	Peter Anzenberger. Competence oriented technical education in Austrian upper secondary technical and vocational colleges (HTL)	English	C1
	54	Miguel Angel Lorenzo Fernandez, Juan Carlos Perez Cerdán, Jose Antonio Cabezas Flores, Carmen Blanco Herrera, Diego Vergara and Leticia Aguado Ferreira. New teaching activities for learning Robot Mechanics	English	C1
	61	Joakim Wren and Johan Renner. Enhancing Student Engagement – A CDIO Approach in an Engineering Physics Master Program	English	C1
	59	Celina Leao, Ronei Moraes and Liliane Machado. Applicability of Serious Games in Statistics education	English	C1
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	32	Edgard Costa Oliveira, Jessica Barros Cavalcante, Pablo Lustosa De Oliveira and Simone B.S. Monteiro. Aprendizado baseado em Projetos na disciplina de Humanidades e Cidadania para engenheiros da UnB, Brasília	Portuguese	C2
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Invited Speakers

PAEE'2011 attracted 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: **Wim Weenk** from University of Twente and **Alex Stojcevski** from Swinburne University of Technology. We are convinced that you will be inspired by their experiences around the world with project approaches to engineering education.

Alex Stojcevski - Swinburne University of Technology, Australia

Shortbio

Alex joined Swinburne University of Technology in October 2009 as an Associate Dean of Learning and Teaching Scholarship. His research interests include pedagogical and organisational change management, educational leadership, organisational development, and problem/project based learning. He has published over 100 book chapters, journals, and conference publications, has supervised PhD students to completion, and is currently the supervisor of four PhD research students. Alex is also an external Associate Professor of Aalborg University Denmark and a council member of the European Society for Engineering Education. Prior to joining SPL, Alex was the Director of the Office for Problem Based Learning at Victoria University, Melbourne Australia.

Keynote Address Abstract

The 20th century belonged to the great innovators of science. Most of the benefits were universal, affecting humans around the world and at all economic levels. The technologies developed and used were diverse and depended on the timely accomplishments of science, quantum theory, nuclear physics, mathematics and medicine. Technological innovations and developments mostly depended on the economic wealth generated by the capital assets dedicated to manufacturing and distribution, oil mines, factories, ships and rails. With innovations in energy conservation, resource protection, food and clean water production, new technology, global communication, traffic and logistics, and knowledge sharing, the 21st century certainly so far belongs to the engineers.

As engineers we continuously discuss and constantly look for way to be innovative, however innovation in engineering education still remains a challenge. The emergence of knowledge society brings in new characteristics of knowledge construction and learning process such as technology bounded, multidimensional, unstable, innovative, collaborative and complex. Professional competences and expertise become progressively more difficult to identify when problems are becoming increasingly ill-defined and interdisciplinary involving a growth of various integrated issues like technology, environment, economy, culture, sustainability and society. This provides challenges to universities, in particular, engineering universities, which traditionally have been playing a role of dissimilating technical discipline which is usually focused and based on individual learning.

Questions have been posed to universities in the globalised society: How do we help engineering students gain contextualised knowledge and competencies which are connected with relevant cultural and collaborative environments? How do we do to prepare engineering students for their professional life with sufficient readiness to collaboratively and innovatively solve the complex and constantly changing problems? How do we align engineering education with the engineering challenges?

In many cases, research suggests that traditional lecture based education has not always successfully addressed these issues. Therefore, it is critical for engineering educators to innovate and sustain pedagogical methods to assist in the development of the 21st century engineering students.

Project Based Learning (PBL) has been well identified as an innovative pedagogy in engineering education. It has been employed as educational philosophy to provide the possibility for students to achieve interdisciplinary, sustainable, transferable skills, while at the same time exposing them to the complexities of global and cultural issues. This keynote address will discuss a theoretical and practical understanding of innovation in engineering education and present project based learning as a strategy in addressing the engineering challenges of the 21st century.

Wim Weenk - University of Twente, the Netherlands

Shortbio

Wim Weenk graduated in Pedagogical Science and Instructional Design from the Universities of Nijmegen and Leiden. He started his career in higher education as a lecturer in Teaching Methodology at the Teacher Training College in Oegstgeest/Den Haag. Since 1988 he has been Senior Officer in Staff Development and Educational Consultant at the University of Twente. He is coordinator and trainer in courses for inexperienced teachers who wish to achieve the Dutch 'University Teaching Qualification'. He dedicates himself to curriculum development and internationalisation, and to the curriculum transformation from a classical approach to the project-led approach. He shares his expertise on how to implement new styles of teaching and learning in higher education institutions by running workshops, seminars and training courses in Belgium, Mexico, Mozambique, the Netherlands, Oman, Portugal, South Africa, Tajikistan and the United Kingdom.

Keynote Paper: Tutors and Teachers in Project-Led Engineering Education-a Plea for PLEE Tutor Training

Tutors and Teachers in Project-Led Engineering Education - a Plea for PLEE Tutor Training

Wim Weenk[*] & Maria van der Blij[*]

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Abstract

Project-Led Engineering Education (PLEE) is a learning environment where students can learn in teams to work on real problems and projects, in which the technical content, skills and attitudes can be applied coherently. This article deals with questions like 'What is a project?' and 'What is (our) view on the role of PLEE Teachers and Tutors?' Finally we hold a Plea for PLEE training tutors.

Keywords: Project-Led Engineering Education - PLEE; Tutor Training.

1 Everyone is doing Projects

"Of course we do project education. Everyone is doing projects these days. Projects are rather like religion, politics and garlic. Everyone has own opinions on these subjects, but few share the same opinions with others" (Powell & Weenk, 2003, p. 27).

The first question that arises when talking about teaching and tutoring in Project-led Engineering Education is: What is a project? Numerous examples of projects are to be found at f.e.

- government level: current issues dealing with problems in water supply, the control of food and safety, avoiding traffic congestion, etc.
- company level: many projects are focused on quality, improving products or services.
- department level in a company: a product or service used by other business units or the relationship with external customers.
- individual level: a recommendation, a decision on the acquisition or an adoption of a device or organizing a party, a vacation, etc.

There is much confusion what exactly is meant by a project. The Chartered Management Institute defines a project as: "an activity that has a beginning and an end which is carried out to achieve a particular purpose to a set quality within a given time constraint and cost limits" (YESIP, Para 1).

In education projects can take all kind of forms. Iindividual projects just before graduation, a small research and essay assignment or a substantial assignment involving a team of students in solving a complex open-ended problem are all examples of a project in education.

1.1 Inductive Teaching methods

Prince & Felder (2006) state that traditional engineering instruction is deductive, beginning with theories and progressing to applications of those theories. According to them inductive teaching and learning is a preferable alternative. "Instead of beginning with general principles and eventually getting to applications, the instruction begins with specifics—a set of observations or experimental data to interpret, a case study to analyze, or a complex real-world problem to solve. As the students attempt to analyze the data or scenario or solve the problem, they generate a need for facts, rules, procedures, and guiding principles, at which point they are either presented with the needed information or helped to discover it for themselves.

Inductive teaching and learning is an umbrella term that encompasses a range of instructional methods, including inquiry learning, problem-based learning, project-based learning, case-based teaching, discovery learning, and just-in-time teaching. These methods have many features in common, besides the fact that they all qualify as inductive" (Prince & Felder, 2006, p. 1-2).

Prince and Felder (2006) review several of the most commonly used inductive teaching methods. They define each method, highlight commonalities and specific differences, and reviews research on the effectiveness of the methods. While the strength of the evidence varies from one method to another, inductive methods are consistently found to be at least equal to, and in general more effective than, traditional deductive methods for achieving a broad range of learning outcomes.

1.2 Project Based Learning (PBL)

Higher Education Projects arise in a variety of contexts and applications. "There is no one accepted definition of PBL" (Buck Institute for Education, 2009, Para 4).

BIE (Buck Institute for Education) defines standards-focused PBL as: "a systematic teaching method that engages students in learning knowledge and skills through an extended inquiry process structured around complex, authentic questions and carefully designed products and tasks. This definition encompasses a spectrum ranging from brief projects of one to two weeks based on a single subject in one classroom to yearlong, interdisciplinary projects that involve community participation and adults outside the school" (Buck Institute for Education, 2009, Para 4).

There is a distinction between PBL and education including (some) projects. In PBL the projects are the central organisation form of the curriculum and a means to acquire knowledge, insights and skills. In the latter the traditional curriculum is enriched by projects in which the earlier acquired knowledge, insights and skills are to be applied.

"More important than the definition itself are the attributes of effective projects. The BIE planning model is based on a number of criteria that distinguish carefully planned projects from other extended activities in the classroom" (Buck Institute for Education, 2009, Para 4-5). Outstanding projects

- Recognize students' inherent drive to learn, their capability to do important work, and their need to be taken seriously by putting them at the center of the learning process.
- Engage students in the central concepts and principles of a discipline. The project work is central rather than peripheral to the curriculum.
- Highlight provocative issues or questions that lead students to in-depth exploration of authentic and important topics.
- Require the use of essential tools and skills, including technology, for learning, self-management, and project management.
- Specify products that solve problems, explain dilemmas, or present information generated through investigation, research, or reasoning.
- Include multiple products that permit frequent feedback and consistent opportunities for students to learn from experience.
- Use performance-based assessments that communicate high expectations, present rigorous challenges, and require a range of skills and knowledge.
- Encourage collaboration in some form, either through small groups, student-led presentations, or whole-class evaluations of project results"

In Engineering Education PBL has been transformed in PLEE (Project-led Engineering Education).

1.2.1 Project-led Engineering Education

Powell & Weenk (2003) define Project-led Engineering Education (PLEE) as:

"Project-Led Engineering Education focuses on team-based student activity relating 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. Students show what they have learned by discussing with staff the 'team-product' and reflecting on how they achieved it. The subject of each project exemplifies the theme, and is appropriate to the levels of competencies in the programme at the time it is done. A project is aimed at competencies and not so much on distinctive knowledge or skills.

A series of projects explores different subjects and themes and develops increasing levels of professional competencies. In this way the students learn to master the competencies specified in the curriculum (knowledge, skills and attitudes) in the context of professional practice. The key features of a project are authenticity and a real problem coupled with a future professional situation and context" (Powell & Weenk, pp. 28-29).

1.3 The rationale behind Project-Led Engineering Education

"Engineers have to face new and complex problems which cannot be solved by a simple back-of-the-envelope calculation or sketch" (Powell & Weenk, 2003, p 32).

Because the problems are new there are no known solutions. To handle the problem the engineers need to work in a team with experts from other disciplines. For a fruitful cooperation the members need to communicate and be open to each other's experiences and expertise.

It is not surprising, therefore, that Ruijter (2002) identifies 4 reasons why PLEE is a good choice for innovation within an 'engineering system':

- it is suitable for educating and training relevant engineering competencies.
- students respond well to more varied learning activities (compared with the traditional approach).
- the social commitment to team work stimulates participation.
- students respond well to the relevance (to engineering practice) of the PLEE learning activities.

1.3.1 Life Long learning

"There is an element of truth in the suggestion that part of the basis for getting an old-style degree involved learning facts and learning the tricks necessary to pass examinations. But the half-life of technical facts is short and getting ever shorter; technical problems in real life are not the straightforward closed-form problems often found in examination papers. It is more important to think, to learn how to identify what is (not) known, to solve problems, to find sources of information, to apply the information to synthesise solutions, and to choose the best solution. We try to encourage openness in students and willingness and the competence to ask relevant questions and get answers in order to ensure progression. This is a firm basis for tackling new problems during a career and a basis for learning/acquiring new skills (long) after graduation ('Life-long-learning')"(Powell & Weenk, 2003, p. 70).

The experience of Powell & Weenk (2003) is that "PLEE can develop well and efficiently the required competencies expected of an academically-trained engineer at the time of graduation, and provides a secure basis for life-long learning. Students respond very positively to PLEE" (Powell & Weenk, p. 99).

1.3.2 Vision on learning

Views on education are constantly changing. Three major changes in the past decennia are addressed below.

Learning objectives are no longer the end goal of degree programs. Nowadays objectives of the program are formulated as competencies that are to be achieved by the students (Weenk & Van der Blij, 2010).

A competence is more than the sum of knowledge, skills and attitude. These elements become a competence when the person has insight in their relation and the application in the given context. Van der Blij (2002) defines a competence as: "The ability to apply integrated complex knowledge, skills and attitude in such a way that the person acts responsible and adequately in a certain context" (Van der Blij, p. 2).

In order to acquire competencies students need to learn and practice with real life problems in an authentic context. Next to the disciplinary competences there is special attention for soft skills, f.e. gathering information, communication and cooperation.

Students are no longer consumers but active learners who construct their own understanding and direct their own learning process.

Loyens (2007) describes four basic assumptions of constructivism:

1. knowledge acquisition is a process of knowledge construction in which prior knowledge comprises the frame of reference for the interpretation of new information.
2. learning involves interactions with others such as fellow-students or teachers.
3. knowledge construction benefits from metacognitive skills such as to plan, monitor, and evaluate one's learning process.
4. it is important that learning takes places in an authentic context, preferably similar to future professional contexts.

No longer should the activities of the teacher be the centre of education but the learning of the student

Students get more responsibility for their own learning process in student-centered educational methods. This is consistent with research findings that students learn by fitting new information into existing cognitive structures and are unlikely to learn if the information has few apparent connections to what they already know and believe (Prince & Felder, 2006).

PLEE is an educational methodology that fits competence learning, constructivism and student centred learning,

1.3.3 Efficiency and effectiveness of learning

"If you want faster students, you should train first-year students in their social skills, instead of threatening them with higher tuition fees and loans. It is clear that being successful in studying is not only about doing what a lecturer asks you to do and handing in papers in time. Others things, like motivation and being part of a social circle, are just as important" says education specialist Lilian Eggens (2011a).

According to L. Eggens (2011b) the size of the social network has a positive influence on the study pace.

For the three Dutch universities offering Mechanical engineering, the motivation to change from a classical approach to a project-based approach was:

- to stimulate and motivate students and to acquaint them at an early stage with the profession of mechanical engineering, in particular the aspects of analysis, planning, design and manufacturing, etc.;
- to increase the efficiency of the system in terms of the duration of the study;
- to improve teamwork and communications skills of the mechanical engineer;
- to arrive earlier than before at a point where the student can make a well-founded decision as to whether or not to continue the study of mechanical engineering at a university level' (VSNU, 2000 p. 13).

According to Powell & Weenk (2003) incoming (first-year) students find the team-based project an excellent motivation for finding out what engineering is all about, as well as starting to learn the 'hard' parts of the curriculum. Their grasp of the theory built-up during the first year is at least as good as under the classical system. During project work students quickly learn to work hard and effectively and the team-work accelerates the learning process.

John W. Thomas (2000) has done a review of research on project based learning. Five conclusions on the merits of PBL are:

- There is some evidence that students have difficulties benefiting from self-directed situations, mainly because of problems with initiating inquiry, directing investigations, managing time, and using technology productively. Therefore it is important to help students learn how to learn.
- There is direct and indirect evidence, both from students and teachers, that PBL is a more popular, beneficial and effective method of instruction than traditional methods.
- PBL seems to be equivalent or slightly better than other models of instruction for producing gains in general academic achievement and for developing lower-level cognitive skills in traditional subject matter areas.
- There is some evidence that PBL, in comparison to other instructional methods, has value for enhancing the quality of students' learning in subject matter areas,
- There is ample evidence that PBL is an effective method for teaching students complex processes and procedures such as planning, communicating, problem solving, and decision making,

According to Mills and Treagust (2003) "students taught with project-based learning may gain a less-complete mastery of fundamentals than conventionally taught students acquire, and some of the former students may be unhappy over the time and effort required by projects and the interpersonal conflicts they experience in team work. Moreover, if the project work is done" (in: Prince & Felder, 2007, p. 16).

University of Twente (Powell, 1999), Technical University of Eindhoven (Eindhoven, 1999) and Université Catholique Louvain, Belgium (Milgrom, 2001) all report positive and encouraging results on improved student progression and competencies after implementing a programme in which PLEE plays a major role.

1.3.4 Developments at the University of Twente

The University of Twente plans a curriculum innovation over all the degree programs (University of Twente 2011a 2011). The education should meet the demands of the future: more emphasis on academic skills (transferable skills), less emphasis on factual knowledge. And education should be more efficient and have less study delay. The University chooses flexible teaching modules; each module (15 EC) has a project included. Here, students integrate the presented material, test their understanding and generate new questions. The University has had good experiences with education projects in several programs. Failure and pace of study are related, but there are important differences. Analyses of causes of study delays at the UT show a similar picture as international studies. Delay is greater if there is less pressure, from staff, from fellow students, or assessment. Because of inflexibility in the curriculum study delay is difficult to compensate later on in the program.

In a more extensive paper on the educational model (University of Twente 2011b 2011) the following is stated: "The University has a responsibility to the students and to society. Formally, we have confirmed our ambitions by signing a multi-year agreement with the Minister of Education and Science. Together with other Dutch universities, we are committed to the goal that by 2014 70% of the undergraduate students achieve their bachelor's diploma within four years. "

In the strategic plan Route '14+, the University of Twente has also chosen for adjustment of educational programmes to diversity among the students. "The diversity of students is related to their personality as well as their scientific interest. Students are (to be) identified as 'researchers', 'designers' or 'organisers' (the RDO concept): they have different learning styles, are motivated for different roles in teamwork, and have different positions in society in mind. The teaching approach of UT will focus more on transferable skills" (University of Twente 2011c).

It is clear that the University expects that Project Education will enhance the achievements and the study speed of the students. In order to accomplish this an appeal is done to all involved in education, managers, teaching staff and support staff. The start of this innovation process was at a university conference (April 2011) about the new educational model.

2 Staff and Students are doing projects in PLEE

"Innovation is in its best form an evolutionary process from within, gradually developed and becoming gradually integrated into the functioning of the school" (Van den Berg & Vernooy, 2000, p. 38).

Goodlad, Klein & Tye (1979) make a distinction between various curriculum representations:

- Ideal curriculum: the original ideas and intentions of the designers
- Formal curriculum: the written curriculum (documents, materials)
- Perceived curriculum: the interpretation of the users (especially the teachers) of the curriculum
- Operational curriculum: the actual instruction in the classroom
- Experiential curriculum: the reactions and outcomes of the students

This makes it clear that it's a long road full of pitfalls from ideas to the desired outcomes.

It all starts with the conversion of the ideas and intentions in the design of the education, the curriculum in documents and materials.

2.1 Curriculum design

The PLEE approach devotes about 20 to 40% of the learning time to project work using student teams. The students are addressing the disciplinary competences as well as the required soft skills.

"The curriculum is arranged so that there is a theme in each academic term which represents a part of the complete engineering discipline of the program. The theme covers at least two (contrasting) project-supporting lecture courses which are not closely related to each other academically, but which are found coupled together in engineering practice. The sum of all the themes therefore covers the curriculum and the discipline in a representative way. It is clear how the lecture courses relate to each other during each term and between different terms" (Powell & Weenk, 2003, p. 35).

Next to the project courses often non project supporting courses are offered.

PLEE is not exclusively student-team-led learning. It involves a blend of team-based project work together with lecture courses and sometimes individual assignments f.e. the final project.

2.1.1 Quartile design

Project work and courses are planned during the whole term. The project is a substantial part of the student learning activity. The project starts at the level of about 1 day per week, and expands to about 4 days per week. Figure 1 shows a typical schematic 1 quartile timetable. Each element of the quartile is separately assessed. The student study time includes lectures, tutorials and private study.

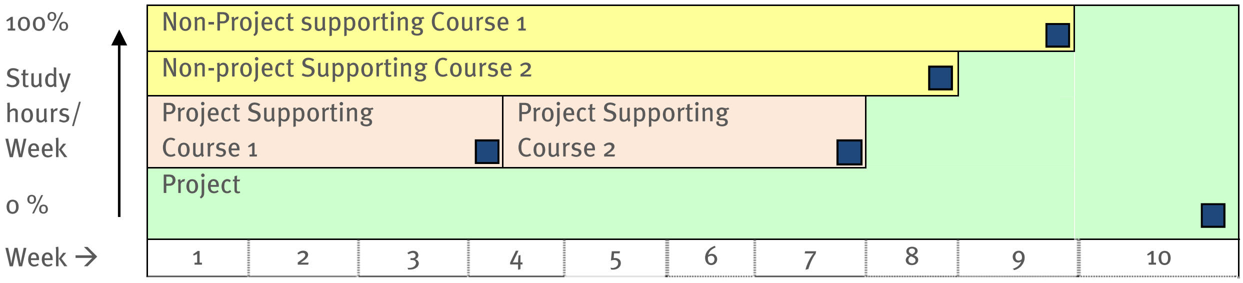

Figure 1: Schematic typical study period (1 quartile) ■ = examination

2.1.2 Project design

The rough outline of project work is as follows: "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. Students show what they have learned by discussing with staff the 'team-product' and reflecting on how they achieved it" (Powell & Weenk, 2003, p. 28).

The project assignment should be designed in such a way that the key principles of PLEE are addressed:

1. The focus is on students learning the desired competencies which employers need, and on the student effort needed to master those competencies.
2. The project assignment directs the student team towards mastering the desired technical competencies. All the key technical areas of the discipline are handled – and given major attention – so that the graduate can be recognised as demonstrating competencies in the technical skills of the discipline.
3. Learning is done mainly in student teams by tackling open-ended problems and by getting feedback on what has been done and on what needs further to be done.
4. Students learn the soft skills of communicating in an active way that is integrated within the handling of the technical aspects of the curriculum.

(Powell & Weenk 2003, p. 131)

Box 1 represents a short description of a typical first-term PLEE project scenario (Weenk & Van der Blij, 2010).

Context: Mechanical Engineering at UT/NL

Theme: Provide first years motivating acquaintance with ME, integration of subjects
Project Assignment: Reduce the internal volume of an empty can by 90%
Aim: students' experience of the complete design and production cycle for a can rushing apparatus to be used in the home kitchen.

Specifications: to make the assignment very challenging, e.g. volume, costs, quality. The student team must make a design for a prototype, make the components for it, plan and carry out the production, assemble the apparatus, test it and improve it if necessary. The assignment provides an open-ended, stimulating focus for students to learn about the 'subjects' in the trimester.

Project-Supporting Courses: design, engineering drawing and computer-aided design, production systems, Statics.

Non-Project-Supporting Courses: e.g. mathematics, communication.

Activities: The student team gets the project on the first day of the first term and is immediately confronted with a real problem representative of professional practice.

Figure 2: Look, ma, something for the kitchen!

(Ray Klumpert in Powell & Weenk, 2003, p. 39)

Box 1: typical first-term PLEE project example

A lot of teachers think that in a team of eight students, only two will do the work, and the rest will sit back and do nothing. In practice this rarely happens. The project is deliberately a little bit too large, so all the students have to do their share fully, otherwise the project cannot be completed on time (and the team fails). There is social pressure from the team upon anyone who will not work. The examination requires that each student shows he can defend the complete project, not just the bit he has (or has not) worked on: with no involvement in the team work, we find that it is impossible that an idle student can defend the project. Moreover the tutors keep an eye on the process of the project, and signal anyone who is not pulling their weight: the examiners are thus well prepared to examine the student closely.

The description of the curriculum and the quartiles, including the courses, and the project assignments are the basis for the teaching staff to implement the curriculum.

3 Teaching activities in PLEE

"Creative activity could be described as a type of learning process where teacher and pupil are located in the same individual." (Koestler, 1905-1983)

As mentioned in the previous chapter the teaching staff is essential for the student outcomes of the curriculum. The way the teaching staff interprets the curriculum in documents and materials, the perceived curriculum is of influence on their activities in the classroom, the operational curriculum.

Powell & Weenk (2003) state that the biggest challenge for implementing PLEE rests by staff members. They need to accept and adopt the vision of PLEE methodology and change their familiar roles and teaching activities.

3.1 Roles of teaching staff

Teaching staff can fulfil different roles in PLEE. In order to fulfil these roles as intended in PLEE a shared vision on education is necessary. Often the teaching staff has already played an important role in the design of quartiles, courses and projects. During this phase many of them have become acquainted with the characteristics and elements of PLEE and the curriculum of their degree program.

The following roles for the teaching staff in PLEE can be distinguished:

- Contractor: The students receive the project assignment from the contractor. The contractor experiences the problem and has the need for the solution. IN order to keep on the right path students need to consult the contractor several times during the project.
- Expert: During the project work students encounter all kind of problems. Often not all the necessary knowledge and skills are already covered in the project supporting courses. It is almost certain that since students define their own problem solving or designing process they need other knowledge then is foreseen. In these cases they may need to consult experts to help them on their way.
- Assessor: The result and the process of project work will be assessed for grading.
- Lecturer: The lecturer is responsible for the courses including lectures and tutorials.
- Tutor: The tutor has the roles of supervisor and monitor during the project work.

"Once teachers feel comfortable with PBL, they usually say they'd "never go back."! They see how well it works for their students, and they enjoy the new role they play. PBL allows a teacher to work more closely with students, acting more like a coach instead of the "sage on the stage." Now, if you *enjoy* being the centre of attention in your classroom, you may think PBL is not for you. But don't fret — there are times when you still will be the focus. Because you know more about the subject, you might still give a lecture, provide a structured lesson, or direct students to resources. Especially in your early projects, you'll still be planning and facilitating much of the work. In future projects as your students are more able to work independently, you may need to plan and facilitate less and less, but you still play a vital role" (Buck Institute for Education, 2009, p. 7).

The next paragraph elaborates on teaching and the role of lecturer, the role of tutor will be covered in more detail in chapter 4.

3.2 Role of the lecturer

The activities of the lecturer are part of the operational curriculum, the last step before the experienced curriculum, the student outcomes. The lecturers are responsible for giving the courses in PLEE. In case of project supporting courses it is important that the lecturer doesn't reveal possible solutions for the assignment. So lecturers should be well informed about the quartile as a whole.

Figure 3: the lecturer (Powell & Weenk, 2003, p.

There is a wide variety of styles of presentation in the lecture room. Some lecturers seem to give effortless and spontaneously an inspiring presentation during which all kinds of slightly related topics are discussed. Others are well prepared and give a structured presentation in which all the important concepts and topics are covered. Some lecturers encourage students to ask questions, others lecturers vary their presentations with small assignments to activate students. And some lecturers want to give their presentations undisturbed by questions of the students. In that case the lecturer in figure 3 is walking in front and his students are following.

In traditional education the lectures are the core of the curriculum. During the lectures the students are supposed to learn knowledge and insights and gain understanding.

The teacher and the teaching is the centre and the students are lost without formal and structured explanation of the concepts. After the lecture they are supposed to do their homework to rehearse what was told.

However, the 'Cone of Learning' (see figure 4) shows that students don't remember too much from lectures in case

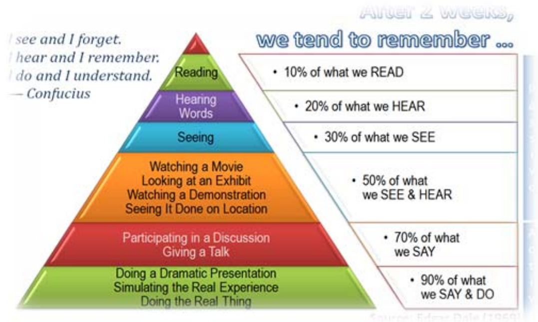

Figure 4: Cone of Learning (Edgar Dale 1969)

they don't do more than reading and listening.

The conclusion is that students remember less from listening alone.

Of course lectures can be of use. Lectures are certainly suitable for survey main topics, explain difficult parts, give examples, demonstrate a systematic approach, stimulate students' interest and offer a framework for self-study and application.

Lectures are less suitable for learning problem solving, remembering much from the lecture content, for mediate or weak students and if content is available elsewhere.

4 Tutor activities in PLEE

In all science, error precedes the truth, and it is better it should go first than last. (Hugh Walpole, 1884-1941)

In traditional education teachers prevent student to make mistakes by telling them the necessary knowledge and how the work should be done. The role of tutor in PLEE is quite different. A tutor supervises the project work of the team and reacts to questions mostly with further questions. Only when students really seem to get stuck the tutor can play a more active role.

Just as the activities of the lecturer the activities of the tutor are part of the operational curriculum, the last step before the experienced curriculum, the student outcomes.

4.1 Leader or manager

"Do you prefer to be a leader or a manager? Leaders facilitate problem solving in a group and help the group find their own solutions. Managers control the process and look for prescribed outcomes. In reality, good teachers go back and forth between the two roles" (Buck Institute for Education, 2009, p.9).

The role of the tutor is to support the students by facilitating learning. During the project work students will encounter obstacles and opportunities. Students can't succeed in PLEE without the support of the tutor.

"Many students want their instructors to tell them everything they need to know for the exam—not one word more or less" (Felder & Brent, 2009, p. 4).

However, support doesn't mean to provide them with the answers. Far more it is letting them struggle and make mistakes. It includes being sensitive to their differences in abilities, aptitudes, and learning styles. This requires interpersonal and communication skills. In first year project the tutor also supports the students with the definition of their planning and the deadlines. But the tutor always is aware of the fact that the students are responsible and that the learning process is more important than the project result.

Asking questions and providing students with feedback fit the tutor role. Asking the right question and giving feedback at the right time not only challenge the team, but avoid having students getting stuck during their learning process and ending up treading water. Tutoring involves listening carefully to what students know and then reacting to the student signals by suggesting new or better approaches.

Above all the tutor does not tell the students what to do nor does the tutor solve the problem for the student or student team. Pictorially the tutor develops a 'smaller mouth and a larger ear' as shown in figure 5. He monitors student team discussion.

Figure 5: Tutor monitors team discussion (Powell & Weenk, 2003, p. 98)

4.2 Tutoring and supervising

Rick Reis quotes Richard M. Felder saying that an important part of the job as teachers is equipping as many of our students as possible with high-level problem-solving and thinking skills, including critical and creative thinking. If there's broad agreement about anything in educational research, it's that well-implemented student-centered instruction is much more effective than traditional lecture-based instruction at promoting those skills" (Reis 2011, Para 1).

The work done in teams must be made functional. Supervision is directed towards the teams getting things going and keeping them going. It is important for teams to function well even without the tutor in the vicinity. Getting real work going and structuring it is the function of team meetings. The task of the tutor is to provide help on the *content* of the project and on the *process* of running the project.

"The tutor will suggest strategies for solving problems but his task is not to 'give answers on how precisely to complete (an element of) the project or problem'.

Figure 6: the tutor (Powell & Weenk, 2003, p. 150)

Students are advised to ask each other about how to solve problems, and only ask the tutor if the team as a whole cannot solve the problem. The tutor focuses his energy on the student team rather than on the individual" (Powell & Weenk, 2003, p. 39).

The tutor is going behind the small student groups, observing individuals (as shown in figure 6), and giving feedback just-in-time in order to keep students going in the right direction and in good speed.

Weenk (2000) compares a PLEE tutor and a volleyball coach during the match:

- The coach is not equal to the team players nor being the leader;
- The team players invest energy in active way; the coach observes;
- The coach is seated outside the boarding, while team players are jumping and smashing;
- If the score is going lose, the coach is enabled to ask for time-out;
- Always discussion, feedback and if necessary changing some players.

The tutor needs many communicative skills to interact adequately with the students. In box 2 is shown how different communicative interventions influence the students. F.e. telling them what to do has a different effect as summarizing.

Non directive	Directive
Listen to understand –Reflect –Summarise –Orden -Ask questions -Add questions -Add experiences -Offer suggestions –Assess -Telling	

Box 2: Classification of communicative interventions from non-directive to directive

4.3 Different tutor sub roles

The tutor may fulfil the next sub roles in the project (based on Powell & Weenk, 2003, pp. 247-249).

Setter of the assignment

A characteristic of project work is that there are certain learning objectives so that the student and the project team have to plan, communicate and work together, make adjustments, agree to compromises, and so forth in order to achieve the outcome. The learning objectives set the degrees of freedom of the students project work. The tutor monitors the learning progress in relation to the objectives.

Stimulator

The tutors can motivate students. They can do this for example through:

- showing interest and giving attention to student's team work; depending on what team members need, the tutor becomes either a listener, or an opponent who challenges through asking questions.
- asking the team members regularly about the why and the how, encouraging creativity and setting them to go into things in more depth.
- helping the team through a difficult period if things are not going too well; and with projects which last a long time that is very likely to occur at some point.

Monitor of the learning process (facilitating co-operation)

Learning to work together in project teams does not always run smoothly. The tutor will be able to observe that. Confusion on the activities and strategy, poor preparation of the meetings and the team climate are indicators of problems.

The tutor can support the good development of co-operative effort for example through:

- ensuring that the team makes a good start. The tutor must be present at the first meeting and introduce him/herself, the project and explicit the mutual expectations of the students and the tutor.
- insisting on drawing up agreements arranging the activities between the meetings.
- seeing to it that the team works hard and focused according to the procedures agreed on and that every member contributes to a satisfactory extent.
- checking that the chairperson takes turns and coaching the discussion leader in preparing the meeting. Chairing a meeting is a learning experience for everyone.
- observe to see that the team is working together in a useful manner and that team co-operation is discussed in a constructive manner.

Evaluator of the process

The tutor can support team process evaluations on different times and in different ways. This is to improve the quality of the work in the course of the project. During the last ten minutes of a meeting the tutor can comment on the way in which the meeting ran, what has gone well and what could go better. The tutor can discuss for example the work done and project team opinions about the way the meeting went. The team members try to find the weak spots for themselves and think about own solutions.

Expert (specialist)

In some programs the role of tutor is fulfilled by (PhD) student assistants. In many programs however, the lecturer is the tutor. In discussions with the team, the tutor tries to avoid explaining and teaching, so that the team is forced taking the active role. When the team is really stuck the tutor may give a short explanation of a difficult point on request of the team in the role of expert. The tutor uses judgement based on academic and professional experience to guide students to reach solutions to open-ended problems. There are no 'perfect' or 'unique' solutions to proper PLEE problems or projects. Staff may from time to time feel exposed to unfamiliar situations where they have no 'ready-prepared' answers to team questions, and feel uncomfortable about this. This need not weaken their position; such exposure places them in much the same position as the students, but the staff can draw upon their wider experience-in-general when handling the student questions or commenting on student proposals.

Another aspect of the tutor role as expert is to pay attention to the soft skills, f.e. communication, planning, gathering information, cooperation. The 'soft' skills are frequently underdeveloped in the traditional approach. All the evidence is that engineers need the soft skills as a part of their necessary competencies. When the students learn to study effectively (often in tutor meetings), they can then learn more engineering more effectively as well.

5 PLEE needs Tutor Training

Whoever is a teacher through and through takes all things seriously in relation to his students -- even himself. (Nietzsche, Beyond Good and Evil, Part Four, p. 63)

As described in the previous chapter the role of tutor differs completely from the more traditional role of the teacher. "New PLEE Tutors are well accustomed to the traditional role of lecturer, but need training to fulfil their new role" (De Grave, Moust & Hommes, 2001).

Prince & Felder 2007 say: "The more resource-intensive the method, the greater the need for existing resources or external support to implement it. Instructors should be mindful of the time demands of each method and take advantage of existing resources, experienced colleagues, and teaching centre consultants who can offer tips on implementing the method and dealing with problems that arise in its use" (Prince & Felder, p. 18).

The implementation of PLEE in Higher education asks a lot of all involved, non-teaching staff, teaching staff and students. Powell & Weenk (2003) say that without staff agreement a PLEE-style reform will lead to an overload of frustration.

The change of the role of lecturer to tutor is not an easy change for everyone. Some lecturers really benefit from support of colleagues or a more formal training to make the transition.

The teachers are employed to do research and to teach engineering to engineering students. Often they do not have the necessary skills to tutor groups during project work and handle team work and play a part in the soft skills. The experience is that "once the teachers see how PLEE is to be handled, they respond well to a good training session on the relevant soft issues. Moreover, teachers are reassured during the tutors' liaison meetings once the project gets under way: the exchange of tips and experiences is very much welcomed" (Powell & Weenk, 2003, p. 93)

The tutor training supports the transition from the formal curriculum into the perceived curriculum, how the documents and materials are interpreted as well as the operational curriculum, the teacher's activities.

In this paper we assume that there is a change from more traditional education to PLEE. The following part will elaborate on tutor training to help the teaching staff to handle the changes.

5.1 Elements of Tutor training

In this paragraph the most important elements of tutor training are presented.

5.1.1 Before the start of the project

Supervising a PLEE project is different from supervising a final project or a course. A PLEE project is closely related to the project support courses and the teaching staff should work as a team during the quartile.

The PLEE tutor should before the project starts be familiar with, and preferably have discussed with colleagues, at least the following issues:

- The planning of the quartile
- The content of the project supporting courses
- The objectives of the project work and the relation with the competencies
- The project assignment and the appropriate activities of the students
- The expected roles of the tutor: f.e. setter of the assignment, supervisor, expert, evaluator
- The composition of the teams: f.e. at free will, based on tests, f.e. Belbin team roles

- The planning of the project: deadlines, etc.
- Assessment of the team work, result and process

This way the tutor is familiar with part of the formal curriculum, in documents and materials. By discussing it with colleagues the interpretation of the quartile, the perceived curriculum, is aligned.

5.1.2 At the start of the project

Powell & Weenk (p. 252) suggest that at the first meeting, the PLEE Tutor will get to know the members of the student team, and the students get to know the tutor. The first meeting sets the tone for the future. It is important that the students and the tutor know what they can and may expect from each other. The relationship between the tutor and the team members often is more close then the relationship between a lecturer and the audience. Students like to get to know the tutor as a person and not only as an expert. So it might be appropriate that the tutor tells something about him or herself, f.e. the research project in progress, the academic background and may be something more personal.

When the students don't know each other the tutor can stimulate that they get acquainted with each other.

Especially in the first year students are often uncertain about what is expected from them. The tutor will clarify and explain the assignment and the expected outcomes. The tutor also "summarise the business of running a project – the objectives, the phases, the end point (deadline), as well as mention the importance of running meetings, working as a team, and planning the project" (Powell & Weenk, 2003, p. 252)

Agreements can be made on the method of working of the student team for example:

- The roles in the team, chairman, secretary, presenter, etc.
- Preparation for the meetings and the general agenda
- Planning of the project work
- Dealing with absence, phone numbers, etc.
- Personal learning questions, f.e. from the previous period
- How to give and receive feedback

5.1.3 During the project

As said before the tutor can fulfil different roles during the project. All of these roles can be addressed in the tutor training.

Setter of the assignment

The tutor can simulate to be the contractor of the assignment. He knows exactly the nature of the problem and has understanding of the criteria for the result. During the project students may wander from the original assignment and the contractor can give them feedback on the focus of the team and the intermediate products. Also he can clarify obscurities in aspects that play a role with the problem.

Stimulator

The tutor sometimes needs to motivate the team or individual students. The role of stimulator is a tricky one. Too much stimulation can make the students dependant on the tutor. Too little stimulation may be interpreted as disinterest. Sometimes students explicitly want to have their questions answered. To respond with another question or only a suggestion where they can find the answer themselves may frustrate them. But some frustration is part of the project work. Together with the team the tutor can explore how the students can motivate themselves and each other.

Monitor of the learning process

The tutor has to monitor the learning process of the team and the individual students. The learning process has two important elements: the academic learning of the disciplinary content and skills and the teamwork including the interpersonal skills. Next to that some individual students have personal learning questions like overcoming fear for presentations. Through observation the tutor gets signals. Sometimes it is better not to react too soon and let the team sort it out themselves, learning from their mistakes. Sometimes it is better to react immediately and prevent big problems later on. When the tutor is also assessor this double role may sometimes hinder the more personal guidance that is needed.

Evaluator of the process

Just as the role of stimulator the role of evaluator may be a tricky one. Often the tutor takes pride in a good result of the team. This can lead to a more directive approach giving the students little room for their own ideas and creativity. On the other hand, too little feedback and direction may leave the team in uncertainty and may even paralyze them. Too much positive feedback may make them over confident, but too much criticism may diminish their motivation. It is important that the evaluator observes objectively and gives constructive feedback so that students learn to evaluate their own process.

Expert (specialist)

Often the tutor is one of the lecturers of a project supporting course. The most important pitfall is that the tutor takes too often and too much the role of expert. Lecturers take pride in their knowledge and like to explain students the way things are. Often they have to learn to take pride in the outcomes by letting the students find the solution themselves. The results may be less perfect but the confidence and pride of the students may be bigger. In the long term this leads to graduates who can solve problems themselves. The role of expert should be executed with caution. The expert gives advice on the problems the students mention and tries to avoid an overload of information. Sometimes the students get a card for ten consultants with the expert. This way they have to determine themselves when it is really needed to get the help of an expert.

The tutor in the role of expert can also be a trainer in soft skills. During tutor meetings the tutor, as monitor and evaluator, makes the students aware of the importance of the soft skills. Short training sessions may help the students to develop these skills.

5.2 PLEE Tutor Training

In the previous paragraph the elements of the tutor training are discussed. This paragraph describes the various activities during the training. The Educational Service Centre at UT offers tutor-workshops beside individual sessions on how to tutor in PLEE. Role-playing and simulations help to understand and develop appropriate tutor competencies.

5.2.1 Outline of the training

The first session (4 hrs.):

- The definition of PLEE
- The vision of PLEE
- Why PLEE

The second session (4 hrs.):

- The tasks of the Quartile coordinator
- Designing the project assignment
- Designing the assessment of the quartile and the project.

The third session (4 hrs.):

- Questions on and issues concerning tutoring
- The Do’s and Don’ts in tutor behaviour
- Agreements for the application of the project

Methods that are used during the training are short introductions, discussions, subgroup work, simulations, role playing, cases studies, etc.

At the end of the training the tutor should be able to answer questions like:

- What is the PLEE methodology?
- What are the roles of the tutor?
- How to give and receive feedback on process and product?
- How to make the students aware of different team roles and their influence on teamwork?
- How to apply the basic skills of communication: diversity of questions, summarize, reflect content and emotions?
- How to monitor the team work?
- How to handle problems in the team?
- How to supervise the first meeting?
- How to supervise the students with developing soft skills?

The next paragraph elaborates on these soft skills.

5.2.2 PLEE Soft Skills.

In the described role of the tutor it becomes eminent that the tutor has a very important role in supervising the process of project work. During the project work the students learn, next to the knowledge and skills necessary for attaining the result, the so called soft skills.

Soft skill examples

According to Weenk & Haijkens (2008) 'soft skills' is a sociological term which refers to the cluster of personality traits, social graces, facility with language, personal habits, friendliness, and optimism that mark people to varying degrees.

The tutor should support the students with the learning of soft skills. The best way the tutor can achieve this is by only asking questions. In box 3 a short overview of soft skills and appropriate questions is given. Of course there are many more skills than mentioned in box 3.

Soft skills	*Discussion aspect*	*Typical (PLEE Tutors') specific questions*
Planning	definition of problem	What is the problem statement?
	research issues	What are you going to research?
	time-work schedule	Who will do what and how and when?
	planning	How will you re-adjust the planning?
Organising	division of tasks	How will you determine who does what?
	team organization	What will you do individually, in sub teams or full teams?
	adjustment of tasks	How will you mutually adjust contributions?
Co-operating	rules	What rules has the team agreed on?
	norms	What are sanctions for exceeding certain rules?
	co-ordination	How has mutual adjustment between sub teams been settled?
	productivity	What agreement has been made on producing output?
Evaluating	procedure	What agreement about evaluating project work?
	product evaluation	What progress did the team make on tackling problems?
	process evaluation	How is the co-operation going within the team?
	result	What is done with the evaluation results?

Box 3: Tutoring soft skills

6 Conclusion

The PLEE methodology is consistent with constructivism and inductive teaching methods. Numerous research findings support the idea that PLEE enhances effectiveness and efficiency of students learning.

The essence of PLEE is that students solve open-ended assignments for which the solutions are not yet known. They do this by gathering actively the necessary knowledge and skills in (inter-disciplinary) team work. These knowledge and skills elements not only concern the discipline(s) but also soft skills for a lifelong learning.

In PLEE the teaching staff performs different roles. The tutor plays an important role. Instead of answering question as is usual in more traditional education, the tutor mainly asks questions. For that the tutor needs to be an expert in the tutor role. That is why tutors need training.

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Workshops

An important feature of the PAEE 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’2011 count on active involvement of its participants. Four different workshops are scheduled, meant to enable the enhancement of project practice and the reflection on practice. You do not need to register in advance for the workshops. This will happen during the symposium.

Workshop A1 – Teacher Professionalisation

Maria van der Blij, University of Twente, the Netherlands

Project approaches need different believes and roles from teaching staff. Change is needed from presenting knowledge to facilitating and stimulating the learning process of students. The preparation for this role in terms of professionalisation and the process of change that teachers experience are the focus of this workshop. The participant will reflect on competencies of teachers and on the (im)possibilities of evaluating these competencies? The role of the organisation in these changes will also be part of the reflection. The workshop is closely related to the keynote speech of Wim Weenk.

Workshop A2 – Aligning teaching and learning: myths and realities of active learning (workshop in Spanish)

Mauricio Duque, Universidad de los Andes, Bogotá, Colombia

Recently, the importance that we attribute to active learning has been increasing. And in fact, when we learn, there is always a part of our brain actively involved and although we may not seem active, we are learning. Active learning cannot be seen regarded as a method, a methodology or a recipe, as often happens. Neither can we call it a new concept, when we look at the pre-industrial teaching and learning practice as e.g. illustrated by Dewey at the beginning of the 20th century. As with all abstract concepts, active learning is characterised by different levels of definitions, depending on its interpretation, starting with the most naive interpretation of making students do something to the most elaborate interpretation that acknowledges that the concept embraces a number of characteristics and principles that refer to the design and development activities of learning that need to be coherent with the way we learn. This workshop consists in activities that aim to evolve the concepts that the participants hold on active learning to a higher level. The workshop will start by exploring existing concepts on active learning and will end with the concept of active learning that the participants will find during the activities.

Workshop B – Project Approaches in Engineering Education: research in practice

Natascha van Hattum-Janssen and Sandra Fernandes, University of Minho, Portugal

Project approaches raise a lot of questions in terms of effectiveness of student learning and perception, teacher roles, assessment methods and short-term and long term results. There are no general answers to specific, contextualised question on how to implement and continue the use of projects in engineering courses. Educational research on a wide range of issues related to project approaches can help to better understand the implications of project approaches. This workshop aims to discuss the role of educational research in the enhancement of project approaches and the improvement of current practice.

Workshop C – Project Management in Engineering Education: staff and students view

Rui M. Lima, Dinis Carvalho, Diana Mesquita and students, University of Minho, Portugal

Working in effective teams is an important feature of project work for students. They need to listen to each other, make decisions, work on several tasks and monitor the process. The coordination of an interdisciplinary project necessarily involves a group of teachers, tutors and other staff. The group that coordinates projects at the Industrial Management and Engineering degree programme at the University of Minho attempts to work as an effective team as well, based on a number of principles that they expect from their students, like well-timed, well-planned meetings, democratic decision making, rotating leadership and a quick and open exchange of information. The workshop will be used to discuss the project management model both for staff involved and student teams.

Communications

Paper Session A1

From the Hands-on Methodology to Problem-based Learning: Experiences and Perspectives of a Non-conventional Introduction to Engineering Course

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Abstract

This essay presents a briefing about the introduction of engineering course of the Center of Science and Technology of the Pontifical Catholic University of Rio de Janeiro, recent tracking, regarding the period from 1997 to 2010, demonstrating the positive background and the obstacles faced during the course's progression, relating all different experiences. The offer of this subject to first period students is been constantly updated through methodological innovations, looking forward to improve the freshmen development, building talents from making students act directly on engineering areas, involving them in practical situations, cooperative work, scientific matters, social and sustainable technologies.

Keywords: Problem based learning; Hands-on Methodology; Introduction to Engineering course; Engineering Education.

1 Introduction

Traditionally, as in many engineering courses, the Introduction to Engineering course has the inherent characteristic of being a subject taught by the use of lectures and films, among others. The first version of this course at the Center of Science and Technology of the Pontifical Catholic University of Rio de Janeiro - CTC at PUC-Rio, when it was implanted in the common studies cycle (basic cycle) of the Engineering department was not so different. Initially, the course was intended to present the professional potentials of the different engineering specialties existent at PUC-Rio, as well as address academic issues related to CTC students in relation to student life at the university. It also aimed to present the education and research possibilities and opportunities at the institution. However, this approach was not attractive to students. Therefore, a new proposal for the course was elaborated, combining two priorities: the familiarization of freshmen with the very essence of Engineering, in itself a constant need shown in several reports of the students themselves, and the work on engineering projects, in order to meet another freshman demand, since the students felt distant from the engineering field during the basic cycle.

From the mid-90s onwards, and, in particular, due to discussions and studies under the REENGE Program (Restructuring of the Engineering Education, a program supported by FINEP- Financier of Studies and Projects, CNPq-National Council for Scientific and Technological Development, SESU-Department of Higher Education and CAPES-Coordination for the Improvement of Higher Education, aimed at restructuring higher education, encouraging the performance of different teaching and learning experiences for the advancement of teaching and research in Engineering), the CTC implemented the hands-on methodology. Thus, beginning in the first semester of 1997, nearly 500 freshmen were divided into classes of up to 30 students. Different engineering CTC areas (at the time Civil, Mechanical, Electrical, Production, Chemistry and Computer Science and Metallurgy, currently including Automation and Control, Environmental and Petroleum) were responsible for each class. A teacher from each of these areas was chosen as coordinator, and was responsible for proposing projects that could be conducted by freshmen students using simple, accessible and affordable material resources, and using only scientific concepts that they brought with them from high school.

From this first experience with the hands-on approach (Costa et al., 1998), the course has undergone several reformulations. In this sense, new methodological approaches have enriched the experience, by promoting entrepreneurial attitudes and, more recently, by applying the Problem Based Learning – PBL – methodology, aiming at student performance in projects related to Concurrent Engineering (concurrent new product development through employing cross-functional teams, from different areas, to reduce cycle time), among others.

2 The Methodologies - From Hands-on to the PBL model

One of the proposals for the Engineering Innovation program (Inova Engenharia - IEL, 2006), is the training of engineers with extensive application of the hands-on learning methodology, according to which the training of professionals should promote the development of projects that encourage the application of theoretical knowledge in solving real problems, thus producing innovations.

The hands-on approach is a methodology based on the resolution of practical issues, and allows an active and cooperative participation, differentiating itself from the traditional methodological paradigms. It can be understood as:

- An active learning, in which the student is at the center of the learning process;
- A cooperative learning, in which the students seek to build the collective knowledge by working in groups, under conditions that assure both positive interdependence and individual contributions.

Among other benefits, this methodology enables the development of a capability for critical analysis, the establishment of a relationship between scientific knowledge and production, a further reflection on reality and the use of different languages and different sources of information.

One of the first projects using the hands-on approach at a gained knowledge level executed during the Introduction to Engineering course of 2002 was the Rodrigo de Freitas Lagoon Project. This project aimed to introduce the notion of engineering activities to students through theoretical and laboratory analyses, accompanied by engineering professionals, in this case, Environmental Engineering, as well as placing the student in touch with teamwork dynamics. The aim was to check the water quality of the Rodrigo de Freitas Lagoon, located in the Southern District of the City of Rio de Janeiro. The proposal was to conduct an evaluation of different parameters indicative of pollution in the waters of the lagoon, considering location and sampling times. To carry out the tasks, students attended lessons about the lagoon's history, characterization, hydrographic contributions and the identification of possible pollution sources. With these tasks at hand, students went to the practical aspects and, guided by a teacher, conducted several *in situ* measurements. Specific times and locations were set, both for lagoon and river and surrounding area samplings. Samples were also collected and analyzed in the laboratory. In possession of these data and supported by research conducted in previous years, plus the interview with FEEMA, the students were able to better understand the results. Each group conducted a presentation about the tasks at the end of the school term.

From the use and experimentation of the hands-on approach, the course began a new phase adopting the Problem Based Learning-PBL model.

The PBL methodology aims, throughout the resolution of a problem, to develop the skills and abilities expected of a future engineer. Since this is a typical real-world situation, and, possibly, multidisciplinary and complex, it does not possess a single answer and, in some cases, students have not acquired any prior knowledge that could lead to a solution (Boesing et al., 2008).

Regarding the Introduction to Engineering course, problems with comprehensive content are chosen, as well as the development of appropriate didactical procedures and materials, in order to display some basic concepts with which students may face contextualized challenges and motivate them towards the engineering field.

The PBL methodology model adopted can be considered a hybrid (Silveira et al., 2009), since this course is given during the first semester, and it was observed that students needed support, in order to find solutions.

To facilitate a better understanding of the subject, there are classes on "Fundamental Concepts of Engineering", which are given as seminars at the beginning of term and for which specific educational material was prepared, involving the following topics:

- The Engineer and Engineering: What is Engineering, the attitude and behavior of the Engineer, the evolution of Engineering, Engineering and Basic Sciences, the interdisciplinary and systemic perspective, the KISS Principle (Keep It Simple, Stupid); teamwork;
- Engineering Project: modeling, simulation, software and models, dimensioning, norms, specifications, costs, inventory, worksheets, and experimental tests;
- Project Management: teamwork, schedules, costs, logistics, quality, marketing;

- Project Presentations: preparation of reports and seminar presentations, the use of graphs and tables, systems of units, measurements, instruments and orders of magnitude; experiment analysis;
- Safety in Engineering: basic safety norms and the need for the use of individual protection equipment.

In the execution phase of the projects, the classes are dived in more or less 6 groups with five or six students, which begin by assessing the challenge and discussing the project. Then, the teams organize themselves and prepare a work plan. Resources are made available (limited), whether human, material or financial resources and the project must take these into consideration. During execution, some lectures or experiments are given regarding the concepts involved and, at the same time, the students gather information and seek solutions. Sources of information are discussed and evaluated. The individual and group activities take place throughout the process. In the end, students develop a written report and orally present their work.

PBL models usually follow a cycle (Ribeiro, 2008), in which case the Introduction to Engineering course can be summarized as follows:

1. The presentation of the problem by the teacher (client);
2. The task assignment among the groups that will be guided by specific monitors;
3. The presentation of partial reports (raising hypotheses and attempting to arrive at solutions with the knowledge available);
4. The identification of learning needs and the concepts and difficulties involved in the problem;
5. Parallel research and learning (concurrent) in order to form the theoretical framework;
6. The sharing of solutions and experiments by the application of the new knowledge learned;
7. Reworking;
8. Prototype or product or service.

To illustrate the transition from the hands-on approach to PBL, the continuation of the Rodrigo de Freitas Lagoon can be cited in this current version. In the new proposal, students seek ways to facilitate the flow of seawater to the lagoon and vice versa, adding to the level of water oxygenation and reducing pollution caused by improper disposal of sewage *in-natura*, proposing corrections to the imperfections of the process used today. The idea was to assemble a practical blueprint of how the exchange of water occurs between the Lagoon and the sea through the channel of the Jardim de Alah and Visconde de Albuquerque Street and propose solutions to make this water exchange more efficient, using models.

3 Current Stage

Society demands engineers qualified to act as specialists, as well as being able to interact with other fields of knowledge. Thus, their preparation, for the purpose of exercising their professional citizenship, has to, increasingly, articulate in an interdisciplinary and multidisciplinary manner, especially regarding innovative activities and attitudes as change agents. Concomitantly, the emergence of new technologies and the increasing complexity of products, among other factors, have resulted in an increased product development period, and a proposed solution to this issue is the simultaneous engineering.

This scenario, coupled with the fact that the freshmen still have little knowledge available to be able to choose their specialty, spurred the current proposal of the Introduction to Engineering course at the CTC, PUC-Rio, which involves the implementation of projects that integrate several engineering areas and work by using concurrent engineering. Thus, this proposal aims to give students the opportunity to learn more about other engineering areas and not only the one indicated initially at the time of admission.

The students are, therefore, enrolled in classes in the specific engineering areas they indicated when applying to the university. These classes are divided into groups that make up the projects that integrate some engineering areas. To implement these projects, students attend both specific engineering classes and those that involve the different engineering areas of the project. Periodically, groups of all the engineering areas that compose the project gather, to assess their progress or to list the parameters (demands and specifications) necessary for its achievement. There is a coordinator for each project who is responsible for organizing the activities, along with the help of specialist teachers and support monitors in each of the areas involved.

An example of this approach, which has been held since 2008, is the **RoC** (**R**ace **o**f **C**hampions) **or Autonomous Ground Vehicles Project**, that involves the Control Engineering and Automation, Mechanical, Electrical, Computer, Civil and Production Engineering freshmen. The challenge essentially consists in developing an autonomous scale car that must be moved on a track, taking a pre-defined route, at a certain distance from the guardrails, without bumping into them, using sensors and / or a pre-established programming.

Each engineering area is responsible for a certain part of the project, namely:

- Mechanical Engineering - Vehicle Construction and Testing
- Control and Automation Engineering - Instrumentation and Simulation
- Computer Engineering - Vehicle Programming
- Civil Engineering – Runway fabrication
- Production Engineering - Project Management and Business

4 Results

From the undertaken questionnaires and reports, some important aspects about the current state of the course could be observed:

- **Difficulty level of the projects**. In some projects, the difficulty level is considered very high, beyond the capability of the students and, sometimes, even of the monitor. This difficulty is not only due to lack of knowledge, but also by the lack of initiative in searching for solutions. It became clear that the PBL methodology is too complex for a large number of students, and that they would certainly work better with more guidance from teachers using the hands-on approach. What is also observed is that not all teachers are really prepared for the implementation of the PBL methodology. The projects are considered real challenges both for the advising teachers and for the monitors that help, and of course, for the freshmen, who have never been exposed to this type of work before.

- **Devaluation of the course with regard to the number of credits.** The issue of why the Introduction to Engineering course does not have its workload increased was raised. The argument was that if the course increased its number of credits, students would strive accordingly, since this subject would then become more important in accounting for the Grade Point Average (GPA), which reflects the overall performance of students throughout the school year. Moreover, there is a consensus among students, monitors and teachers that there should be more time for project delivery. Also according to these teachers this point was emphasized, since the involvement and dedication necessary for project organization requires a much greater workload than normally given to "conventional" blackboard and chalk course, or, nowadays, "data-projectors" courses, and that they are, not infrequently, a simple transfer of the "pasteurized" knowledge found in text books. It is not enough to just prepare for the subject or the project once, because every term new steps must be performed with a new group of students, that should be formed so as to continue the project from the stage reached in the previous term.

5 Challenges

Some difficulties (Boud et al., 1999) have been found among the students and faculty involved in these projects. Among them, the following can be highlighted:

- Projects that involve concepts not yet learned in high school. The issues involved should promote the transfer of conceptual and procedural content, as well as attitudes, to the situations involved in the project. However, the teachers claim that they show a common doubt between teaching detailed content that students still are not substantiated enough to grasp, versus revising a few concepts in the form of a "black box".
- Joining PBL work alongside learning some of the fundamental concepts in Engineering. Due to the dynamic nature of the adopted methodology it is difficult to close class planning in advance, and some concepts are often no longer covered. Also, because it is student-centered, in a way, it's up to them how the course goes, which may differ from the way previously planned by the teachers. Another difficulty is the creation of evaluation mechanisms that indicate how deeply the students grasp these concepts.
- Get students to work in teams. During High School usually students are not encouraged to really work as a team. What often happens is group work, where some of the more passive students hide behind other more active ones, preventing equal participation. Students also do not always know how to

respect diverse opinions and build a consensus. Likewise, not all students show the same level of responsibility with regard to compliance with the timetable for the project planning.

- Have students identify what task they must perform. It was observed that this difficulty, as expected, was higher than estimated. According to the students themselves, the course lacks the assignment of more specific tasks by the teacher, a more objective approach, basically telling the students what to do. This was also expected, but not to the extent in which it was presented.
- Allowing the students increased opportunities to gain a broader view of the several engineering areas, without losing sight of their desire to deepen their knowledge within the area chosen on admission.

6 Final Considerations

The Introduction to Engineering course is becoming, year after year, of great importance for the CTC at PUC-Rio and its freshmen, since it has contributed to reducing the dropout rate and in supporting the increasing student interest in engineering. Some results can be seen as progress:

- Attitude changes in the classroom, by both students and teachers (with students becoming more active and teachers acting as mediators);
- The appreciation of individual student ideas, but also the socialization of these ideas with the whole group, contributing to the collective creation of knowledge for the development of respect and for the creation of critical thinking, fundamental for an engineer;
- Further development of oral and written expression;
- Greater student satisfaction for having their expectations met regarding learning more about their future professional area as well as having a broader vision in relation to other engineering fields;
- Greater student encouragement to seek participation in other activities such as class monitoring, scientific research work, or participation in student competitions.

Therefore, the improvements made in the course since its inception, are just some of many options that can be implemented within its current format. Regarding future work, we intend to strengthen the sense of Ethics and Social Responsibility, and of Innovation with Sustainability. Certainly many other developments are still ahead, but always seeking to meet the expectations of incoming students as well as making them experience and understand the procedures involved in the processing of engineering projects.

Finally, we observe that the Introduction to Engineering course supports and has served as a pillar for the development of the Lapin Project (Laboratory of Learning in Innovation), coordinated by Prof. José Alberto dos Reis Parise, under the auspices of FINEP and the CTC at PUC-Rio, and whose goals and guidelines are aligned with the current phase of the course.

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Project-based Practicum Experience in the Almadén School of Mines (UCLM. Spain): the Case of Mining and the Environment

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Abstract

The Almadén School of Mines (*Escuela de Ingeniería Minera e Industrial de Almadén*). University of Castilla-La Mancha, is a 230-year-old school of mines. adapting nowadays to the Bolonia criteria for technical studies. The practicum of subject "*Medio Ambiente Minero*" (Mining and Environment) has been implemented on the basis of projects to be carried out by the students, with the support of the teaching staff. We have established three model projects, based in the monitoring of mercury contents in air, soils and surface waters respectively, as a basis for a global environmental risk assessment. Their final output are isovalues maps of mercury in air and soils, and the final goal of integrating these information for the risk assessment is done in a general meeting of the whole group. Results of the first year of this activity have been very satisfactory.

Keywords: project-based practicum; mining engineering; environment; mercury.

1 Introduction

Environmental concerns are an important issue in Mining Engineering studies. In the Almadén School of Mines (University of Castilla-La Mancha, Spain) we aboard this subject on the basis not only of knowledge and comprehension of environmental implications of mining activity, but also on how an environmental study can be carried out, best techniques that can be useful, data treatment and conclusions of this kind of studies.

The Almadén School of Mines is a good scenario to develop a project like this, because it is located in the immediate proximity of a huge mercury mining district, the largest in reserves and production worldwide. Mining activity has ceased on 2003 but was active since romans times, producing a wide dispersion of this heavy metal in the environment. Teachers staff involves on this subject has been working in the characterization of these contaminated site during the last 10 years, acquiring information of mercury in all environmental compartments (Higueras et al., 2005; Molina et al., 2006; Martinez-Coronado et al., 2011; Llanos et al., 2011), as well as mercury speciation (Higueras et al., 2003; Esbri et al., 2010) as well as in how this mercury is transferred to the human population in the studied area (Díez et al., 2011).

2 Project

The main goal of the environmental project carried out by the students of the subject "Medio Ambiente Minero" (Mining and Environment) was to acquire data of mercury dispersed on Almadén town and surrenders in order to make possible an evaluation of mercury exposure of Almadén inhabitants. Three groups of students were selected to cover main environmental compartments (soils, water and air).

During project works, each group uploaded their data to the subject web, with the aim that all students could know the advances in monitoring works not only in their environmental compartment, but also in the others that could be related with their work.

2.1 Soil Group

Soils group carried out their research on the last contaminated site near the town of Almadén: Huerta del Rey. This was an ancient mining and metallurgical precinct that lacks any reclamation measures, and so it encloses a couple of old mine galleries, the rests of the metallurgical area (almost completely disappeared) and the rests of a dump of calcination residua (calcines). 10 soil samples were taken from inside this precinct, from the subsurface horizon (AC limit) (see figure 1 for more details), stored in plastic bags, annotated and carried to the laboratory for analyses. These included soil conductivity, reactivity (pH), organic matter content, clay content and total mercury concentration. Before analyses samples were dried, sieved to minus 2 mm and splitted to get aliquots for the different determinations. Each of the parameters determinations was carried out using the habitual procedures for commercial determinations of these parameters, including the mercury analysis by means of atomic absorption spectrometry.

Figure 1: Soil survey sites location (left) and performing the clay content determination (right).

2.2 Air Group

Air group developed their work in a sampling network covering the whole Almadén city (Figure 2). Measurements were carried out in 5 different days, during three months (October-December 2010), and included total gaseous mercury by means of a portable atomic absorption analytical device, as well as meteorological data (temperature, humidity, solar radiation and wind speed) by means of also portable devices. Every student had one device under his/her responsibility, with rotation for the different survey days, and another student annotated the data for each measuring site. Figure 2 displays the measuring network, and shows a photograph of the work in one of the sampling sites. It is interesting to note that one of the days the device did not work properly, what was discussed in detail during the survey.

Figure 2: Location map for the sampling sites (left) and three students measuring wind speed (right, on foot), mercury (center, seated) and annotation the data (left, on knees) respectively.

Data collected from the sites was analysed using different software, in particular numerical analysis and correlations between mercury contents and meteorological parameters was carried out using MINITAB 15.0 Statistical package, and the geographical distribution of the results was performed by means of SURFER 8.0 Surface Mapping software.

2.3 Water Group

The study of water group was focused on main streams from Almadén town and tributaries of Valdeazogues River, as well as main springs used by Almadén inhabitants (figure 3). USEPA protocol 1669 was used for sampling water and AMA254 for analysis of total mercury. Students receive a field book with USEPA protocol, sampling network proposed, goals of project and principles of analysis method. Students receive also a brief training on the best way to carry out the sampling during the first day. After that, they continue with the sampling autonomously. In the field, they had to select by their own the appropriate person to take samples, describe sampling site or acquire physical-chemical parameters, with freedom to decide, for example, if a rain period was interesting enough to take samples just after that, to know how much mercury is transported on mining drainage network when water volume increases.

In the laboratory, students receive a brief training on analytical procedures during the first day, and make the following analysis only with teacher aid to resolve problems with the equipment or interpretation of anomalous results.

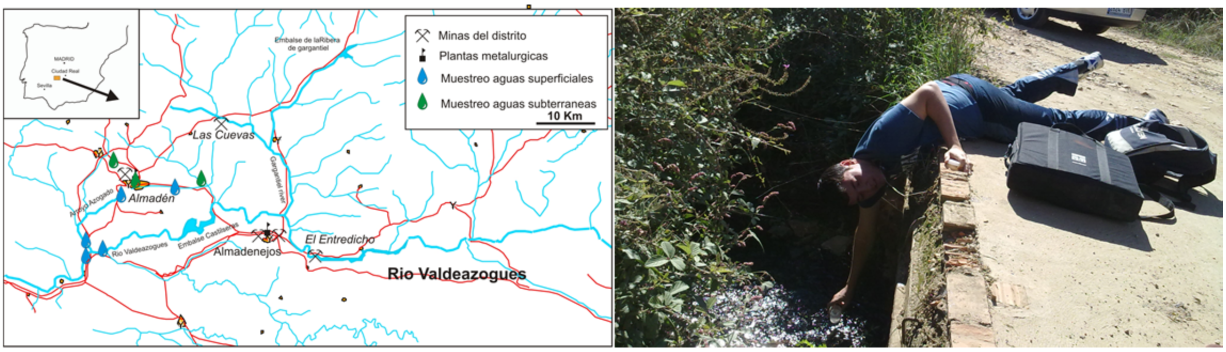

Figure 3: Sampling network of Water Group and a student taking a sample from La Pila stream.

2.4 Presentation of results

Each group made a statistical treatment of data and their own powerpoint presentation with the structure of a scientific communication: introduction, materials and methods, results and conclusions. During a three hours session, all groups explained their work and conclusions to the others, discussing their own data in relation with data acquire by the others groups and agreeing conclusions with teacher's suggestions.

In soils the results put forward that mercury contents in contaminated soils in the surroundings of Almadén were high to very high, in particular inside a decommissioned mining and metallurgical precinct (Table 1 and Figure 4). This was adequately interpreted as a result of the manipulation of the mercury ore, and the metallurgical activity carried out in the past in the area, as well as due to an inefficient reclamation of some minor dumps still present in the precinct. The conclusion was that the area deserves reclamation measures. In air, students found that mercury contents were lower than it would be expected. In the last years, the main mercury vapour source (dump of Almadén mine), were encapsulated, and so the presence of mercury vapour in the local atmosphere has fallen dramatically, from average values in the order of 1000 ng m^{-3} in 2002 to the averages below 100 ng m^{-3} calculated with the student's surveys. All this information was given to the students, so that they could also have a good indication of the consequences of the reclamation of a mercury mine dump.

Table 1. Main soil parameters and mercury content in soils from Almadén mining district

Sample	pH	Conductivity (μs cm^{-1})	Org. Matt (%)	Clay (%)	Hg (mg kg^{-1})
HR-1	6.2	646	2,4	12	195
HR-2	6.0	277	14,5	17	255
HR-3	5.7	193	10,5	16	715
HR-4	6.3	98	6,9	6	443
HR-5	7.3	387	3,3	17	3320
HR-6	6.8	138	10,2	15	2140
HR-7	7.9	252	9,3	13	1190
HR-8	6.3	143	11,5	15	421
HR-9	6.0	684	7,2	14	1390

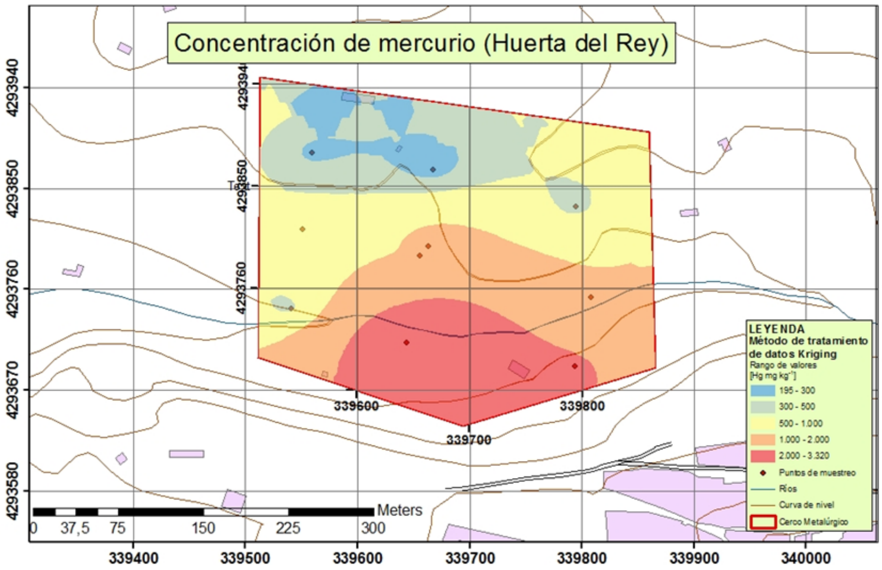

Figure 4: Mercury contents in the Huerta del Rey precinct.

In air, mercury contents were lower than it would be expected. In the last years, the main mercury vapour source (dump of Almadén mine), were encapsulated, and so the presence of mercury vapour in the local atmosphere has fallen dramatically, from average values in the order of 1000 ng m^{-3} in 2002 to the averages below 100 ng m^{-3} calculated with the student's surveys (Table 2 and Figure 5). All this information was given to the students, so that they could also have a good indication of the consequences of the reclamation of a mercury mine dump. The conclusion was that this reclamation process was very effective, minimizing in three orders of magnitude the local mercury gaseous mercury concentration in the town area.

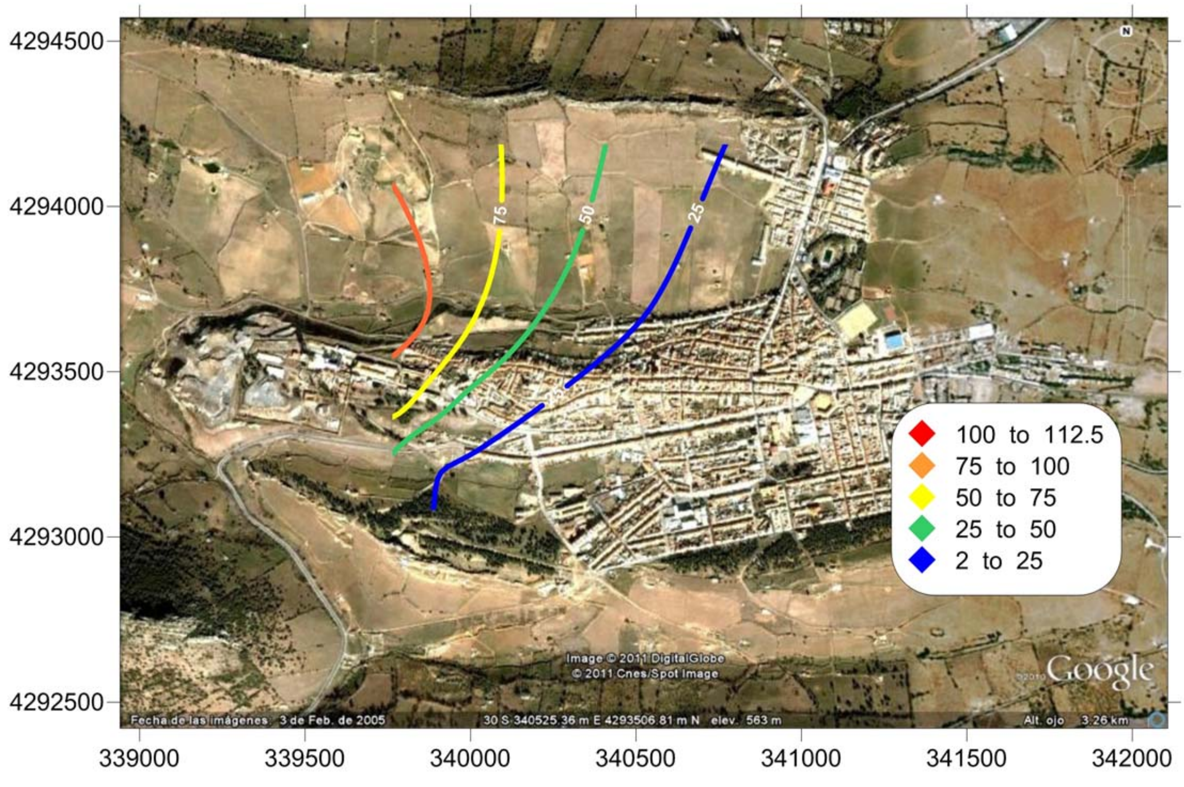

Figure 5: Map of mercury concentrations isolines at Almadén town. Values in ng m^{-3}.

Table 2: Atmospheric mercury concentrations from previous surveys, and from students' survey (last line, in italics). Values in ng Hg · m^{-3}

Date	N	Mean	GeomMean	Maximum
05/03/2003	9900	258	75	9485
03/05/2006	4351	887	81	49333
03/05/2006	3522	1128	32	23426
25/05/2007	4212	114	58	4359
19/11/2010	*4018*	*23*	*11*	*410*

Water Group analyse their physical-chemical parameters (table 3 and figure 6) and found that pH was neutral, between 6.6 and 7.8; conductivity was higher than in a clean environment (330-700 S µS cm^{-1}) and ORP was typical of oxidants waters (10-50 mV) except one sample they think was anomalous because the batteries equipment was exhausted. Mercury contents were higher in second survey due to a heavy rain period that lixiviates more mobile mercury species from soils and mining materials, but all mercury data were below limit for drinking water (1000 ng l^{-1})

Table 3: Mercury contents in waters from Almadén mining district

Location	Code	Hg (ng l^{-1})		
		Survey 1 (01/10/10)	Survey 2 (11/10/10)	Survey 3 (11/11/10)
Azogado 1	AZG1	33.9	77.2	26.9
Azogado 2	AZG2	12.1	87.4	41.1
Azogado 3	AZG3	54.9	91.9	49.4
Valdeazoge 1	VAL1	62.2	67.9	33.8
Valdeazoge 2	VAL2	16.0	20.4	17.7
El chorrito	PILA1	5.0	16.5	8.9
El chorrito	CHO1	13.4	9.2	14.5
Pilar de la legua	PILA2	16.0	22.8	14.0
Pilar de la legua	CHO2	6.9	7.0	11.2
Arrollo de la pila	ARROLLO PILA	14.0	16.1	9.4

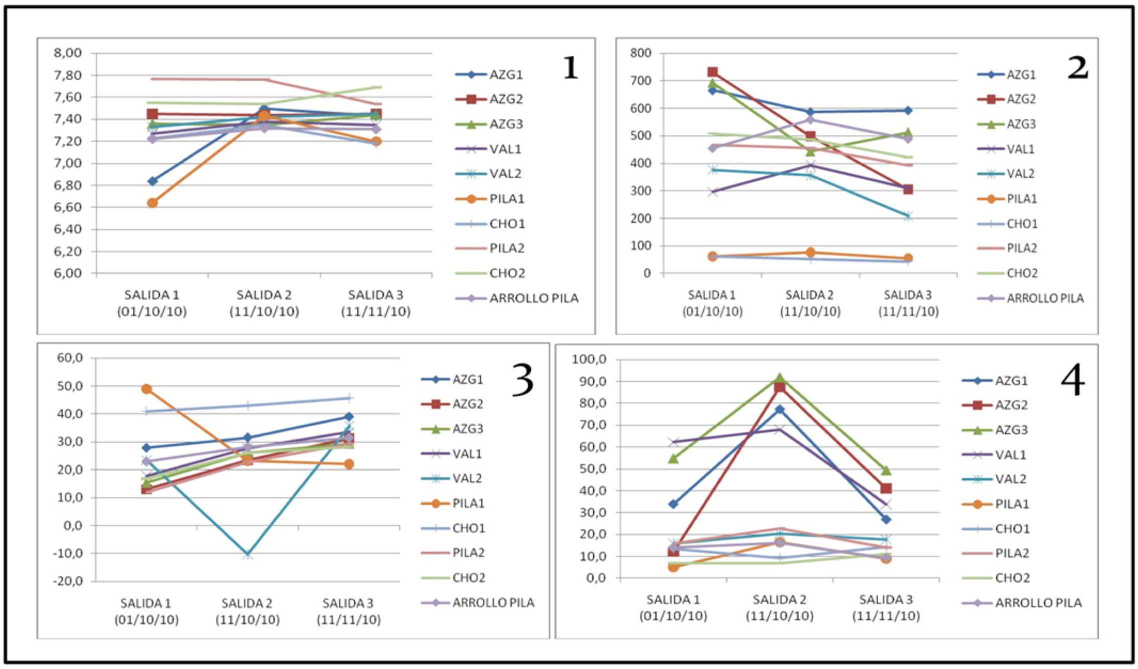

Figure 6: Physical-chemical parameters (graph 1-3, pH, conductivity and ORP respectively) and total mercury (ng l^{-1}) in waters from Almadén mining district (graph 4).

3 Conclusions

After finalization of the project, all students shows an acceptable degree of commitment, showing sufficient capacity to identify main sources of mercury in Almadén area, knowing natural dynamic of mercury in their environmental compartment and seems to have enough knowledge and capacity to apply principles of environmental assessment on mining activities, as well as capacity to get environmental data and integrate them with geological-mining data.

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The Blurred Line between Failure and Success in Student–Industry Projects

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Abstract

This paper presents a framework for describing various student–industry activities in terms of their relative positions on three scales and it further examines success factors for a specific student–industry collaboration model employed in engineering education: The Industry Link course. The Industry Link study indicates that the line between failure and success in student–industry projects is blurry: Projects delivering results that meet company requirements may fail to satisfy student aspirations, while other projects, which fail to meet company expectations, may be considered rewarding by students. The Industry Link study highlights the importance of the relationship between students and company representatives, as the quality of the relationship clearly influences both how students perceive their activities and the results delivered to the companies.

Keywords: Student–industry activities; collaboration strategies; real-client projects; project approaches.

1 Introduction

Student–industry activities are often heralded as win–win–win activities in which students gain knowledge of their future professional fields, companies access student knowledge, and universities both offer students stimulating learning opportunities and strengthen ties with industry. Student–industry projects can be defined as an active learning methodology characterized by pedagogical values such as improving student understanding of the concepts, motivation, interest in the subject, and work efficiency (Barak, 2009). Biggs and Tang (2009) find that a stimulating learning environment relies on three main components: 1. an open environment, 2. worthwhile tasks, and 3. demands that students can realistically hope to meet. In the same vein, Perkins (1991) stresses the importance of learners' attitudes towards the learning situation and of students' "buying in" to the instruction agenda, factors that are much more easily stimulated when students are confronted with real problems by stakeholders than when presented with constructed problems in simulated situations. Leenders and Maufette-Leenders (2010) argue that a fictitious scenario will not appear credible and not engage students the way an authentic situation does. Authentic learning "focuses on real-world, complex problems and their solutions" (Lombardi, 2007), and introduction into a professional environment helps students become "enculturated" into the discipline, a crucial concept according to Lave and Wenger, as "a training program that consists of instructional settings separated from actual performance would tend to split the learner's ability to manage the learning situation apart from his ability to perform the skill" (1991). University representatives generally agree that student–industry activities make students more employable after graduation (Dawson et al., 1997). Seen in this light, one may wonder why so many student–industry activities are established, only to survive a few iterations. Student–industry activities are by no means homogenous, and include a wide variety of collaboration models ranging from short undemanding meetings between students and industry representatives to long complex relationships demanding considerable effort from universities, companies, and students alike. We have no reason to believe that the success factors for these widely divergent collaboration models are identical. In approaching the concept of "success", we find it desirable to distinguish between various student–industry activities in a defined framework. In the project management field, critical success factors are often discussed and identified (Pinto and Prescott, 1988; Westerveld, 2003); to better the odds of survival of student–industry activities, the same needs to be done in the field of university–industry collaboration to create more stable student–industry activities.

2 Research questions

The research presented here investigates the collaboration between industry and higher education institutions and identifies possible success factors in a specific student–industry collaboration model. More specifically, we seek to answer the following questions:

- How can various collaboration models be categorized?

- How can a successful “Industry Link” project be described?
- What are the success factors for Industry Link projects?

3 Study

The research presented here investigates the collaboration between industry and higher education institutions and identifies possible success factors on four levels (Figure 1).

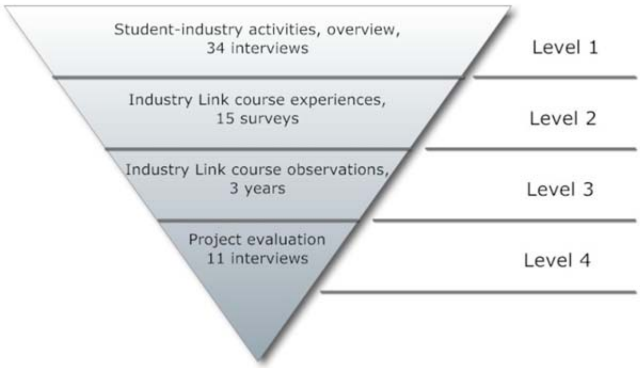

Figure 1: Structure of the present research

The top level and starting point of this study is the initial interview study involving 34 in-depth interviews. The interviews were based on a flexible design (Robson, 2002) incorporating semi-structured (i.e., open-ended) questions. This top-level study focuses on engineering education, understood broadly, in order to include a variety of student–industry activities. All interviews except one face-to-face interview were conducted over the phone and lasted 20–30 minutes. The interviewees were staff from thirteen companies, eight teachers representing four universities, and thirteen students; all interviewees had experience of student–industry activities. Before the analysis, all interview material was fully transcribed. The material was coded according to predefined categories and analysed and discussed by us before the results were recorded. From the results of the interviews, two main collaboration models were identified: 1. collaboration models delivering real results to industry (e.g., projects and theses), and 2. collaboration models not delivering real results to industry (e.g., guest lectures and study visits). A third hybrid category was also identified: 3. collaboration models in which the output depends on the interpretation and implementation of the collaboration model (e.g., workshops and practical training). These three categories were then used to further categorize the various collaboration models according to their characteristics.

We designed a framework for describing and grouping student–industry activities that would allow a structured approach to the various activities. The framework describes student–industry activities in terms of their relative positions on three scales capturing: 1. type of contact between student and company; 2. student activity in relation to the company, and 3. degree of student responsibility in relation to the company. We then decided to examine, in greater depth, a specific collaboration model belonging to the first category, i.e., collaboration models delivering real results to industry. The “Industry Link” project course was chosen for this closer scrutiny in what constitutes level two of the study. Industry Link is taken by students in their third year of a three-year computer engineering programme. The course lets students prepare for their future professional careers and facilitates their introduction to the industry. More specifically, the students should be able to work in teams and to participate actively in a project-driven environment in collaboration with industry. Students taking the course are divided into project teams of 5–7 members, and each team is assigned to a company and presented with a problem formulated by the company. Several companies are involved, and each project team works on a unique problem. From a pedagogical perspective, the central aim of Industry Link is that students should achieve learning outcomes that foster understanding of the project development process and, specifically, of their own roles in projects. The Industry Link project is a subset of the whole course.

The 15 students who took the course in the same semester were surveyed using paper questionnaires. This survey derived and documented broad experiences of the collaboration model represented by the Industry Link course. We then analysed and discussed the gathered material before substantiating the results.

To identify the success factors for Industry Link, during level three of this study, the course was observed and logged for several years. All experiences, changes, and evaluations were logged and documented in a study protocol. The observations and documents regarding Industry Link were coded, first, in a first-level coding into key areas and then in a second-level pattern coding in which the initial codes were broken down into a number of subareas. We then analysed and discussed all the coded material, drawing conclusions after reviewing the coded text. The results of the survey and observations were used as a framework for level four of the study: an interview study of 11 students who had participated in the course. The interview study aimed to pinpoint what makes a project in a project course, such as Industry Link, successful from the student perspective. Projects from the Industry Link course were randomly selected, and the students involved in the selected projects were contacted and interviewed. As in the top-level interview study, the interviews were based on a flexible design using open-ended questions. Seven interviews were conducted over the phone and four were conducted in person; all interviews lasted 20–40 minutes.

The final deliveries from the student teams to the companies (logged during level three of the study) were evaluated against the initial project descriptions and divided into three categories: 1. successful delivery according to project description, 2. partly successful delivery according to project description, and 3. unsuccessful delivery according to project description. The student evaluations of the Industry Link project, derived from the level-four interview study, were then mapped against the company delivery categories. Two more mappings were also conducted: the second mapped student evaluations of the company relationship against student evaluations of the Industry Link project, while the third mapped student evaluations of company relationship against delivered results.

3.1 Validity

According to Yin (2003), validity can be categorized as construct validity, internal validity, external validity, and reliability. Construct validity can be threatened by participant bias, i.e., the participants may misunderstand terms or questions and interpret them differently, which is a threat in both interview and observational studies. To reduce this threat in the four levels of this study, the interviewer was able to give explanations during the interviews to prevent misunderstanding. Participant bias could still pose a threat in this study if interviewees deliberately answered incorrectly, for example, focusing excessively on their own side of the story, articulating a distorted view of reality, and trying to defend their own actions. There is also a risk that interviewees might feel they were being evaluated, since the university commissioned the interviews, even though the interviewers were external and it was initially explained to the students that this was an independent study. A threat to external validity is that participants may not be representative of the target population; to reduce this risk, all interviewees were required to have personal experience of student–industry collaboration activities. While we sought to reduce internal validity threats, we drew no conclusions as to causal direction. Researcher bias must not affect the interpretation of the material, since this would threaten reliability, so after the interviews and observations were completed, we provided valid descriptions of them. Observer triangulation (Robson, 2002) was implemented by having two researchers with different roles cooperate during the study, and by considering alternative interpretations and explanations. Both observer and data triangulation were used to reduce the risks of reactivity (Robson, 2002) and respondent bias. Using data from a range of sources, i.e., interviews, observations, questionnaires, and documents, we achieved data triangulation.

4 Results

4.1 Framework for defining and grouping student–industry activities

The level-one interview study revealed a large number of differently named and structured student–industry activities, some of which shared some similarities. There is little doubt that the activities also differed in applicability, as any given collaboration model will be better suited to certain learning situations than to others. Likewise, the success factors for one activity will differ from those for another. A tool is obviously needed for describing and grouping collaborative activities. As our main concern here is student–industry dynamics, the framework used is based exclusively on the interaction between student and company. The collaboration models encountered in the level-one interview study would typically differ (or be alike) in relation to three sets of parameters. We therefore suggest a framework for describing various student–industry activities in terms of their relative positions on three scales. The first scale concerns the *type* of contact between student and company. Activities that help students get an inside view of the company, to understand its internal structures and processes may include: individual contact with company representatives, being present in the company, and participating in company activities. A different type of activity, such as guest lectures, may offer students inspiration, but does not give them firsthand experience of the company and its day-to-day activities; such activities can be said to give students an outside view of the company. Accordingly, a student–industry activity can be described by its relative position on an inside view–outside view scale. The second set of parameters concerns the degree to which a student is *active* in relation to the company, i.e., whether or not the student is working actively on a company assignment, is forced to

relate to company requirements, or has to deliver some sort of result to the company. The second scale describes the degree to which a student participating in an activity is expected to be active or passive. The third set of parameters concerns how much *responsibility* is placed on the student. As our main concern is the relationship between student and company, the parameters we include in our description of responsibility concern responsibility for an activity, for maintaining relationships with company representatives, for following the agreed-on time schedule, and for ensuring the delivery to the company is timely and of the right quality. When applicable, the parameters may also indicate whether the project outcome has potential to affect the company.
Three collaboration models, one from each of the three main categories (i.e., collaboration delivering real results to the company, collaboration delivering no real results to the company, and a hybrid type of collaboration where output depends on the interpretation and implementation of the collaboration model), illustrate how relative placement on the three scales can describe the student–industry activity. It should be noted that, as several variations have been encountered in the study, the charted value is what is typical of the encountered models.

Project courses, as a type, exemplify collaboration models that deliver real results to the company. Students participating in such courses must typically work actively and be responsible for both process and outcome; although they are collaborating with the company, they are not as a rule involved in the company's ordinary workflow (Figure 2).

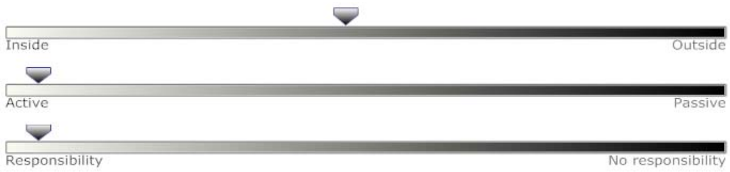

Figure 2: Project course, a type of collaboration delivering real results to the company.

Guest lectures exemplify collaboration models that do not deliver results to the company. When students attend guest lectures they may become inspired and gain new insights, but the guest lecture offers no first-hand company experience, the activity is performed by the lecturer, and students have no responsibility for carrying out the activity (Figure 3).

Figure 3: Guest lecture, a type of collaboration delivering no real results to the company.

Internships represent the hybrid category of models, in which the output depends on the interpretation and implementation of the model. The form of internship encountered in the study was one-semester placements at a company; in these, students participated actively in day-to-day activities at the company, but were not personally responsible for processes or projects (Figure 4).

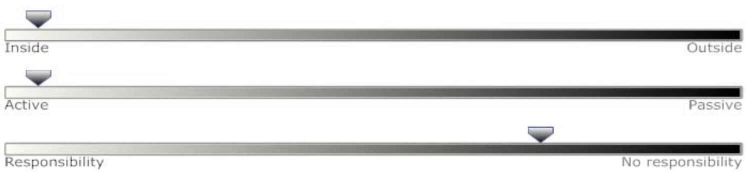

Figure 4: Internship, a hybrid type of collaboration.

4.2 Industry Link course: three dimensions of success

The Industry Link course belongs to the subcategory "project course" in the category "collaboration models that deliver real results to the company". The project part of the course is student driven and the student teams bear responsibility for all communication with the company. They are also fully responsible for both the project process and final delivery to the company.

Traditional university courses involve two parties, university and students, and the relative success of a university course is usually determined using two instruments: an examination and a course evaluation. The examination allows university representatives to describe, as objectively as possible, the degree to which students have achieved the course's learning outcomes, while the course evaluation encourages students to describe their relationship with the university and to assess their own learning. The moment we engage in student–industry activities, the dynamics of the learning situation change fundamentally: a third party from outside – a company – is introduced. Involving industry directly in education adds a new dimension to determining the relative success of a course. Not only should students achieve the learning outcomes formulated by the university, find the course worthwhile, and have a satisfactory relationship with the university; in addition, interaction with the company should be rewarding and, in the case of student–industry projects, students should also deliver a result to the company. From a pedagogical perspective, we may wish to view industry, in this context, as an extension of the university, providing valuable learning environments for students, but industry's main concern is not educating students. A company will bring its own definition of success to the collaboration. An earlier study (Jensen and Lindholm, 2011) of the motives of universities, students, and companies for entering into student–industry collaboration demonstrated that the single most important reason for a company to engage in student projects was to access student knowledge to create value for the company: A company hosting a student project expects the student team to deliver an acceptable result.

Every interviewed student in the Industry Link study had passed the course exam at the time of the interview; one student had initially failed the exam, but passed it on a second attempt at a later date. By university standards, every student in the study had succeeded.

As the main reason why companies collaborate with students is to access the value they generate, we may regard successful delivery to the company as indicating that the company finds the activity a success. The scope and planned results of an Industry Link project are described in the student team's project plan, and a more detailed description is found in the requirement specification; both the project plan and requirement specification are continually revised during the project process and discussed with both company representatives and university supervisors. Frequently, a company will rethink the project goals, as the team's and their own knowledge of the problem increases, and these changes are then reflected in an updated project plan and requirement specification. This results in a final project plan and requirement specification that together outlines the delivery the company expects at the end of the project. Comparing the student teams' actual deliveries with the teams' project plans and requirement specifications indicated that six of 11 Industry Link interviewees had participated in projects with results that met company expectations, three had participated in projects with results that partly met company expectations, and two had participated in projects that did not meet company expectations.

Success from a *student* perspective was explored in the interview study. During the interviews, students were asked to describe whether they considered their Industry Link project a success or a failure: seven interviewees declared their projects successes (i.e., a positive evaluation), two partial successes (i.e., a neutral evaluation), and two unequivocal failures (i.e., a negative evaluation).

4.3 Student evaluation of the Industry Link project

At first glance, it would seem that a positive, neutral, or negative student evaluation should largely coincide with a successful, partially successful, or unsuccessful delivery to the company. However, when student evaluations are mapped against the three categories, a surprising picture emerges (Figure 5). In seven of 11 cases, the relative success of the delivery is not correlated with the student evaluation of the project.

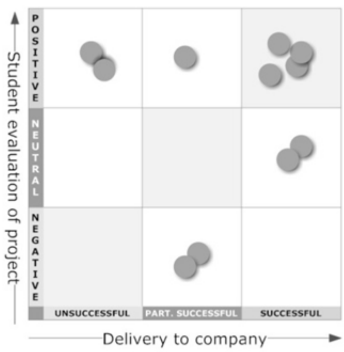

Figure 5: Mapping student evaluations against successful, partially successful, and unsuccessful deliveries to hosting companies.

Obviously, students evaluate the Industry Link projects independently of the delivery to the company. The interviewees were clearly aware of the status of the final delivery to the company, but this did not influence how they judged the project. "The result was a success – we delivered what we were supposed to, but it wasn't a very good experience", one student commented. Another student said, "I think it was good, because you got to see how you worked on projects – that was overall a useful experience"; later in the interview, that same student went on to describe practical problems and concluded "… so we didn't finish the project". Notably, the student who, throughout the interview, most consistently expressed a positive attitude to the Industry Link project, had participated in a project in which the team failed to deliver acceptable results to the company: "It was a fantastic project. We had difficulties. It was really tough – we just wanted to skip the whole project. But now afterwards … we have learned valuable lessons. I am grateful that we had this project and that we had these problems". Later in the interview, he added: "I am glad that we made our mistakes in school – better than making them as professionals. Now I know what to do – think ahead, every step of the way – not just jump in". Interviewees who had participated in teams that delivered adequate results expressed satisfaction that the project assignments were completed and met company requirements and expectations, but this did not automatically lead them to describe the project activity as successful. Likewise, some, but not all, of the students whose teams had failed to deliver the expected results to the companies expressed mild regret that their teams had not delivered the planned results, but none of them rated the Industry Link course in accordance with the quality of their team's delivery.

Nine of 11 interviewees mentioned experience of and insight into professional working situations as positive outcomes of the Industry Link course. Five interviewees also mentioned personal contact with companies and company representatives as a positive outcome, while four interviewees stressed that they had come to trust their own judgment more and come to see the importance of taking one's own initiative.

4.4 Industry Link project: three relationships

Students engaged in Industry Link projects have three types of working relationships: with fellow team members, university supervisors, and company representatives.

4.4.1 Team relationships

One learning outcome of the Industry Link course is the ability to work in a team. The student teams are free to create their own internal organization, but must be able to describe the team structure; the individual members must formulate what they themselves bring to the team and what they expect from their fellow team members. All interviewees expressed satisfaction with their teams. Most interviewees (eight) had clearly defined roles and responsibilities in their teams; several of these commented on the positive effects of clearly defined roles, which were found to be especially useful when handling internal conflict. One student, whose team did not have a clear distribution of roles and responsibilities, regretted this and described this lack as a "failure".

4.4.2 Relationships with supervisors

One defining feature of Industry Link projects is student ownership of the projects; accordingly, university supervisors primarily concern themselves with how the teams are handling the project process and are seldom actively involved in the team's actual problem analysis, design, or implementation. This is reflected in how students from Industry Link projects comment on their relationships with their supervisors. Ten of 11 found the relationships "OK" or "good", while one found the supervisors "distant". Eight interviewees thought that their supervisors had exerted little influence on the project outcome, while three found the supervision constructive. Several interviewees commented that they found the different expectations of the company and university (as represented by their supervisors) disconcerting: the company wanted a delivered result, while the university also expected students to analyze and question suggested solutions.

4.4.3 Relationships with company representatives

While the interviewees differed little in their evaluations of both team relationships (very good) and supervisor relationships (acceptable), they had markedly dissimilar experiences of company relationships. Six interviewees described their relationships with company representatives as very good, finding that they were highly accessible, answered questions promptly, readily gave feedback, and reacted quickly to requests. Three students rated their relationships with company representatives as very poor. They all described that their first interactions with the company went as planned, but before long, company representatives repeatedly postponed or cancelled meetings, were slow responding to e-mails, and were unresponsive to phone messages. Two students had experienced unengaged company representatives, who had at times been difficult to contact and slow to answer questions, so these relationships were described as only partly acceptable. When mapping students' evaluations of their company relationship against their evaluations of the Industry Link project as such (Fig. 6), it appears that, in eight of 11 cases, students' evaluations of the Industry Link project were consistent with the quality of their relationships with the company, in two cases partly consistent, and in one case inconsistent. It is hardly surprising that the relationship with the company is important to how most interviewees evaluate the Industry Link project. To three of the interviewed students, however, other factors were obviously more influential than were company relationships when evaluating the Industry Link project. All three of them cited the same reason for their diverging evaluation: experience of their future professional field. Valuable experiences caused two students with poor and adequate relationships with their company to rate the Industry Link project a success. They commented: "Actually, it was very good, because you got to see what the working field was like, you learned how to contact people at a company" and "I thought it was good, because you got to know how to work on a project and how everything works. You learned to take the initiative. It was a good experience". The third student who had experienced a good relationship with his company, but found the Industry Link project only partly satisfying (rated "neutral" in Figure 6), explained that he already had years of professional experience, so working with a company presented little that was new, although he was convinced that his fellow team members had benefited greatly from being confronted with the company's expectations and requirements.

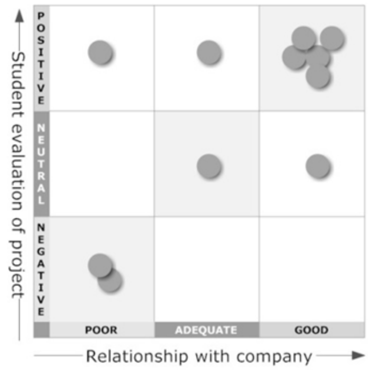

Figure 6: Mapping student evaluat. of company relationships against student evaluations of the Industry Link project.

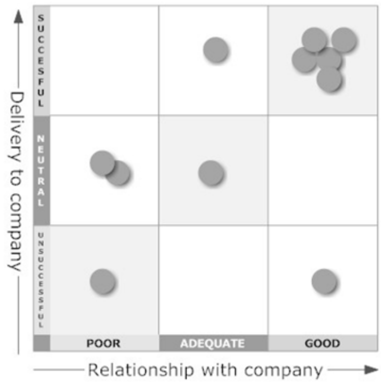

Figure 7: Mapping student evaluations of company relationships against delivered results.

Mapping students' evaluations of their company relationships against the quality of the results delivered (Figure 7) reveals that in seven of 11 cases the students' evaluations of their relationships with the company are consistent with the quality of the delivered results. Three students delivered more successful results to the company than would be expected from their poor or mere adequate evaluation of the company relationship. All students cited good working relationships in the team as the most important reason for their relative success. One student reported that, despite having a well-functioning relationship with the company, his team failed to deliver an acceptable result. This student said that the working relationships in the team were good, but that the team found the project process difficult to handle; notably, a number of process restarts are recorded in the logged material for this project team.

5 Discussion and conclusion

The Industry Link case indicates that it is not a foregone conclusion that student–industry projects lead to win–win–win outcomes. Projects delivering results that meet company requirements may fail to fully satisfy student aspirations, while other projects, which fail to meet company expectations, may nevertheless be considered rewarding by students. In fact, one project examined in this study, which failed to deliver an acceptable result to the company, gave rise to an exceptionally positive evaluation by a participating student. Student learning is one of university's main concerns and, from a *pedagogical* perspective, it is irrelevant whether or not a project delivery satisfies a company, as long as students achieve the learning outcomes and evaluate the learning experience positively. However, from a *strategic* point of view, it is in a university's best interest that companies involved in student activities should find the collaboration rewarding. A company that is satisfied with the project outcome is more likely to continue collaborating with the university and to have a positive impression of both students and university. The challenge facing the university is to groom as many projects as possible to be true win–win–win enterprises. The Industry Link interviews highlight the importance of the relationship between students and company representatives, as the quality of the relationship clearly influences both how students perceive their activities and the results delivered to the companies. Regarding *how students perceive* the project, a less than perfect company relationship can be compensated for by valuable experience, for example, yielding insight into professional working conditions and how projects are conducted at companies; when it comes to the *result* delivered to the company, a weak student–company relationship can at least be partially compensated for by an internally well-functioning student team.

The Industry Link project belongs to the group of student–industry activities that deliver results to companies, and one of its characteristics is a high degree of student responsibility for both process relationships and outcomes. The Industry Link case indicates that three success factors relating to a student perspective are essential for an overall successful outcome when engaging in this type of student–industry collaboration. The first and most important is a well-functioning relationship between student team and industry representative.

This implies that the university should devise strategies for supporting the personal relationship between student and company, preferably without undermining student responsibility for the enterprise. The second success factor is well-functioning student teams. Effective tools supporting stable and well-functioning teams, including clearly defined roles and clear division of responsibility between team members, seem to increase the probability of successful outcomes. The third success factor is the scope and quality of student experience. Course directors and teachers may support this by constructing frameworks and assignments that lend themselves to varied experiences in terms of both project processes and interaction with the company.

As the success factors for the Industry Link course are closely connected to the type of student–industry activity and its characteristics, further study will be needed to investigate the success factors in other collaboration models.

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Peer-Assessment in Projects: an Analysis of Qualitative Feedback

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Abstract

Learning through projects can increase involvement of students in the assessment process, especially in the assessment of the development of transferable competencies. The responsibilities in the assessment process can be shifted from the teacher to the students, so that the students become engaged in a process that helps them to analyse and understand the way they perform in a group project and how this performance contributes to the final result of the project. In the context of a 15 ECTS course at the second and final year of Informatics Engineering Master´s Degree programme, students had to carry out a project in the first semester. The performance of each student was evaluated through peer assessment in subgroups. This paper describes the peer assessment schedule that was used, analyses the qualitative comments that were given and reflects on the impact of the peer assessment scheme on the results of the project.

Keywords: peer assessment; feedback; team work.

1 Introduction

Assessment of learning in project-based approaches is often considered complicated. For both teachers and students involved in project-based learning, free riding is the focus of many complaints (Brooks & Ammons, 2003). Free riding or social loafing (Powell & Weenk, 2003) means that not all students do a fair part of the work that has to be done for a project. Some students contribute much more than others, although all may end receive the same final grade for the group work, which can have a moderating effect on the final individual grade (Almond, 2009), an effect especially not wanted by the best students, who tend to receive a lower grade in this case. Another aspect of assessment of projects is the assessment of both the final result of the project as well as the individual learning results of the students. On the one hand, students have to work on a real problem that needs to be solved by in the end. The project requires a working solution, a prototype, a report etc. On the other hand, the students have to develop a number of technical and transferable competencies at the individual level. There can be tension between these two outcomes, as the project work itself does not necessarily guarantee the development of technical and transferable competencies and formative and summative assessment are usually used to assure that students develop competencies in the different disciplinary areas related to the project.

Projects provide learning experiences for the development of both technical and transferable competencies and both need to be assessed. The instruments that are used for the assessment of technical competencies can, partly, be used for transferable competencies as well. A final report, for example, can be used to assess the quality of the solution for a specific technical problem. At the same time, the report provides information that can help to assess the students' writing skills. With just one specific assessment instrument, one cannot easily test other transferable competencies. Leadership, interpersonal communication, teamwork and time management can hardly be tested by a formal written test, which would be appropriate for specific technical competencies. As a response to these and other difficulties, peer and self assessment methods have been implemented in project-based learning in many ways. This paper discusses the characteristics of peer and self assessment methods in group work and describes a project experience in which those methods were used in large groups of students.

2 Peer assessment in group work

Peer- and self assessment of learning shift responsibilities from teachers to students. In peer and self assessment, students are responsible for the complete or partial assessment process, starting with the definition of the assessment method, the definition of criteria, continuing with the evaluation and feedback process and ending with the grading, if required. Topping (1998) defines peer assessment as 'an arrangement for learners to consider and specify the level, value or quality of a product or performance of other equal-status learners' (p. 20-21). In his review on peer assessment, the author gives a typology of peer assessment in higher education, identifying 17 parameters of variation between peer assessment projects reported in the literature. In this study, the peer assessment component of the project was used to assess the development of transferable competencies related to group work. The goal was mainly formative, but the peer assessment scores also led to a final grade that serves as a correction factor for the project grade.

Peer assessment in project approaches is used for the assessment of technical as well as transferable competencies. The use of peer- and self assessment methods for transferable competencies often happens in project approaches. Many of the transferable competencies that are developed through the teamwork are not visible for teachers, so students themselves need to monitor the development process through peer- and self assessment. Leadership or communication within the student team cannot easily be assessed by someone who is not actively participating in the team work. Therefore, the team members themselves assess their own performance and the performance of their peers. They are the only ones who can obtain a realistic perspective on the performance of team members within the team. Although questions can be raised on the validity and reliability of peer- and self assessment for transferable competencies, most students are able to assess themselves and their peers, so students participate actively. The shift or responsibilities from teachers to students though, can be almost complete or rather limited. In some project experiences, students are limited to filling out a small number of questionnaires developed by their teachers. Other projects allow the students to think about the assessment methods and instruments themselves and making them plan most of the process. In this way, students experience an increased responsibility and are no longer carrying out activities that are planned by others. Their sense of ownership of the processes increases.

Peer and self assessment make the learning approach of students more profound (van Hattum-Janssen, Pacheco, & Vasconcelos, 2004). Students learn less superficial, as they need to reflect on the material several times, in order to be able to make a meaningful judgment on the work of the peers. Making these reflections explicit as part of the grading process, helps on the one hand to prevent inflation of grades and on the other hand serves as feedback to those who receive the grades. A team of students or an individual student grades a peer and subsequently justifies this grade. The justification serves as information for the teachers on the motives of the grade and also serves as feedback for the student who receives the grade. In this way, the process of grading and giving feedback is intertwined. Cheng and Warren (1999) use a number of studies to illustrate that peer assessment excels traditional methods of assessment in a number of ways. They refer to more valid, reliable, practicable, fair and useful assessment, to the contribution to student-centred learning through the training of students to judge the quality of the work of others objectively, and to the critical reflection of the learning experiences. In the context of engineering programmes, peer assessment has shown to contribute to greater student involvement in the subject, enhance motivation and deepen student learning (Fernandes, 2010). Liu and Carless (2006) make a useful distinction between peer-assessment and peer feedback, the latter being primarily about rich detailed comments but without formal grades, whilst peer assessment denotes grading (irrespective of whether comments are also included).

Creating more opportunities to provide feedback to students through peer-assessment is perhaps its most important feature (Topping, 2009). Students receive comments on their performance from more than one peer at several moments during a project semester. A difficulty with peer-assessment and in particular with peer feedback can be the reluctance to criticise peers (McMahon, 2010). Students do not feel at ease criticising their peers and may have a tendency to make rather general comments that do not help their peers to improve their performance. In this study, the comments of students were analysed to establish what types of comments students make and to what extent the nature of the comments changes along the process of project work.

3 The project at Informatics Engineering

The peer-assessment and feedback as used in this study took place in the context of a 15-ECTS course in the Master´s Degree programme in Informatics Engineering. In this course, students attend seminars given by invited speakers, both from industry as well as academia, they write a state-of-the-art report on a topic they choose, and they carry out a software project in a large team of students. The development of a realistic and product-focused software project, sufficiently complex and requiring the development of competencies that can only be fulfilled by a reasonable large team, is one of the main goals of this course. The project was aimed at developing both technical as well as transferable competencies. Teams of around 15-20 students were created in order not to exceed a maximum of four teams in total. In the teams, students were supposed to:

- Organise themselves and find the best people for all tasks
- Promote team leadership, internal reporting and project management practices, making students reflect on the team role that suits them best, given their personality, background and experiences.

- Hold weekly management meetings with the teachers –that act like managing directors of a company–, in order to assess the project overall status and to raise issues that needed to be tackled by the teachers.
- Dedicate one full day a week to the project on-site, although collaborative electronic work was encouraged.
- Use wikis and other collaborative tools extensively, in order to create the necessary documentation support to the teams.
- Work on project planning and issue tracking, to allow the team management to have an overall view of the project status.
- Organise weekly reporting to the management.
- Held regular meetings with the clients to ensure validation of the requirements.

Projects were either proposed by students or proposed by external customers, the latter providing a better simulation of the conditions that students will find in their professional lives. Four projects were developed: external customers proposed three and the other was suggested by a group of students. The first project was the development of a virtual tape library (VTL) proposed by a local company. VTL is a data storage virtualization technology used for backup and recovery purposes. The second project was the development of a module for floating insurances for integration with the ERP system of a insurance broker. The third project aimed to develop a software application for managing the digital signage of an organisation. The client of this project was the Department of Informatics of the University of Minho, although the students were challenge to make the solution as generic as possible. A group of students, all members of a local student association, proposed the final project. They developed a web-based application for the management of student associations, including support for managing the members, for managing and planning activities of the group, and for providing a web presence for the group.
The student teams were formed randomly and the leaders of each team had the possibility to exchange students between groups. Most teams were around 15-20 students and the team members chose the leader of the team. Each team divided itself in sub-teams, dedicated to specific tasks.

4 Peer assessment

At the very beginning of the project, the teacher explained to the students that peer assessment would be part of the assessment method of the project, focusing on processes that are mostly visible to the students. They received a brief explanation on the characteristics and the use of peer-assessment in team work. In order to increase the involvement of the students in their assessment, they were given the responsibility to define criteria for the assessment of their peers with regard to the team work. According to the instructions of the teacher, students had to

- Define five to seven criteria for the assessment of the team work of their peers;
- Establish relative weights for each of the criteria; and
- Describe the criteria in such a way that interpretation by all team members is likely to be similar.

They had a limited amount of time in the lesson to work on the criteria and they had to send the criteria and the descriptions to their teacher by e-mail before the end of the week. Students were informed that peer-assessment would take place four times during the project and that the result would lead to a correction factor that would be applied to the grade that the student team would receive at the end of the project. Web-based forms to carry out the peer-assessment sessions were developed, based on the criteria of each group. In each group, sub-groups were created and students had to decide on a schedule of who is assessing whom. As the goal of this peer-assessment is formative, students were asked to not only grade the performance of their peers, but also to give comments that would help their peers to improve their performance.

At the end of the semester, students completed a questionnaire on the whole course, including 7 specific items on the peer-assessment method adopted in this course.

5 Results

The four teams defined criteria and relative weights of the criteria. The criteria were sent to the teacher together with a short description that helps the students during the peer assessment process. Team 1 established punctuality (0,10), transparency (0,30), complying with deadlines (0,30), proactivity/initiative (0,20) and critical attitude (0,10). Team 2 also defined five criteria and sent the following list to the teacher: effort (0,30), assiduity (0,10), quality of work (0,25), team work (0,20) and complying with deadlines (0,15). The third team also included assiduity (0,20), complying with deadlines (0,20) and team work (0,20) and have established organisation (0,15) and conclusion of tasks (0,25) as well. The fourth team proposed conclusion of tasks (0,60), assiduity in meeting (0,10), number of working hours (0,10), proactivity (0,10) and creativity (0,10) as criteria for peer assessment.

Students graded each other in sub-teams and wrote a justification of the grades they attributed. These justifications also served as feedback as they were available to the students who received the grades. The comments of the students that accompanied the grades at each one of the four assessment moments were analysed and categorised. Four apparent categories were defined at first, based on the intents of formative assessment as defined by Topping (2009): identify strengths, identify weaknesses, target areas for remedial action and the development of professional skills. The remaining comments were divided into six different categories. The following table describes the categories as used for the content analysis:

Table 1: Categorisation of comments

Category	Description	Examples
1. Identification of strength	Identification of a strength in the behaviour of a student in the project team	*He is very punctual and has taken initiative.*
2. Identification of weakness	Identification of a weakness in the behaviour of a student in the project team	*Always too late. Works less than the rest of the team.*
3. Remark on specific task	Comment related to specific tasks in the project	*Worked on the codification. Did the Wiki's, Took care of the wireframes.*
4. Remedial action	Comment aiming to improve the behaviour of the student	*He should take more initiative.* *She needs to worry more about the deadlines of the tasks she is doing.* *He must communicate much more.*
5. General encouragement	Comment aimed at praising a student for his or her effort	*Good work!* *Congratulations!* *Please go on like this.*
6. Justification of grade	Comment explaining why a certain percentage was attributed to a student	*There is nothing to improve in terms of team work, so I gave 100%.*
7. Specific comment on transferable skills	Comment aimed at the development of a specific transferable skill	*He is a good leader.* *Needs to work on critical attitude.*
8. Not enough information	Statement of inability of assess due to lack of information on the behaviour of a student	*The student has not done enough yet to be able to assess this criterion*
9. No comments	Observation stating that a there is nothing to say about a student's behaviour	*Nothing to say.* *Nothing to add here.*
10. Other	Remaining comments	*He recently arrived in our team.* *He changed from one team to another.*

Table 2, 3, 4 and 5 show the distributions of the type of comments over the different categories. The identification of strengths is the most used type of comments in each team and at each assessment moment. The second most mentioned category varies between the identification of weaknesses, remarks on specific tasks and recommendations for future performance.

Table 2: Comments 1st Peer Assessment Moment

Category	Team 1	Team 2	Team 3	Team 4
1. Identification of strength	32%	58%	46%	64%
2. Identification of weakness	12%	3%	10%	12%
3. Remark on specific task	11%	27%	7%	23%
4. Remedial action	24%	1%	8%	1%
5. General encouragement	4%	3%	0%	0%
6. Justification of grade	6%	0%	5%	0%
7. Specific comment on transferable skills	4%	1%	1%	0%
8. Not enough information	5%	4%	17%	0%
9. No comments	25	3%	5%	0%
10. Other	0%	0%	1%	0%

At the first assessment moment, most teams mainly made comments on strengths, apart from Team 1, that also dedicated a large percentage of the comments to recommendations. Members of Team 3 made clear that they did not have enough information to assess their colleagues properly.

Table 3: Comments 2nd Peer Assessment Moment

Category	Team 1	Team 2	Team 3	Team 4
1. Identification of strength	47%	63%	66%	61%
2. Identification of weakness	15%	3%	11%	11%
3. Remark on specific task	4%	7%	0%	11%
4. Remedial action	27%	13%	10%	2%
5. General encouragement	2%	1%	0%	0%
6. Justification of grade	0%	2%	2%	1%
7. Specific comment on transferable skills	0%	1%	1%	6%
8. Not enough information	0%	6%	1%	0%
9. No comments	3%	2%	8%	0%
10. Other	2%	1%	2%	8%

At the second peer assessment moment, Team 3 had enough information to carry out the assessment and the main part of the comments consisted of strengths and weaknesses. Team 1 still dedicated a relatively large part to recommendations.

Table 4: Comments 3rd Peer Assessment Moment

Category	Team 1	Team 2	Team 3	Team 4
1. Identification of strength	53%	68%	73%	44%
2. Identification of weakness	10%	14%	13%	36%
3. Remark on specific task	2%	0%	0%	10%
4. Remedial action	23%	13%	7%	4%
5. General encouragement	0%	1%	0%	0%
6. Justification of grade	0%	0%	1%	0%
7. Specific comment on transferable skills	0%	0%	0%	0%
8. Not enough information	2%	0%	0%	1%
9. No comments	2%	1%	3%	0%
10. Other	9%	1%	2%	4%

The third assessment moment shows an increased number of weaknesses identified by the members of Team 2 and 4. This is the penultimate assessment moment and the teams prepare for the final activities of the project.

Table 5: Comments 4th Peer Assessment Moment

Category	Team 1	Team 2	Team 3	Team 4
1. Identification of strength	54%	59%	72%	78%
2. Identification of weakness	28%	14%	14%	6%
3. Remark on specific task	0%	1%	0%	7%
4. Remedial action	10%	20%	3%	3%
5. General encouragement	0%	1%	0%	2%
6. Justification of grade	0%	1%	3%	0%
7. Specific comment on transferable skills	0%	0%	0%	0%
8. Not enough information	4%	1%	1%	1%
9. No comments	4%	1%	6%	1%
10. Other	0%	3%	1%	2%

The fourth and last assessment moment was mainly focused on strengths, although Team 1 had a high number of weaknesses to identify.

6 Discussion

All teams defined criteria and described the criteria in detail. Through an online platform, they submitted the grades and the comments for each one of their peers in the sub-team. The results as presented in the previous section indicate that students express themselves in different ways, varying from general remarks to specific suggestions for the improvement of performance. Most comments are pertinent, but the comments are not yet well balanced between the different categories that can be distinguished. Out of 16 peer assessment moments, four for each team, 12 are characterised by comments that consist for more than 50% in the identification of strengths. The high frequencies for the category identification of strengths possibly indicate a certain reluctance of students to be critical towards their peers.

Only Teams 1 and 3 at the first assessment moment, Team 1 at the second and Team 4 at the third moment attributed more than half of the comments to other categories than the identification of strengths. Identification of weaknesses and remedial action are also categories that students use a lot to express their opinions on their colleagues. Especially Team 1 makes many comments containing suggestions or recommendations for future performance. The high frequencies for 'no comments' and 'not enough information' at, respectively, the first assessment moment in Teams 1 and 3 are likely to be related to the start off of the project. Some of the sub-teams did not start right away at the beginning of the project, so it was not possible to assess all members of all teams properly.

7 Conclusions

The four peer-assessment moments have proven to be useful in different ways. Students received feedback from their peers in a way that the teachers could not have provided by themselves, due to lack of time and lack of inside information on the functioning of each team member. The quantity of feedback is by far larger than the quantity of feedback that could have been given by a teacher. For a teacher, it is practically impossible to give relevant comments on different criteria to around 80 students at four different moments.

The lack of critical comments, like the identification of weaknesses and suggestions for improvement at the first moment and especially in Group 3 and 4 at the last two assessment moments, does not reveal much of a critical attitude of the students towards their team members. A more balanced set of comments and the identification of weaknesses that students can work on could be helpful to give students more insight in their role in team processes and in project work.

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Engineering in México: Present and Future

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Abstract

At the globalization scenery, technological innovation is hanged to market needs and globalization environment, which obeys to reasons applied to satisfy market requirements for constant renovation of products and due to increasing of a knowledge complex system and applications that curiously unfix and re-fix engineering profession. This work pretends to show in a clear and concise way a state of the art of engineering in Mexico besides its requirements and challengers that the country should face comparing advances in engineering education in different parts of the world, in order to avoid important gap, it'll be described a critical route which shows proposed strategies to follow with this objective and aligned to the economic and political situation of Mexico versus other countries.

1 Background

In the past, Mexico's engineering has had intermittent outbreaks with some meaningful approaches in specific areas but it hasn't reached a continuous and consistent development. Engineering in the world, as a formal discipline, had maybe its origins in the European medieval gremials or in similar ways in other cultures and other times. In Mexico, at the pre-Columbian age, people reached outstanding development in some branches such as construction, mining, and hydraulic with historic products registered. These developments were interrupted by colonization causing loss of knowledge. During colonization, there was development in mining, sugar production, tobacco processing, textile industry and coining. However, Spain dependency maintained a stationary economy and manufacturing kept in artisanal and preindustrial stage. Nevertheless at the end of XVIII and beginning of XIX century, there was great interest in science. Indeed Alexander Von Humboldt said that "the initial passion in hugging exact sciences at Mexican capital was greater than old science and literature" and that "new philosophy principles were spreader in Mexico than in other peninsula parts", cited by H. Aréchiga, La ciencia mexicana en el contexto global, CONACYT, 1994. There were intermittent science outbreaks such as the discovery of a new element called 'eritronio' by Andres Manuel del Rio but it was not validated on time according to Humboldt recommendations and 20 years later it was called 'vanadio' by Niels Sefström. Unfortunately these lightings in science life were brief and no one Mexican contribution could access to the science knowledge of XVIII century. Starting XX century, world indeed lived intensive industrial revolution consequences. In 1900 Mexico was eminently agrarian and rural but there was certain engineering activity and there were groups with knowledge of steam machines, train, cars, electricity, movies and aviation. But they were only a watching minority. Most of limited engineering activity was developed by 'Porfirism' protected foreign empires so richness coming from these empires and engineering or technology value generated was extracted out of the country or approached by a few families. Richness invested for engineering development into the own empires or educative instances was minimum. Technology and engineering were developed in other place and for Mexican filial industry they were only reinvestment used mostly in a blinded way to approach and explode the natural resources. In the post-revolutionary time is intended to take revolutionary reforms as axis for Mexico's development. Among these reforms, educative one pretends to make poor people instruments or their own freedom and to integer them to the modern production vies. 'Cardenism' looks to strong and broad the first post-revolution impulse. 'Cardenism' supports technological education at all levels with labor relationship. His maximum success is the creation of the Instituto Politecnico Nacional in 1936 that uses the slogan 'la tecnica al servicio de la patria'. This was really an emblematic achievement for engineering in that period because the institution grouped to several higher schools besides basic and next level borning later the so named Institutos Tecnologicos Regionales. Then in a global way, in XX century, certain bases were created for sustainable development of Mexico's engineering. In education, la Universidad Nacional Autonoma de Mexico (UNAM), and the engineering institute; the Instituto Politecnico Nacional and the Centro de Investigación y Estudios Avanzados (Research and Advanced Studies Center), other State Universities and the System of 'Institutos Tecnologicos' and some private schools. In relation with promoting research centers, it was created the 'Consejo Nacional de Ciencia y Tecnologia'. In the industrial field there were development too interacting with research and government. But conditions changed again during 1st world war and then 2nd world war, cold war until the change of developing model and economical opening signing the free trade agreements with the corresponding economical, industrial, scientific and technological effects. In 1942 and 70's was another change in education: postwar and urbanization in Latin-America and start Ávila Camacho, Miguel Alemán y Ruiz Cortines governments. The 'Asociación Nacional de Universidades e Institutos de Enseñanza Superior', A. C. (ANUIES) was created in 1950. During Luis Echeverría, López Portillo, Miguel de la Madrid and Salinas governments financial resources do not flow causing scholar outstrip. Technological universities were created in 1991.

2 New sceneries and profiles for engineering

According to experts, future engineering must act in 4 sceneries (National Academy of Engineering. The engineer of 2020: Visions of engineering in the new century, 2004 y National Science Foundation Environmental science and engineering for the 21st century, 2000):

1. In Continuous scientific revolutions and without limits where engineers will explode totally science knowledge and promoting new sciences.
2. In Biotechnological revolution, which will requires engineers in different fields of action including genetic.
3. In Ecology, this will appoint natural and environmental topics with efficient answers.
4. In global changes involving migration themes.

New profile of engineer:

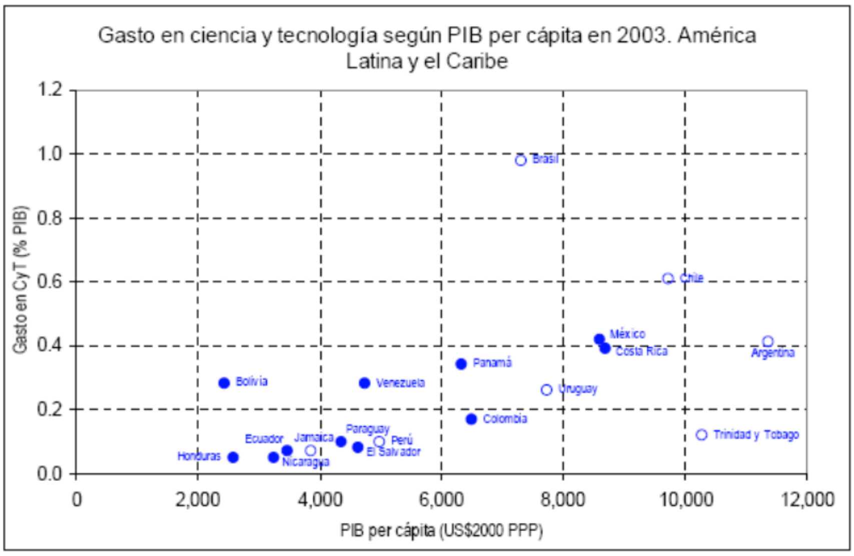
- At a globalized world, engineer must acquire new abilities for a new environment. This means a professional holistic oriented.
- Holistic formation will be a new feature of future engineer with a more mental flexible attitude and leadership to conduct groups.
- According to a Brazilian report about future engineering (Instituto Euvaldo Lodi. Inova Engenharia. Brasilia, 2006) an engineer must live together in diverse communities, work and communicate with multidisciplinary teams.

In 1993, derived from a meeting of the Mexican Engineering Academy, and the Asociacion Nacional de Facultades y Escuelas de Ingenieria (ANFEI), generated institutional planning about global competitivity.

According to OCDE (Organización para la Cooperación y Desarrollo Económico), competitivity is the ability to produce goods and services which fulfill standards of international market permitting to producer inhabitant to improve their willing (*The World competitiviness Report*, 1994). Unfortunately and even efforts, according to a source ("*Horizontes de Desarrollo Global 2011*" del Banco Mundial), for year 2025, six big emerging economies will represent 50% of the total production and Mexico will not be among them.

3 Status of technological innovation in Mexico

Scientific and technological activities are narrowly related with generation, improving, diffusion and application of knowledge. Expenditure in science and technology can be used as an investment indicator for innovation. As seen in figure 1, in Latin America, Brazil outstands in expenditure in science and technology near to 1% of PIB. Cuba invested 0.65% (it is not shown in the graph) and Chile is above 0.6%. Rest of countries destined less than 0.43% of PIB. This is less that 20% of world average. In real terms, no one of Latin America Countries grew consistently in the period 1996-2003. There is no also a clear science and technological investment policy with fluctuating expenditure rate with respect to national PIB.



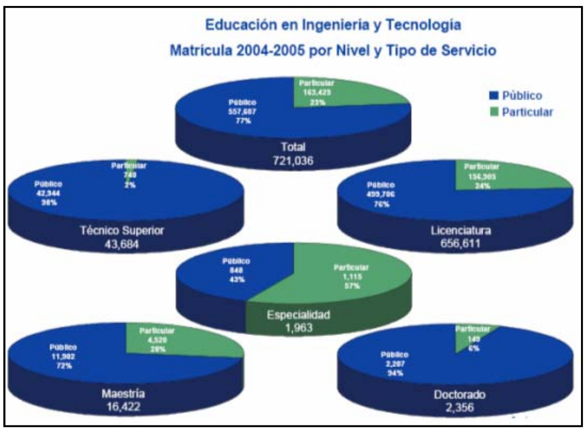
Fuentes: UNEP Internet: United Nations Environment Programme GEO Data Portal (http://geodata.grid.unep.ch/).
World Bank: World Development Indicators 2006 (http://devdata.worldbank.org/wdi2006/contents/index2.htm).

Figure 1: Expenditure in Science and Technology in Latin America and Caribe

In this graph it is shown that Brazil disposes 1% while Mexico invests only 0.4% of PIB. Under this tendency, it'll be difficult that Mexico develops a viable strategy which permits to enter to a high competitive zone or at least near to high competitive countries. In this sense, Arturo Cepeda y Margarita García (*Ingeniería: palanca de desarrollo, 2006, pp 7-8)*) appoint that countries of high income 30 times more in research and technology for each million inhabitants than Mexico and have 14 times more engineers and scientists in proportion to the amount of inhabitants. All these aspects are related with richness and level of a country.

Indicators in engineering education in Mexico

Engineering enrollment represents 57% in technical level, 30% in bachelor level and 14% in postgraduate level. Percentage of enrollment diminish as education level increase as shown in Figure 2.



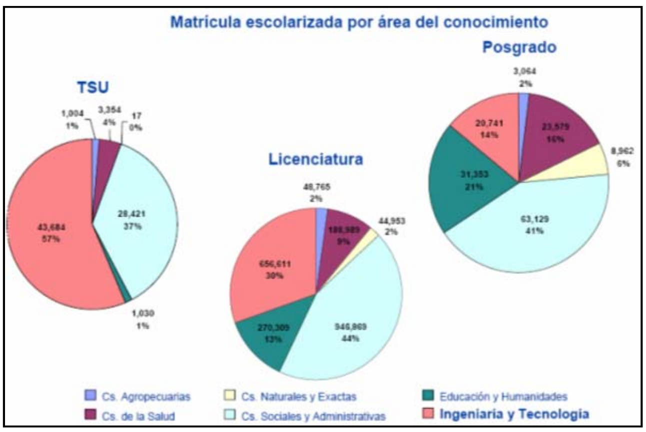


Figure 2: Scholar enrollment by knowledge area

Figure 3: Enrollment by level and kind of service

As shown in Figure 3, we can see that prevails public education: technical level 98%, bachelor level 76%, master level 72%, PhD level 94%. Private schools outstand in specialties with 57 % of enrollment. Considering total enrollment in bachelor engineering level, public schools cover 77% and so 23% correspond to private schools. Women represent 1/3 of population in engineering schools, as seen in figure 4.

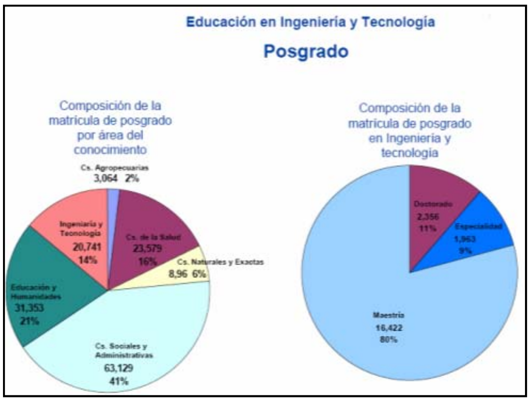


Figure 4: Distribution by gender and level

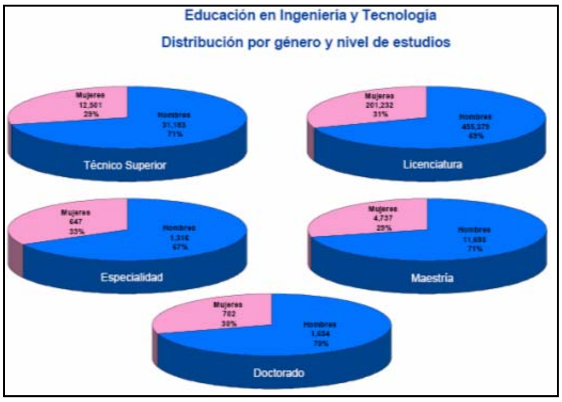


Figure 5: Distribution of postgraduate-engineering

Engineering represent 14% of national enrollment in postgraduate. Postgraduate enrollment composition in engineering and technology is strongly concentrated in master level: 80%. Doctorate represents 11% and specialties 9% (Figure 5).

Other methodologies to consider

Experts consulting represents one commonly procedure in prospective field because it leads qualitative possible futures sceneries based in well informed and reasoned opinions. Due to this, in this paper is reported a prospective and substantive exercise consisting of interview to recognized experts in engineering education in Mexico. Results are next:

Globalised guidelines knock down national engineering empires

World liberalization of market (at the beginning of 70's), resulted to be a strategy of developed countries to set their surplus in bigger markets and all over the world; this strategy is based in their technological development to get lower costs and high quality products.

Effects of these guidelines are resumed next:

First, creation of a global conscience to create public infrastructure without enough financial resources.

Second, scheme of globalization makes to grow the demand of public infrastructure.

Third, organized engineering passes from infrastructure production to operation.

Mexican engineering crisis is due to failed policies and not to formation of engineers

A globalization export delocalizes design and production centers and focuses them where work mind exist instead of cheap work.

Using TIC innovate practice in engineering

Strong and radical changes due to access to information technologies.

Board of future game

Future vision that experts said is about tendencies of productive model which will continue joined to technical scientific development and to the market factors: novelties and comparative advantages. Engineering will have to work in the field of innovation and competitivity. As they said it themselves:

Market dynamism of global engineering

Utility margins will reduce so construction industry will tend to scale. Engineering will be ever more expensive in developed countries keeping their hegemony.

Great changes for future

Aeronautic and satellite industry will develop. It'll be necessary to create more public infrastructure.

TIC will become an inflexion point

They'll open opportunities and present menaces meanly in specialists internationalization and knowledge production. Electronic and new materials will change engineering practices.

4 Strategies and final conclusions

Traditional and innovative professional practices will live together without disappearing the first ones. Traditional careers will continue, hybrids and new ones will emerge. Engineering new practices will situate converging in math, physics, chemistry and biology. A particular appointment is about restructuring educative offer of engineering schools in Mexico reducing and focusing it. It is very disperse: 116 specialties dusting engineer identity. It'll be necessary to replant knowledge areas by regions diminishing diversification. Professional fields will stay in basic engineering (civil, mechanical, electrical) incorporating new ones (bionic, mechatronics, telematics. For Mexico, 5 strategic drivers were fixed: energy, infrastructure, agro foods, tourism, and logistics. Indeed nanotechnology, food safety, new energy sources, etc.

4.1 Public policies

Mexico requires a giant effort to plan with long vision in order to build a solid infrastructure to become a viable country. It is needed to strong investment to define a **national policy of development**.

Public policies must be shock therapy to reactivate the differentiated development with the science as key code with technology and education aligned to industry and culture. It is necessary to join industry, government, research, engineers, in a same way.

Public policies to develop Mexican engineering must have as a priority the geo-economical diversity.

Technology must be property of Mexico.

Public policies must be focused to increase Mexico's competitivity in a global world with fiscal aids, industry supports, and clear rules.

4.2 Route sheet

First. To understand the sense of change. Globalization is modifying the know ledges.

Second. Interpretation of changes and the way to adapt to Mexico. This means that educative system/engineering, must precise-define, educative offer by regions.

Third. To define fields of scientific and technology developing of the country to impulse a science and technology policy polycentric regionalized, with enough budget and growing establishing the adequate drivers.

Fourth. To understand that in the two first steps cited above, schools can intervene directly.

Mexico requires:

A deep engineering in knowledge, comprehensive and innovative in its practice: with competitive mentality, open, practice and nationalist, with social sensibility and clear vocation: fighting positions in world economy and considering the need for new proposals of project approaches in engineering education.

In order to get the above mentioned, Mexico would have to count with engineering schools that become knowledge industries, certifiers of quality, promoter centers of change and generating high qualified human resources strongly ventured with empires by regions, offering a dual education: in the classroom and in the productive system with equipped laboratories that generate virtuous circles between production-school.

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The Importance of the Project Theme in Project-Based Learning: a Study of Student and Teacher Perceptions

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Abstract

Motivation to Learn represents a prime driving force in Engineering Education. It encompasses a multitude of facets relating the learning process itself and the learning agents, namely students and teachers. Motivation is triggered both by learning agents inner strengths, level of interaction and particular perception of the learning objects relevance. This paper investigates the relevance of the project themes within the context of interdisciplinary project-led engineering education at University of Minho, Portugal. The study is backed-up by results from the 2010-2011 PLE edition of the Integrated Master degree on Industrial Management and Engineering. This includes results from a questionnaire applied to students, a questionnaire applied to the group of teachers. Analysis of results show a strong link between students and teachers perceptions on theme relevance, while giving insights into aspects that should be taken into account when analysing and making a decision on semester-wide project themes.

Keywords: project based learning; active learning; motivation; project theme.

1 Introduction

This paper studies the relevance of the theme of interdisciplinary projects, in the context of active learning methods in engineering education, namely in Project-Led Engineering Education (PLE). The study is based on the interdisciplinary project of the first year of the Integrated Master´s degree in Industrial Management and Engineering (IME) at the University of Minho (Portugal). The case study (IME1.1) enabled data collection on motivational aspects of the theme of the project, through questionnaires to students and teachers, complemented by a workshop held at the end of the semester. The paper seeks to present the results of the data collection, followed by a critical analysis and validation of the results, as well as to present conclusions on the results.

The PLE methods has been implemented in a number of Institutions of Higher Education in Europe as well as North-America and Australia (Powell & Weenk, 2003). The University of Twente, the Netherlands, adopted the method in 1994 (Ponsen & Ruijter, 2002) aiming to prepare engineers for the labour market, with solid technical background along with team working practice and experience in tackling and solving multidisciplinary problems, apart from a high level of performance, autonomy and communication skills (Powell & Weenk, 2003; Helle et al., 2006).

One of the main goals of the PLE methodology is the increase of students motivation in the development of technical competencies (embodied in the courses that support the interdisciplinary project) and for the development of transferable competencies (like project management, conflict management, oral and written communication, self-regulation of learning, etc.). It is supposed that the project theme plays a crucial role in stimulating the interest and motivation of the students, allowing at the same time for interdisciplinarity in the approach, and as such providing an intrinsic interest in the technical competencies of the related courses.

Powel and Weenk (2003) describe the characteristics that a good project should have and distinguish academic issues (e.g. compliance with course goals, offering multidisciplinary open-ended tasks, enabling integration of knowledge, attitudes and values), reality issues (e.g. relevance for students, connections with real life and connections with business), student issues (e.g. requiring a team challenge, requiring individual responsibility, allows teams to reach distinctive solutions) and the end product (e.g. a working prototype, drawings, an invention or a written report).

The theme of the project is the actual starting point of the project semester. According to a study of Gommer and Rijkeboer (2010) with the teaching staff at the University of Twente using a PLE approach, there are various strategies to catch and maintain the interest of motivated students, to carry out the project till its very end. They refer that projects should be fun (Gommer and Rijkeboer, 2010, pp. 102) and they explain the fun-factor as follows.

- Connect with the interests and environmental perceptions of the target group. For example, projects in the first year of the mechanical engineering programme are perceived as 'fun' when students are asked to design a so called 'demolishing device' (e.g. a can crusher).
- The value of the solution to be designed has to be clear to students. An example of a less successful project is designing a shoe polishing machine. This is something that can be easily done by hand. Students didn't see the use for a machine to solve this problem.
- Connect with actuality or a so called 'hot item'. Sustainability for example is a theme that is perceived as relevant by industrial design engineering students.
- Manufacturability. Especially for students in the first year of the programme, it's motivating to design a solution that can be made into a working full-scale prototype. Often, a fun closing session is organized, in which a contest is held with the working prototypes (battle robots, baking sausages on barbeque designs, etcetera).

The same study also highlights that for the teaching staff, the so-called fun-factor is important. The project assignment, when carrying out projects year after year, needs to be original and appealing to them in order to keep them engaged (Gommer and Rijkeboer, 2010, pp. 102). Moreira and Sousa (2008) describe the use of prototypes of production systems in interdisciplinary IME projects. Their study reports on the increased enthusiasm, autonomy in the development of prototypes as well as the cooperation and competition between contending teams and seem to confirm some of the results recorded by Gommer and Rijkeboer (2010).

2 Project Theme and Motivation

According to features of PLE, the importance of interdisciplinarity is in the definition, development and evaluation of the project. The interdisciplinarity is an important dimension to take into account in the planning of the project, particularly in the definition of the theme, in order to assure the demands of the different curricular units. The integration of the contents is one of the most complex and challenging dimensions in this methodology. However, some barriers to interdisciplinarity are discussed in literature: (1) differences in the characteristics of disciplinary knowledge; (2) differences in disciplinary traditions to teaching and learning; (3) different approaches to student learning; and (4) different conceptions of teaching and learning (Bradbeer, 1999).

The project theme in PLE is expected to be based on the professional context in order to provide learning situations to students, where they can apply knowledge to solve engineering problems and they can also develop competencies related with the engineering practice (Pesches & Reindel, 1998; Moesby, 2005; Nair et al. 2009). In the definition of project theme there is a concern of the teachers to choose one that may keep students' motivated during the semester. At same time, the theme should be a motivator for teachers in order to encourage students, to ensure the quality of the process and to bring innovation with great enthusiasm in teaching practice (Lam et al., 2008).

Motivation is a central issue in the life-cycle of the project, so is an important dimension for the learning process and for the relation between students and teachers. Hill (2007) mentions the factors that affect students' motivation to learn: contextualization learning in the students' world, bringing real-world issues into the learning contexts, giving students choice, autonomy and self-regulation over their learning, and providing feedback. Schunk (1999) developed this idea establishing the relation between two variables: expectations, which involve the capabilities for learning (self-efficacy) and perceptions of the consequences of learning; and value which is related to perceiving the importance of learning. In this order, motivation drives behaviour and in the project students are oriented through objectives that they must achieve not only at the end (learning outcomes) but also during the process. For that reason, the project theme is crucial for the students' and teachers' motivation, because it has an impact on learning and teaching process. Additionally, it is the theme that allows an interdisciplinary approach in the project, relating competencies that students are to develop in each individual course to achieve the objectives of the project.

3 Methodology

In order to collect data on the perceptions of students regarding their participation on the 2010/2011 edition of the first year first semester IME project, a questionnaire (*Questionnaire* A_1) was developed and applied. A second questionnaire (*Questionnaire A_2*) was developed and applied to teachers, tutors and educational researchers, involved in the same project.

Questionnaire A_1 was intended to extensively collect students' perceptions on the full project experience. It consisted of 46 closed items and two open items. The closed items were divided into six scales having between six and ten items each. The first scale focused directly on the project theme of the semester: Air_2Water - specification of a portable device for the production of drinking water from air humidity and the specification of its respective production system. It contained six questions related to e.g. the relevance of the theme and the motivation for the theme. The remaining scales were focused in several other aspects which are out of scope of the present study. These were targeted at learning and competencies developed, teamwork, role of the tutor and of teachers involved, project assessment methodology, and contribution of project-led education methodology to the learning process. The open questions referred to positive and negative aspects of the project experience, as well as suggestions for improvement.

Questionnaire A_2, for teachers, tutors and educational researchers, was aimed specifically at project themes, not only of the last project, but of all projects that have been run. The questionnaire had five scales, of which the last two were exclusively directed at teachers. The first scale, with six items, aimed specifically the present PLE edition theme, i.e. Air_2Water project. The second scale asked the respondents to rank all eight project themes of projects that have taken place between 2004/2005 and 2010/2011 from 1 to 8, the former being the most important one. The respondents needed to justify their ranking. The following question required the respondents to identify what aspects of a project theme they considered most important, e.g. social relevance, innovation, economical potential. The last two questions asked teachers to reflect on the choice of this year´s project theme and the initial expectations with regard to the theme in comparison with the results of the project.

The sample for A_1 was a group of 24 students out of a population of 42, meaning 57% of the total population. The sample for A_2 73%, 11 out of a population of 15. The questionnaires were both applied at the end of the first semester of the academic year 2010/2011.

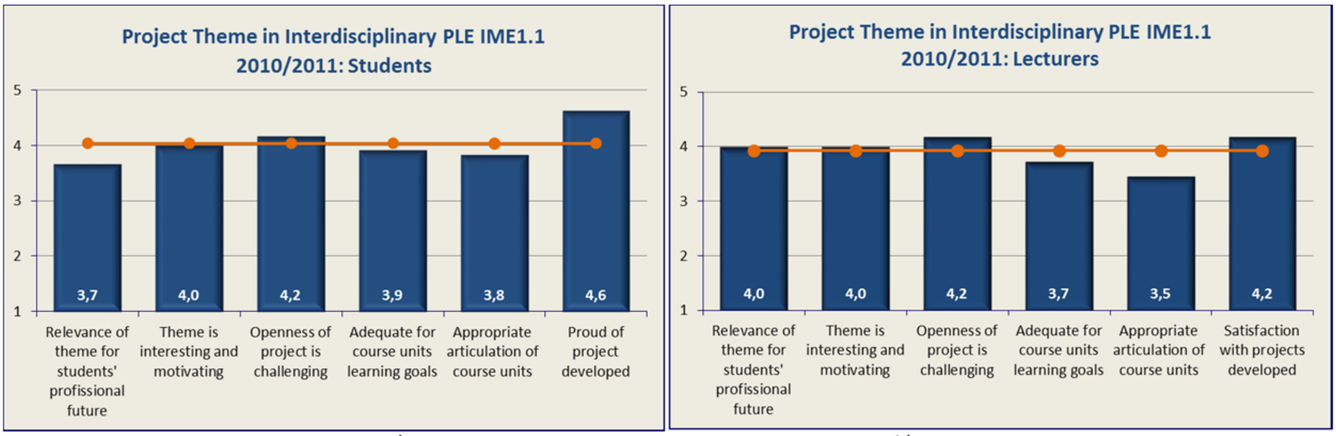
4 Findings

A good rate of responses was attained to both Questionnaires A_1 and A_2. Three of the teachers (pertaining the teachers/tutors group) were simultaneously tutors of student teams and lecturers of a course unit. In this way, among teaching staff, only one of the teachers of the courses involved and one of the tutors did not respond to the questionnaire. For simplicity of reading respondents to Questionnaires A_2 (tutors only; teachers/tutors; teachers only; and educational researchers) will be referred as lecturers. The detailed figures for respondents are exhibited in Table 1.

Table 6: Milestones

Respondents	Population	Sample	Percentage
Questionnaire A1			
Students	42	24	57%
Questionnaire A2			
Tutors only	3	2	67%
Teachers/Tutors	3	3	100%
Teachers only	5	4	75%
Educational Researchers	4	2	50%

The average results of each item pertaining scale 1, which relates to Project Theme Relevance, are depicted in figure 1. Figure 1a) show results to *Questionnaire A_1 (students)* and Figure 1b) show results to *Questionnaire A_2 (lecturers)*. Overall results indicate a very similar pattern of perceptions between students and lecturers regarding all six closed items. A more detailed analysis of the results follows.



a) b)

Fig. 1 Project Theme relevance (section 1). a) Results to *Questionnaire* A_1; b) Results to *Questionnaire* A_2

The similarities between students and lecturers perceptions are evident, according to results on all items of scale 1. The mean score on scale 1 is 4.0 for students and 3.9 for lecturers. The scores on this first scale indicate an overall positive opinion with regard to the project theme.

The strongest agreement between results of questionnaire A_1 and A_2 is to be found in item 2 – *Project theme is interesting and motivating for students;* and item 3 – *Openness of project is challenging* - (scores of 4.0 and 4.2 respectively). The clearest discrepancy between students and lecturers (0.4 points) is found on item 6 – *Proud/satisfaction for the project developed by the students*. But, such deviation is not attributed to low satisfaction levels by lecturers (averaged 4.2, which is a good mark overall) with the projects developed by students' teams. Rather, it is essentially attributed to an abnormally high students pride with the projects that teams have developed along the semester (having a 4.6 mean score).

The item that showed most concern for lecturers (lowest mean score of all items of the section) is related to the success of articulation between the different subjects involved in the semester (item 5 – *Appropriate articulation of course units*). The mean score was 3.5. It is less worrying for the students as their mean score was 3.8.

The item that showed most concern for the students refers to the relevance of the project theme and how that is related to their professional future (item 1), being characterised by 3.7 mean score. Results to item 1 on Questionnaire A_2 (lecturers) does not indicate equivalent concern (mean score of 4.0).

Item 4 – *Adequate for course units learning goals*, has been scored with 3.9 by students and 3.7 by lecturers.

Section 2 of the lecturers' questionnaire (A_2) sought to identify the perceptions with regard to the project themes of all interdisciplinary projects that have taken place between 2004 and 2011 in eight editions of the perfect. Table 2 ranks all these projects.

Table 2: Rank of relevance of themes of IME interdisciplinary projects (lecturers' perceptions).

Rank	Project theme	PLE IME1.1 Edition
1st	Production system of biodiesel	2004/2005
2nd	Specification of a system for the transformation of forest biomass	2005/2006
3rd	Production of batteries for an electric car; specification of the battery and its production system	2008/2009
4th	Specification of a production system for fuel cells	2006/2007 S_1
5th	Use of organic waste for the production of bio-alcohol	2009/2010
6th	Desalinisation of sea water	2007/2008
7th	Air_2Water – Specification of a portable device for the production of drinking water from air humidity and the specification of its respective production system	2010/2011
8th	Space Tourism	2006/2007 S_2

As table 2 shows, the theme of the very first edition of the project, a production system for the production of biodiesel, was regarded as the most relevant one. The least motivating one took place in the second semester of 2006/2007 and was aimed at Space Tourism; this rank was unanimous among lecturers.

The theme of the most recent project was considered the penultimate one in terms of relevance, which is surprising considering the positive scores to 2010/2011 project theme, given by students and lecturers, expressed in the results shown in figure 1a) and 1b). The comments that the teachers gave on the open items indicate reasons to explain the importance of a theme:

- Appropriateness for the course involved
- Possibility to apply contents of courses involved
- Appropriateness of the theme
- Relevance for the IME professional profile
- Theme close to actual reality
- Realistic theme
- Level of complexity adequate for 1st year students
- Theme that is well embedded in the thematic technology of a specific edition
- Theme with a strong environmental focus, sustainability and economic potential
- Theme that relates well to the different subjects involved
- Perception (at the end of the project) that the students liked the project and achieved the learning goals
- Theme that provides an easier view on the productive process
- Motivating challenge
- Theme that offers an urgent problem (pointing at the "perfect" solution/application)

With regard to the less important themes, the following reasons were indicated in the open question:

- Theme is not interesting for the students
- Theme is not important
- The relevance for the professional future is low
- The perception that students considered the theme as little relevant and distant from the professional competencies in Industrial Engineering.

In section 3 of questionnaire A_2, the teachers had to identify the three most relevant aspects concerning the choice of the project theme for first year first semester project (1 – most important, 3 – least important).

- *Theme well embedded in currently relevant issues*
- *Innovating theme*
- *Theme with clear links to the competencies to be developed in the related courses*
- *Theme with high economic potential*
- *Theme with high social relevance*
- *Theme focused on environmental or energy questions*
- *Theme related to the professional profile of a Industrial Management and Engineering graduate*
- *Other, please explain.*

The aspect that was considered most important was *Themes related to the professional profile of a Industrial Management and Engineering graduate,* followed directly by *Theme with clear links to the competencies to be developed in the related courses*. The theme being related to current issues and the energy/environment link were also considered important aspects. The remaining aspects were considered less important for the definition of a project theme.

The fourth section of the teachers' questionnaire was exclusively aimed at the teachers who were responsible for the courses involved in the project. As indicated above, seven out of eight teachers responded to this section. The first question referred to the level of satisfaction with the project theme taking into account the appropriateness of the project theme for the learning outcomes of the course that the teacher is responsible for. Out of seven, four were satisfied and three were very satisfied with the appropriateness of the theme. The first four teachers made the following comments:

> *"The students could choose, within certain conditions, what they wanted to do. And it was possible to apply part of the content in the construction of the artefact" (the production of water from air humidity)*

> *"The project allowed for the application of concepts of discrete production, part of the learning outcomes of the course"*

> *"It is never a 100% as there will always be contents that are not covered by the project"*

The three teachers who were very satisfied commented:

> *"I believe that the established goals were achieved, explaining my satisfaction"*

> *"The theme allowed for the achievement of the Industrial Management and Engineering learning outcomes"*
>
> *"Very happy with the choice – great application potential. Little satisfaction with the concretization as the students were not able to put the solution into practice (I had high expectations)"*

The second question in section 4 was related to the level of satisfaction of the initial expectation compared to the development of the project in the first semester of the first year by the students of the academic year 2010-2011. Six out of seven teachers said to be *satisfied* and one was *very satisfied* with regard to the comparison between initial expectation and the development of the project. Some of the first six commented:

> *"In the beginning I was not very happy as I could not envision the development of a production system, but later on I saw that the project was adequate."*
>
> *"The groups developed the device and the production systems, meeting the standards for a first year first semester course of a five year degree programme."*
>
> *"In general, I think that the groups did a good Job. In order to classify for "very satisfied", the projects had to be more different"*

The teacher that was *very satisfied* with the projects, was surprised that final results matched initial expectations.

5 Conclusions

The data obtained in this study are on both student and teacher opinions on the impact of a project theme. Due to the research design of the study, the student opinions only refer to the last edition of the project and the opinions of teachers refer to all past editions as well. In spite of this incongruence in the data, some conclusions on the choice of a project theme and the factors that should be taken into consideration can be drawn.

Firstly we can conclude that both teachers as well as students find that a specific project theme has an impact on their motivation for the project. With regard to the most recent project, the opinions of students and teachers largely coincide, as both find the openness of the project and the challenge it offers a crucial factor for the success of a project, as well as the final result that can be achieved through the project. The way the theme articulates the connections between the courses involved in the project seems to be a first worry for lecturers, but of less importance for students. Looking back to previous projects, the teachers highly agree on what were the most and the least interesting project themes. The very first project theme on biodiesel was considered the most appropriate theme and the theme on space tourism was unanimously referred to as the least interesting one. Looking at the comments that teachers gave, the latter is not difficult to explain. The most relevant aspect for the choice of a theme is, according to the teachers, the relationship with the professional reality of an Industrial Management and Engineering graduate and the space tourism theme was the least realistic theme. It offered a large challenge to the students and was contextualised by existing space tourism initiative, but in the end the students found the theme rather artificial and not properly preparing them for their future work. The biodiesel, as well as the themes that ranked second and third, were directly related to current energy and environmental concerns.

The results of the study indicate that the initial stage of the project, in which the project theme is defined, should carefully take into account all aspects that can influence motivation and especially link to students' future professional reality. A focus on sustainability, energy and the environment is also important to take into account.

Furthermore, the results learn that a longitudinal study on both the teacher and the student perspective on the impact of the project theme will provide more balanced results that enable for a more insight into how project theme influences the learning outcomes and perception of the project results.

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Paper Session A2

Uma Experiência de Aprendizagem Colaborativa Interdisciplinar no Desenvolvimento de um Veículo Elétrico na Universidade de Brasília

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Abstract

Engineering education in Brazil faces increasingly complex challenges: it must encourage innovation and be innovative, must include contemporary issues such as concern for the environment and simultaneously provide students with the development of so called “soft skills”. Moreover, the technical content of each specific discipline should be presented in a contextualized manner, emphasizing its integration in interdisciplinary contexts, thereby contemplating the epistemological transformations underway. The present case study refers to the designing of an electric vehicle. The adopted procedures are presented, as the results shown. The project refers to knowledge generation, technological education, personal development of participants and interdisciplinary.

Keywords: problem based learning, electric vehicle, selective waste collection, interdisciplinary collaborative learning.

1 Introdução

A educação em engenharia no Brasil enfrenta desafios cada vez mais complexos: deve incentivar a inovação e ser inovadora, deve contemplar temas contemporâneos como a preocupação com o meio ambiente e simultaneamente proporcionar aos estudantes o desenvolvimento de competências transversais. Os conteúdos técnicos devem ser trabalhados de maneira contextualizada, ressaltando sua integração em contextos específicos. Na Faculdade de Tecnologia da Universidade de Brasília (FT/UnB), durante o processo de discussão dos projetos pedagógicos dos cursos de engenharia, em eventos organizados pela então criada comissão de reforma curricular durante o ano de 2006, sobrevieram propostas para implantação de projetos de síntese e integração de conhecimentos, seguindo as orientações das Diretrizes Curriculares Nacionais do Curso de Graduação em Engenharia do Conselho Nacional de Educação. Estes projetos foram pensados considerando seus marcos conceituais, situacionais e operacionais (Viana, 2009). Um dos aspectos do marco conceitual foi a adoção de abordagens conhecidas como PBL (problem based learning) e PLE (project led education) ou aprendizagem baseada em problemas e ensino baseado em projetos. Estas propostas, apresentadas na ocasião por um grupo de estudo formado por docentes da FT/UnB, revelaram-se como recursos essenciais para complementar a formação profissional dos estudantes, tanto por contextualizar conhecimentos adquiridos em disciplinas teóricas, como por possibilitar abordagem de aspectos sociais, econômicos e ambientais sob a forma de temas transversais, ou por simular situações a serem vivenciadas no futuro 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 freqüentes em disciplinas tradicionais.

Com este propósito, em janeiro de 2010, no curso de Engenharia Mecânica, foi proposto como tema de projeto integrador, o desenvolvimento de um projeto de veículo elétrico para apoio à coleta seletiva de resíduos sólidos. Tal proposta contemplava em boa medida a complexidade desafiadora do ensino integrado de engenharia e resultaria em um laboratório para se refletir questões relativas à educação em engenharia. Para a estruturação da disciplina ao longo do semestre, foram pensadas as condições necessárias para a criação de um ambiente de aprendizagem adequado.

O objetivo aqui é discutir os resultados obtidos durante o desenvolvimento deste projeto interdisciplinar voltado à construção de um veículo elétrico que possa servir ao transporte de material reciclado dentro do Campus da Universidade de Brasília. Ainda em curso, o projeto envolve a participação de estudantes advindos de diversos cursos dentro da universidade, incluindo os departamentos de Engenharia Mecânica, Elétrica e Mecatrônica, Desenho Industrial, Administração e Serviço Social. A idéia é criar e desenvolver um veículo que possa transportar material reciclável depositado em contêineres em pontos específicos do campus da universidade até uma central de triagem. Com data prevista para entrega em dezembro de 2011, o veículo elétrico proporciona aos alunos a oportunidade de desenvolver um projeto real onde os conhecimentos apreendidos em sala de aula são aplicados no desenvolvimento de um produto de baixo custo e com alta demanda. A realização do projeto está dividida em quatro principais etapas: i) elaboração da proposta de solução, ii) desenvolvimento da solução, iii) plano de implementação e, iv) monitoramento da solução. O trabalho preservou os princípios do método científico e garantiu aos estudantes integrantes a oportunidade de vislumbrarem a completude do projeto e vivenciarem suas partes desde a implementação, até a entrega do produto final em 2011. O presente artigo irá apresentar os resultados da gestão do projeto em equipe e as soluções encontradas pelos estudantes ao longo do desenvolvimento do projeto.

Desta forma, na primeira parte do texto são apresentadas as categorias teóricas envolvidas no desenvolvimento do projeto, entre elas, a própria denominação adotada para a disciplina, o tema do projeto a ser desenvolvido, as disciplinas participantes, a definição das atividades a serem realizadas, a formação dos grupos executores. A principal referência para o desenvolvimento deste apoio teórico foi a tese de doutorado de Santana (2009) e os trabalhos desenvolvidos na Universidade do Minho (Lima, 2005; Vasconcelos, 2007). Outras referências teóricas utilizadas ao longo da estruturação do ambiente de aprendizagem surgiram na medida em que o projeto do veículo elétrico foi avançando. Na segunda parte do texto é apresentada a metodologia utilizada e os métodos aplicados para o alcance dos objetivos propostos para o projeto. Finalmente, na última parte do texto são apresentados os resultados obtidos na aplicação da aprendizagem colaborativa interdisciplinar no desenvolvimento do veículo elétrico na Universidade de Brasília.

1.1 Marcos Conceituais

Ao longo dos anos novas tecnologias surgiram e novas técnicas de ensino também, porém, colocá-las em prática exige uma organização pedagógica, administrativa e técnica, a qual vem sendo buscada por professores do departamento de Engenharia Mecânica desde 2007 (Viana, 2008 e 2009). As exigências destas mudanças passam a ocorrer em função do aumento exponencial do conhecimento humano e o surgimento contínuo de novas tecnologias sofisticadas que exigem uma preparação dos profissionais para atuarem no mercado com ágil capacidade de inovação e interação.

Santana (2009) considera que atualmente os currículos dos cursos de engenharia devem ser mais flexíveis, com foco em habilidade e competências ao contrário do anterior que era baseado em conteúdos e carga horária. Ainda, o enfoque dos grupos operativos tal como proposto por Pichon Reviere foi relevante para a diferenciação entre tarefa e objetivos do grupo. Desta forma foi entendido o veículo elétrico como a tarefa a ser realizada pelo grupo e os objetivos a seguir listados foram definidos a partir desta distinção.

O delineamento do objetivo geral da estruturação do ambiente de aprendizagem foi realizado na medida em que os diferentes referenciais teóricos adotados vinham sendo agregados ao projeto de forma à expressá-lo como sendo: trabalhar o conhecimento como processo mais do que como resultado e produto, vivenciando a indissociabilidade entre o ensino, a pesquisa e a extensão. Os objetivos específicos foram: i) identificar mecanismos para integração dos elementos curriculares da formação em engenharia; ii) incentivar a aprendizagem compreensiva dos conteúdos, mais do que sua memorização;iii) desenvolver as relações entre professor e aluno baseadas em parcerias; iv) variar e ativar metodologias; v) realizar avaliações na análise do processo, dos alcances e da reorganização das ações.

O desenvolvimento do projeto do veículo demandou a integração de conhecimentos específicos dos cursos de Engenharia Elétrica, Mecânica e Mecatrônica. Assim, serviram de base teórica para o estudo os conteúdos das disciplinas: Máquinas Elétricas, Conversão de Energia, Instrumentação de Controle, Mecânica dos Materiais, Projeto de Máquinas, Desenhos de Máquinas, Materiais de Construção Mecânica, entre outras.

Na medida em que o projeto pretende contribuir com os seguintes aspectos: melhoramento das técnicas locais de coleta seletiva, adaptação de tecnologia moderna ao meio ambiente e às condições da comunidade, fomento da pesquisa científica e tecnológica para identificar e resolver problemas imediatos, a idéia inicial consiste em propor um desenvolvimento a partir de dentro de uma comunidade envolvida no processo e não por intervenção externa. Aspectos econômicos, organizacionais e políticos relacionados às centrais de coleta seletiva de materiais recicláveis levaram à proposta de um projeto piloto dentro do campus Darcy Ribeiro em um primeiro momento.

Referências quanto às questões relacionadas à coleta seletiva em si, no âmbito legal, administrativo, econômico e ambiental foram assumidas: no âmbito legal, o decreto presidencial número 5.940, de 25 de outubro de 2006, que instituiu a coleta seletiva nos órgãos e entidades federais e a sua destinação às associações e cooperativas de catadores; no âmbito administrativo, as demandas específicas do Campus Darcy Ribeiro da Universidade de Brasília que levaram à criação de um Centro de Gestão de Resíduos Sólidos a ser efetivado por meio do Grupo de Trabalho em Gestão Compartilhada de Resíduos Sólidos. Ainda, no âmbito econômico e ambiental, foram assumidas referências quanto aos aspectos relativos à economia de recursos naturais e também ao aproveitamento destes.

Abordagens relativas à organização do trabalho como layout da central, percurso do veículo e raio de ação, procedimentos de coleta e seleção, uso de equipamentos, questões ergonômicas foram consideradas na definição dos requisitos do veículo a ser construído. Outra área de conhecimento própria da engenharia de produção importante no contexto dos estudos foi a pesquisa operacional, que propiciou analisar as necessidades sobre quantidade de carregadores de baterias a serem disponibilizadas nos pontos de abastecimento e a definição do percurso otimizado por meio do desenvolvimento de algoritmos apropriados.

Estudos sobre veículos elétricos são a referência teórica comum a todos os participantes, sendo o elemento teórico integrador por apresentar orientações sobre, modalidades, limitações, histórico de experiências anteriores no Brasil e no exterior, conhecimentos sobre o estado da arte da tecnologia, suas limitações e possibilidades ao estudo no seu todo, nas partes e na relação entre elas.

Além das referências teóricas expostas até aqui, por se tratar de uma experiência de educação em engenharia, estudos sobre este enfoque também foram delineadores de orientações teóricas visando superar o método tradicional de ensino baseado em aula expositiva, a qual dá ao aluno a condição de ouvinte e a de professor de responsável pelo processo de ensino-aprendizagem. Este modelo de ensino está perpetuado nas escolas de engenharia do país desde que elas foram criadas, tendo sido implementado pela inexistência de condições para a formação de professores na área pedagógica e os poucos recursos tecnológicos disponíveis (Souza, 2007).

2 Metodologia

Para a estruturação da metodologia da pesquisa, partiu-se dos princípios da pesquisa-ação uma vez que todos os envolvidos no ambiente aprendizagem são também seus estruturadores. Um ponto relevante é a necessidade de integração dos princípios do método científico com os princípios do processo de desenvolvimento de produtos de Engenharia. Assim foram consideradas, para o desenvolvimento do produto quatro principais etapas: a elaboração da proposta de solução, o desenvolvimento da solução, o plano de implementação e monitoramento da solução e a aplicação do plano de implementação e monitoramento da solução. Assim, preservando os princípios do método científico e simultaneamente garantindo aos estudantes a oportunidade de vislumbrarem a completude do projeto e vivenciarem suas partes no semestre em que estavam participando da disciplina. No primeiro semestre foi proposta a solução para o problema, baseada em aspectos teórico-conceituais a ele pertinentes e estabelecidas metas para a solução. No segundo semestre foi desenvolvido o projeto. No terceiro semestre será desenvolvido o protótipo e, no quarto, a realização de sua aplicação e análise, completando o ciclo previsto em projetos técnico-científicos. Foram criadas ainda duas disciplinas: Projeto Integrador I e II para atenderem à realização de projetos como o citado.

Nesta perspectiva, antes de iniciarem-se as matrículas dos alunos na disciplina Projeto Integrador 1 foram feitos os contatos iniciais com os professores especialistas nas áreas técnicas envolvidas no desenvolvimento de um veículo elétrico. Estes contatos visavam envolver os professores com a tarefa como também contar com a colaboração deles na divulgação do projeto entre os alunos matriculados em suas disciplinas e na realização da orientação aos alunos.

Pela metodologia da disciplina Projeto Integrador, os alunos matriculados nas disciplinas que servem de apoio técnico ao desenvolvimento do produto a ser projetado são nelas avaliados pelos resultados obtidos naquela. As atividades pedagógicas e de organização da disciplina são de responsabilidade dos professores coordenadores e colaboradores do projeto. Paralelamente foi realizado contato com especialista na aplicação da técnica dos grupos operativos para atuar como facilitador na montagem da equipe e tutor durante a execução do projeto.

Durante a elaboração da proposta do projeto foram realizados os contatos com o Grupo de Trabalho em Gestão Compartilhada de Resíduos Sólidos. O objetivo era envolver a comunidade acadêmica com a proposta e facilitar as atividades futuras dos estudantes visando levantar os requisitos necessários ao projeto para adequação e bom desempenho do veículo.

A partir do estabelecimento das condições mínimas para a criação do projeto foi marcado o primeiro encontro com os estudantes que participariam da disciplina Projeto Integrador no primeiro semestre de 2010. Na primeira reunião do grupo foram realizadas dinâmicas visando à apresentação dos participantes e o levantamento de seus interesses pessoais com a participação no projeto.

Na disciplina Projeto Integrador 1 foi desenvolvida a etapa do projeto denominada por proposta de solução, que se caracterizou por um estudo exploratório no qual foram realizados os levantamentos de informação junto à comunidade e identificação dos requisitos de desempenho necessários ao veículo elétrico, a definição da estrutura do veículo, o projeto preliminar e a seleção dos elementos que iriam constituí-lo. Os resultados das atividades previstas foram apresentados em forma de relatórios parciais e final.

Os relatórios parciais são entregues em seções denominadas pontos de controle, na qual uma banca formada por professores especialistas de várias áreas tem a função de realizar a avaliação. Os pontos de controle são realizados ao longo do semestre com intervalos de aproximadamente um mês entre eles a partir do final do primeiro mês de atividade. Esta etapa do projeto foi finalizada no final do primeiro semestre do ano de 2010. Os aspectos avaliados são relacionados ao mérito técnico da solução apresentada e às habilidades ditas transversais apresentadas pelo grupo como um todo e pelos alunos individualmente.

Na disciplina Projeto Integrador 2 foi desenvolvida a etapa de detalhamento do projeto, realizada a partir das soluções propostas pelos alunos do primeiro semestre. Nesta etapa foi definida a solução mais adequada para a construção do protótipo. Seu início ocorreu em outubro de 2010, quando novamente foram estabelecidos contatos prévios com os professores das disciplinas que iriam dar suporte técnico ao desenvolvimento do projeto do veículo elétrico para o planejamento da disciplina. Por conseguinte ocorreram mudanças na equipe de professores responsáveis – com a inclusão de duas disciplinas de apoio: Projeto de Máquinas 2 e Materiais de Construção Mecânica 2 – e mudanças na equipe de projeto para incluir os novos estudantes advindos destas disciplinas. Estas alterações tiveram por intuito fortalecer o projeto mecânico do veículo para viabilizar a construção do protótipo.

No que diz respeito à metodologia de avaliação da disciplina Projeto Integrador 2 foram mantidos os pontos de controle, a entrega de relatórios e a banca de professores especialistas. Na reestruturação da equipe de projeto formaram-se novos grupos com a responsabilidade do projeto das partes específicas do protótipo.

3 Resultados

Os resultados e produtos obtidos até o presente momento podem ser agrupados em três categorias: conhecimento gerado, desempenho dos alunos e atividades acadêmicas desenvolvidas. Quanto ao conhecimento gerado, os relatórios finais dos alunos trazem os seguintes parágrafos (Costa, 2010; Orrico, 2011):

> "A primeira fase do trabalho consistiu em uma pesquisa sobre a teoria que envolve carros elétricos, estruturas e dinâmica veicular dentro da literatura disponível sobre o assunto, sendo que dentro desses temas, o de mais difícil obtenção foi o material sobre estrutura veicular. Essa pesquisa teve por objetivo fazer com que os membros da equipe adquirissem o embasamento teórico necessário para desenvolver as outras etapas do trabalho. Esta fase também incluiu uma pesquisa sobre os carros elétricos utilizados para carga que existem atualmente no mundo. Sendo observadas as especificações de cada um e comparando-as com as do nosso projeto" (Costa, 2010; Orrico, 2011).

Os itens investigados e atualizados para o problema em estudo foram: materiais recicláveis no campus Darcy Ribeiro – quantidade, tipo, forma; pontos de carga e descarga de materiais recicláveis; percurso presumido do veículo e otimização de percurso, cálculo da força de tração e do torque do motor, geometria geral do veículo, disposição dos componentes no veículo; dimensões do veículo e sua estrutura básica; sistema de controle para um motor CC; eletrônica embarcada (computador de bordo) para veículo de coleta seletiva, propostas de automação para carga e descarga do material reciclável. Além disto, os estudantes elaboraram uma lista bibliográfica das fontes pesquisadas e organizaram um repositório de informações técnicas.

Somado aos conhecimentos na área de engenharia, os estudantes do curso de Desenho Industrial contribuíram com a elaboração de uma logomarca para o projeto e apresentaram croquis de possíveis formas finais a serem assumidas pelo veículo. Também foram realizados estudos e simulações com a colaboração de especialista em pesquisa operacional, sobre número de baterias, tempo de chegada dos veículos para abastecer e tempo de espera - visando definir a quantidade de carregadores necessários para recarregar as baterias dos veículos nos prováveis pontos de abastecimento.

O desempenho dos estudantes foi avaliado com base em resultados quantitativos (tarefas realizadas) e qualitativos (resultados alcançados, cumprimento dos objetivos estabelecidos). O texto apresentado no relatório final contribuiu no julgamento qualitativo deste desempenho. Na introdução do trabalho os alunos apontam que O projeto de um veículo elétrico para transporte de materiais recicláveis do campus da Universidade de Brasília oferecido pela disciplina "Projeto Integrador" criou uma oportunidade dos cursos de engenharia elétrica, mecânica, mecatrônica, desenho industrial e serviço social vivenciarem as relações e o ambiente para a busca de um propósito coletivo.

Neste microambiente, os alunos tiveram que se organizar e vivenciar a experiência de elaboração de projeto. Colocaram os seus conhecimentos à prova e suas habilidades de relacionamento interpessoais e emocionais, que são fatores primordiais no ambiente de trabalho.

Puderam também ter contato com as ferramentas de gestão de projeto e ampliar sua visão profissional e sócio-ambiental, sentir as fases de nascimento e maturação de um trabalho coletivo. Além disso, ser provocados e estimulados a realizar uma contribuição ambiental e social a partir de suas áreas de formação. Visualizar a interação entre áreas conexas e o papel de sua profissão junto das outras.

Assim, este relatório é fruto dos esforços somados de diferentes visões em busca de único ideal, gerando impacto positivo não só para os alunos, mas também trazendo um retorno direto à sociedade e ao meio ambiente.

Na conclusão do relatório final os estudantes apontam:

> “A disciplina de Projeto Integrador foi oferecida este semestre com uma proposta mais ousada do que as anteriores, com o intento de reunir alunos de várias Engenharias para desenvolver um projeto de um veículo elétrico para coleta seletiva no campus da UnB. O projeto inicialmente tem vários focos, ampliando a visão dos alunos para questões que não só envolvem problemas de matemática e física, mas principalmente questões ambientais e sociais. Antevendo as complexas relações que o trabalho exigiria, a equipe de alunos conseguiu modificar o requisito da proposta inicial de formar vários grupos que teriam vários projetos diferentes e passaram a formar um único grupo de alunos desenvolvendo um único projeto. Com um maior número de integrantes na equipe, pudemos montar subgrupos com áreas específicas do projeto possibilitando uma maior dedicação a cada uma delas”.
>
> [...] Inicialmente os alunos da Mecânica ficaram responsáveis por realizar um estudo de viabilidade do veículo elétrico na UnB, e fizeram várias pesquisas sobre o funcionamento e a tecnologia envolvida em veículos elétricos, bem como suas mais variadas aplicações na sociedade e na indústria. Todo esse trabalho foi apresentado no primeiro ponto de controle. Logo após essa apresentação o grupo se dividiu nos seguintes subgrupos: motor, baterias, dinâmica e estruturas, controle e integração. Em seguida, devido a um pedido dos grupos de motores e baterias, o grupo de dinâmica e estruturas se concentrou em determinar qual o torque e a potência que o motor deveria possuir. Até aí não tivemos grandes problemas. O maior problema foi quando começamos a nos concentrar na parte de estrutura do veículo, assunto que nós não dominávamos e não sabíamos por onde começar. Devido a essa situação, no início nos concentramos na teoria sobre projetos de veículos elétricos e veículos terrestres em geral, e principalmente a parte de projeto estrutural desses veículos. Além disso, nos encontramos com vários professores, buscando uma orientação sobre qual maneira conduzir melhor o trabalho. Só então percebemos que deveríamos retomar as fases iniciais de projeto, que são as fases de pesquisa e de brainstorm.
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> Depois que essas fases foram retomadas, pudemos ter uma visão mais ampla do projeto e assim prosseguir no desenvolvimento das atividades. Sabemos que não cumprimos com os prazos iniciais, mas o cronograma inicial foi elaborado sem uma noção de como o projeto funcionaria, mas já definimos quais serão as próximas atividades do grupo de dinâmica e estruturas. Seria muito interessante aumentar o número de pessoas desse grupo, devido a grande abrangência dessa área, e que indica que os trabalhos crescerão consideravelmente.
>
> Percebemos ao longo do semestre que esse é um projeto onde todas as áreas estão extremamente interligadas e que não é possível tomar decisões sozinhos. As escolhas de um grupo afetavam diretamente outro grupo, tornando o processo bastante complexo. Quando a equipe percebeu isso, começou-se a organizar reuniões conjuntas entre os subgrupos relacionados, o que promoveu uma integração muito grande da equipe, representando uma experiência muito importante para todos os membros”.

As atividades acadêmicas realizadas, tomadas como produtos resultantes do projeto e abertas à comunidade foram: palestras sobre trabalho em equipe, gestão do processo de projeto de produtos de engenharia, e sobre aspectos técnicos e organizacionais do projeto em si; visita técnica ao metrô; curso sobre ferramentas de apoio a gestão de projetos.

3.1 Análise dos Resultados

Os objetivos específicos foram alcançados na medida em que foi possível delinear uma nova forma para os elementos curriculares da formação em engenharia. Na disciplina foram tratadas simultaneamente diferentes áreas de conhecimento integradas na tarefa de projetar um veículo elétrico.

Foi possível contextualizar as demandas deste veículo de acordo com a sua aplicação futura, supô-lo de diferentes formas, estudar as possibilidades e fazer escolhas, além de ter possibilitado a interação entre as áreas de conhecimento e os participantes do projeto. Neste contexto, foi estabelecida uma referência para o desenvolvimento de disciplinas apoiadas em projetos voltadas para a solução de problemas específicos e de integrar diferentes áreas de conhecimento.

Ao longo da experiência não foram realizadas provas exigindo dos alunos a memorização. Simplesmente eles tomavam a iniciativa de direcionar suas leituras e utilizavam-nas para uma aprendizagem compreensiva dos conteúdos. Não há transmissão de conhecimento no formato tradicional, mas troca de saberes: dos estudantes ao investigarem e trazerem questões importantes no contexto do problema que procuram solucionar, dos professores ao orientarem as reflexões.

Quanto à avaliação do processo, abrangências e organizações das ações, pelo depoimento apresentado no relatório final e reproduzido no item anterior fica evidenciada a sua ocorrência ao longo do processo vivenciado pelos estudantes.

O tema "Veículo elétrico para coleta seletiva" foi considerado motivador e contribuiu para o sucesso do projeto. Também abre possibilidade para realização de pesquisas visando diminuir o impacto ambiental ao melhorar o desempenho do veículo no que diz respeito ao uso das baterias, materiais constituintes, ergonomia, sistema de abastecimento e tantos outros.

4 Conclusão

Em termos de metodologia de pesquisa, a experiência vem se consolidando como uma estratégia baseada na abordagem de pesquisa-ação, onde os professores e estudantes participam como pesquisadores que atuam diretamente no ambiente de aprendizagem em criação permanente. Em cada etapa do desenvolvimento do veículo são colocadas novas questões de pesquisa, proposições são confirmadas ou refutadas e o conhecimento vai sendo construído pela coletividade dos envolvidos no processo.

Quando questões novas surgem são acionados outros agentes que contribuem para o processo, como foi o caso dos estudantes de desenho industrial, comunicação, serviço social, colaboradores desenvolvedores de rede social e de algoritmos matemáticos bem como os especialistas em educação ambiental.

A experiência vivenciada aponta para a possibilidade de se realizar ensino, pesquisa e extensão de forma integrada através da estruturação de ambientes de aprendizagem abertos, não limitando a atuação do estudante a uma atividade específica e pré-definida. O projeto mostra que é possível desenvolver competências, como o trabalho em equipe e a capacidade de resolver problemas, requeridas para o desempenho das funções do futuro engenheiro. Sobre outro aspecto, também possibilita maior autonomia para estruturar as questões de pesquisa ao estudante que pretende se iniciar no campo de pesquisa científica uma vez que, durante o processo, este é capaz de perceber a necessidade das regras metodológicas e de financiamento. Deste modo, o projeto colaborativo interdisciplinar instiga maior atenção dos dirigentes acadêmicos para apoiar ações semelhantes.

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Disciplinas de projeto e a integração do ensino, pesquisa e extensão: um estudo de caso a partir do desenvolvimento de uma plataforma experimental de veículo elétrico.

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Abstract

In the project subjects of Engineering courses, the methodology called Project Based Learning (PBL) is generally being applied without taking into consideration the existing potential, in such subjects, of the integration among teaching, research and university extension activities. Aiming at contributing to the broader use of this potential, a case study, which was performed in the context of a project subject applied to three teams that carried out studies for the development of an experimental platform for electrical vehicles, is presented. The methodology to develop the study is research-action. We applied, as a theoretical reference to organize the project subject, considering teaching, research and university extension activities, a model used in the modeling of processes that considers three groups of variables associated to the axes of a tridimensional system, which represent the orientation or direction of the subject, its infra-structure and the subject itself. The study revealed that this model favors the observation of the integration potential among teaching, research and university extension activities, in the context of the project subject, increasing the cost-benefit gains for all of those involved: professors, students, the institution and society.

Keywords: Project subjects; Project Based Learning (PBL); Integration among research, teaching and university extension activities.

1 Introdução

A disciplina de projeto que oportunizou o desenvolvimento da experiência aqui relatada tem as seguintes características gerais: é desenvolvida por um conjunto de quatro a cinco professores; um professor faz o papel de coordenador geral da disciplina e os outros são orientadores das equipes de alunos nela matriculados. As tarefas de tutoria são desenvolvidas pelo próprio orientador de cada equipe. As equipes são constituídas voluntariamente, em média, compostas por 10 alunos. O tema do projeto a ser desenvolvido pelas equipes é apresentado pelo professor orientador. A disciplina tem uma carga horária de 60 horas, sendo que vinte horas iniciais são utilizadas visando à preparação dos estudantes em três temas principais: atividades em equipes, gestão de projeto e metodologia científica. Esta preparação se dá através de palestras ministradas por especialistas ou por seminários desenvolvidos pelos próprios alunos sob a coordenação e orientação do professor coordenador. A disciplina de projeto é obrigatória no quinto semestre. No oitavo semestre os alunos cursam a segunda disciplina de projetos do curso, a qual é também obrigatória. A experiência aqui relatada diz respeito à participação dos estudantes na disciplina do quinto semestre.

Cerca de doze horas da carga horária da disciplina são utilizadas para o processo de avaliação constituído de três apresentações orais intercaladas em períodos de, aproximadamente, um mês, realizadas para uma banca constituída de três professores escolhidos entre os que exercem as funções de orientadores ou coordenador. Na primeira apresentação oral é exposto o plano do projeto, na segunda os estudantes apresentam o andamento do projeto até o momento e o desmembramento futuro. Na terceira, os estudantes apresentam a versão final do projeto que desenvolveram no semestre. Cerca de 8 horas são utilizadas para o planejamento inicial do projeto e definição das equipes. A carga horária restante é utilizada em reuniões de orientação das equipes sob a coordenação dos professores orientadores. Na ementa da disciplina é previsto que os alunos deverão despender quatro horas semanais de estudo para a disciplina, além da carga de 4 horas semanais prevista.

A experiência no desenvolvimento da plataforma experimental de veículo elétrico foi realizada no primeiro e no segundo semestres de 2010, sendo que, no primeiro semestre de 2010, duas equipes desenvolveram projetos a ela relacionados. Os focos dos projetos foram o estudo do veículo para realização do processo de conversão e o desenvolvimento de uma metodologia para conversão de motores de veículos à combustão para elétricos. O tema desenvolvido pela equipe do segundo semestre foi sistema controlado de recarga de baterias para veículos elétricos. O conhecimento gerado sobre estes enfoques estão apresentados no item três. Todos os três enfoques visavam contribuir para o desenvolvimento de uma plataforma experimental de veículo elétrico, tema escolhido pelo professor orientador com a anuência dos demais.

No próximo item é apresentada a estrutura teórica utilizada visando apoiar a metodologia adotada para planejar a disciplina, buscando estabelecer uma referência complementar à programação da disciplina, que até então se restringia à determinação das atividades previstas e de suas datas de ocorrência.

2 O contexto teórico das disciplinas de projeto

A principal questão que orientou o desenvolvimento do estudo foi como estabelecer uma nomenclatura e uma metodologia que possibilitem o planejamento da experiência, visando contemplar a relação entre a disciplina de projeto e a integração das atividades de pesquisa, ensino e extensão. Para responder a esta questão buscou-se estabelecer uma estrutura teórica específica apresentada a seguir.

O estabelecimento da referida estrutura teórica se deu a partir das publicações que tratam da aplicação da abordagem da Aprendizagem Baseada em Projetos (PBL). Estas publicações embora tenham contribuído, significativamente, em termos metodológicos para o avanço da experiência realizada, são apresentadas, em geral, sem consideração de aspectos sociais, políticos e ideológicos envolvidos em instituições de ensino. Esta desconsideração faz com que, de fato, estes passem a ser os referenciais sociais, políticos e ideológicos já pré-existentes em tais instituições e passam a ser apresentados em forma de uma objetividade a partir da qual o mundo deve ser percebido. Com isto, abre-se espaço para que em nome da técnica banalizam-se as individualidades na generalização, restringindo a oportunidade dos estudantes interpretarem sua subjetividade e desenvolverem atenção à realidade contextualizada historicamente.

Diante do exposto, pode-se inferir que a estruturação de disciplinas de projeto, exclusivamente, a partir de uma metodologia de ensino-aprendizagem, já aponta na visão dos autores, uma simplificação do processo de planejamento de tais disciplinas, ao ponto de ser considerada possível sua oferta nos cursos de Engenharia com base no princípio de “não onerar professores, alunos e a grade curricular” (Santana, 2009).

Diante da evidência da impossibilidade de tal princípio observada a partir da experiência dos autores com disciplinas de projeto procederam-se à busca de referências que pudessem indicar quais seriam as variáveis organizacionais de uma instituição de ensino envolvidas no processo de planejamento de disciplinas de projeto. Experiência em pesquisa na área de modelagem de processos complexos aproximou os autores do modelo tridimensional de representação da realidade, proposto por Gattaz Sobrinho (apud Moresi, 2001). O referido modelo é constituído por três eixos, aos quais são associadas variáveis organizacionais, cujos valores qualitativos vão determinar os resultados do processo que representa. Os três eixos considerados são: o eixo da atividade resultante do processo, o eixo da axiomática e o eixo da infra-estrutura. As relações entre os eixos são explicitadas pelo autor do modelo como sendo: o eixo da axiomática orienta o eixo da atividade e influência o eixo da infra-estrutura. Este último influencia o eixo da atividade. O eixo da atividade representaria as variáveis dependentes.

Aplicando o modelo no problema em estudo, a disciplina de projeto seria o processo a ser modelado e estaria representado no eixo da atividade. As orientações institucionais para elaborar a disciplina estariam representadas no eixo da axiomática. Por fim, o eixo da infra-estrutura representaria recursos físicos e humanos envolvidos no desenvolvimento da disciplina.

Definido o modelo a ser adotado para planejar a disciplina restava ainda denominar as variáveis que deveriam ser associadas a cada um dos três eixos considerados no modelo. Recorreu-se então a autores que tratam da metodologia PBL. Entre eles, identificaram-se na abordagem apresentada por Walsh (2007) considerações que apontam o potencial da metodologia PBL na criação de uma nova cultura em departamentos de Universidade com base na confiança e no respeito à contribuição do estudante, em oposição àquela propiciada pelo ensino tradicional, na qual os estudantes são vistos como membros externos ao departamento, com pouco ou nada a contribuir. Com a metodologia PBL, eles são encorajados a contribuir, juntamente com o educador. Walsh (2007), a partir disto, compara o papel dos estudantes com o papel exercido pelos colaboradores em equipes de atividades profissionais. Logo em seguida, relaciona cada um dos 14 passos de Deming sobre a qualidade nas organizações com a aplicação de disciplinas baseadas em PBL nos departamentos de Universidades. Os 14 passos são sinteticamente apresentados a seguir, interpretados aqui como as orientações que poderiam ser adotadas para a implantação de disciplinas de projeto baseadas na metodologia PBL.

As orientações são: necessidade de uma visão compartilhada no departamento sobre a metodologia PBL; comprometimento da direção com as mudanças acadêmicas necessárias apesar das resistências em aplicálas; escolha de um método de ensino que maximiza os benefícios mais que os custos -, PBL não reduz os recursos, mas pode aumentar a produção total como, por exemplo, através de publicações -; consideração da participação ativa do estudante, também em nível de graduação, tendo em vista que este pode contribuir para o desenvolvimento de pesquisa em determinados temas; disseminação dos princípios da aprendizagem entre professores e estudantes; lideranças das chefias de departamentos, tanto no ensino como na pesquisa, apesar da predominância do comprometimento dos docentes com a pesquisa; disseminação de cultura de confiança e respeito mútuo, visando à geração de grupos de estudantes de excelência, sendo esta uma consideração essencial da PBL; promoção da aproximação dos cursos de graduação das atuais atividades de pesquisa através de estudos de caso PBL; análise de dados, envolvendo ativamente os estudantes e professores de outros departamentos; substituição de chavões pela confiança, respeito e reconhecimento de que muito do que há de errado com o desempenho dos estudantes é um problema de gestão; desenvolvimento de esforços para eliminar restrições quantitativas, tais como crédito, restrições de ponto e atribuição restritivas de requisitos e prazos; desenvolvimento de uma cultura de espírito de equipe -, que é intrínseca à PBL -; a preparação dos alunos para a aprendizagem contínua e a adoção do entendimento de que os problemas ocorrem pelo não-gerenciamento.

Neste contexto, as orientações estabelecidas foram tomadas como variáveis representativas do eixo da axiomática. Elas representam as orientações teórico-filosóficas da instituição consideradas para o desenvolvimento de disciplinas de projeto. Quanto às variáveis representativas do eixo da infra-estrutura foram consideradas: o espaço físico, os recursos materiais e humanos: os professores -, orientador, avaliadores e coordenador -, e os estudantes. No eixo da atividade em si – a disciplina - foram consideradas como variáveis que caracterizam a experiência: tema; enfoque das atividades propostas em termos de pesquisa, ensino e extensão; objetivos; qualidade do produto resultante dos projetos – solução e relatório - e o desempenho dos estudantes. Tais variáveis foram definidas a partir da bibliografia consultada. A discussão dos efeitos das variáveis representativa do eixo da axiomática sobre as variáveis que caracterizam o eixo da atividade, bem como, da sua influência sobre o eixo da infra-estrutura está apresentada de forma resumida nos parágrafos que se segue.

A definição do tema dos projetos está diretamente relacionada com o objetivo pretendido a partir da disciplina de projeto. Este objetivo pode ser definido pela instituição ou pelo professor orientador, especificamente, para os grupos que orienta. Assim, por exemplo, se o objetivo para a disciplina é aumentar a produção total como, por exemplo, através de publicações, com a participação ativa dos estudantes, o professor orientador pode se motivar a participar em projetos com focos de seu interesse, podendo inclusive contabilizar estes projetos como projetos de pesquisa que irão contribuir para a sua progressão funcional na instituição.

Alguns enfoques de um mesmo tema podem ser diferenciados de um semestre para outro sem o risco de cópia. Um exemplo é a disciplina de projeto na Universidade do Minho em Portugal. A partir do tema Planejamento e Controle da Produção (PCP), projetos desenvolvidos junto a empresas, são replicados a cada semestre, em empresas diferentes, oportunizando aos estudantes conhecerem realidades distintas daquelas estudadas pelos colegas que os antecederam nos semestres anteriores, embora possam usar o mesmo referencial teórico. O orientador pode, por exemplo, direcionar os projetos de forma a obter estudos comparativos a respeito do processo de PCP em diferentes empresas (Universidade do Minho, 2009).

Outro aspecto a ser considerado é a integração das atividades da disciplina em termos de ensino, pesquisa e extensão. A constância de propósitos buscando tal integração exige um esforço do orientador em criar um ambiente de aprendizagem que a favoreça, onde o desenvolvimento do projeto é visto mais como um processo do que uma oportunidade para que este gere um conhecimento apresentado em forma de relatório ou de um produto desenvolvido (FORGRADE, 2000). O enfoque é mais a tarefa, do que o objetivo (Quiroga, 1989). O critério, neste sentido, é escolher um tema que abrigue as ações desenvolvidas pelos estudantes, tanto no aspecto de processo como no de produto – conhecimento e produto resultantes. No aspecto de processo, a contribuição dos estudantes está na idiossincrasia de sua experiência individual, no desenvolvimento colaborativo do objetivo geral, vislumbrado pelo orientador. Ainda, no que tange ao processo, se for considerado o conhecimento gerado, este pode ser tomado como uma síntese deste processo e pode representar apenas a reunião e sistematização de informações pertinentes ao tema. Estas, passam a ser uma referência para outros enfoques dentro de um mesmo tema que venham a ser desenvolvidos por outras equipes, em semestres subseqüentes. O mesmo pode ser dito em relação ao produto. Os estudantes podem apresentar o projeto de um produto, que não necessariamente será o definitivo. O que determina o caráter processual é a percepção de todos os envolvidos da evolução gradual na construção de conhecimento relativo a um determinado tema.

Quanto às atividades de extensão, seu papel no ambiente de aprendizagem de disciplinas de projeto pode ser entendido como o de significar à aprendizagem ocorrida. O interesse de terceiros no produto desenvolvido possibilita ao estudante observar o significado de seu produto fora do aspecto acadêmico apresentado pelos professores. Professores e estudantes são confrontados com outros critérios que lhes permitem comparar a pertinência ou não das exigências acadêmicas, surgindo assim, a oportunidade para suas evoluções.

Neste contexto, o que altera é o olhar aplicado e não as atividades em si, se de pesquisa, ensino e extensão. Elas podem ser promovidas tanto em termos de direcionamento metodológico como de produto resultante. Se o olhar não estiver alinhado com a idéia de processo, o direcionamento pode recair exclusivamente no ensino, e a disciplina passa a ter uma característica muito semelhante às disciplinas tradicionais dos cursos de Engenharia, mesmo em se tratando de conteúdos como: gestão de projetos, metodologia de pesquisa, trabalho em equipe e abordagens metodológicas relativas ao desenvolvimento de produtos tecnológicos. O mesmo podendo acontecer se o direcionamento for exclusivamente a pesquisa, as atividades como: levantamentos bibliográficos, aplicação de técnicas de pesquisa e elaboração de publicações científicas não as diferenciariam de experiências que os estudantes vivenciam quando integram grupos de iniciação científica. Se o foco da disciplina é a extensão, as atividades propostas podem ser direcionadas à resolução de problemas, com soluções exclusivas de interesse das organizações parceiras, restringindo a busca por outras soluções, que podem oportunizar aos estudantes, vivências mais abrangentes tanto em termos metodológico como de produto resultante.

O direcionamento em relação a ensino, pesquisa ou extensão está associado também à definição dos objetivos da disciplina. A adoção da metodologia de desenvolvimento de produtos tecnológicos contribui para a qualidade do projeto desenvolvido e para a aprendizagem dos alunos. Dopelt (2005) pondera que muitas estruturas genéricas para o processo de desenvolvimento de produtos são apresentadas na literatura, mas que o ensino de desenvolvimento de produtos tecnológicos, usando um processo de projeto genérico, é considerado por alguns como difícil aos estudantes e até mesmo para professores aprenderem como aplicá-los, principalmente, porque cada área de atuação no campo tecnológico utiliza-se de um modelo de processo de projeto. O autor então propõe um processo simplificado, isto é, constituído pelas etapas que denomina por proposta, entradas, soluções, escolhas e operações. A adoção desta simplificação contribui para a determinação do nível de detalhe que o projeto deve alcançar, podendo este abranger apenas a definição de requisitos ou o desenvolvimento de um protótipo de baixa, média ou alta fidelidade. A definição do nível de detalhe que o projeto deve alcançar depende do tempo total da disciplina e do número de disciplinas que os alunos estão envolvidos simultaneamente à disciplina de projeto.

Estas dependências talvez incentivassem usar o bom senso e se estabeleceria para o produto resultante, nível de detalhe mais baixo, principalmente, quando se trata da primeira experiência dos estudantes com o desenvolvimento de produtos tecnológicos. O objetivo da disciplina estaria voltado mais para proporcionar a estes estudantes o conhecimento através de uma experiência que pode ser uma simulação da realidade de como se desenvolve um produto, do que para desenvolver o melhor produto. Entretanto, esta posição normalmente é difícil de ser consenso entre os professores, principalmente, entre aqueles com formação exclusiva na área tecnológica.

Mohan at al (2009) relatam o exemplo em que engenheiros quando exercem o papel de gerentes de projeto na indústria tendem a se concentrarem mais em questões técnicas do que na gestão profissional, por considerarem estas habilidades menos importantes. Como conseqüência, seus planos ficam aquém dos propósitos da estratégia global da organização. Ainda, conforme Mohan et al (2009), os engenheiros aprendem estas habilidades *on the job,* a qual tem sido descrita como uma aprendizagem de habilidades *soft* através de uma maneira *hard*.

Experiências como estas são uma referência para definição do objetivo das disciplinas de projeto, valorizando o desenvolvimento de habilidades *soft,* diminuindo a ênfase no aspecto técnico. Esta alternativa é viável, principalmente, em casos em que a disciplina é oferecida em dois semestres. No primeiro semestre, os alunos desenvolvem as habilidades *soft* e no segundo semestre, as exigências podem recair sobre aspectos técnicos da solução, exigindo-se níveis de detalhes mais altos.

Outra abordagem que pode contribuir para a reflexão em torno da formulação dos objetivos da disciplina é quanto às modalidades de pensamentos envolvidas na resolução de problemas apresentadas por Doppelt (2005). O autor considera as modalidades de pensamento lateral e vertical. O pensamento lateral, que se refere à descoberta de novas idéias a serem adotadas, e o pensamento vertical, que possibilita o aprofundamento de idéias, confrontando-as com critérios objetivos pré-estabelecidos, como é o caso quando se pretende atender requisitos de produtos. Pensamento lateral e vertical são processos muito diferentes. Porém não é uma questão de valorizar um em detrimento do outro, pois ambos são necessários. Ao contrário, a fim de poder usar os dois de forma eficaz, deve-se valorizar suas diferenças. O pensamento lateral é um componente central, mas não único, do pensamento criativo. Durante o desenvolvimento de um projeto tecnológico, o pensamento lateral inicia o processo de aprendizagem, enquanto os estudantes buscam alternativas e analisam as diferentes soluções. O pensamento vertical é essencial na fase de escolha de uma solução e de seu desenvolvimento.

Seguindo este raciocínio, a questão é: como dimensionar o tempo necessário a cada projeto para que os estudantes realizem de forma satisfatória as atividades relativas tanto ao pensamento lateral como ao vertical? Na falta da resposta a esta questão, dada a especificidade de cada projeto, pode-se adotar algum critério como, por exemplo: as atividades associadas ao pensamento lateral seriam mais valorizadas na primeira experiência dos estudantes com disciplinas de projeto. A falta de experiência, possivelmente, leva-os a apresentarem maiores dificuldades em tomar decisões. Com isto, naturalmente, se preocupariam em conhecer todas as alternativas possíveis. O pensamento vertical seria enfocado na segunda experiência do aluno com disciplinas de projeto, pois já estariam mais habilitados para tomar decisões e detalhá-las adequadamente.

Com isto, o objetivo de disciplinas de projeto pode ser orientado pela consideração dos níveis de investimento nestas duas modalidades de pensamentos, de tal forma que quando o enfoque for valorizar as habilidades transversais e gerenciais as atividades a serem realizadas são aquelas que buscam ampliar o entendimento e as possibilidades de soluções em detrimento daquelas que contribuem para a escolha da solução, ainda que uma solução possa ser adotada, mesmo esta não sendo a melhor. O que estaria em observação, no caso, é o uso adequado dos procedimentos para apresentar a solução mais do que a solução em si. Quando o enfoque for mais técnico que gerencial, invertem-se os critérios de valorização, de forma que as atividades valorizadas passam a ser aquelas em que maior detalhamento técnico na escolha de uma solução possa ser apresentado, garantindo exeqüibilidade do produto projetado.

A discussão apresentada acima foi tomada como a estrutura teórica necessária para estabelecer uma nomenclatura e uma metodologia que possibilitassem o planejamento da experiência aplicada a uma disciplina de projeto contemplando a sua relação com a integração de atividades de pesquisa, ensino e extensão. Daí se estabeleceu as variáveis do eixo da axiomática, as do eixo da atividade e as do eixo da infra-estrutura. A designação de tais variáveis pode ser vista na tabela 1 apresentada no item 4 a seguir.

3 Metodologia

O estudo aqui apresentado é de cunho teórico. O esforço foi na identificação de terminologia e modelo de planejamento de disciplinas de projeto que possibilitasse incluir outras variáveis, além de prazo, horário, conteúdo a ser ministrados e procedimento de avaliação. Embora, tais fatores sejam relevantes para definir o plano da disciplina, eles o são enquanto elementos significantes da disciplina, mas não enquanto significado. A metodologia utilizada para realizar o estudo é de cunho qualitativo e se caracteriza como pesquisa-ação, uma vez que a experiência onde foi realizado sofreu influência do mesmo.

4 Resultados

Os resultados do estudo estão sumarizados na tabela 1 apresentada a seguir. Além da denominação das variáveis adotadas para o planejamento da disciplina, são apresentados os valores qualitativos a elas atribuídos considerando as condições em que a experiência foi realizada. Também são apresentados como resultados as descrições dos produtos resultantes das atividades de projeto de cada uma das três equipes participantes da experiência realizada. A experiência realizada contava com um professor orientador e o apoio do professor, então, coordenador da disciplina.

Tabela 1: Resumo do Planejamento da disciplina de projeto

Variáveis
1. Eixo da infra-estrutura (recursos)
1.a. **Espaço físico**: Foi reservado o espaço físico com bancadas de trabalho e espaço para análise do veículo a ser estudado.; 1.b. **Materiais e equipamentos**: Foi providenciada a aquisição do veículo por doação intermediada pelo professor orientador, assim como os demais componentes necessários para a realização do protótipo do eletro posto; 1.c. **Estudantes**: além do backgraund normal adquirido ao longo dos dois anos e meio nos cursos de Engenharia, dois estudantes com experiência profissional na área de mecânica de automóveis compunham a equipe; 1.d. **Professores**: além do professor orientador foi estabelecida uma rede de professores e técnicos especialistas em assuntos pertinentes ao projeto tanto nos aspectos técnicos como educacionais.
2. Eixo da axiomática (orientações)
2.a. **Visão compartilhada da metodologia de organização entre os professores orientadores**: a visão compartilhada entre os professores – orientador e coordenador - foi expressa como sendo: a disciplina de projeto visa proporcionar uma formação que incentive o futuro profissional atuar com autonomia e competência para um fazer vinculado à prática social, geradora de novos saberes e novos fazeres viabilizados pela integração entre ensino, pesquisa e extensão. 2.b. **Comprometimento dos professores orientadores com as mudanças acadêmicas necessárias:** para o desenvolvimento das atividades propostas no projeto, os esudantes serão imersos em um ambiente de aprendizagem que valorize mais o processo de aprendizagem do que os produtos dele resultante. 2.c. **Escolha de um método de ensino**: o método de ensino escolhido é a metodologia PBL, a qual já foi descrita brevemente na introdução do presente artigo. 2.d. **Incentivo à participação ativa dos estudantes**: além de ser condição inerente na metodologia PBL, são previstas ações motivadoras, como visitas técnicas, oficinas de demonstração de automóveis convertidos, entre outras; 2.e. **Divulgação dos princípios da aprendizagem entre os estudantes:** serão propostas palestras e seminários, envolvendo temas sobre trabalho em equipe, com enfoque na teoria dos grupos operativos de Pichon Reviere, aplicada à aprendizagem; 2.f. **Participação dos professores orientadores em pesquisa e ensino:** o professor orientador desenvolve pesquisa na área do tema do projeto e o professor coordenador na área de ensino de EEngenharia. Ambos atuam em atividade de extensão; 2.g. **Existência de cultura de confiança e respeito mútuo visando à geração de grupos de estudantes de excelência**: preparação dos alunos em temas de trabalho em equipe através de palestras e seminários por eles apresentados; 2.h. **Promoção de atividades de pesquisa**: a faculdade que abriga os cursos de Engenharia não possui cursos de pós-graduação na área do projeto, o que incentiva os professores desenvolver atividades de pesquisa junto aos estudantes de graduação; 2.i. **Integração entre os estudantes dos quatro cursos de Engenharia**: as equipes são formadas por, no mínimo, dois estudantes de um dos quatro cursos de Engenharia da faculdade: automotiva, energia, eletrônica e software; 2.j. **Valorização da capacidade individual dos estudantes e da gestão para garantir melhor desempenho dos alunos**: provisão de uma estrutura de apoio para o desenvolvimento das atividades dos projetos com espaço físico, materiais, equipamentos e ferramentas e estrutura de transporte quando necessária. 2.k. **Eliminação de restrições quantitativas**: professor orientador com disponibilidade de tempo para atendimento dos alunos fora do horário convencionado para a disciplina; 2.l **Incentivo ao desenvolvimento do espírito de equipe**: propostas de atividades acadêmicas e sociais para promover a interação das equipes; 2.m. **Direcionamento para valorizar a aprendizagem contínua**: promoção da aprendizagem significativa, produzidas a partir da aquisição do conhecimento socialmente elaborado e contextualizado; 2.n. **Valorização da gestão**: incentivo às equipes orientadas à aplicação de metodologias de gestão de processos de desenvolvimento de produtos tecnológicos com incentivo à assistência das apresentações das demais equipes nos seminários de pontos de controle das atividades da disciplina, para fins de estabelecimento de referências comparativas.
3. Eixo da atividade (a experiência das três equipes)
3.a. **Tema:** O tema escolhido é veículos elétricos. Dentro deste tema, enfoques diferentes podem ser realizados. Inicialmente serão priorizados os temas: estudo do veículo e do processo de projeto do motor elétrico, estudo de metodologia de conversão e estudo de modelos de recarga de baterias para veículos elétricos. 3.b. **Enfoque das atividades propostas em termos de pesquisa, ensino e extensão**: em termos metodológicos o enfoque será a extensão através de envolvimento dos alunos com visitas técnicas, levantamento de opiniões, participação em oficina de demonstração de veículo convertido e metrologia automotiva. Em termos de produto resultante, serão exigidos os critérios aplicados para os demais grupos participantes na disciplina em relação à solução do produto e aos relatórios. 3.c. **Objetivos:** adoção da metodologia de desenvolvimento de produtos tecnológicos tendo como referência as regras da metodologia de pesquisa científica e levando em consideração o tempo de três meses para desenvolver o projeto e o envolvimento dos alunos com outras disciplinas. A ênfase é no desenvolvimento de habilidades *soft,* mais do que na melhor solução para o produto, o que em termos de modalidade de pensamento se traduz em priorizar atividades que permitam investimento no pensamento lateral, mais do que o vertical. 3.d. **Desempenho dos estudantes.** O desempenho dos estudantes será avaliado considerando-se: a) domínio de conceitos multidisciplinares em Engenharia; b) os efeitos da atuação individual do estudante sob a atuação dos demais participantes em um ambiente colaborativo de desenvolvimento de projeto; c) visão geral da solução; d) conhecimento de soluções alternativas; e) cumprimento de prazos; f) justificativas das decisões; g) relacionamento interpessoal; h) elaboração de relatórios técnicos e; i) apresentações orais.

4.1 Grupo 1 – Estudo do carro a ser convertido e determinação das especificações do motor elétrico

Este grupo tinha como foco o estudo do carro a ser convertido, e a determinação da especificação técnica dos componentes que deveriam ser trocados ou adaptados para a nova situação de funcionamento do veículo. A seguir é apresentada a descrição do produto resultante do estudo. O veículo a ser convertido é de pequeno porte, desenvolvido pela empresa brasileira fabricante de automóveis, a Gurgel, em 1991, com um peso total de 995 kg e movido por um motor de30 HP de combustão interna a gasolina de 2 cilindros. O veículo foi considerado adequado para a conversão, por ser leve, ter sua estrutura construída em fibra de vidro e apresentar mecânica simplificada para a sua unidade de motor. O objetivo foi estabelecido como sendo elaborar o projeto para transformar o carro, visando a sua utilização como uma plataforma experimental de custo baixo para os cursos de graduação em Engenharia de energia, automotiva, software e eletrônica, mantendo as características gerais do veículo como limite de peso, dimensões e comportamento dinâmico. A conversão foi projetada para ser executada mediante a utilização de peças de veículos comerciais, que servirá de base para o estudo e para o desenvolvimento de kits de conversão que podem ser instalados em qualquer veículo a preço competitivo. O primeiro esboço do veículo foi detalhado com software CatiaV6R19®, e foi projetado para ter uma autonomia de 50 km com um motor 10 HP de indução de corrente alternada com um controlador que permite a frenagem regenerativa. Esta autonomia é garantida por um conjunto de baterias de 10KWh, sendo o mesmo adequado para veículos de uso diário. A maioria dos veículos urbanos raramente ultrapassa essa demanda. A acumulação de energia nas baterias é um dos principais gargalos para veículos elétricos. Existem vários tipos disponíveis no mercado. Devido à restrição financeira, foram escolhidas baterias de chumbo ácido comercial. Para atingir a autonomia prevista, 14 baterias automotivas comerciais de 75AH foram planejadas. A instalação das baterias no veículo será feita de forma a manter a distribuição de peso sobre o eixo dianteiro e traseiro, sem deslocar o centro de massa do veículo. Como este projeto é uma plataforma experimental, será possível substituir as baterias de chumbo-ácido, com uma tecnologia mais eficiente em uma fase posterior. O custo de conversão é de aproximadamente R$ 15.000,00, onde 35% deste montante é para a unidade de motor e controlador, 30% para as baterias e os restantes para a fiação, carregadores de bateria, conversores e adaptação mecânica. A configuração proposta é adequada para ser usada como uma plataforma experimental para os cursos de graduação em Engenharia tendo sido escolhido por ser um instrumento motivador para a aprendizagem multidisciplinar.

4.2 Grupo 2 – Metodologia de conversão

Para a realização da conversão de um automóvel de combustão interna para um veículo elétrico, é necessária uma metodologia de conversão a ser seguida para a execução do projeto. Tomando-se esta medida, economiza-se tempo de execução e reduzem-se custos ao longo de todo o projeto. Esta metodologia segue uma seqüencia simples de conversão, que se baseia, inicialmente, em um levantamento de dados do carro escolhido como: dimensões, potência do motor de combustão, peso e também no levantamento da autonomia do futuro VE, sendo esta última calculada de acordo com a necessidade do usuário e da capacidade de suporte do carro. Realizada a primeira etapa do processo da conversão, faz-se a escolha do tipo de motor a ser adaptado no carro, o que definirá, conseqüentemente, o tipo de controlador. Definidos o motor e o tipo de controlador, deve-se definir o tipo de bateria a ser instalada. O mercado atual oferece diversos tipos de baterias, porém esta escolha é feita em função da autonomia que se quer atingir, juntamente com as condições econômicas que apresenta o comprador. As baterias de chumbo-ácido, que são as mais baratas existentes no mercado, embora viáveis economicamente, apresentam baixa densidade energética, ou seja, seu peso é superior quando comparado com outros tipos de baterias, o que desfavorece sua escolha. Definida a quantidade de baterias de acordo com autonomia desejada e a distribuição espacial no automóvel das baterias e do motor, inicia-se a fase da retirada de peças inutilizadas do antigo carro, e em seguida é feita a instalação das peças que irão compor o sistema elétrico do veículo.

4.3 Grupo 3 – Sistema Micro controlado de Recarga de Baterias para Veículos Elétricos

Como resultado foi proposto um sistema de recarga das baterias do tipo chumbo-ácido para veículos elétricos, o sistema é micro controlado para fornecer às baterias a corrente correspondente a créditos que são determinados via cartão magnético (sistema de tarifação). Para tal propósito será utilizada a placa 8051, a qual usa o micro controlador Atmel AT89S51. O sistema conta inda com um medidor de tensão SAGA 1000 ou ZMD318, um leitor de cartão magnético ligado a um microcomputador e um carregador de baterias. O medidor será colocado na Placa 8051, o valor de tensão que passa para a bateria será mostrado pelo *display* do medidor. O micro controlador irá receber, através de porta serial, a informação de quanto de energia será fornecida para a bateria através do leitor de cartão magnético, que indica o valor pré-definido. O micro controlador interrompe o fluxo de energia, fechando a chave quando o valor do cartão for atingido. O sistema de tarifação será composto pelo leitor de cartão magnético e o microcomputador. A interface com o usuário será feita através de um software que o orienta quanto ao procedimento para uso do cartão magnético.

5 Análise

O modelo utilizado contribui para identificar as relações de orientação e influência sobre a caracterização da disciplina. Estas relações foram discutidas no item 2, numa perspectiva de modelo genérico. Dada a restrição de espaço para o presente texto, apresenta-se no próximo parágrafo uma análise sintética dests relações no âmbito da especificidade da experiência em que foi aplicado a terminologia e modelo propostos. A influência das variáveis da infra-estrutura na caracterização da disciplina pode ser depreendida da tabela 1.

As variáveis de orientação representam as variáveis independentes da relação entre os eixos considerados, uma vez que orientam o eixo da atividade (a experiência das três equipes) e influenciam o eixo da infra-estrutura (recursos). Algumas variáveis orientadoras foram definidas no contexto geral da disciplina e não no contexto específico da experiência das três equipes aqui em pauta. Porém, todas as variáveis deste eixo orientaram a escolha do tema, pois este deveria ser do interesse do professor orientador, é um tema que possibilita diferentes soluções dependendo dos requisitos de desempenho considerados, o que exigiu grande investimento dos estudantes em atividades de determinação destes requisitos e de soluções que os integrasse considerando as características do veículo em estudo. Estas atividades de pesquisa foram formalizadas nos relatórios exigidos das equipes como produto resultante. O tema também confronta o atual paradigma tecnológico da indústria automobilística brasileira, colocando os estudantes frente aos problemas sociais, políticos e econômicos nele envolvidos. Estes aspectos, por si só, foram motivadores para garantir a participação ativa dos estudantes nas atividades previstas. Os próprios estudos incentivados sobre trabalho em equipe também promoveram a motivação dos alunos para participarem ativamente e para estabelecer-se uma cultura de confiança e respeito mútuo. As restrições de tempo e dificuldades de reuniões presenciais obrigavam os estudantes se utilizarem de métodos de gestão para alcançarem os objetivos que se propunham nos intervalos de tempo entre as apresentações dos relatórios.

6 Considerações finais

O modelo de representação tridimensional utilizado para planejar a experiência favoreceu a reflexão sobre as orientações que facilitam sua expansão para além do aspecto do ensino, contribuindo para a integração das atividades a ele associadas, com atividades de pesquisa e extensão. Ressalta-se que os próprios valores qualitativos atribuídos as variáveis consideradas em cada eixo, podem ser tomados como referência em reflexões que visem ampliar o planejamento de disciplinas de projeto para além da definição de prazos, horários, conteúdos a serem ministrados e procedimentos de avaliação, embora, tais fatores também tenham sido considerados.

A experiência permitiu a vivência dos alunos em atividades de pesquisa, ensino e extensão, contribuindo para que estabelecessem suas próprias referências comparativas entre os aspectos acadêmicos considerados e as referências da sociedade. Alguns membros das bancas examinadoras questionavam os resultados obtidos, por atribuírem ênfase maior em atividades direcionadas pelo pensamento lateral. O professor orientador considera que o desempenho dos alunos foi adequado em termos de habilidades para participar de atividades de ensino, pesquisa e extensão. Se este desempenho não alcançou níveis máximos, deve-se a limitações de recursos didáticos para sintetizar e sistematizar certas situações vivenciadas pelos estudantes, tendo em vista a pouca experiência tanto dos docentes da faculdade onde ocorreu a experiência como da própria faculdade em prover tais recursos.

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Batalha Naval dos Extremos Locais: Jogos de Aprendizagem para o Ensino dos Cálculos

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Abstract

Optimization problems are presented to Engineering students very early in the courses of univariate and multivariate calculus. The traditional approach is to present this subject from a purely mathematical point of view, emphasizing the relationship with the derivatives of a function and its critical points. The present work describes an approach to introduce the students to the traditional optimization problems using learning games. In comparison with the traditional expository lesson, the use of games promotes a more engaging and meaningful learning experience. They represent, in Ausubel's theory of learning, an advance organizer that should promote a meaningful learning of the subject of critical points when they are later formalized by the teacher in classroom.

Keywords: learning games; meaningful learning; calculus; Battleship game.

1 Introdução

Os estudantes de Engenharia têm o primeiro contato com problemas de otimização ainda no ciclo básico. Esses problemas são tradicionalmente abordados a partir da identificação de extremos de funções de uma variável em um contexto puramente matemático. Em consulta aos estudantes, constatou-se que esta experiência de aprendizagem tradicional não era considerada motivadora e que existem dificuldades em compreender aspectos básicos deste conteúdo.

Este trabalho propõe dois jogos de aprendizagem que representam organizadores prévios segundo a teoria da aprendizagem significativa de Ausubel. O objetivo é tornar o conteúdo de extremos de funções potencialmente significativo e incentivar o engajamento em sala de aula e elevar a taxa de retenção do conhecimento pelos estudantes.

A “Batalha Naval dos Extremos Locais” faz alusão ao jogo de “Batalha Naval”, onde são depositados objetos em dois ambientes distintos a serem descobertos pelos competidores. Na atividade proposta, o ambiente é o plano cartesiano e os objetos são os pontos críticos de funções definidas por cada grupo de estudantes. Apesar de ser um problema de otimização formalmente bem definido, sua solução permite abordagens múltiplas e formulação de hipóteses. A atividade despertou grande interesse nos estudantes.

2 Jogos Educativos e a Aprendizagem Significativa

Existem poucas dúvidas que jogos de aprendizagem sejam capazes de promover o aprendizado efetivo, particularmente na área das matemáticas (Bright *et al.*, 1985). A questão central nesse debate está em determinar quais são as características dos jogos e quais são as situações de aprendizagem que tornam o seu uso mais eficiente que as aulas expositivas tradicionais. Essa discussão é particularmente relevante nos desafios colocados para o ensino para a nova geração dos chamados “nativos digitais” (Prensky, 2001). Os novos estudantes cada vez mais percebem a aula tradicional como sendo enfadonha e desmotivadora e cobram um modelo de aprendizagem mais dinâmico e divertido com o qual eles consigam se engajar. Os mesmos estudantes frequentemente usam seu tempo de lazer em jogos eletrônicos e são facilmente motivados a tentar resolver os desafios propostos nos mesmos.

Essa mudança no perfil dos alunos é percebida por diversos educadores e instituições de ensino. Como consequência, as dinâmicas de aprendizagem inovadoras, como o uso de jogos na sala de aula e Aprendizagem Baseada em Problemas (PBL, do inglês Problem-Based Learning), estão se tornando cada vez mais comuns nos novos currículos. No entanto, segundo Walker e Shelton (2008), os de jogos de aprendizagem comumente falham em aspectos fundamentais: alguns jogos estimulam uma experiência de aprendizagem rica e estruturada, mas oferecem pouco em termo de diversão aos aprendizes; outros jogos sofrem do problema oposto, em que são capazes de prender a atenção dos estudantes, mas não oferecem muitas oportunidades para estruturar os conhecimentos adquiridos. Apesar de os jogos do segundo tipo não oferecerem uma experiência de aprendizagem completa, eles podem ser muito efetivos para promover o aprendizado quando associados a outras atividades em sala de aula.

O jogo não precisa cumprir sozinho o papel de engajar os estudantes em uma atividade de aprendizado, sugerir e induzir que os estudantes produzam as estratégias e o conhecimento capazes de abordar o problema proposto e, além disto, organizar e formalizar estes conhecimentos na estrutura cognitiva do mesmo. O objetivo principal dos jogos aqui discutidos é engajar o estudante na tarefa de aprendizado, fazendo com que o conteúdo discutido torne-se significativo e motivador.

A análise desse processo é feita segundo a teoria da aprendizagem significativa de David Paul Ausubel que trata de uma teoria cognitivista focada na ideia de como os conceitos se relacionam de maneira substantiva dentro da estrutura cognitiva do sujeito. Ausubel (1968) afirma que o fator principal da aprendizagem está no que o aprendiz já conhece, e, para que um novo conceito seja aprendido e retido em sua estrutura cognitiva, os conceitos prévios existentes devem servir de ancoragem para esses novos conceitos. Desse modo, elementos com maior poder de abstração e generalidade servem como ancoradouro para conceitos mais específicos.

Segundo Ausubel, quando o novo material é ancorado ao conceito, ideia ou proposição já retidos na estrutura cognitiva, chamados de subsunçores (do inglês subsumer), estes são modificados e se tornam mais desenvolvidos e inclusivos. Nessa interação entre o novo conceito e o conceito subsunçor, ambos são alterados com base nessa ancoragem resultando em conceitos mais abrangentes, estáveis e bem elaborados. Mas, se a aprendizagem significativa não ocorre com frequência em direção a um subsunçor em específico, este se torna limitado e pouco desenvolvido (Ausubel, 2003).

Para que ocorra a aprendizagem significativa é necessário que o material a ser estudado seja potencialmente significativo, ou seja, que seja suficientemente não arbitrário e não aleatório de modo que possa ser relacionado de forma substantiva à estrutura cognitiva do sujeito da aprendizagem. O outro fator necessário para a aprendizagem significativa é que o estudante tenha em sua estrutura cognitiva, conceitos prévios específicos que proporcionem a possibilidade de ancoragem para o novo material. Por fim, é necessário que o aprendiz tenha motivação para relacionar o novo conteúdo transformando-o de material lógico para psicológico, isto é, com significado próprio e idiossincrático para o estudante (Moreira, 2006).

Como apoiadores da aprendizagem significativa, são bastante populares os mapas conceituais, os organizadores prévios e Vê epistemológico de Gowin. Os organizadores prévios são materiais introdutórios com alto nível de abstração e generalidade apresentados antes do material a ser aprendido. A principal função dos organizadores prévios é manipular a estrutura cognitiva do estudante de modo a facilitar a ocorrência da aprendizagem significativa, ou seja, é um instrumento que visa aproximar o que o indivíduo conhece e o que deve ser aprendido. Os mapas conceituais são diagramas bidimensionais que procuram mostrar as relações entre conceitos de uma disciplina ou subdisciplina. O Vê epistemológico é um diagrama que pode servir para análise de currículo, instrumento de ensino, de aprendizagem ou de avaliação da aprendizagem e que consiste em uma heurística para organizar a produção do conhecimento. De modo mais específico, o Vê de Gowin separa em grupos o domínio conceitual, o domínio metodológico, as questões básicas de pesquisa e os eventos específicos e objetos. O objetivo principal do Vê dentro do ensino é utilizá-lo na sintetização dos conceitos aprendidos, destacando aspectos relativos à produção do conhecimento (Moreira, 2006).

3 Atividade Proposta: Batalha Naval dos Extremos Locais

A batalha naval é um jogo bastante conhecido em todo o mundo e foi inventado no início do século 20. Trata-se de um jogo de estratégia em que dois participantes distribuem seus navios em seus respectivos campos de batalha e o vencedor da disputa é aquele que descobrir a localização dos navios adversários em menor tempo. O campo de batalha é uma matriz quadrada (geralmente 15x15), onde cada linha é determinada por uma letra e a coluna identificada por um número. Os jogadores se permutam na tentativa de descobrir a localização dos navios do adversário por meio das coordenadas cartesianas.

Na Batalha Naval dos Extremos Locais (BNEL), o campo de batalha é o gráfico de uma função contínua desenhada no plano cartesiano que seja definida em um intervalo aberto que contenha [-10, 10]. Cada jogador deve fazer o gráfico de uma função de x contendo três pontos críticos, ou seja, valores de x em que a derivada é igual a zero ou não está definida (ponto anguloso). Esses pontos devem possuir valores inteiros entre -10 e 10 e o vencedor é o jogador que descobrir os três pontos críticos e classificá-los como pontos de máximo local, mínimo local ou inflexão. A figura 1 mostra um exemplo de gráfico em que A, B e C são os pontos a serem descobertos. Nesse exemplo, é necessário descobrir que os pontos críticos estão nas posições x=-8, x=0 e x=7 e que x=-8 é um ponto de mínimo local, x=0 é um ponto de inflexão e x=7 é um ponto de máximo local.

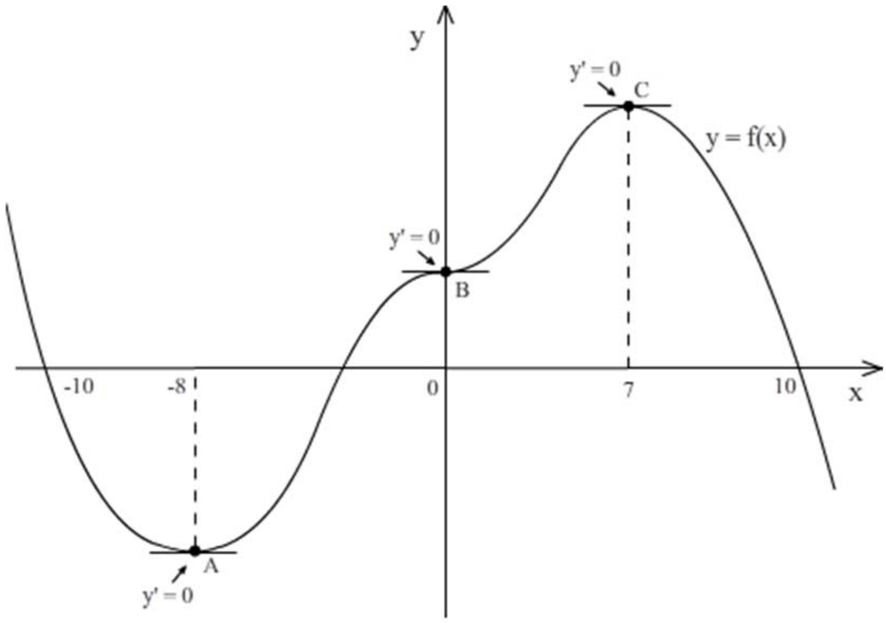

Figura 1: Um exemplo de função escolhida por um competidor.

Após os estudantes terem feito o gráfico de suas funções, eles se permutam na tentativa de descobrir os pontos dizendo um valor de abscissa entre -10 e 10. Enquanto um estudante escolhe um valor x=xo, o outro verifica o sinal da derivada para aquele valor específico, ou seja, y'(xo). Em analogia com a batalha naval original, se a derivada de um determinado valor for zero, então um navio foi atingido restando agora identificar o tipo de ponto crítico que foi encontrado.

A tabela 1 mostra um exemplo de um possível jogo realizado entre dois estudantes em que o primeiro desenhou seu gráfico como o da figura x e o segundo desenhou outro gráfico que pode ser inferido pelos dados da tabela.

Tabela 1: Exemplo de uma competição da Batalha Naval dos Extremos Locais.

Rodada	Jogador 1 pergunta	Jogador 2 pergunta
1	Jogador 1: x=1 Jogador 2: y´<0	
2		Jogador 2: x=0 Jogador 1: y´=0
3	Jogador 1: x=5 Jogador 2: y´<0	
4		Jogador 2: x=5 Jogador 1: y´>0
5	Jogador 1: x=8 Jogador 2: y´>0	
6		Jogador 2: x=10 Jogador 1: y´<0
7	Jogador 1: x=6 Jogador 2: y´=0	
8		Jogador 2: x=7 Jogador 1: y´=0

Rodada	Jogador 1 pergunta	Jogador 2 pergunta
9	Jogador 1: x=0 Jogador 2: y´=0	
10		Jogador 2: x=-5 Jogador 1: y´>0
11	Jogador 1: x=-10 Jogador 2: y´<0	
12		Jogador 2: x=-10 Jogador 1: y´<0
13	Jogador 1: x=-6 Jogador 2: y´=0	
14		Jogador 2: x=-7 Jogador 1: y´>0
15	Jogador 1: x=-1 Jogador 2: y´>0	
Jogador 1 anuncia: x=-6 (Mín. local), x=0 (Max. local), x=6 (Mín. local)		

A atividade proposta pode ser desenvolvida em sala de aula, dividindo os alunos em duplas ou em pequenos grupos com até 4 estudantes. Foram feitas experiências com grupos maiores, mas frequentemente alguns estudantes perdiam o interesse pela atividade. Além disso, é possível que os vários grupos possam competir entre si e não apenas em pares, bastando determinar uma ordem para os ataques.

Como a BNEL se trata de um jogo de aprendizagem para o ensino de Cálculo, há de se ter em mente quais são os objetivos da aprendizagem de modo a planejar o melhor momento para ser introduzida em sala de aula. O objetivo da BNEL é o estudo das técnicas de determinação dos extremos de funções, onde os estudantes conseguem desenvolver uma percepção natural sobre o teorema da primeira derivada e o teorema do valor intermediário. O teorema da primeira derivada pode ser utilizado para descobrir se um ponto é extremo local com base no estudo do sinal da primeira derivada antes e depois de um ponto crítico. O teorema do valor intermediário pode ser utilizado quando o estudante descobre uma variação no sinal da primeira derivada em um intervalo e descobre que necessariamente há um ponto interno ao intervalo em que a derivada se anula. Outro conceito que pode ser trabalhado é a confecção de gráficos, pois, o estudante geralmente constrói em sua mente um esboço do gráfico, na medida em que descobre os sinais da primeira derivada da função proposta pelo seu oponente.

3.1 Logística para turmas grandes

Essa atividade foi realizada em oito turmas de Cálculo entre 2003 e 2008, sempre em turmas pequenas, com até 40 estudantes. Em 2010, a atividade foi repensada para poder ser trabalhada em duas turmas com 130 estudantes de Engenharia da Faculdade UnB Gama na Universidade de Brasília. Para isso, a metodologia foi mantida em boa parte, havendo alteração apenas na fase inicial e no número de participantes por grupo. Para turmas grandes, o grande desafio está em fazer uma dinâmica que os estudantes se sintam motivados a participar e isso acontece com frequência quando o aluno participa ativamente da aprendizagem.

A estratégia escolhida foi que, no primeiro momento, o docente explica aos alunos como é a atividade com base em um gráfico feito no quadro ou com o uso de algum dispositivo gráfico qualquer. Depois, mostra o padrão de resposta esperado com base na derivada de alguns valores de abscissa sugeridos pelos estudantes.

O próximo passo é solicitar que algum estudante fique de costas para o quadro (ou dispositivo gráfico) e tentar descobrir os pontos críticos de uma nova função determinada pelo docente. O estudante faz a escolha de vários valores de x e é uma possibilidade de explicar melhor algumas regras da atividade. Nesse momento, os estudantes estão todos bastante atentos, pois representa uma experiência nova e um colega do grupo está participando.

Após essa fase, em que só um competidor tenta acertar os extremos da função, o professor solicita que os estudantes façam a Batalha Naval um contra um (preferencialmente) ou em duplas. O docente também deve especificar um limite de tempo para a experiência para que não haja dispersão ao final da atividade.

Esgotado o tempo para realização da BNEL, que serve como um organizador prévio da aprendizagem significativa, o docente consegue abordar algumas estratégias para determinar os pontos onde a derivada se anula como, por exemplo, a bissecção do intervalo para diminuir o número de tentativas com uso do teorema do valor intermediário. Além disso, o mesmo teorema pode ser análise fazendo a Engenharia reversa, ou seja, como fazer um gráfico com menos informações relevantes que possam ser utilizadas pelo adversário.

A dinâmica continua com o docente formalizando o teorema da primeira derivada para identificação dos extremos da função e estendendo a temática para extremos globais. Como trata-se de uma aprendizagem baseada em um jogo de aprendizagem, a experiência poderá ser retomada futuramente ancorando novos conceitos como, por exemplo, a confecção de gráficos. Na verdade, muitos estudantes conseguem construir os gráficos mentalmente na tentativa de visualizar os pontos ótimos da função.

3.2 Estendendo a atividade para o cálculo multivariado

A atividade da "Batalha Naval dos Extremos Locais" não pode ser aplicada sem modificações para abordar funções de duas variáveis, pois o gráfico das mesmas é uma figura tridimensional que não pode ser facilmente desenhada pelos alunos. Optou-se então pela criação de jogos de aprendizagem eletrônicos.

A "Batalha Naval dos Extremos Locais 3D" é uma adaptação da atividade proposta anteriormente para o curso de cálculo multivariado e tenta reproduzir os benefícios do uso de jogos de aprendizagem verificados anteriormente no tratamento de extremos locais de funções de várias variáveis. Nesta atividade, o professor desafia a turma a encontrar os máximos locais de funções de duas variáveis dentro de uma região pré-determinada. Esta região consiste em um quadrado 10x10 no primeiro quadrante com um vértice na origem. Impõe-se também a restrição de que estes máximos devem estar em pontos com coordenadas cartesianas inteiras.

A dinâmica do jogo ocorre da seguinte maneira: primeiramente os estudantes são apresentados ao tabuleiro com as possíveis posições do máximo. Um programa de computador sorteia uma função bi-variada de acordo com um certo conjunto de instruções pré-estabelecidas e posiciona o máximo da mesma em um ponto aleatório com coordenadas inteiras dentro deste tabuleiro. Em cada turno do jogo, a turma deve então escolher uma informação que deseja obter sobre um ponto qualquer do tabuleiro. Esta informação consiste no valor da função, do seu gradiente ou ainda da sua Hessiana. O objetivo, logicamente, é encontrar o máximo no menor número de turnos.

Uma vez que se trata de uma atividade em que o professor desafia a turma, e não uma atividade competitiva entre os alunos, não existem vencedores. O jogo também poderia ser organizado de maneira competitiva, bastando eleger o vencedor de cada etapa como aquele que encontrou o máximo da função no menor número de turnos. Para isto, no entanto, seria necessário que cada grupo de competidores tivesse acesso a um computador.

O objetivo pedagógico da atividade é apresentar como a noção de máximos e mínimos locais de funções multivariadas se relaciona com o conceito de gradiente, previamente abordado em sala de aula. Na teoria de Ausubel, o jogo proposto representa um organizador prévio que visa tornar significativo o aprendizado do conceito de extremos locais de funções multivariadas. Diferentemente do que ocorre na atividade anterior, os estudantes já possuem uma experiência prévia com problemas de otimização devido à experiência em um curso anterior de Cálculo. Deste modo, a turma é capaz de formular e testar hipóteses com conteúdo matemático bastante elaborado.

O jogo proposto é dividido em várias “fases” com graus de dificuldade crescente. Esta organização foi escolhida para que seja possível explorar gradualmente alguns problemas específicos na otimização de funções multivariadas. A primeira fase do jogo consiste em encontrar o máximo de um parabolóide circularmente simétrico. Esta etapa foi concebida para que os estudantes descubram que o gradiente fornece uma informação potencialmente mais útil sobre a localização do máximo (ou mínimo) de uma função que o próprio valor da função. Devido às particularidades da função parabolóide adotada, o gradiente é proporcional à distância com relação ao máximo e decresce gradualmente até atingir um valor nulo quando se atinge o ponto desejado.

As etapas seguintes foram criadas com funções simples, mas que violam a propriedade de concavidade constante do parabolóide. Nesta etapa, discute-se que o comportamento observado para o gradiente da função na fase anterior, em geral, é válido apenas numa região próxima ao máximo. No decorrer destas etapas, os estudantes descobrem intuitivamente que podem utilizar um algoritmo de subida de gradiente para encontrar o máximo local de uma função e que este máximo pode ser identificado com o ponto onde o gradiente é nulo.

As etapas seguintes foram concebidas para ilustrar algumas dificuldades específicas que podem ser encontradas em problemas de otimização. Primeiramente discutiu-se o fato que o gradiente pode não existir no máximo, utilizando uma função do tipo cone como exemplo. Em seguida, foi apresentada uma função com mais de um máximo local. Finalmente, discutiu-se também a situação em que o máximo se encontra na borda do domínio.

Quando o máximo é encontrado, mostra-se um gráfico com o caminho percorrido junto com as curvas de nível e o gráfico tridimensional da função na região considerada. Isto cria uma oportunidade para o professor discutir com a turma quais foram os conceitos explorados e para esclarecer como eles se relacionam com o problema específico de encontrar o extremo de uma função. A figura 2 ilustra a informação mostrada aos estudantes quando um máximo é encontrado.

4 Resultados

A experiência da BNEL foi realizada em dez turmas de Cálculo 1, no período de 2003 a 2010, com oito turmas com até 40 estudantes e duas contendo 130. Nessas turmas, a verificação de impacto foi feita com base na observação do docente sobre a mudança de comportamento dos estudantes durante as aulas.

Nas turmas com um número menor de estudantes, o desenvolvimento da atividade pôde ser acompanhado com maior proximidade pelo docente e foi observado que pequenos grupos de 3 ou 4 aprendizes proporcionam uma atmosfera mais producente e dinâmica. Contudo, mesmo com grupos menores de 1, 2 ou 3 alunos, a atividade conseguiu manter o interesse dos alunos por todo o período da atividade. Para grupos com mais de 4 sujeitos, alguns estudantes dominam as escolhas do gráfico e das tentativas de descoberta e os demais ficam desmotivados.

Devido à oportunidade de acompanhamento mais próximo do docente, foi possível verificar que boa parte dos estudantes descobre a estratégia ótima de inserir três pontos de inflexão em seu campo de batalha, haja vista que não será possível utilizar a variação de sinal da primeira derivada para encontrar os pontos críticos.

No momento após a BNEL, os estudantes ficam de sobremaneira motivados quando são feitas associações entre o que foi vivenciado e a formalização da teoria, pois é uma estratégia para o jogo. Desse modo, se o docente informa que alguns estudantes escolhem utilizar três pontos de inflexão de modo a dificultar a descoberta dos pontos críticos, existe a possibilidade de associação do conteúdo com o que foi vivenciado e com outros conceitos subsunçores tais como gráficos, raízes de funções e o próprio jogo de batalha naval original. Como o estudante está bastante motivado, também mostra na maior parte das vezes disposição para fazer tais associações.

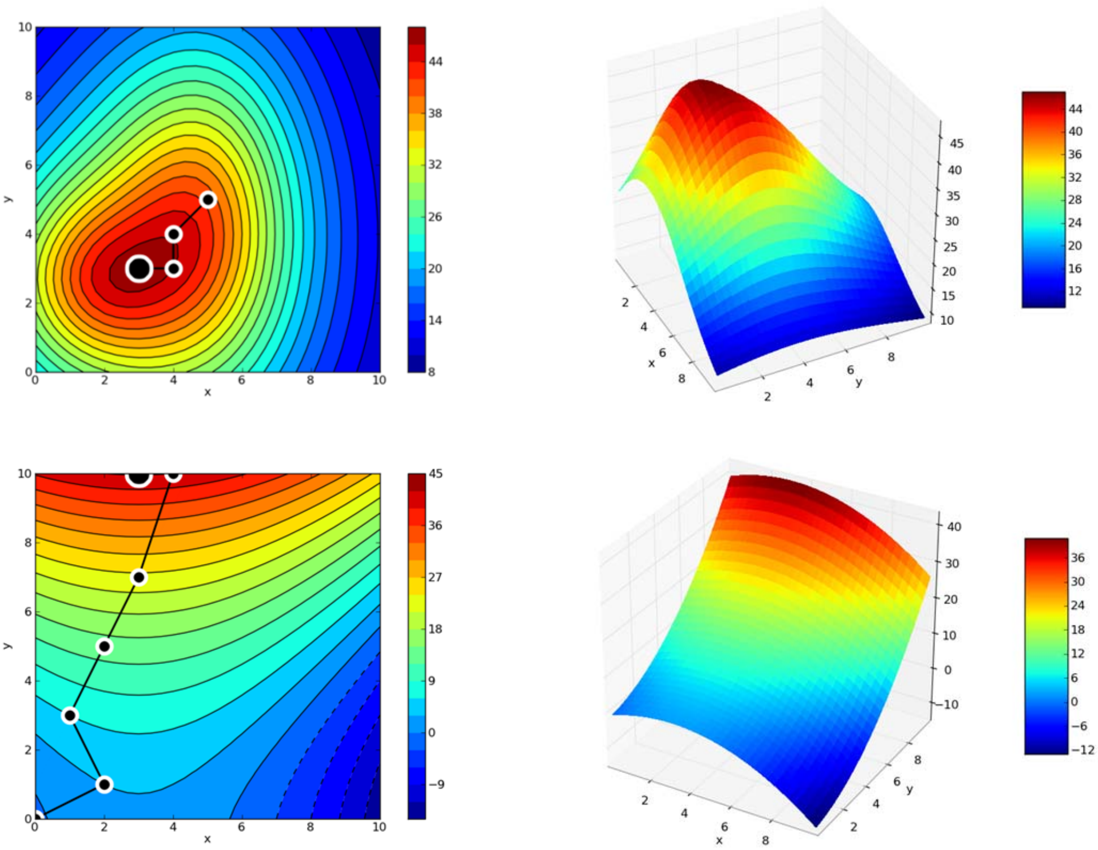

Figura 2: Impressão da tela que mostra dois possíveis caminhos percorridos pelo estudante (figuras à direita) para encontrar o máximo das funções representadas à esquerda. Estas figuras são mostradas aos estudantes após o máximo da função ter sido encontrado.

Após a explicação da estratégia ótima, vale sugerir que seja adicionada a regra de que tenha pelo menos um ponto de máximo ou mínimo local. Desse modo, a experiência fica enriquecida pelo fato de que é possível descobrir os pontos em menos tentativas.

Outro conceito que é trabalhado logo a seguir é o teorema da primeira derivada que não é apresentado antes da dinâmica. Neste caso, a descoberta feita pelo estudante sobre este tópico durante o jogo é bastante abrangente, restando formalizar suas características e especificidades, tais como em funções descontínuas. Por fim, é possível trabalhar ainda os conceitos de segunda derivada para classificação do extremo local e a confecção de gráficos com base no estudo de sinal da primeira e segunda derivada, valendo evidenciar que ainda faltam alguns elementos como o estudo dos limites laterais em descontinuidades e limites no infinito.

Para as turmas grandes, a dinâmica também foi muito bem recebida pelos estudantes e o grande ponto-chave que diferencia a atividade para turmas pequenas ou grandes é acerca da necessidade de determinar um limitador para a BNEL. Um limitador de tempo para a atividade utilizado foi o total de três partidas. A explicação prévia sobre os procedimentos após a BNEL também facilitam a ter a atenção integral da turma durante a formalização dos conceitos.

Também foi observado que nas turmas com maior número de alunos, o número máximo de participantes em um grupo é reduzido para dois. Com três estudantes ou mais, não há um rendimento satisfatório e alguns estudantes ficam isolados ou desmotivados.

5 Conclusão

Por meio dos resultados apresentados, é possível concluir que a BNEL é um jogo que motiva os sujeitos a participarem da experiência educativa que visa ao estudo de extremos de funções. Além disso, é um material potencial para a ocorrência da aprendizagem significativa, haja vista que as experiências estão altamente relacionadas com a formalização dos conceitos do estudo do sinal da primeira derivada e gradiente para a determinação de extremos locais de funções de uma variável.

A Batalha Naval também foi estendida para turmas com 130 estudantes e o parâmetro que mais influenciou no bom andamento da atividade foi a determinação de um limite temporal para as disputas. Além disso, uma explicação clara e detalhada das etapas bem como das regras com base em uma prática feita entre o docente e um estudante podem auxiliar em uma boa execução. Também foi observada uma possível relação entre o número de participantes em cada grupo e o tamanho da turma, no sentido de que são inversamente proporcionais.

A atividade proposta para o curso de cálculo multivariado depende do uso de recursos computacionais quem nem sempre estão disponíveis. Em particular, para que os alunos possam competir entre si, o que aumentaria o engajamento com a aula, idealmente seria necessário utilizar 1 computador para cada 2 alunos. Devido à dificuldade de se alocar tais recursos computacionais, espera-se futuramente adaptar a atividade descrita para o uso de apenas papel e lápis, como acontece com a BNEL 2D. Nesse caso, os alunos proporiam funções multivariadas desenhando as respectivas curvas de nível. Essa atividade permitiria organizar os conceitos básicos de problemas de otimização e as relações entre gradiente, extremos locais e curvas de nível.

Para complementar o trabalho atual, pretende-se verificar a retenção dos conceitos trabalhados com a BNEL com a metodologia de turmas de controle. Outra melhoria possível é introduzir outros dispositivos para formalização dos conceitos trabalhados, em especial com o uso do Vê epistemológico de Gowin.

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O Labirinto do Rato Cego: Aprendizagem Baseada em Projeto em Algoritmos e Programação de Computadores

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Abstract

It is not uncommon to find among the students of the Introduction to Computer Science and Programming course those who, despite having an interest in computers, become demotivated with the arduous task of learning how to program. The goal of the "Blind Mouse Labyrinth" project is to make the learning process more appealing and significant, by presenting a problem more similar to the ones a professional engineer encounters. The puzzle of a blind agent trapped inside a labyrinth searching for the exit is presented at the beginning of the semester, together with a program which solves the problem randomly. The student's task is to understand and modify the program, seeking the most effective solution they can. By tackling this simplified version of the problem of localization and movement of a robot, students take a step toward the study of Artificial Intelligence and its applications, enhancing their curiosity and creativity.

Keywords: blind mouse labyrinth; introduction to programming; computer simulation; artificial intelligence.

1 Introdução

A disciplina de Algoritmos e Programação de Computadores (APC) aborda tópicos básicos de programação essenciais para um futuro engenheiro, sendo a primeira de uma série que concerne à programação durante o curso de Engenharia. Alguns alunos, embora acostumados desde cedo com computadores, muitas vezes se vêem frustrados ao se depararem com o árduo aprendizado da programação. A curiosidade pela tecnologia muitas vezes é acompanhada por uma falta de interesse sobre o seu funcionamento, visto que muitas vezes é muitíssimo mais fácil utilizar uma tecnologia que aprendê-la e entendê-la. Aulas expositivas tradicionais seguem os tópicos da disciplina sem que seja dada uma ênfase a aplicações no trabalho do dia-a-dia de um profissional de engenharia. Deste modo, o aluno geralmente inicia a disciplina com interesse e com a perspectiva que ao final do semestre poderá criar um programa de padrão comercial como aqueles com os quais está acostumado a lidar, mas se desmotiva ao longo da disciplina por não ver aplicação direta daquilo que está aprendendo. Este fato tem graves conseqüências e se reflete na dificuldade de aprendizado em disciplinas subseqüentes como Estruturas de Dados, Programação Orientada a Objetos, Microcontroladores e Microprocessadores, que fazem parte da formação de um Engenheiro Eletrônico ou de Software e que necessitam de um sólido entendimento dos princípios básicos da programação.

O conteúdo da disciplina APC aborda a resolução de problemas (algoritmos), tipos de dados, operadores, operações primitivas sobre os dados, variáveis e expressões, entrada e saída de dados, estruturas condicionais e de decisão, estruturas de repetição, vetores e suas aplicações e funções. Usualmente, tais tópicos são trabalhados por meio de exemplos como programas para imprimir certos conjuntos de números, transformar unidades, cadastrar usuários, dentre outros problemas que são escolhidos pela simplicidade de resolução em detrimento da satisfação que o aluno terá ao alcançar a solução.

A proposta do projeto "Labirinto do Rato Cego", baseada na teoria de aprendizagem significativa de Ausubel e na aprendizagem baseada em problemas (PBL), é a de inverter a lógica mais comumente seguida, apresentando inicialmente ao aluno um problema mais complexo que será estudado e modificado durante o curso. O aluno tem um objetivo concreto a ser alcançado até o final da disciplina, caracterizando uma atividade que se assemelha mais com o cotidiano profissional em que metas são delineadas no início do projeto e em que há uma data limite para o seu final. Desta maneira o aluno poderá desenvolver, além do seu aprendizado, a sua criatividade e pode muitas vezes até mesmo exceder o que é esperado de um aluno ao final de seu primeiro curso de programação.

Com isso em mente, propõe-se no início das aulas o projeto "Labirinto do Rato Cego" que tem como objetivo principal motivar, enfocar e tornar a aprendizagem mais significativa para o estudante. A idéia de um robô que consiga se locomover por conta própria é algo que fascina as pessoas desde cedo. A sua construção, no entanto, é bastante complexa e pode ser subdividida em várias subtarefas. Um dos problemas com que um

Engenheiro se depara no projeto de um robô é a questão de sua localização espacial e o subseqüente tratamento dos dados obtidos por meio de seus sensores para sua movimentação. Neste contexto, o "Labirinto do Rato Cego" é um projeto educacional em que grupos de estudantes devem desenvolver um programa de computador que simula as decisões que um agente inteligente "cego" deve tomar para encontrar a saída de um labirinto. Ao final da disciplina é realizado um desafio em que são realizados duelos entre os programas de cada grupo; o grupo vencedor é aquele cujo programa consegue acumular mais vitórias, ou seja, o programa que consegue sair do labirinto no menor tempo em média.

Para tornar a construção do rato virtual mais interessante para os estudantes, cada grupo recebe um rato que toma decisões aleatórias com todos seus módulos já bem estruturados, restando apenas o desenvolvimento da inteligência do rato. O aprendizado de cada conteúdo da disciplina se dará com o intuito de entender e aprimorar os diversos módulos desse programa inicial. O objetivo educacional foi incentivar a confecção de programas mais interessantes e a promoção da curiosidade para que o estudante busque conhecimento além do contexto curricular com a motivação de que se está dando o primeiro passo em direção ao estudo da Inteligência Artificial e suas aplicações.

O presente artigo está organizado da seguinte maneira: na próxima seção será dado um breve resumo sobre as aprendizagens significativa e baseada em projetos; na terceira seção os programas que compõem o rato e o labirinto serão apresentados, bem como a estrutura de comunicação entre eles; na quarta seção serão apresentados alguns resultados da experiência em sala de aula e o desenvolvimento de uma atividade de extensão universitária que tem como base o "Labirinto do Rato Cego". Por último, na conclusão serão apresentadas perspectivas futuras sobre modificações nos dados disponíveis para o rato.

2 Aprendizagem Significativa e a Aprendizagem Baseada em Projetos

A teoria de David Paul Ausubel é cognitivista e está centrada no conceito da aprendizagem significativa. Segundo Ausubel (1968), o principal isolado mais importante que influencia a aprendizagem está naquilo que o aprendiz já conhece. Para que um novo conceito seja aprendido e retido em sua estrutura cognitiva, conceitos prévios existentes devem servir de ancoragem para os novos. A aprendizagem significativa é um processo pelo qual uma nova informação interage com um aspecto relevante da estrutura cognitiva do sujeito, tal como um conceito ou proposição.

Esse elemento preexistente da estrutura de conhecimento do aprendiz é chamado de subsunçor (do inglês *subsumer*) ou conceito subsunçor e o armazenamento de informações no cérebro é organizado em uma hierarquia de conceitos, sendo que elementos mais específicos são ligados a conceitos mais abrangentes e inclusivos. Além disso, se um novo conceito é ancorado ao conceito subsunçor, este é modificado e se torna mais desenvolvido e inclusivo. Contudo, se a aprendizagem significativa não ocorre com freqüência em conjunção com um subsunçor em específico, este se torna limitado e pouco desenvolvido (Ausubel, 2003; Moreira, 1999).

Segundo Ausubel, é mais fácil para o ser humano aprender significativamente conceitos mais inclusivos e depois captar os conceitos mais específicos como diferenciação do todo, do que aprender as partes para chegar ao todo (Moreira, 2006). Ausubel, Novak e Gowin apresentam instrumentos potencialmente úteis para apoiar a busca pela aprendizagem significativa tais como o uso de organizadores prévios, mapas conceituais (Novak, 1977) e o Vê epistemológico (Gowin, 1981). Os organizadores prévios são materiais introdutórios apresentados antes dos tópicos a serem aprendidos e que possuem um alto nível de abstração, generalidade e inclusividade. A principal função dos organizadores prévios é servir como ponte cognitiva entre o que o indivíduo conhece e o que deve ser aprendido promovendo ainda uma disposição por parte do sujeito em aprender significativamente o novo material. No contexto do "Labirinto do Rato Cego", o organizador prévio é o programa entregue inicialmente aos alunos que busca a saída do labirinto de forma aleatória.

Os mapas conceituais são diagramas que mostram relações não triviais entre conceitos e que buscam refletir uma organização hierárquica dos mesmos em relação à sua inclusividade e generalidade. Os mapas conceituais podem ser utilizados no ensino, na aprendizagem e na avaliação da aprendizagem quando construídos pelos estudantes. Os diagramas V ou Vê epistemológico de Gowin são dispositivos heurísticos para sintetizar e analisar o processo de produção do conhecimento. Os diagramas V podem também ser utilizados como instrumentos de análise do currículo e de avaliação da aprendizagem (Moreira, 2006).

A teoria significativa de Ausubel, principalmente no que tange ao elemento do organizador prévio, está diretamente relacionada ao método da aprendizagem baseada em problemas (PBL), uma metodologia de ensino e aprendizagem que utiliza problemas para tornar a aprendizagem dinâmica e fundamentada na construção do conhecimento em contraste com a recepção passiva de informações. Desse modo, é incentivado o estudo em busca de significados e não apenas a memorização de conceitos, uma atitude que pode permanecer pelo resto da carreira profissional do estudante. Além disso, a PBL pode oferecer respostas satisfatórias a problemas intratáveis da formação profissional, tais como a alienação dos alunos no chamado "ciclo básico", a ausência de integração entre a teoria e a prática e a dificuldade em promover conhecimentos além dos técnico-científicos no contexto curricular. Outro ponto fundamental promovido pela PBL é o desenvolvimento de habilidades (trabalho em grupo, comunicações oral e escrita e resolução de problemas) e atitudes (ética, responsabilidade profissional e social, adaptabilidade e disposição para a aprendizagem contínua e autônoma), além de garantir uma base conceitual sólida aos alunos, sem sobrecarregar ou estender seus currículos (Prince, 2004; Ribeiro, 2008).

3 Atividade Proposta: Labirinto do Rato Cego

O Labirinto do Rato Cego (disponível em *www.ratocego.com*) é uma atividade em que o objetivo é desenvolver um programa de computador que simule as decisões de um agente inteligente "cego" para sair de um labirinto. O programa a ser desenvolvido deve encontrar a saída do labirinto com base nos dados informados pelo labirinto a cada ponto-chave (PC) e em sua memória sobre os caminhos já percorridos. Um ponto-chave é um ponto do labirinto em que há uma intersecção de caminhos possíveis, ou seja, é um ponto onde é necessário decidir qual direção seguir.

O programa que irá tomar as decisões sobre a direção a ser tomada é chamado de "Rato Cego" ou simplesmente "rato". O rato irá se comunicar com outro programa chamado "labirinto" que dará as direções possíveis a cada ponto-chave do labirinto.

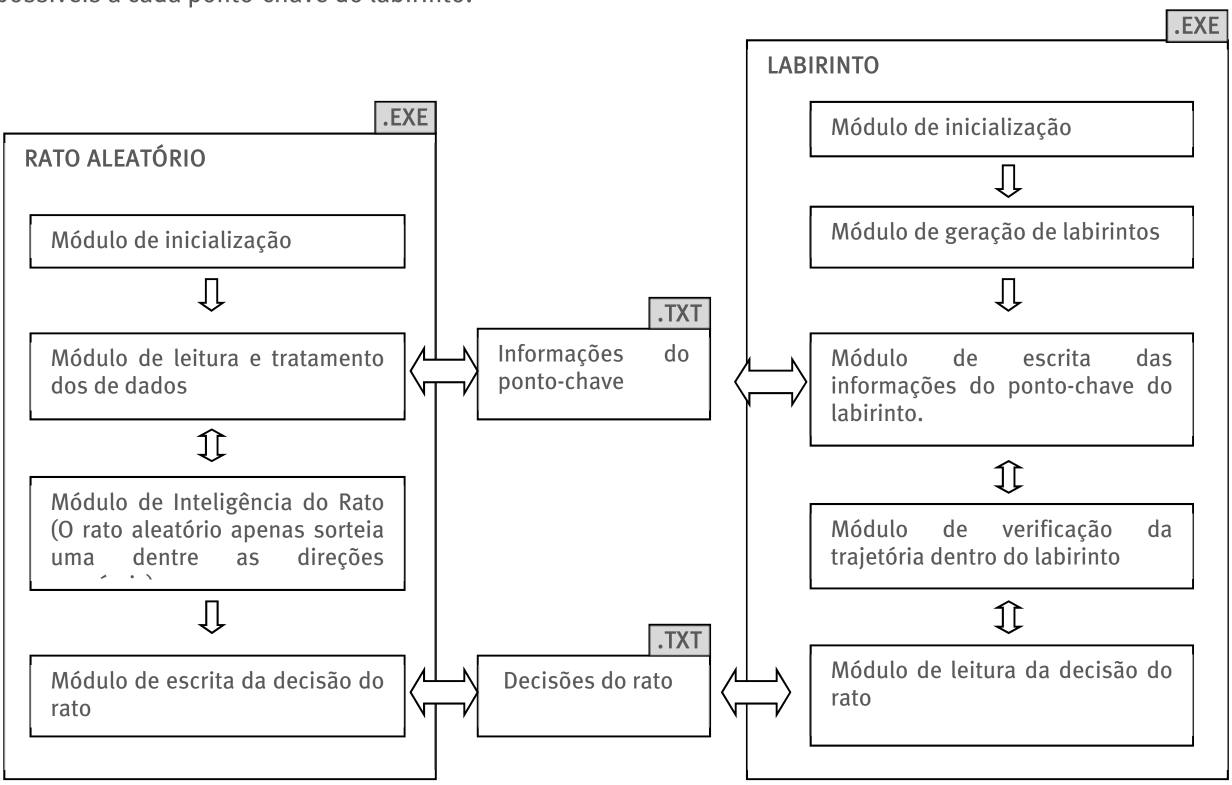

Figura 1: Estrutura dos programas "rato aleatório" e "labirinto" e sua intercomunicação

3.1 O Rato aleatório: Um Organizador Prévio

Para que o estudante possa utilizar melhor o seu tempo para o desenvolvimento da inteligência do rato, é disponibilizado um rato padrão chamado de "rato aleatório" que faz um sorteio entre as direções possíveis em cada PC. Mesmo sendo um rato pouco inteligente, o código desenvolvido em linguagem C já possui os módulos de leitura, escrita e tratamento dos dados bem trabalhados (figura 1). Desse modo, a tarefa concreta para o estudante é trabalhar no desenvolvimento de um rato mais eficiente que o rato aleatório.

Após a exibição do rato aleatório e de uma primeira discussão sobre possíveis estratégias de saída, o professor apresenta o conteúdo que será trabalhado durante a disciplina fazendo correlações entre os conceitos que serão trabalhados e as estratégias propostas pelos estudantes. Exemplos destas correlações são "o uso de variáveis para o armazenamento da última decisão tomada pelo rato", "o uso de estruturas de decisão para que ele não volte para o último ponto visitado quando ele alcançar um novo PC que não seja um beco sem saída" e "como utilizar variáveis indexadas para fazer um mapa bidimensional do percurso realizado, simulando a mente do rato virtual".

Segundo a teoria ausubeliana, é possível dizer que o rato aleatório serve como um organizador prévio da aprendizagem significativa, visto que apresenta o problema em grande amplitude e com um conteúdo lógico, sendo a ponte cognitiva entre o novo conhecimento e aquilo que o estudante já conhece.

3.2 Comunicação entre um Rato e o Labirinto

A comunicação entre os programas rato e labirinto se dá por meio de arquivos de texto, ou seja, o labirinto escreve em um arquivo de texto as informações referentes ao ponto-chave onde o rato está em um determinado momento e o rato escreve em outro qual a sua decisão. A primeira escrita é feita pelo labirinto indicando quais as direções estão disponveis para o rato. O rato decide qual direção seguir e a registra no arquivo texto que será lido pelo programa labirinto. Com base na direção escolhida pelo rato, o labirinto verifica qual o próximo PC a que o rato irá chegar e, desse modo, escreve no arquivo de comunicação as novas informações desse PC. Esse processo de troca de mensagens continua até que o rato encontre a saída do labirinto ou esgote o limite de 999 decisões.

Como a troca de mensagens é feita por meio de arquivos de texto, os ratos podem ser desenvolvidos utilizando qualquer linguagem de programação com a qual o estudante se sentir mais confortável. Contudo, pelas experiências educativas já realizadas, percebe-se que somente os estudantes mais avançados se aventuram a desenvolver programas com linguagens distintas daquela originalmente utilizada no rato aleatório. O arquivo escrito pelo labirinto a cada ponto-chave possui a configuração do Quadro 1.

Quadro 1: Configuração das informações escritas pelo labirinto

A	B	C	D	E	F	G	H	I	J	K
X	XXX	XXX	X	X	X	X				

No Quadro 1, as letras de A a K identificam o tipo de informação e cada letra X representa um algarismo decimal utilizado para a descrição de uma informação. A codificação segue o seguinte padrão:

- A: informa se o rato chegou à saída do labirinto ("0"- não; "1"- sim)
- B: informa qual o número da requisição, ou seja, qual o próximo movimento do rato (3 dígitos)
- C: informa a quantidade de passos que o rato deu do último ponto-chave visitado até o atual (3 dígitos)

Os dígitos seguintes informam o grau de liberdade do rato em que "0" indica que não possui liberdade para o movimento na direção especificada e "1", que a possui. O padrão adotado foi D: leste, E: norte, F: oeste e G: sul.

Se, por exemplo, o labirinto informar "00160050101", significa que o rato não chegou ao fim do labirinto (A=0), está tendo que tomar a decisão número 16 (B=016), deu 5 passos desde a última decisão (C=005), e pode decidir entre ir para o norte ou sul (D=0, E=1, F=0, G=1).

Possíveis movimentos a serem adotados em novas experiências, tais como a combinação dos citados anteriormente (por exemplo, sudoeste, noroeste, etc.) ou movimentos em outras dimensões (3D, 4D) podem ser concebidos em projetos futuros com a inclusão das legendas H, I, J, etc.

A configuração do arquivo de resposta do rato é dada no Quadro 2.

Quadro 2: Configuração das informações escritas pelo rato

A	B
XXX	X

Nesse padrão, a letra A indica a resposta a qual movimento (3 dígitos) e B informa a decisão acerca de qual direção a ser seguida (1 dígito). Nesse caso, se o rato responder 0162, significa que está respondendo à requisição número 016 e decidindo tomar a direção 2 (norte).

3.3 Duelo entre Ratos e Visualização

O programa labirinto é executado e escolhe-se dentre diversas opções o estilo do labirinto em que o duelo será realizado. Para cada estilo de labirinto (figura 2), também há uma série de opções dos pontos de entrada e saída do labirinto que proporciona experiências novas a cada execução do programa.

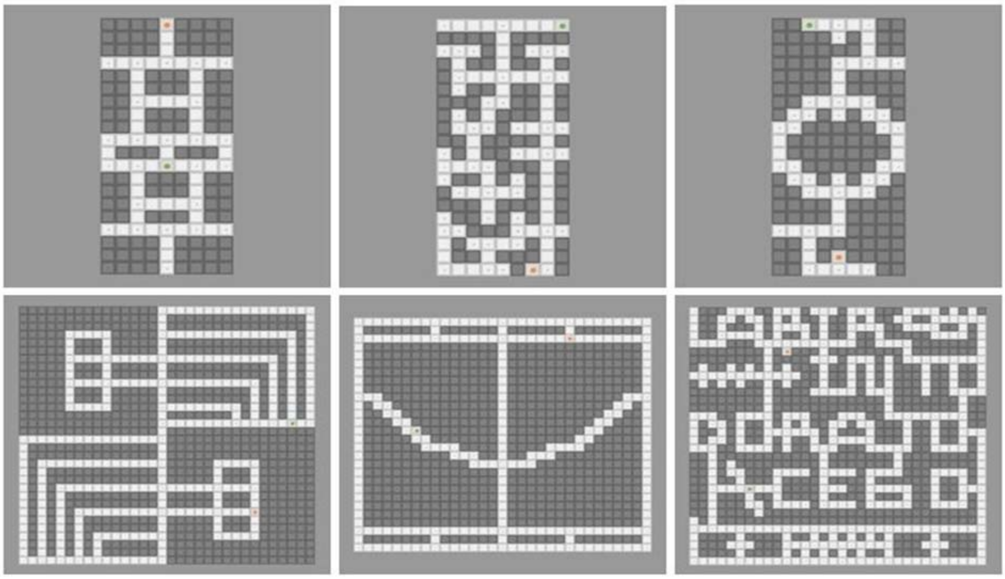

Figura 2: Alguns estilos de labirinto da Competição

Após inicializado o labirinto, os ratos são executados e é gerado um arquivo de texto de saída contendo as informações sobre o labirinto e os percursos dos ratos. O arquivo de texto é lido por outro programa desenvolvido em Macromedia Flash MX Professional com programação em ActionScript 2.0 e o duelo é então exibido ao público (figura 3). No programa de visualização é possível modificar a velocidade dos ratos bem como ângulos de visualização e outros elementos da Computação Gráfica.

4 Resultados

Os resultados da atividade do Labirinto do Rato Cego podem ser divididos em três etapas. Na primeira, a experiência foi realizada em três turmas de APC no período de 2005 a 2006 e a verificação de impacto foi feita com base na observação do docente sobre a mudança de comportamento dos estudantes durante as aulas.

Nessa primeira fase, foi possível observar que os estudantes se mostraram mais interessados nas aulas presenciais conseguindo fazer associações, muitas das vezes por iniciativa própria, entre o conteúdo apresentado e sua aplicação na confecção da inteligência do rato cego.

Figura 3: Resultado de um duelo entre dois ratos

Desde o momento em que o rato aleatório é apresentado no primeiro dia de aula de APC, é possível perceber que alguns estudantes começam a questionar sobre como o programa consegue sortear dentre as direções possíveis e principalmente como eles fariam melhor. Com a execução do rato padrão, os estudantes buscam conceitos em sua estrutura cognitiva que poderiam auxiliar na escolha de melhores estratégias para encontrar a saída do labirinto e compartilham com toda a turma suas descobertas. Muitas vezes algoritmos conhecidos de solução de labirintos, como por exemplo a regra de caminhar sempre com a mão direita encostada na parede, são redescobertos pelos alunos.

Por conta das freqüentes discussões sobre o rato em sala de aula e pelo interesse comum dos estudantes pela estratégia que iriam desenvolver, os estudantes foram aos poucos se socializando e isso trouxe uma atmosfera mais produtiva em sala de aula. Esse intercâmbio de informações entre os estudantes é saudável e pode auxiliar o aprendizado de estudantes com maior dificuldade ao interagirem com estudantes mais capazes. Todo o conteúdo da disciplina foi trabalhado por meio deste projeto e os estudantes consideraram essa metodologia mais interessante e dinâmica do que as aulas tradicionais de programação.

Para a segunda geração de resultados, a atividade foi desenvolvida em uma turma de APC em 2007 em que foram utilizados fóruns de discussão on-line planejados para estudar as expectativas dos estudantes quanto à Engenharia, à disciplina e ao andamento dos trabalhos durante o período letivo.

No fórum de abertura, trabalhado nas duas primeiras semanas de aula, foi levantado o tópico “Por que você decidiu fazer Engenharia?” para verificar quais as expectativas quanto ao curso e verificar se o planejamento do projeto “Labirinto do Rato Cego” estava em conformidade com os interesses dos estudantes. Apesar de ser uma turma com apenas 40 alunos, os resultados confirmaram as observações realizadas pelo docente nas turmas anteriores. Participaram do primeiro fórum 35 estudantes, sendo que a maior parte (21) escolheu o curso de Engenharia porque gostavam das matérias de Exatas, geralmente associando essa decisão também ao mercado (8), à confecção de projetos (8), ao gosto pela informática (8) e à influência dos pais (5). Por outro lado, mesmo com boa parte dos estudantes tendo interesse pela computação, poucos citaram explicitamente o gosto pela programação (3) e um estudante descreveu que, apesar de ter interesse pelas Exatas, “programação é algo de que ainda tem que aprender a gostar”.

No segundo fórum “O que você espera de uma disciplina chamada Algoritmos e Programação de Computadores? Você gosta de problemas de lógica?”, o objetivo era verificar se os estudantes tinham algum tipo de expectativa sobre a área de programação e associar essa percepção ao gosto por problemas de lógica. O índice de participantes foi de 39, sendo que somente uma minoria (2) disse não ter idéia sobre o que esperar. Dezoito pretendem aprender a escrever programas de computadores, valendo destacar que 3 disseram que esperam aprender a utilizar a programação como uma ferramenta para solução de problemas em Engenharia. Vinte e cinco estudantes disseram gostar de problemas de lógica e, desse montante, 5 afirmaram ter dificuldades. Um não gostava de problemas de lógica e outro disse gostar pouco.

No terceiro fórum, o objetivo era verificar se as discussões em sala de aula feitas até a primeira aula prática foram significativas para os estudantes e se estavam motivados com a disciplina. Participaram 39 estudantes, sendo que 26 disseram que gostaram muito, 6 gostaram e 1 não gostou, pois considerou que poderiam ser mais rápidas. Quatro estudantes narraram ter se perdido em alguns momentos das aulas, mas consideraram a aula original e esperam estudar mais para acompanhar.

Com o objetivo de verificar o andamento das aulas, foi criado um quarto fórum sobre a estratégia do uso de projetos e programação e o resultado foi a participação de 30 estudantes dos quais 21 consideraram as aulas muito boas, 4 consideraram as aulas boas e apenas um estudante destacou que estava com dificuldades de acompanhar. Três estudantes destacaram que as aulas estavam dinâmicas e interessantes, sendo que um deles afirmou estar contente, pois imaginava que só iria aprender algo com aplicação prática na metade do curso de Engenharia.

O último fórum, em que os estudantes versaram sobre a metodologia de uso de projetos e da teoria ter sido desenvolvida ao mesmo tempo em que era feita a construção de programas, teve a participação de 28 estudantes e as considerações mais relevantes foram que os projetos ajudam no aprendizado (7), na fixação de conceitos (4), no desenvolvimento de criatividade (2) e na transformação da matéria em algo mais interessante e instigante (3). Os estudantes destacaram ainda que o novo método é mais interessante e aconselharam a continuar com esse método (6) em que é mais fácil entender a passagem do algoritmo para a confecção do programa e onde o inexperiente tem a oportunidade de internalizar melhor o conteúdo (7). Resultados similares aos anteriores foram encontrados com a realização da atividade em turmas nos anos de 2008 e 2009.

A terceira fase de resultados, realizada com o objetivo de verificar o alcance da atividade proposta, foi desenvolvida em uma atividade de extensão universitária que fez parte do II Encontro de Ciência e Tecnologia da Faculdade UnB Gama em 2010. Na ocasião, a atividade "Labirinto do Rato Cego" foi aberta para estudantes mais adiantados no curso, o que proporcionou uma maior interação entre os estudantes novatos e veteranos, além da possibilidade de troca de idéias e familiarização com tópicos mais avançados. O sucesso da atividade está refletido no fato de que houve um convite para que ela conste novamente no III Encontro de Ciência e Tecnologia da Faculdade UnB Gama a ser realizado no segundo semestre de 2011.

5 Conclusão

A pesquisa feita no início do período letivo mostrou que os estudantes de engenharia têm gosto natural por problemas de lógica e ficam motivados quando é feita uma escolha por projetos com possível aplicação em sua vida profissional. Por meio dos resultados apresentados é possível concluir que o uso de uma metodologia de ensino para a área de programação de computadores baseada em projetos é melhor no sentido de proporcionar uma aprendizagem mais instigante, dinâmica e significativa. Os estudantes também se mostraram mais motivados durante as aulas e sociáveis na busca de melhores soluções.

Com base nos dados obtidos dos fóruns on-line foi possível observar que a motivação inicial, obtida com a apresentação do rato aleatório como um organizador prévio, perdurou durante toda a disciplina e a grande maioria aprovou a metodologia de ensino adotada. Apesar de apenas um estudante ter explicitado a sua satisfação em ter feito uma aplicação prática da Engenharia, o que, segundo ele "só iria aprender algo na metade do curso", ficou claro que esta é uma afirmativa verdadeira ao analisar as expectativas levantadas no início do curso e as apresentações finais dos ratos desenvolvidos.

O projeto pode ainda ser aplicado em outras disciplinas mais avançadas desde que com algumas modificações. O problema de encontrar a solução ótima, ou seja, um rato que busque o ponto de controle com direções ainda não visitadas mais próximo a sua posição atual chegou a ser desenvolvido por um estudante. Esse problema pode ser apresentado a alunos com mais facilidade de aprendizagem ou em um curso de Estrutura de Dados, visto que é uma aplicação da busca do menor caminho entre nós de um grafo (Tenenbaum, Langsam & Augenstein 1989).

Como perspectiva futura, uma possível modificação do labirinto para que estudantes comecem a estudar efetivamente a Inteligência Artificial é a inclusão de variáveis extra em cada ponto de controle que representem, por exemplo, o odor de um queijo encontrado na saída do labirinto, ou ainda de variáveis que não têm necessariamente uma relação com a saída do labirinto. Desta maneira, a tarefa tornar-se-ia mais complicada, uma vez que seria necessário o desenvolvimento de um programa que estudasse a correlação existente (ou não) entre tais variáveis e o tempo efetivo de saída, aprendendo com a experiência em labirintos passados e decidindo se o novo dado disponível é ou não útil para facilitar a saída.

Finalmente, para complementar o trabalho atual, pretende-se estudar a percepção, a retenção e a evolução das notas obtidas pelos estudantes sobre os conceitos trabalhados, por meio da comparação entre uma turma de controle, com aulas expositivas tradicionais, e outra com o uso do labirinto do rato cego. Outra melhoria possível é utilizar outros instrumentos para avaliação do alcance da atividade como, por exemplo, mapas conceituais e Vês de Gowin.

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Uso de Objetos de Aprendizagem Interativos, Adaptativos e Multiformes Como Apoio ao Ensino Presencial

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Abstract

It is common to find a large gap of students' knowledge in relation to requirements for educational development in the disciplines in the initial stages of an engineering course. This study used interactive learning objects in order to use them as powerful tools for meaningful learning, while also providing support for project-based learning. The learning objects were produced to generate several possibilities of action learning and were used to support classroom learning and the problem-based learning. The union between educational objects and design of a machine or structure has enhanced the work in the classroom and in a qualitative research done through discussion forums showed that digital objects motivated students in the study of fundamental knowledge for product development, while the project itself estimulated the students's curiosity for matters beyond the curriculum.

Keywords: meaningful learning; project-based learning; adaptive learning objects; multiform learning objects.

1 Introdução

Não é rara a percepção dos docentes relacionada ao grande desnível dos estudantes concernente aos requisitos necessários para o bom desenvolvimento educacional em disciplinas dos primeiros ciclos de um curso do Ensino Superior. No caso de cursos de Engenharia, essa problemática é potencializada devido à dificuldade em motivar o alunado na busca de conhecimento específico de Matemática e Física fora do horário da aula presencial.

A disciplina em que foi desenvolvida a experiência descrita neste artigo pertence ao fluxo normal do curso de Engenharia Elétrica (em geral, também para os demais cursos de Engenharia) e cursada no quarto semestre letivo. Mesmo não sendo uma disciplina do ciclo básico, ainda sofre pela necessidade de uma base sólida dos estudantes nos conteúdos de matemática e física do Ensino Médio, além de utilizar recursos de Cálculo Diferencial e Integral, Mecânica Clássica e Cálculo de várias variáveis.

O panorama geralmente encontrado nessa disciplina, e com certa segurança podendo ser estendido para as demais disciplinas do ciclo básico da maior parte dos cursos de Exatas, foi de um desnível muito grande entre os estudantes. Tal problemática muitas vezes faz com que o professor tenha que se preocupar em atingir um ponto de equilíbrio entre o mínimo e o razoável a ser ensinado. É possível observar ainda que poucos docentes se aventuram a discutir assuntos mais elaborados e intelectualmente mais desafiadores pelo fato de causar repulsa a boa parte da turma. Esse quadro torna frustrante o papel do educador que retribui com aulas clássicas e monótonas para um grupo de alunos que vive o dinamismo da tecnologia e da internet (Fragelli, 2010).

O quadro específico da disciplina sofre ainda de mais um agrave, pois a mesma possui conteúdo mais atrativo para estudantes de Engenharia Mecânica ou Civil que os de Engenharia Elétrica. No contexto de uma turma previamente desmotivada e com o preocupante quadro de heterogenia em relação ao conteúdo requisitado para a disciplina, o desafio era como estimular o estudo dentro e fora do ambiente da sala e a solução proposta é uma aprendizagem baseada em projetos e suportado por Objetos de Aprendizagem (OA) interativos, adaptativos e multiformes.

Sendo assim, o objetivo principal deste trabalho foi o de utilizar projetos de máquinas e demais estruturas para a aprendizagem ativa e, em especial, para a ocorrência da aprendizagem significativa e usar objetos de aprendizagem interativos como alternativa para estimular o estudo fora do ambiente da sala de aula em prol de um nivelamento de conteúdo entre os estudantes.

2 Aprendizagem Baseada em Projetos e a Aprendizagem Significativa

A aprendizagem Baseada em Projetos ou *Problem-Based Learning* (PBL) é fundamentalmente um método de ensino e aprendizagem caracterizado pelo confronto com problemas e projetos reais que podem ser encontrados na vida profissional. Desse modo, é possível contrastar com a recepção passiva de informações do ensino dito tradicional e colocar o estudante em contato com a realidade profissional estendendo também a aprendizagem para além do currículo de uma determinada disciplina (Dochy *et. al.*, 2003).

Apesar do PBL ser um bom método para melhorar o desempenho, a motivação e a formação do estudante, há de se buscar suporte em teorias de aprendizagem já bastante conhecidas e utilizadas como Ausubel, Bruner, Piaget, Vygotsky, Rogers, Freire, dentre outros (Dochy *et al.*, 2003; Ribeiro & Mizukami, 2005). Neste trabalho, preferiu-se o apoio da teoria ausubeliana que possui aplicações bastante práticas dentro da Educação em Engenharia, em especial na concepção de métodos das tecnologias de informação e comunicação (Tavares, 2004; Fragelli, 2010).

A teoria de David P. Ausubel é cognitivista e está centrada no conceito da aprendizagem significativa na qual afirma que o principal fator que influencia na aprendizagem são os conceitos subsunçores (do inglês *subsumer*). Segundo Ausubel, não importa se a aprendizagem é indutiva ou dedutiva e sim quais as associações feitas de maneira substantiva e não arbitrária entre o novo conhecimento e o aprendiz já conhece, chamados de conceitos prévios ou subsunçores. A aprendizagem significativa é um processo pelo qual uma nova informação interage com um aspecto relevante da estrutura cognitiva do sujeito, tal como um conceito ou proposição.

Desse modo, elementos mais abrangentes e inclusivos servem de ancoradouro para conceitos mais específicos. Quando esse novo conceito é interage com o subsunçor, pela ação do sujeito, eles se modificam de forma que ele se torna mais bem elaborado, desenvolvido, estável e inclusivo (Ausubel, 2003; Moreira, 2006).

Para a ocorrência da aprendizagem significativa, os fatores principais são um material com conteúdo lógico, chamado de potencialmente significativo, haver subsunçores sufucientes na estrutura cognitiva do estudante de modo a ser possível fazer correlações com o novo material e o sujeito ter a disposição para realizar tais correlações de modo substantivo e não arbitrário (Moreira, 2006).

Para auxiliar na ocorrência da aprendizagem significativa, Ausubel defende o uso de organizadores prévios que são materiais introdutórios apresentados antes dos tópicos a serem aprendidos e que possuem um alto nível de abstração, generalidade e inclusividade. Em pesquisas recentes, os OA's interativos, em especial, simuladores, estão sendo utilizados como uma boa alternativa para os organizadores prévios servindo de suporte cognitivo no caminhar de novas descobertas (Tavares, 2003; Fragelli, 2010).

Outro dispositivo que pode apoiar no alcance desse tipo de aprendizagem são os mapas conceituais, diagramas bidimensionais que exibem relações hierárquicas entre conceitos e que também podem ser trabalhados no campo das novas tecnologias de comunicação e informação (Tavares, 2003; Fragelli, 2010). Os mapas conceituais também podem servir como instrumento de organização da aprendizagem e avaliação da aprendizagem significativa.

3 Objetos de Aprendizagem como apoio ao PBL

Conforme destacado anteriormente, o uso de uma aprendizagem baseada em projetos e com apoio de OA's interativos foi a solução escolhida para o enfrentamento do quadro já narrado. A experiência descrita passou por várias fases e descobertas em um período de 2002 a 2010 com um montante de mais de vinte turmas de Mecânica Geral, com cerca de quarenta a cinqüenta estudantes cada. Apesar da narrativa do artigo permanecer na fase de otimização das medidas e instrumentos didáticos da disciplina, as primeiras quatro turmas foram trabalhadas com aulas expositivas, dinâmicas diversas em sala de aula e com apoio de fóruns e material on-line.

Com a mudança para a inclusão de um projeto final da disciplina, os estudantes se mostraram mais dispostos em sala de aula, contudo, essa motivação da turma foi ligeiramente aumentada com o desenvolvimento do conteúdo com base no projeto da disciplina, o que ocorreu a partir da sétima turma de Mecânica Geral. Alguns exemplos de projetos desenvolvidos pelos estudantes são "Cadeira de rodas que fica na posição vertical", "Calça-cadeira", "Garra mecânica automática com extensão do antebraço", "Braço hidráulico inteligente", entre uma grande variedade de outros (Figura 1).

Figura 1: Imagens de uma garra mecânica desenvolvida durante a disciplina de Mecânica Geral
(*as imagens foram modificadas de modo a garantir o anonimato do estudante*)

Mesmo assim, foi possível verificar que apesar da motivação inicial da turma, boa parte não conseguia visualizar elementos básicos para resolução de problemas da disciplina como esforços e reações de apoios e conexões. Foi então que começaram a ser desenvolvidos os OA's interativos para suporte ao PBL que posteriormente acrescentaram elementos de inteligência artificial e hipermídia adaptativa.

Os OA's digitais são bastante conhecidos dos educadores, contudo, mais utilizados na educação a distância do que como suporte ao ensino presencial. Em especial, se tais instrumentos educativos fornecem um bom nível de interatividade com o estudante, tornam-se naturalmente uma ferramenta potencial para a aprendizagem significativa (Ausubel, 2003).

Um objeto de aprendizagem é basicamente uma entidade digital que possui um objetivo educacional específico, que pode ser reutilizado em outros contextos educacionais, que possui metadados para sua identificação e que são executados por meio de um computador digital (Tavares, 2004; Fragelli, 2010).

Os OA's construídos para a disciplina de Mecânica Geral são diferentes do que geralmente são encontrados nos repositórios de conteúdos, pois, além de interativos, são também adaptativos às características dos estudantes e fazem a geração de novas situações de aprendizagem de acordo com a ação do estudante sobre o objeto educativo. Com isso, é possível que o estudante explore diversas vezes um mesmo objeto educacional com novas situações a serem estudadas. Foram também desenvolvidos agentes pedagógicos virtuais para alguns objetos que fazem a tutoria on-line (Figura 2).

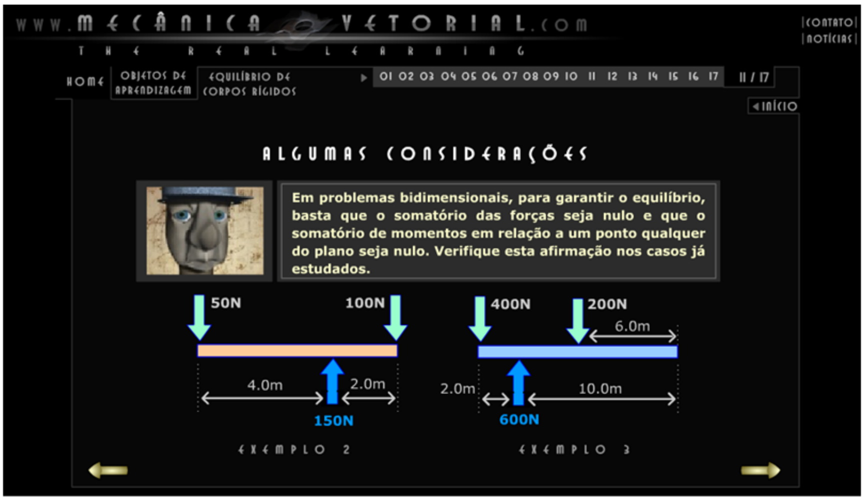

Figura 2: Exemplo de Objeto de Aprendizagem Interativo desenvolvido

Os documentos também foram disponibilizados em um *Learning Manegement System* (LMS), onde foram utilizadas outras ferramentas usuais da educação a distância (mural de avisos, documentos compartilhados, Digital DropBox, fórum, etc.) (Fragelli, 2009).

Alguns dos OA's interativos desenvolvidos fazem uso de agentes inteligentes (Cocco, 2004) e realizam a geração de um sem-fim de situações de aprendizagem podendo ser reutilizáveis por um mesmo estudante quantas vezes desejar. Em outras palavras, utilizou-se programação nos OA's para que os mesmos possam ser exibidos de forma adaptável de acordo com as ações e necessidades do estudante (Figura 3).

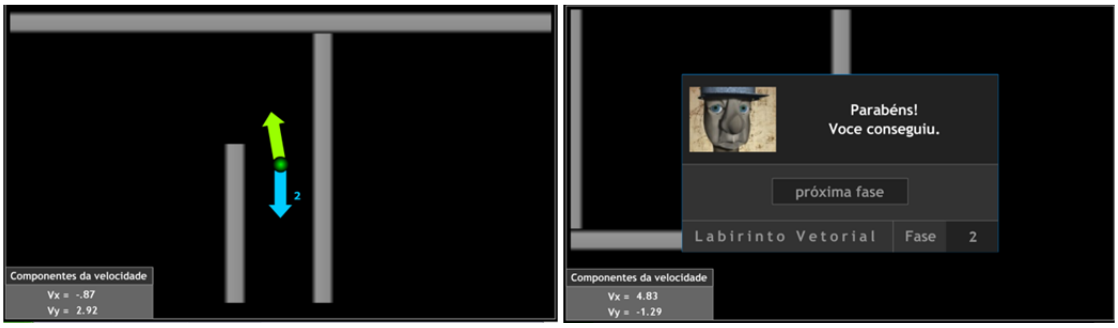

Figura 3: Exemplo de um OA de simulação "Labirinto Vetorial" e ação de um tutor online

O último avanço realizado foi em relação aos objetos foi a disponibilização de alguns objetos para o público em geral (*www.mecanicavetorial.com*) e a confecção de objetos com acesso a banco de dados para tornar o conteúdo mais adaptável.

Para a construção dos objetos de aprendizagem foi utilizado o Macromedia Flash MX Professional com programação em ActionScript 2.0. Para o pano de fundo do site em que parte dos objetos foram disponibilizados para os estudantes e comunidade, foi utilizada linguagem HTML e, para comunicação com o banco de dados construído com mySQL, foi utilizada a linguagem PHP. Arquivos em PHP também foram confeccionados para uso dos scripts dentro do Flash.

4 Resultados

Mesmo tendo sido desenvolvidas muitas atividades para a disciplina de Mecânica Geral, havia uma percepção do docente de que os OA's e o projeto final da disciplina sobre o qual os conceitos principais da disciplina eram construídos tinham sido mais significantes para os aprendizes. Em especial, os projetos pareciam estar na preferência dos estudantes, haja vista que muitos deles versavam sobre a importância do projeto para a sua formação como Engenheiro e que a maior parte dos estudantes das turmas, para todo o período analisado, conseguia visualizar aplicações concretas para os projetos realizados e se mostravam motivados na busca de conceitos fora do domínio da disciplina.

Essa análise vai ao encontro de outras pesquisas em Educação em Engenharia na qual os estudantes ficam mais motivados quando trabalham assuntos referentes à vida profissional e, no sentido oposto, propícios à evasão do curso quando não chegam ao ciclo profissional (Silva, 2002).

Desse modo, para verificar a veracidade das percepções iniciais do docente, foi feita uma pesquisa por meio de fórum em uma turma de 40 alunos e participaram 33 respondentes. Desses, 32 consideraram o projeto muito importante para a disciplina, dos quais 13 informaram também destacar que é uma iniciativa que auxilia na interação entre a teoria e a prática. Doze estudantes disseram que gostaram da metodologia de ensino, principalmente porque o projeto provocou uma investigação de assuntos fora da matriz curricular. Boa parte dos estudantes (8) narrou que o projeto é também uma ótima forma para avaliação da aprendizagem, estimula a aprendizagem porque proporciona um contato com problemas de Engenharia (17).

Para avaliar se a utilização dos OA's teve relevância no aprendizado quando comparado aos demais recursos pedagógicos da disciplina, optou-se também pela metodologia de avaliação qualitativa por meio da participação dos estudantes em fórum de discussão ao final da disciplina. Para isso, ao invés de haver um tópico específico sobre os OA's, foi criado um tópico com uma questão aberta onde os estudantes colocariam suas opiniões gerais sobre a disciplina.

Participaram do fórum 35 alunos de um total de 40 e, mesmo não havendo um direcionamento em relação às atividades extra-classe e quais medidas poderiam ser tomadas para uma melhora na disciplina, foi possível observar que a maior parte das citações (33) sobre pontos positivos da disciplina tinham relação com o posicionamento do docente em sala de aula. Desses, 17 estudantes apontaram como ponto positivo a aula mais lúdica (13), o bom relacionamento entre docente e aluno (7), o uso de projetos (5) e aulas críticas e diferentes das aulas tradicionais (11). A aula excessivamente lúdica (2) e muito espaço para discussão (1) afetaram uma grupo bastante reduzido da turma que classificaram como pontos negativos.

O baixo número de citações referentes ao projeto da disciplina (5) e ao desenvolvimento mais prático da disciplina possivelmente classificados como pontos positivos deve-se ao fato de que o fórum precedente tratou especificamente deste assunto.

Por meio das opiniões livres no fórum, percebe-se que o posicionamento do docente em sala de aula é o teve maior relevância para os aprendizes, contudo, tal visão só foi possível pois as demais ações propiciaram um ambiente acolhedor e motivador para as experiências educativas. Essa análise pode ser feita pelos pontos a serem melhorados em que 23 estudantes citaram assuntos relacionados ao projeto, à vida profissional do Engenheiro ou aos OA's interativos.

Por meio das opiniões registradas pelos estudantes, é possível concluir que, mesmo dentre várias outras atividades realizadas durante a disciplina, os estudantes ficaram bastante estimulados com os elementos hipermidiáticos, que receberam destaque nas mensagens nas quais sugeriram estendê-los para a sala de aula como melhoria da disciplina. Os estudantes deram o mesmo nível de importância em estender os objetos para a sala de aula (8) e a criação de um laboratório para o desenvolvimento dos projetos de Mecânica (9).

Dois estudantes levantaram a questão da heterogeneidade entre o grupo de alunos, inclusive em relação à faixa etária, e a dificuldade em se encontrar um bom tom para uma aula presencial pois "(...) algumas pessoas são mais sérias, mais sisudas". Nesse sentido é que OA's interativos e demais ferramentas de suporte à aprendizagem presencial se fazem necessários.

Além disso, por meio do painel de controle do LMS em que fica registrado o percurso de cada estudante pelas áreas de conteúdo do LMS, observou-se um acesso de 100% da turma (com exceção de trancamentos e cancelamentos) pelos objetos educacionais ao longo do semestre letivo e uma procura cerca de 10 vezes maior pelas áreas dos objetos interativos. Pelo painel de estatísticas do site Mecânica Vetorial onde alguns OA's foram disponibilizados, foi possível observar um acesso de mais de 120 mil internautas ao longo dos anos de 2006 e 2010, o que mostra a popularização e o aspecto motivador que os objetos interativos possuem em relação ao público em geral. Como exemplo bem sucedido, tem-se os jogos Antena e Antena 2 (Figura 4) onde os usuários podem fazer projetos de uma base de suporte para uma antena parabólica sob a ação de forças externas foram utilizados por mais de 60 mil estudantes e professores.

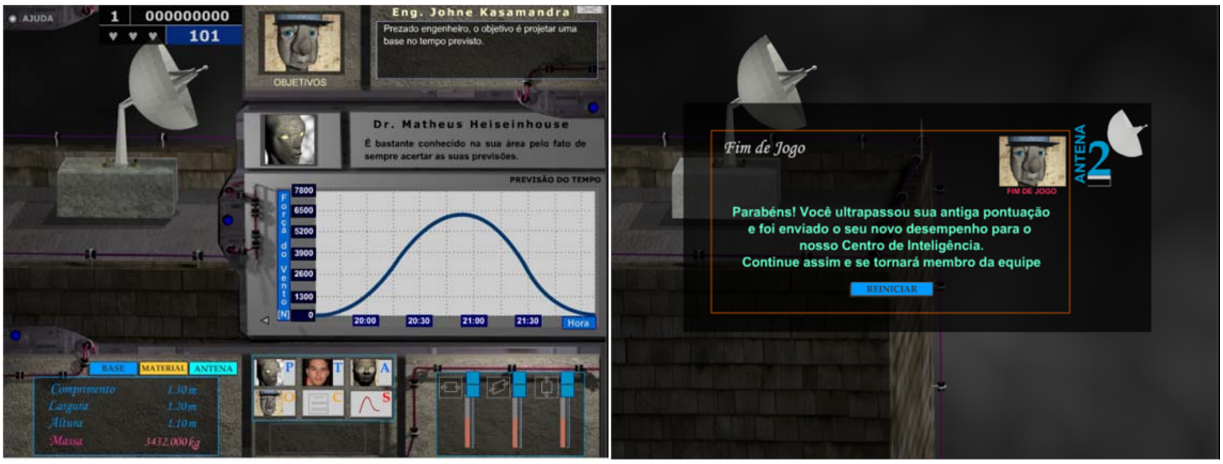

Figura 4: Antena 2 – jogo educativo sobre o projeto de uma base de sustentação

Especificamente sobre a turma de Mecânica Geral, pode-se observar pelo painel de vencedores dos Jogos educativos que os estudantes com menções finais mais altas, mais participativos em sala de aula e com melhores projetos finais, estão na listagem dos mais assíduos nos jogos.

5 Conclusão

Com base nos resultados apresentados e nas experiências vivenciadas, é possível concluir que a interatividade transforma os OA's digitais em ferramentas potenciais para a aprendizagem significativa e dão suporte à aprendizagem baseada em projetos. Se um OA é trabalhado de modo a simular situações distintas de acordo com a ação do estudante, estes se tornam mais atraente para os estudantes que fazem uso mais frequente da ferramenta.

Os objetos digitais motivaram os estudantes no estudo de conhecimentos fundamentais para o desenvolvimento do produto, enquanto que o projeto em si provocou uma investigação de assuntos fora do contexto técnico-científico da matriz curricular e tratou o problema da ausência de integração entre a teoria e a prática. O projeto proporciona a necessidade de enfrentamento de vários pequenos problemas cujas soluções envolvem ativamente o estudante no processo de aprendizagem e desenvolvem competências de elevado nível cognitivo (Watts, 1991).

Outro ponto observado com o uso do projeto da disciplina foi o desenvolvimento de habilidades, tais como trabalho em grupo, comunicações oral e escrita e capacidade de resolução de problemas; e atitudes, tais com adaptabilidade e disposição para a aprendizagem contínua e autônoma.

Por meio da análise do sistema de gerenciamento e controle de um ambiente virtual de aprendizagem, observou-se ainda que os OA's interativos foram substancialmente mais procurados pelos estudantes que os demais objetos educacionais desenvolvidos para a disciplina. Para a replicação da experiência relatada, pode-se destacar a construção de bons objetos, com boas temáticas, alto grau de interatividade e liberdade de controles pelo estudante.

A experiência de utilizar OA's interativos e com geração de múltiplas situações de aprendizagem, onde o estudante possua um extenso campo para exploração pode ser replicada sem grandes alterações para um grande número de disciplinas. Em especial, disciplinas que possuam conteúdo que envolvam algum tipo de cálculo matemático, os respectivos objetos educacionais são facilmente programáveis.

Em disciplinas ou conteúdos que não tenham nenhum tipo de cálculo matemático, sugere-se a utilização de simuladores de situações e o acompanhamento de agentes virtuais.

Conforme visto nos resultados do fórum, os objetos interativos também possuem uma grande receptividade em seu uso em sala de aula ao invés das tradicionais aulas de exercício. Dentre diversos aspectos, basta considerar que o estudante pode ser autor dos exercícios e para cada resposta (ou ação) do estudante, o objeto se comporta de uma forma distinta. Desse modo, além da atenção de toda a turma, as várias experiências virtuais podem servir para a construção de novos conceitos transformando em uma aprendizagem significativa de modo similar ao realizado pelo projeto da disciplina.

Como continuação deste trabalho, pretende-se verificar a percepção e retenção dos conceitos trabalhados em Mecânica Geral com uma turma de controle com o PBL tradicional e o PBL com OA's interativos como suporte. Outra melhoria possível e já em fase de investigação é o uso de menus interativos em formato de mapas conceituais para avaliação do alcance da atividade.

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Aprendizagem Baseada em Problemas e o Uso de Mapas Conceituais

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Abstract

The challenges of learning are enormous for students, whatever is the teaching methodology employed since they are asked for developing multidisciplinary ability and knowledge on languages, geography, history, biology, chemistry, math, physics, and technological contents. One of the stages of PBL methodology is referred to a cooperative activity where knowledge acquired individually by students for solving a problem is applied and some systematization of concepts is carried out. The strategy for consolidation of concepts and their relationship can be achieved by construction of a conceptual map which graphically illustrates all actions developed for the problem solving. In this article we present a reflection on the use of conceptual maps in tutorship as a facilitator strategy for students learning.

Keywords: conceptual maps; significant learning; tutorships.

1 Introdução

A Aprendizagem Baseada em Problemas, conhecida internacionalmente pela sigla em inglês PBL (Problem Based Learning), teve seu início na Universidade de McMaster no Canadá, no final dos anos 1960 para o desenvolvimento de uma nova escola de medicina. O PBL foi introduzido como uma nova metodologia educacional em que a aprendizagem está centrada no aluno. O modelo de McMaster se tornou um referencial a partir do qual outros se desenvolveram como, por exemplo, em Maastricht, na Holanda e Newcastle, na Austrália, que passaram a utilizar esta metodologia de ensino em seus cursos de medicina.

Desde então, experiências têm sido realizadas em diferentes áreas tais como Economia, Direito e, mais recentemente, na área de Engenharia. Neste último caso, o PBL tem sido utilizado como uma estratégia parcial ou em um período pré-determinado, envolvendo uma ou algumas disciplinas, mas não o currículo de forma integral (PERRENET, BOUHUIJS, SMITS, 2000).

No Brasil, a experiência do PBL é relativamente recente e também teve início em cursos de medicina, como os da Faculdade de Medicina de Marília (FAMEMA - 1997), da Faculdade de Ciências Médicas da Universidade Estadual de Londrina (UEL - 1998) e da Faculdade de Ciências Médicas da PUC-SP (2004). Na área de Engenharia, a PUC-SP é pioneira na implantação do curso de Engenharia Biomédica integralmente em metodologia PBL (Manrique, Dirani, Campos (2010), Campos, Manrique, Dirani (2010), Dirani, Manrique, Campos (2011)).

Neste texto iremos apresentar uma reflexão a respeito da tutoria realizada na metodologia PBL, bem como a fundamentação teórica desta metodologia. Também é apresentada a estratégia facilitadora de aprendizagem, denominada mapa conceitual, com exemplo de aplicação em um projeto que pode ser utilizado no ensino médio.

2 Aprendizagem significativa e mapas conceituais

Uma aprendizagem é significativa quando um novo conhecimento relaciona-se de maneira substantiva e não arbitrária a informações previamente adquiridas pelo aluno. A relação substantiva exprime que a aprendizagem não depende de determinadas palavras ou representações particulares do novo conhecimento, ou seja, é a substância do conceito que se incorpora à estrutura cognitiva. A não arbitrariedade implica que o novo se relaciona com conhecimentos relevantes do indivíduo, de maneira que estes funcionam como pontos de ancoragem àquele (MANRIQUE, 2003).

Ausubel (1978) denomina subsunçor, "um conceito, uma idéia, uma proposição já existente na estrutura cognitiva capaz de servir de âncora para a nova informação de modo que esta adquire, desta maneira, significados para o indivíduo (isto é, que tenha condições de atribuir significados a essa informação)" (MOREIRA, 2000, p. 11). Dessa maneira, os subsunçores estando adequadamente claros e disponíveis na estrutura cognitiva permitem a incorporação, a compreensão e a fixação de novas idéias, conceitos, proposições, e, conseqüentemente, também vão se tornando mais estáveis e mais diferenciados, porque existe uma interação e não uma associação entre a estrutura cognitiva e o novo conhecimento. (AUSUBEL, 1978, MOREIRA, 1997).

A aprendizagem significativa não apenas pressupõe que exista uma manifestação por parte do aluno, para relacionar de forma substantiva e não arbitrária a nova informação à estrutura cognitiva, como também que o material seja potencialmente significativo para o aluno, isso quer dizer que o material deve relacionar-se de modo intencional com as idéias, conceitos e proposições que o aluno possui (AUSUBEL, 1978).

Dessa maneira, distinguem-se dois fatores associados à aprendizagem significativa: um deles, que a natureza do material tenha significado lógico – por exemplo, os conteúdos das disciplinas escolares normalmente são logicamente significativos –; e o outro, que a natureza da estrutura cognitiva permita transformar o significado lógico em significado psicológico.

Por significado psicológico entende-se uma experiência cognitiva idiossincrática, ou seja, a maneira pessoal de ver, sentir e reagir a uma situação de aprendizagem. Assim, um material pode ter significado lógico, porém será sua relação com a estrutura cognitiva do indivíduo (que deve ser de maneira substantiva e não arbitrária) que possibilitará transformar significado lógico em psicológico.

Por ser um fenômeno idiossincrático, o significado psicológico depende da existência de subsunçores na estrutura cognitiva. Entretanto, a existência deles não garante a aquisição de conhecimentos. Por exemplo, se o aluno possui idéias e conceitos relacionados ao novo conhecimento na situação de aprendizagem, mas seus significados psicológicos não são compartilhados pela comunidade ou adequadamente claros, a aprendizagem do novo conhecimento ficará comprometida.

Para que a aprendizagem significativa ocorra, os mapas conceituais apresentam possíveis estratégias facilitadoras e podem representar a estrutura conceitual e proposicional do conhecimento de um indivíduo, sendo, nesse caso, um instrumento de meta-aprendizagem. Novak e Gowin (1999, p.31) definem um mapa conceitual como "um recurso esquemático para representar um conjunto de significados conceituais incluídos numa estrutura de proposições".

Assim, mapas conceituais são representações gráficas da linha de pensamento elaborada durante um projeto, estudo ou apresentação. Essa representação é criada através de conceitos que possuem relação, criando assim uma linha lógica de raciocínio, organizando o pensamento (Novak e Cañas, 2008).

Os mapas conceituais podem ser utilizados como ferramentas no ensino e na pesquisa. Por ser uma técnica flexível, pode ser usada em diversas situações com inúmeras finalidades, tais como: análise de currículos, técnica didática, recurso de aprendizagem, meio de avaliação, pesquisas, elaboração de projetos. Portando, o uso de mapas conceituais reforça a compreensão e a aprendizagem por parte dos alunos (BREZOLIN, 2010, p. 41). Os resultados de Brezolin (2010) mostraram que a implementação da técnica de mapas conceituais se constituiu numa ação potencialmente facilitadora de aprendizagem.

Donner Junior, Infante-Malachias e Correia (2006) desenvolveram um trabalho com alunos do ensino médio em aulas de química e biologia. Este experimento foi realizado com trinta alunos do 2º ano do ensino médio. Os alunos trabalharam em grupos de até 5 estudantes, para discutir e partilhar diferentes conhecimentos e elaborar mapas conceituais. Os resultados apontaram que os alunos que participaram do trabalho realizado conseguiram assimilar melhor os conteúdos das aulas quando em seus estudos elaboravam mapas conceituais.

Segundo Ellis, Rudnitsky e Silvertain (s/d), antes do uso de mapas conceituais os alunos pesquisados tinham dificuldade de compreender os conteúdos estudados, pois não organizavam seus próprios conhecimentos de forma a facilitar o entendimento e aplicação no que era ensinado. Com o uso dos mapas, os alunos passaram a organizar e assimilar o conhecimento, tornando o seu uso uma estratégia facilitadora da aprendizagem.

Fonseca e Extremina (2008), com foco no ambiente de desenvolvimento de pesquisas, iniciaram um experimento em 1998 com grupos de pesquisadores e perceberam que, com os mapas conceituais, a comunicação entre os grupos, a organização dos arquivos, a divulgação do pensamento e a interconexão entre o conhecimento dos pesquisadores passou a ser melhor desenvolvida.

Orue, Alvarez e Montoya (2006) defendem o uso do Software Cmap Tools, desenvolvido pelo Institute for Human and Machine Cognition – IHMC (http://www.ihmc.us), pois com o uso de tais mapas, os pesquisadores da área de engenharia e matemática conseguiram estabelecer uma melhor comunicação entre si, em palestras e conferências.

Ramírez, Flórez e Barros (2008) mostraram que o uso de mapas conceituais pode ajudar a resolver problemas de engenharia em uma indústria. Como os problemas ocorriam em áreas diferentes, tornava-se um problema complexo e multidisciplinar, requerendo aplicações técnicas e sociais do conhecimento, que acabava englobando ambientes diversos da indústria. Assim, cada área desenvolvia um mapa conceitual e, após serem entregues os mapas, um engenheiro os analisava e desenvolvia um mapa final com todas as melhorias que iriam afetar todas as áreas, ficando claro e lógico seu raciocínio.

Já no processo de construção do conhecimento, Arellano e Santoyo (2009) classificam os instrumentos de investigação como qualitativos ou quantitativos, conforme mapa conceitual ilustrado na Figura 1. Os dois tipos de instrumentos se completam e não se excluem.

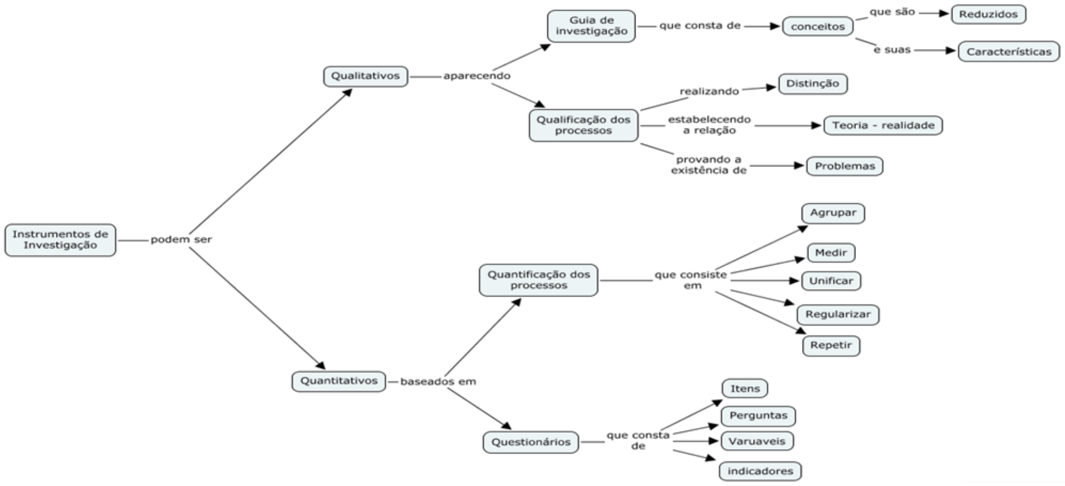

Figura 1: Instrumentos de Investigação. Fonte: Arellano e Santoyo (2009, p.143)

Os instrumentos qualitativos coletam dados, por meio de um guia de investigação, que apresenta os conceitos e suas características, e qualificam processos. Os instrumentos quantitativos coletam dados por meio de questionários e quantificam os processos.

Dessa maneira, os elementos qualitativos e quantitativos dos processos se constituem em uma multiplicidade de características essenciais e secundárias, integradas e formando, em conjunto e dinamicamente, a natureza do processo (Figura 2).

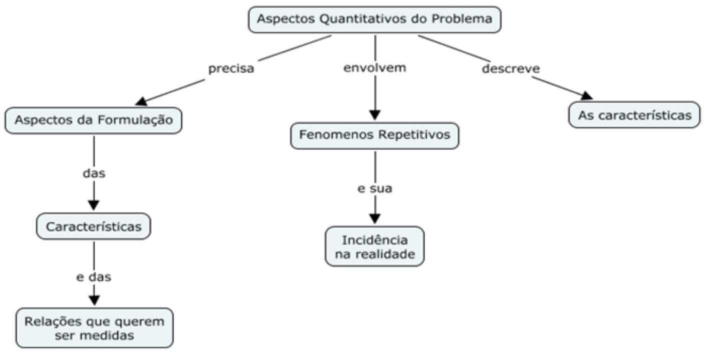

Figura 2: Aspectos Quantitativos do Problema. Fonte: Arellano e Santoyo (2009, p.153)

Os mapas conceituais apresentam dados quantitativos e qualitativos de processos, sendo, portanto, usados como ferramenta para ajudar a captar, organizar e gerar conhecimento.

3 Modelo de ambiente com aplicação dos mapas conceituais

Um modelo de ambiente para apresentar os conteúdos envolvidos em uma pesquisa científica sobre o tema de "Nariz Eletrônico" é apresentado a seguir (Enzenmüller e Manrique, 2010, Gonçalves e Dirani, 2010). Este tema de pesquisa científica procura analisar a utilização de sensores artificiais, simulando o nariz humano, para a detecção de álcool. O objetivo é o de desenvolver um sistema que identifique a presença e o tipo de álcool em soluções com diferentes diluições de água.

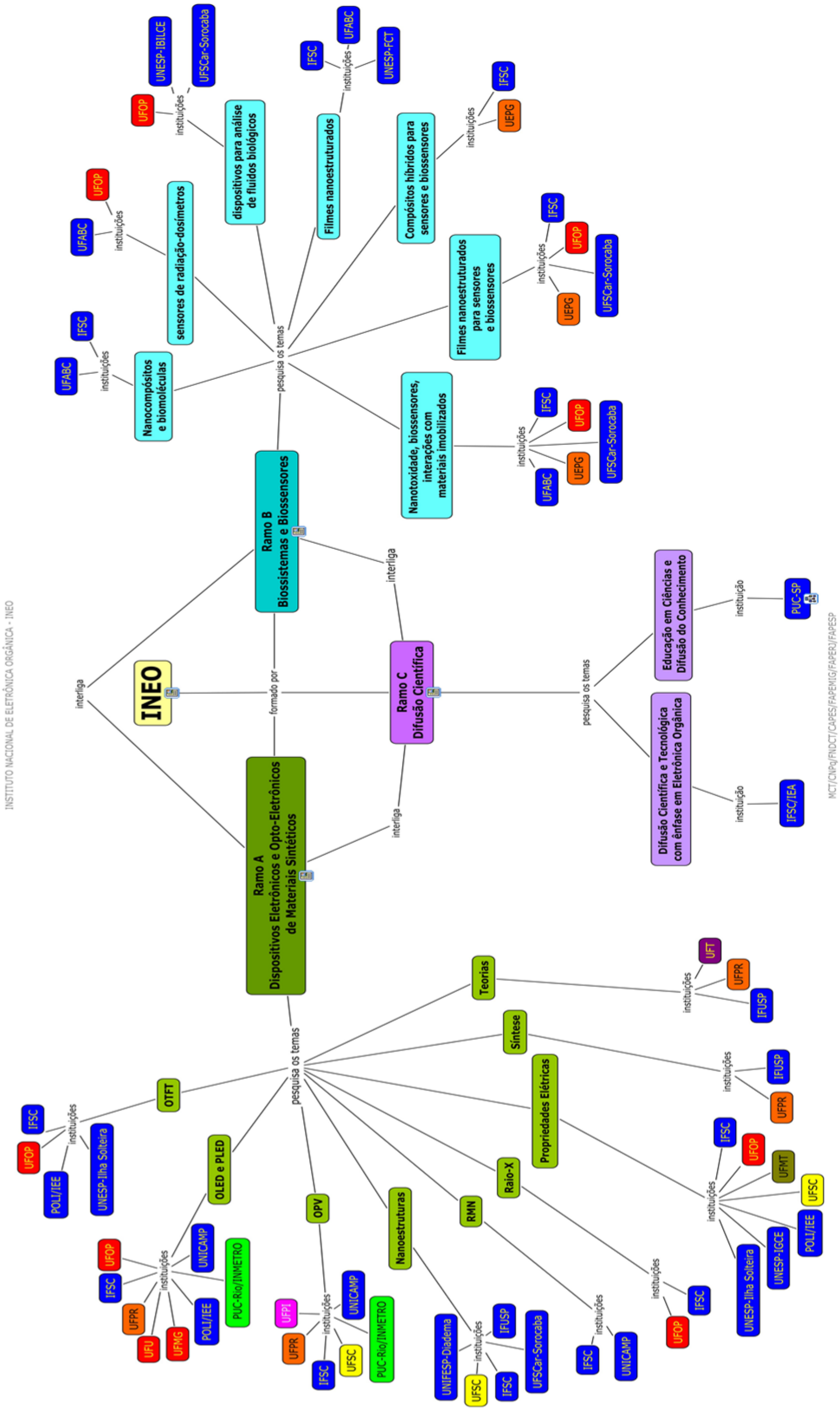

Figura 3: Mapa conceitual do projeto INEO – Instituto Nacional de Eletrônica Orgânica – com os ramos de pesquisa envolvidos

O trabalho citado utiliza uma série de conceitos básicos das diferentes áreas de conhecimento (tais como Química, Física, Biologia e Matemática) que, postos em conjunto, fornecem elementos para a compreensão do "Nariz Eletrônico". A função do mapa conceitual, portanto, é a de unir esses conceitos de forma lógica e ordenada, com diferentes métodos de exemplificações e explicações (textos, imagens, vídeos), para assim mostrar as relações entre todos eles.

Os mapas conceituais foram construídos pela ferramenta Cmap Tools e neste espaço virtual, ao invés de explicar um experimento por meio de textos encadeados, é possível o estudo de um modelo de conhecimento, por meio de imagens, vídeos, áudios, textos, simulações, páginas web, etc.

Assim, foi elaborado um tutorial para o uso do programa CMap Tools (http://cmap.ihmc.us), criando um ambiente num diretório denominado INEO (www.ineo.ifsc.usp.br), como referência ao grupo de pesquisa e ao projeto em rede que está sendo desenvolvido por diversas universidades no Brasil, no âmbito dos Institutos Nacionais de Ciência e Tecnologia – INCT (MCT, CNPq, Capes, FAPESP). Este ambiente permite a divulgação dos mapas via web e a publicação de um mapa conceitual na rede pública do IHMC que representa uma das pesquisas realizadas no âmbito do INEO (Figura 3).

Uma das principais contribuições que se espera deste projeto de pesquisa é o de buscar a consolidação de uma rede de pesquisa multidisciplinar no tema da divulgação científica. A idéia é fornecer um espaço de alta rotatividade e interatividade para que todos possam compartilhar e interagir com seus pares e com especialistas, estabelecer redes de cooperação e ter acesso a informações atualizadas e de qualidade que privilegiem a integração de linguagens, em particular as midiáticas e o uso de computadores para a pesquisa na internet, simulações, argumentação e registro.

No mapa conceitual da Figura 4 são apresentados os temas de pesquisa da PUC/SP no projeto INEO. E no mapa da Figura 5 (ver no final do artigo), os conceitos são apresentados com todas as inter-relações, podendo ser identificados os conteúdos de matemática, biologia, física e química.

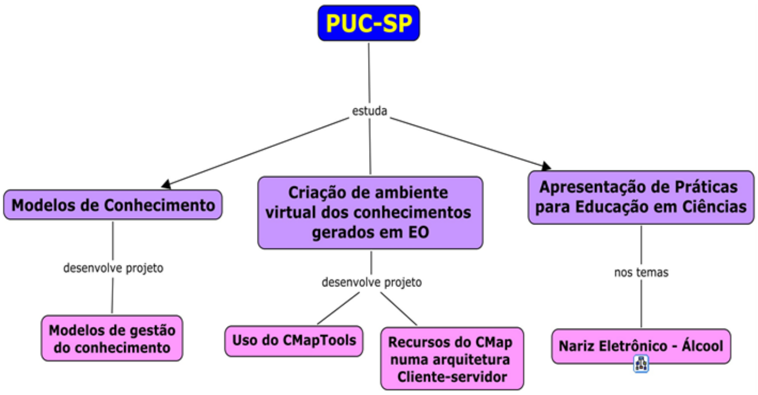

Figura 4: Mapa conceitual dos temas de pesquisa da PUC/SP no INEO

4 Conclusão

Os desafios de aprendizagem dos alunos são imensos, qualquer que seja a metodologia de ensino utilizada, por demandar destes mesmos o desenvolvimento de habilidades multidisciplinares e conhecimentos em língua portuguesa e estrangeira, geografia, história, biologia, química, matemática, física e conteúdos tecnológicos.

Desta forma, a utilização de mapas conceituais propicia a explicitação, a representação e a avaliação dos conceitos aprendidos e as relações estabelecidas com os conhecimentos prévios.

Manrique (2003, p.125) aponta que as relações estabelecidas nas situações de aprendizagem interferem neste processo:

> "As relações com o saber não são somente com o conteúdo a ser estudado, envolvem relações do professor com os outros elementos presentes na ação educativa: com os formadores, por validarem o saber explicitado; com os outros docentes, por co-construírem o saber e o partilharem entre si; com ele próprio, por necessitar enfrentar diversos dilemas para que o saber possa ser adquirido; e com a atividade proposta, por propiciar exploração do conteúdo em suas diversas representações, gerando uma aprendizagem significativa".

Barrows (1984) apud Perrenet, Bouhuijs e Smits (2000) descreve o PBL como um processo cíclico dividido em três fases. Na primeira fase, os alunos encontram, primeiramente, problemas ao invés de fatos e teorias. São desenvolvidas, nesta fase, habilidades para raciocinar sobre problemas e são identificadas as necessidades de aprendizagem em um ambiente cooperativo, onde o professor desempenha um papel diferente do habitual. A próxima fase compreende o estudo individual auto-dirigido, motivado pelas necessidades identificadas na fase anterior. O ciclo se fecha com uma nova etapa cooperativa, onde são aplicados os conhecimentos adquiridos individualmente pelos alunos para a resolução do problema e ocorre também a sistematização dos conceitos estudados. A partir daí, um novo ciclo é iniciado com a apresentação de um novo problema.

O PBL deve ser entendido, então, como uma estratégia de construção curricular, mais do que um simples método educacional. Para a sua aplicação adequada é necessário criar espaços para o auto-aprendizado e outras atividades educacionais de apoio. Ao propiciar a mudança no desenho curricular, o PBL permite que outras formas de educação problematizadora sejam também utilizadas.

Ao invés de o professor fornecer ao aluno a informação e todos os dados, mediante aulas e anotações, no PBL ele deverá facilitar e guiar o processo de aprendizagem. Deverá permitir que os alunos determinem, por eles mesmos, o que precisam aprender e, ao mesmo tempo, saibam que recursos lhes serão necessários.

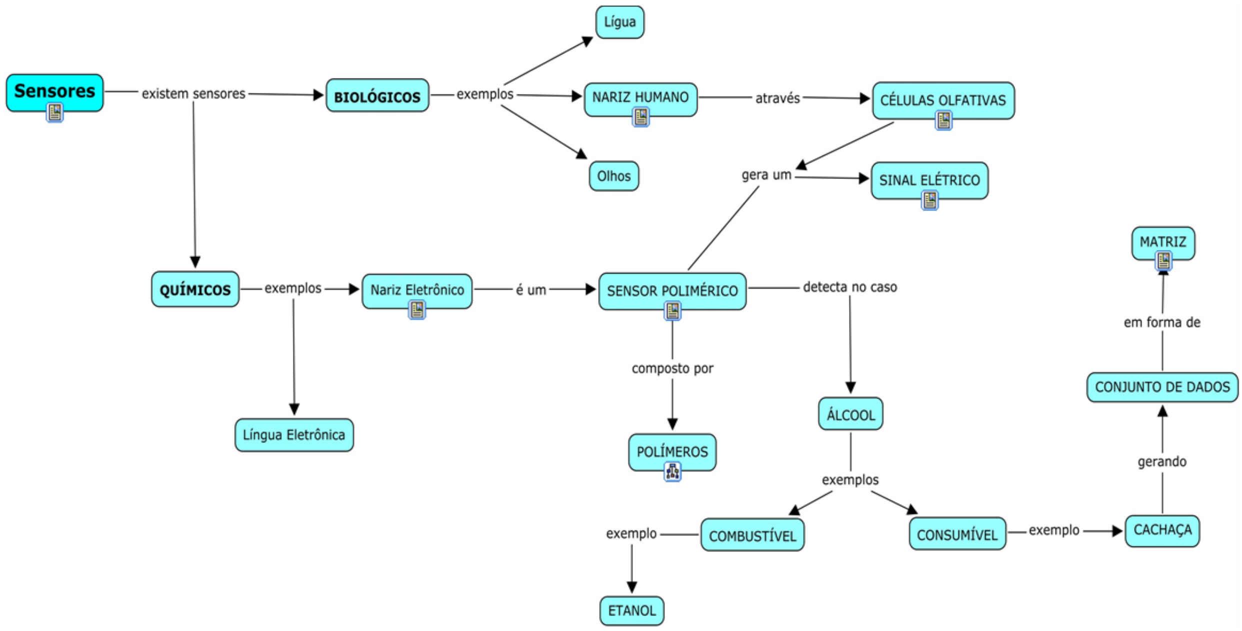

Figura 5: Mapa conceitual – nariz eletrônico para educação básica

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Paper Session A3

El Trabajo en Equipo y su Relación con la Motivación del Estudiante de Ingeniería Industrial y de Sistemas

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Resumen

Los cursos de Química General 1 y Química General 2 actualmente se ubican en el primer y tercer semestre de la currícula de Ingeniería Industrial y de Sistemas de la Universidad de Piura. En ambos cursos se viene implementando una metodología mixta con permanente trabajo grupal y aplicación de situaciones de ABP. El presente trabajo pretende ser una reflexión acerca de la práctica pedagógica en el curso de Química General 2 desde el enfoque de la influencia que el trabajo en equipo ejerce sobre los estudiantes, principalmente en su motivación hacia el aprendizaje y en el cambio de actitudes.

Abstract

General Chemestry courses (QG1 and QG2) are currently located in the first and third semester of the curriculum of Industrial and Systems Engineering at the University of Piura. In both courses in being implemented a mixed methodology with continuous application of group work and problem-based learning (PBL). This work aims to be a reflection on teaching practice in the course of General Chemestry 2 from the viewpoint of the influence of teamwork has on students, mainly in the motivation of learn and change attitudes.

1. Metodología de trabajo

A raíz de una reestructuración en la currícula de la carrera de Ingeniería Industrial y de Sistemas, se ha cambiado la posición del curso de Química General 2. Originalmente estaba ubicado en el segundo año de la malla curricular en el cuarto semestre, moviéndose al tercer semestre. La modificación podría parecer poco significativa, sin embargo implica una menor madurez del estudiante.

Al inicio del semestre se seleccionan los grupos de trabajo, conformados por cuatro estudiantes, que serán permanentes tanto en aula como fuera de ella. Igualmente se les informa la metodología de trabajo y la manera en que serán evaluados. El curso se trabaja desde el primer día en base al trabajo en grupos. Trabajar en equipo y con situaciones ABP, lo más cercanas posible a la realidad, implica por si misma objetivos específicos, entre ellos un mayor interés hacia los temas a estudiar, aprender a valorar el trabajo en conjunto y fomentar una codependencia positiva, así como mejorar habilidades sociales.

Para cubrir los contenidos del curso, en las sesiones de clase se realizan actividades secuenciales diseñadas con anticipación, con diversos objetivos de aprendizaje: tanto conocimientos, como habilidades y actitudes, todas trabajadas en equipo. Esta afirmación corresponde a una cuidadosa elaboración de criterios para evaluar las competencias previstas. A modo de ejemplo se muestra el objetivo general del tercer capitulo, parte de las competencias que se planifica alcanzar y algunos de los criterios a utilizar:

Capítulo III: El estado de equilibrio en los procesos químicos

Tiempo: 4 semanas

Objetivo: Reconocer como la ciencia provee los medios para el desarrollo de productos mejores y menos dañinos en base al conocimiento de los factores que hacen posible viabilizar, mejorar y controlar la obtención de los productos deseados en determinado proceso, haciendo uso del conocimiento de algunas sustancias importantes, incluidos ácidos, bases, su neutralización y la influencia del pH.

Tabla 7: Competencias

Contenidos conceptuales	Habilidades-procedimientos	Actitudes
Concepto y características del equilibrio químico. Cambios en las condiciones de equilibrio. Principio de Le Chatelier. Cociente de reacción y constantes de equilibrio. Uso cuantitativo de la ley de equilibrio y control industrial de reacciones químicas a partir del equilibrio.	Comprende el concepto y lo relaciona con sus vivencias y las reacciones químicas. Calcula las constantes y comprende e interpreta su uso y aplicación. Emite hipótesis y analiza situaciones que puedan alterar el equilibrio. Utiliza el desplazamiento del equilibrio y la estequiometría para resolver problemas cualitativos.	Mejora sus habilidades de comunicación. Escucha, respeta opiniones, acepta sugerencias, facilita la resolución de conflictos dentro del grupo. Propone alternativas y toma decisiones, incrementando su pensamiento crítico e imaginativo.

Criterio: Emite hipótesis y analiza situaciones que puedan alterar el equilibrio.

Indicadores:

- Relaciona e interpreta correctamente los valores de constantes con el grado de disociación para resolver problemas cualitativos y cuantitativos sencillos.
- Evalúa adecuadamente las condiciones para favorecer o desfavorecer un proceso químico y lo relaciona con su rendimiento económico.
- Aplica conceptos y principios de equilibrio para tomar decisiones en cuanto a eliminar o disminuir la formación de sustancias contaminantes.

Criterio: Mejora sus habilidades sociales y de comunicación.

Indicadores:

- Participa e intercambia opiniones con sus compañeros
- Interacciona con profesores y los asistentes.
- Muestra mayor disposición para realizar preguntas y expresa sus ideas en forma verbal y escrita.

Adicionalmente, se desarrollan prácticas de laboratorio, orientadas a solucionar la deficiencia en la comprensión de conceptos propios de la ciencia y su aplicación. Se mantiene siempre el mismo grupo de trabajo.

Durante el semestre, y dividido en base a las prácticas calificadas que se programan oficialmente, se trabaja un proyecto que involucra los contenidos del curso, cubriendo en cada etapa los temas tratados. El proyecto es por lo general un caso de alguna industria que debe resolver algún tipo de problema: ambiental, de producción, de procesos, de organización, etc. Se procura abarcar las unidades programadas: termodinámica, velocidad de reacción, equilibrio químico y electroquímica, teniendo como eje transversal la educación ambiental. La nota grupal de cada etapa del proyecto forma parte de la calificación de cada práctica programada en el calendario académico; sin embargo, la evaluación del proyecto es individual – colectiva, puesto que cada integrante deberá ir mostrando en un portafolio particular su contribución y ser “calificado” por sus iguales (coevaluación) y por los docentes (heteroevaluación). Esto se realiza con la finalidad de obtener una única nota grupal y asegurar una contribución equitativa. El desarrollo del proyecto se realiza en parte dentro del aula y por lo general se culmina fuera de ella.

Dentro del aula, se realizan las actividades que también están diseñadas para ser trabajadas en pareja y en grupo. Los fundamentos teóricos, necesarios para la solución de las actividades, se adquieren primordialmente de dos formas: lecturas individuales previas y mini exposiciones, ya sea entre pares o por parte del docente. La comprensión y aplicación de los fundamentos se realiza a través de preguntas de análisis y solución de problemas.

Puesto que, tanto el docente como los asistentes de docencia (dos personas de apoyo, adecuadamente entrenadas). se encuentran permanentemente monitoreando el avance de los alumnos, la interacción personal y la observación constituyen una herramienta de evaluación adicional especialmente valiosa.

La idea central, tanto de las actividades como del proyecto, es recordar que para el caso de Ingeniería, en cualquiera de sus formas, el conocimiento científico no es el fin, sino es el medio para aplicarlo. por lo que resulta importante alinear la teoría y la practica, de tal manera que se interpreten los fenómenos para poder utilizarlos en la solución de problemas. Finalmente, el alumno deberá ser capaz de aplicar las habilidades aprendidas a diferentes situaciones reales usando su propio estilo.

4.1 Enseñar: ayudar a aprender

En la sociedad cambiante en que vivimos, se hace necesario propiciar en las aulas tiempo para reflexionar, analizar, sintetizar, es decir, tiempo para desarrollar trabajo intelectual y construir conceptos a los que se les encuentre significado. Estos objetivos buscan hacer más eficiente la tarea docente, lo que obliga a incluir metodologías activas, donde el estudiante asume un rol comprometido y se hace responsable de su propio aprendizaje.

Tanto la enseñanza como el aprendizaje son tareas complejas. No existe un único modo de aprender; por lo tanto, tampoco un modo de enseñanza que podamos definir como el mejor. Sin embargo, las condiciones en que se desarrolle el proceso enseñanza-aprendizaje es uno de los factores relevantes al decidir cuáles metodologías de enseñanza implementar. Sí lo que se quiere es que aprendan cosas muy diversas y al mismo tiempo prepararlos para seguir aprendiendo una vez hayan pasado nuestro curso, entonces, tendrá que haber una serie de actividades tales como: explicaciones, discusiones, investigaciones, resolución de problemas, etc. En conclusión: es importante la forma en que se presentan los estímulos. Cuanto más involucrado se encuentre un estudiante, mayor será su interés por responder y en consecuencia la forma en que asuma la búsqueda de "su" verdad.

Debido a la fuerte interdependencia entre la respuesta (aprendizaje) y el estímulo que la provoca (la enseñanza), será importante poner atención a las condiciones en que se desarrolle el proceso.

Puesto que se trata de dotar al estudiante de conocimientos, modos y formas que le permitan interpretar y transformar la realidad, lo que quiere decir que, deberán aprender a localizar información, organizarla, procesarla y aplicarla creativamente. En ese sentido, se apuesta por la enseñanza activa. Esta decisión se basa en que esta metodología tiene comprobados resultados según las investigaciones. Como sabemos, este tipo de metodología se apoya primordialmente en la cooperación y el trabajo de grupo.

¿Por qué trabajo cooperativo? Porque al hacerlo se trabajan habilidades y actitudes que son difíciles de conseguir al trabajar de manera "convencional". Existen numerosas investigaciones, sobre todo en el trabajo de casos y el uso del ABP, que han mostrado que se obtienen beneficios adicionales con este tipo de enseñanza. Así tenemos: " El aprendizaje cooperativo promueve un mejor aprendizaje y una mayor retención en las habilidades verbales, matemáticas y físicas" , "Los estudiantes disfrutan más las experiencias, poseen mejores actitudes hacia los temas, desarrollan habilidades sociales mejores, poseen mejor capacidad de expresión y son más tolerantes a los puntos de vista diferentes que aquellos bajo el estilo tradicional de charlas. "los estudiantes enseñados con casos aprendieron nuevas formas de pensar sobre un tema", "los estudiantes admiten que tienen más probabilidades de hacer estudios independientes fuera del salón de clase con el fin de mejorar su comprensión del material" , " los estudiantes demostraron, de una forma u otra, que ellos aprendieron más en las clases que usaron casos de estudio" (Herreid, C. F.)(1)

En mi caso, el análisis de los resultados de las encuestas de opinión realizadas a los alumnos durante los últimos años (desde 2006), la observación reiterativa del cambio en la actitud, tanto en clase como fuera de ella, respecto al trabajo que se le les pide realizar y los comentarios verbales de los alumnos, una vez aprobado el curso, confirman año a año, la valoración positiva hacia este tipo de metodología, coincidiendo efectivamente con lo que expresado en el párrafo anterior.

Es importante tener presente que la metodología de aula es clave para un real aprendizaje cooperativo, no se trata de realizar actividades grupales con el único objetivo de realizar una tarea. La estructura deberá contemplar la necesidad de realizarse en equipo, debe propiciar la interacción entre los componentes, el reconocimiento mutuo y una participación igualitaria en lugar de competitiva. En cuanto al trabajo grupal es un hecho que ayuda a desarrollar el conocimiento de sí mismo y reconocer otras formas de pensamiento, contrastar opiniones, así como tomar decisiones que favorecen al grupo. Esto lleva implícito motivarlo y despertar su interés por la búsqueda de explicaciones.

4.2 Enseñar: realidad compleja

En el caso particular de la Química, persiste la idea de que es un curso "duro", sin embargo, al menos en el caso de la Universidad, se considera una de las ciencias básicas importantes, junto a física y matemáticas, por lo que el alumno por lo general ingresa al curso con la convicción que es un curso necesario. Sin embargo, el que ellos sepan que es un curso que necesitan para su futura profesión, no ayuda a que lo aborden con entusiasmo, sino al contrario; llegan a él con bastante desánimo. La realidad es que los alumnos traen una concepción desde secundaria de lo que es la química, y de su experiencia previa.

A pesar de los esfuerzos por proponer nuevos proyectos curriculares, poco se ha avanzado, y es un hecho que los resultados obtenidos en el proyecto *Conceptual Structure of School Chemestry (CSSC),* que se inicio en la Universidad de Utrecht en Holanda, cuyo objetivo fue conocer si había una estructura común en la enseñanza de la Química en los diferentes países y que fue publicado en el año 2000, siguen siendo igual de validos hoy.

Para Chamizo, J.A (2) integrante del Foro Internacional a raíz del proyecto CSSC, es de suma importancia dar a conocer las sustanciales carencias del curriculum actual, donde ….. la principal conclusión obtenida del Foro Internacional y que se debe entender como un diagnóstico, fue: " …La educación química normal está aislada del sentido común, de la vida cotidiana, de la sociedad, de la historia y filosofía de la ciencia , de la tecnología, de la física escolar y de la investigación química actual" ….. La ciencia en general y la química en particular se centra en el objetivo de transmitir la mayor cantidad de conocimientos científicos, por lo que ¡hay que cubrir los programas! ¿Para qué? ¿Quién sabe? Poco se ha hecho y discutido sobre otros objetivos……"

Pienso que la situación sigue siendo la misma, la mayor parte de profesores de química, la enseña, con la idea de que es un curso que los estudiantes deben aprobar; de manera que simplemente se dicta como un conjunto de ejercicios que deben resolver, aunque no comprendan lo que hacen, por qué lo hacen, ni lo que significa realmente. En otros casos, la presión de la institución porque esos cursos “duros” no sean la razón de la deserción estudiantil, se enseña de manera tan superficial que el estudiante termina el curso con la sensación de que verdaderamente no sirve para nada. Otra situación común es que algunos profesores opinan que los alumnos tienen una capacidad limitada para entender “ciertas cosas”, por lo que evitan el análisis y propician simplemente seguir la receta. En concordancia con Chamizo, lo primero que hay que hacer es definir claramente las metas, objetivos y logros, para a partir de allí decidir contenidos, modos y formas de lograrlo. Esto, por supuesto determina también la forma de evaluarlos.

Es claro que los alumnos ya cuentan con un conocimiento científico “alternativo”. Muchos años de investigación han mostrado que el estudiante trae una enorme variedad de conocimientos alternativos, ellos tienen ideas sobre su mundo, explicaciones sobre cómo y porqué las cosas se comportan de determinada forma, etc. En consecuencia es importante tomar en cuenta su presencia al momento de diseñar situaciones de aprendizaje.

Por lo general los alumnos no son entrenados, ni evaluados en la comprensión de la ciencia o en su capacidad para interpretar y razonar sobre conocimiento científico. Personalmente, opino que la ciencia es una poderosa manera de entender el mundo, pero no es la única, se encuentra ligada a factores sociales y filosóficos, así que es necesario no olvidarlo y tomarlo en cuenta al momento de realizar el diseño.

El propósito deberá ser mantener un equilibrio entre la enseñanza de conocimientos, habilidades y actitudes, es decir que tanto la enseñanza de habilidades como de actitudes sean parte de la didáctica del profesor. En consecuencia, hablamos también de los modos y formas del docente. Se trata de desarrollar competencias tales como la comunicación oral y escrita, el desarrollo de trabajo en equipo, habilidad para aprender por cuenta propia (aprender a aprender), así como actitudes positivas hacia el trabajo, el estudio y la vida con congruencia en pensamiento y acción.

Nuestra misión primordial debe ser captar la atención del alumno:

- Acercar el aprendizaje a sus intereses en su propio contexto y cultura. Conviene recordar que la imagen de sí mismo se construye en base a las experiencias vividas de toda índole y que no se interrumpe a lo largo de la vida.
- Mantener el interés durante el curso completo: provocar la expresión de emociones, diversas modalidades de relación y cooperación. Por lo general son fruto de las expectativas y apoyos sociales.
- Despertar su interés para el futuro: potenciar actitudes y capacidad de expresión tanto de pensamiento como de forma de aprender.

En la medida que logremos esos objetivos tendremos un alumno motivado, lo que se traduce en ganas de aprender.

5 Trabajo en equipo y motivación

Vygotsky, en su concepto de *Zona de desarrollo próximo,* habla de la diferencia entre el nivel de aprendizaje que una persona puede alcanzar sola, y el nivel que podría alcanzar con la ayuda de otras personas y los instrumentos adecuados. El rol del docente como profesional que ayuda al estudiante, así como el de su grupo de compañeros, es valioso en el proceso de enseñanza – aprendizaje.

Como ya se mencionó, al iniciar el semestre los estudiantes forman grupos de cuatro personas. Es importante enfatizar que el trabajo en grupo no siempre resulta en un aprendizaje cooperativo, de hecho la cooperación contempla condiciones especiales y resulta ser más bien un proceso paulatino que no llegan a alcanzar todos los grupos.

El primer día de clase se forman los grupos y se presenta el proyecto a nivel macro, el cual resolverán durante el semestre y se instruye a los alumnos en cuanto a las reglas que deberán seguir. Encontrarán toda la información que requieran para las clases, laboratorios y proyecto en la Intranet de la Universidad, siendo su obligación imprimirla o leerla según sea el caso.

- Actividades en aula: Se realizan durante las sesiones programadas de clase. Por lo general son evaluadas. Se trabajan tanto conceptos como principios y aplicaciones, un promedio de cuatro actividades por cada práctica oficial, que forman parte de la calificación. Con esa premisa, puesto que cada actividad tiene un tiempo programado y dado su interés por la nota, buena parte de los alumnos trabaja de manera individual y pretende realizar todo solo, a pesar de que se les instruye sobre la importancia de colaborar y compartir entre ellos. Las primeras sesiones resultan por lo tanto muy tensas para ambas partes, para los docentes que al monitorear observan y van exhortando a cambiar la actitud y para el estudiante cuya preocupación inicial es simplemente terminar y obtener el puntaje. En las primeras semanas los estudiantes se quejan principalmente de falta de tiempo, de la dificultad de la actividad, de que el profesor no explica lo suficiente, etc. En mi caso, la protesta es directa ya sea en clase o bien acercándose a la oficina a conversar. En todos los casos se les escucha y responde de manera cordial, se les recuerda que depende de ellos, que cualquier duda que tengan cuentan con nuestro apoyo y que si comparten la responsabilidad les resultará menos agobiante. En general, según se continúan las sesiones se observa que la comunicación en el grupo es más fluida, que a pesar de procurar terminar ya no están tan pendientes del tiempo, que se apoyan mutuamente si alguno queda rezagado, que preguntan con más facilidad y que las preguntas van adquiriendo más consistencia. Ya no son del tipo: "no entiendo, ¿qué me pide?" Muestran una actitud más favorable, lo que se refleja en su asistencia regular, tanto a clases como a orientación y consultas fuera del aula. Se aprecia que asisten con agrado, se establece una relación amical de manera que no temen dar su opinión o su visión acerca de una situación en especial.

- El proyecto: Se realiza por etapas. Cada etapa abarca los temas tratados en clase durante el periodo previo. Los estudiantes encuentran en la Intranet los criterios con los que serán evaluados en la calificación del avance, los puntajes y las fechas respectivas. La primera etapa debe resolverse aproximadamente para la tercera semana. Casi siempre ocurre que para esa etapa los estudiantes se dividen el trabajo en cuatro partes de modo que cada uno resuelve su parte. Con suerte se reúnen al final, para darle los últimos toques y establecer el mismo formato. Suelen realizar las investigaciones y solución del problema planteado los días previos a la entrega, de manera apresurada. El resultado, con contadas excepciones, suele ser de baja calidad y sin coherencia. Otro factor es que muchas veces hacen caso omiso de los criterios de evaluación. Para las siguientes etapas suele ocurrir, después de recibir su evaluación con las anotaciones y sugerencias pertinentes, del mismo modo que se aprecia en las sesiones presenciales, que se reúnen y trabajan en equipo. La calidad de los trabajos, presentaciones, debates, dramatizaciones o lo que se les pida va mejorando, de la misma manera que distribuyen o manejan mejor el tiempo que le dedican.
- La enseñanza experimental: su objetivo es adquirir o reforzar conocimientos, habilidades y actitudes, razón por la cual no se limitan al laboratorio, los dos últimos semestres se vienen realizando mini-experiencias muy sencillas, que se incluyen en las actividades de aula. Este tipo de trabajo experimental refuerza la comunicación, el vínculo afectivo y la capacidad de liderazgo entre los integrantes del grupo.
- Los formatos de auto y coevaluación: se aplican cada vez que se culmina una etapa del proyecto (coincide con la práctica calificada correspondiente). Cada alumno llena una lista de criterios donde autoanaliza su desempeño y aporte dentro del grupo, haciendo lo mismo con sus compañeros. El formato se encuentra en la Intranet y cuenta con un espacio donde pueden hacer sugerencias y/o comentarios. Lo envían vía correo electrónico de manera personal, de modo que se sienten en libertad de expresar opiniones y discrepancias. Estos formatos ofrecen información adicional para juzgar el funcionamiento de un grupo. Es aquí donde algunos alumnos muestran su adaptación o no al trabajo en equipo.

En resumen, ¿Por qué un verdadero trabajo en equipo ayuda a mantener motivado al estudiante?

Para que un equipo trabaje de manera competente es necesario que sus integrantes estén convencidos que obtendrán mejores resultados que haciéndolo de manera individual. El primer paso es definir un objetivo común, lo que les permite definir como actuaran al respecto, elaborar planes e intenciones y orientar sus esfuerzos. Llegar a la convicción de que se pueden lograr los objetivos. Se hace posible porque la imagen de sí mismos va transformándose, todo ello tiene mucho que ver con los procesos psicológicos que se desatan al alcanzar las metas, se fortalece la imagen propia y eso le da impulso a un nuevo esfuerzo, manteniendo así la motivación (Levoyer,C.L.)[3]. El verdadero trabajo en equipo es un gran incentivo para el aprendizaje cuando las relaciones interpersonales son cordiales y el trabajo se reparte y realiza equitativamente, entonces, la persona desea participar y se siente apoyada, pero, también es cierto que puede desmotivar si alguno de los integrantes no participa con el mismo empeño.

La actitud del profesor debe acompañar y promover el aprendizaje de sus alumnos, mostrar interés sincero por sus trabajos, fomentar la responsabilidad, mostrar seguridad y convicción en lo que se hace, confiar en la competencia de los aprendices, cuidar el impacto de éxitos y fracasos hasta persuadirlos de que son capaces de llegar a buenos resultados.

Las actitudes son por lo general estados perdurables una vez formadas, determinan modos de conducta que pueden ser de aceptación o rechazo. De modo que la relación entre las actitudes de profesores y estudiantes explica en parte el éxito o fracaso de determinado curso. El incremento de la motivación viene acompañado de una mayor participación.

La retroalimentación debe ser un propósito que forme parte de la tarea docente, debe hacerse de manera regular y continua y es responsabilidad del docente que se lleve a cabo.

5.1 Evaluando: análisis de encuestas

Al final de cada semestre se aplica una encuesta anónima donde se investiga acerca de la percepción de la metodología empleada, sobre los factores que más influyen en el aprendizaje y sobre los beneficios que obtienen con este tipo de enseñanza – aprendizaje. Los resultados más relevantes a través de los años se mantienen en promedio:

- Alrededor del 70% considera que con la metodología activa – ABP se logra un mayor aprendizaje.
- Los dos aspectos que consideran de mayor beneficio son la tutoría directa y el trabajo en equipo, en un porcentaje de 75% y 78% respectivamente.

Los dos últimos semestres se ha incorporado a la encuesta dos preguntas, una donde se indaga sobre por qué consideran al trabajo en equipo como uno de los factores más relevantes para su aprendizaje y la otra sobre el impacto de las mini- experiencias que se han incorporado y realizado en el aula. En relación a la incorporación de una parte experimental, casi el 90% considera que los ayuda en la comprensión del concepto o principio involucrado.

En cuanto al trabajo en equipo se hace referencia a una serie de factores que los alumnos calificaron en una escala de 1 (en desacuerdo) a 5 (totalmente de acuerdo)

- El 65% considera que el trabajo en grupo ayudo a mejorar su actitud hacia el aprendizaje, mientras 18% piensan que no influyo y 17% que no mejoraron su actitud.
- 58% están de acuerdo con que disfrutan más la experiencia de enseñanza- aprendizaje al trabajar en grupo, para el 25% no influye y el 17% no disfrutaron trabajar en grupo.
- En cuanto a que compartir la responsabilidad de la nota los ayudo a ser más responsables individualmente, 82% estuvieron de acuerdo, para el 10,7% no influyo y 7,3% no están de acuerdo en que los ayudó a ser más responsables.
- Para el 39% compartir la responsabilidad de las notas fue causa de stress, al 32% no los afecto y el 29% opina que es una causa de stress.
- 76% considera que mejoró su actitud para escuchar y expresar opiniones y el 24% restante piensa que no cambiaron su actitud.
- Al trabajar en grupo, se hicieron más tolerantes ante puntos de vista diferentes a los suyos el 64,3% mientras 35,7% piensan que no los afecto.
- 60,8% opinan que el apoyo grupal los ayudo a soportar mejor los resultados de la evaluación, 21% no sintieron influencia y al 7,2% no los ayudo.
- Finalmente 7,2% consideran que se perjudico su desempeño al trabajar en grupo, 25% que no afecta y 67,8% dicen que no los perjudico

Al final de la encuesta hay un espacio donde se pide que hagan comentarios relevantes, ya sea sobre la metodología, los asistentes o el trabajo grupal, a continuación transcribo alguna de las opiniones referentes al último:

- “Trabajar con otras personas y puesto que la nota depende de ello, implica aprender a comunicarse de manera más eficiente, te das cuenta que hay otras maneras de enfocar y enfrentar un problema, aprendes a ver otros puntos de vista”.
- “Es bueno porque te obliga a comunicar tus ideas a otros”
- “Cuando trabajas con otros de manera constante, sientes que son un apoyo adicional para aprender el curso, ya que de tu buena relación con los compañeros depende parte de tu propia nota. Es importante que todos sean responsables para que el grupo funcione ok”
- “Trabajar en grupo es bueno cuando tus compañeros aportan, te alienta y animan, pero representa un problema cuando no se cumple y uno debe hacer casi todo el trabajo.
- “Es más fácil cuando cuentas con el apoyo de tus amigos”
- “Ayudo mucho la discusión de temas y la autoevaluación dentro del grupo. Reconocer cuál es la función de cada uno dentro y frente a las habilidades que ayudaban a que el grupo funcione mejor”
- “Es ideal trabajar en grupo y aprender con los demás”

6 Conclusiones

El trabajo en equipo debe cumplir una serie de requisitos para que resulte verdaderamente valioso. Aporta en la adquisición de competencias y puede resultar ser un elemento de motivación importante. En el trabajo en equipo todos deben avanzar al mismo nivel y para esto se tienen que tener los objetivos claros. Si embargo el trabajo en equipo, involucra la responsabilidad de cada uno de los integrantes, y cuando no sucede así causa insatisfacciones.

Cuando se trabaja en grupos, el aula de clases resulta un lugar bullicioso. Es importante contar con el respaldo de la institución. La universidad de Piura apoya el uso de diversos entornos de aprendizaje, incluidas las actividades fuera del aula.

Como se ha mencionado en las sesiones de clase también se trabajan las actividades en grupo. Al tener un único horario y trabajar por lo general con un promedio de 30 a 40 alumnos, muchas veces los estudiantes ya se conocen de cursos anteriores, incluso en muchos casos llevan otras asignaturas juntos y a veces pueden haber realizado algún trabajo juntos, aún así, adaptarse a trabajar en equipo es un proceso que requiere tiempo, se debe llegar a confiar en los miembros, lo que significa responsabilidad mutua. Inician con mucha tensión y trabajando individualmente, poco a poco lo hacen en parejas (inicialmente con el compañero por quien sientan más afinidad), para luego empezar a compartir información y ayudarse unos a otros. En cuanto al proyecto, cuya mayor parte se trabaja fuera del aula, pueden repartirse el trabajo, pero aprenden a reunirse para comentar, discutir y analizar lo hecho, llegando a un acuerdo general.

La motivación es fundamental para el aprendizaje y se relaciona directamente con las metas e intereses personales del individuo. Lograr que descubran la relevancia del curso es importante, pero lo es más que se sientan a gusto en el entorno de aprendizaje, creando una atmosfera positiva y estimulante, donde el trabajo de grupo juega un papel fundamental al permitirle sentir que sus esfuerzos valen la pena y que tiene más control sobre los desafíos, ya que tanto en los triunfos como en los fracasos se cuenta con el apoyo de los demás. Cabe resaltar que el apoyo por parte del docente y de los asistentes de docencia es permanente, siempre hay quien está disponible para consultas y resolución de dudas. De todas maneras, también sucede que algunos miembros de grupo nunca se acercan. El hecho es que el trabajo en equipo brinda una fortaleza y seguridad adicional a cada miembro, lo que hace que se motiven unos a otros. Esta metodología los mantiene alertas y finalmente se involucran.

Es necesario recordar que los cursos de Química General se ubicaban, hasta hace un año, en el tercer y cuarto semestre y que con el cambio en la currícula, Química General 1 (QG1) se imparte en el primer semestre, mientras Química General 2 (QG2) en el tercero, por lo que en los últimos semestres los alumnos de QG2 no han seguido el curso previo con la misma metodología. Hasta el año 2009, los alumnos de QG1 eran entrenados paulatinamente en este tipo de trabajo: Iniciando con trabajo en parejas en el aula y con mini casos con algunas unidades de aprendizaje, hasta concluir con un trabajo final grupal. En la actualidad los estudiantes ingresan a QG2 sin experiencia previa. Adicionalmente, los cursos ahora, no son consecutivos y se matriculan un semestre antes, lo que explica la observación de que les es más difícil adaptarse al trabajo en equipo.

Por ser la Universidad de Piura una sede reciente (sexto año en Lima) los horarios de ambos cursos son únicos, lo que hace imposible contrastar resultados entre diferentes horarios y/o metodologías para un mismo ciclo de estudios. Se trata de valoraciones cualitativas en diferentes semestres y reflexiones en referencia a los cambios de actitud que se observan en los alumnos y que muestran su interés creciente.

Otro factor clave es, que cualquiera que sea la metodología que se emplee, la comunicación docente-alumno deberá ser cordial, entendiendo por cordial, que hay suficiente confianza como para que el alumno se sienta en la libertad de preguntar las veces que sean necesarias y buscar en el docente la ayuda que requiera. Que el estudiante se sienta escuchado y valorado lo anima a comunicarse con su grupo e ir forjando relaciones que a la larga ayudan a motivarlo a aprender.

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Proyecto Ecológico y entornos virtuales web 2.

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Abstract

The main objective to develop ecological project as:" Production of clean energy and green manure from pig feces, using virtual environments as WEB 2.0 "is: Have a better water management, as a result of implementing the measures and technologies about water reuse. Beginning with this we can generate a greater environmental awareness and a culture of eco-efficiency, because we believe in this problem as a global problem that affects the entire planet and the solution is a challenge for the XXI century education. In our community "Aucallama" we have a problem with the soil contamination, soil and air by the dumping of pig manure from farms to waterways for irrigation. Therefore our learning community are interesting in this problem which is considered as a possibility and opportunity to generate goods and services. The focus in the authentic problem-based learning provides for us, an excellent way for a breadth of knowledge, and it is in consistent with the project that we have developed with teachers, students and district authorities about autonomy, leadership, learning and teaching in this digital age we need enterprising students who apply and develop innovation projects "friendly and sustainable with the environment and life.

1 Introducción

El distrito de Aucallama, afronta el problema de la contaminación del agua de riego por el arrojo de los excrementos de los cerdos. Los pobladores de esta zona han hecho llegar su disconformidad a la municipalidad, gobernación y hospital porque ocasiona un olor fuerte y desagradable, contamina el agua de riego, contamina el suelo. Los productos tales como: Verduras, frutas de tallo corto son altamente contaminados las cuales afectan la salud del consumidor, también dicha agua se filtra al subsuelo contaminando el agua de pozo que los pobladores utilizan para consumo. Los estudiantes del cuarto año de secundaria preocupados por este problema se pusieron a investigar sobre alternativas de solución.

Los estudiantes de hoy son capaces de auto aprender, generar, intercambiar y auto gestionar su conocimiento a través de proyectos y entornos virtuales de: web 2.0 (blog, pbworks, groups, Twitter, Facebook, skype y second life).

Por lo tanto consideramos importante el Aprendizaje Basado en Proyectos porque es un modelo de aprendizaje en el que los estudiantes planean, implementan y evalúan proyectos que tienen aplicación en el mundo real más allá del aula de clase (Blank, 1997; Dickinson|, et al, 1998; Harwell, 1997).

Para el desarrollo del proyecto ecológico se integró diversas áreas curriculares como: Comunicación, Matemática, Arte, Ciencia y Ambiente porque nos permiten considerar los estilos de aprendizaje, antecedentes étnicos y culturales, impulsa la innovación, asegura la soberanía, facilita la inclusión digital en un país puricultural.

El proyecto fué relevante en la vida de los estudiantes, porque aprendieron los conocimientos de cada área e integrarlos para contribuir con propuestas de solución de "Producción de energía limpia y abono ecológico a partir del excremento de cerdo" utilizando un biodigestor con materiales reciclados. El cual se expuso en un debate tipo asamblea con la participación del juez de paz, gobernador y director de la institución educativa. Y en los docentes el trabajo en equipo es muy importante, porque aumenta los sentimientos de autoeficacia y capacidad de innovar.

2 Planteamiento del problema

El distrito de Aucallama, afronta el problema de la contaminación porque las granjas votan los excrementos de cerdos a los canales de riego y los pobladores de este lugar están preocupados por su salud. Los estudiantes, hijos de agricultores, están interesados en resolver dicho problema planteándose diversas preguntas: ¿Cómo evitar el olor desagradable que ocasionan los excrementos de cerdos que votan las granjas? ¿Por qué debemos cuidar el agua de riego? ¿Cómo la estadística nos ayuda a comprender mejor las consecuencias de la contaminación del agua de riego? ¿Cómo los medios de comunicación influyen en la sensibilización del cuidado de las aguas de riego? ¿Cómo el lenguaje audio visual nos ayuda a comprender los efectos que produce la contaminación del agua de riego en nuestra salud? ¿Qué enfermedades son transmitidas por alimentos contaminados con excrementos de cerdos?

3 Propósito

El propósito fundamental de este proyecto es integrar diferentes áreas curriculares para que los estudiantes desarrollen diversas capacidades que les permiten solucionar problemas de su comunidad.

3.1 Ciencia tecnología y ambiente - conocimiento

- Enfermedades transmitidas por alimentos contaminados con agua de riego.
- Contaminación del agua, Procesos de análisis de agua, fuentes.
- Contaminantes del agua de riego, métodos de prevención.
- Diseñar experimentos para purificar el agua de riego.
- Factores que determinan el crecimiento de los microorganismos.
- Hábitos y sistema de vigilancia de medidas de higiene en la escuela y la comunidad
- Vigilancia ambiental de agua de riego, desechos sólidos.
- Proyectos de tratamiento del agua de riego contaminado, para la promoción de la salud local y regional.

3.1.1 Capadidades a desarrollar

- Realiza mediciones de temperatura, PH, con instrumentos adecuados a las características y magnitudes de la contaminación de agua de riego.
- Registra las observaciones y resultados utilizando esquemas, gráficos y tablas.
- Investiga la utilidad de los microorganismos.
- Realiza cálculos cuantitativos en los fenómenos químicos.
- Elabora conclusiones de los experimentos que realiza.
- Investiga el equilibrio ecológico y sus implicancias en la naturaleza.

3.2 Matemática

- Variables discretas y variables continuas.
- Histograma de frecuencias absolutas.
- Asimetría de las medidas de tendencia central.
- Medidas de dispersión: varianza, desviaciones media y estándar.
- Espacio muestral.
- Sucesos. Frecuencia de un suceso.
- Frecuencia relativa y frecuencia absoluta.
- Operaciones con sucesos.
- Probabilidad en diagramas de árbol.

3.2.1 Capacidades a desarrollar

- Elabora histogramas de frecuencias absolutas sobre la contaminación.
- Grafica e interpreta operaciones con frecuencia de sucesos de contaminación.
- Resuelve problemas que involucran el cálculo de medidas de tendencia central, dispersión.

3.3 Comunicación

- Forum y debates.
- Radiograma.
- Periódicos murales, boletines, trípticos y función comunicativa.
- Reportajes y columnas. Características. La imagen (fijas y en movimiento).
- Función comunicativa. La entrevista. Características y estructura.
- La charla radial. Características. •La publicidad radial. Características.
- Páginas web , web blog y biblioteca virtual. Utilidad.

3.3.1 Capacidades a desarrollar

- Elabora reportajes, columnas y otros textos periodísticos, incorporando imágenes, gráficos, infografías y utilizando fuentes provenientes de Internet la información y preparando recursos de apoyo a su intervención.
- Debate sobre temas de contaminación, opinando sobre ellos con oportunidad y pertinencia, demostrando serenidad y consistencia en la argumentación.
- Informa sobre sucesos o tareas realizadas, presentando los hechos de la contaminación en forma organizada y clara, sin contradicciones o redundancias innecesarias.
- Relata charlas radiales y realiza entrevistas, manteniendo la coherencia y la naturalidad en el discurso; y utilizando inflexiones de voz apropiadas.

3.4 Arte

- Producción teatral.

3.4.1 Capacidades a desarrollar

- Identifica las características de una producción teatral.
- Analiza e interpreta el drama creativo y construye su propio personaje.

4 Metodología

Inicialmente se explica a los padres de familia, estudiantes y directivos de la Institución Educativa sobre la metodología a emplear "Aprendizaje basado en proyectos integrando las TIC"

El proyecto se inicia mediante una evaluación diagnostica sobre el problema de la contaminación del agua de riego utilizando organizadores visuales, lluvia de ideas para recopilar información sobre sus saberes previos.

En grupo de 5 los estudiantes elaboran preguntas sobre el problema a investigar y en función a ello se diversifica los conocimientos del DCN (diseño curricular nacional), para integrar las áreas curriculares tales como: matemática, comunicación. Ciencia y ambiente, arte. Los estudiantes se agrupan voluntariamente en grupo de 4, considerando lo siguiente: que en cada grupo cada estudiante debe desempeñar un papel de acuerdo a sus intereses: habrá un comunicador, un ecologista, un diseñador de web blog , wiki o página web , un matemático y un coordinador.

Trabajo en equipo. Cada grupo elaborará un informe de investigación que cumpla con los siguientes:

Redacción: Tipo y número de letra libre, extensión: 20 páginas como mínimo, incluye descripción de cada item, imágenes, cuadros, relacionadas con la investigación, podrás anexar gráficos descriptivos.

Estructura: Título del informe, introducción, descripción de los elementos y compuestos químicos que contaminan el suelo, subsuelo, aíre y agua, zonas de mayor contaminación, estudio de las enfermedades por la contaminación, medidas de prevención efectivas, propuestas de solución al problema de la contaminación, conclusiones de la investigación, fuentes de investigación: textos, libros de consulta, web.

Durante el desarrollo del proyecto se realizó visitas de campo para realizar: Entrevistas, recojo de muestras, análisis del resultado, conclusiones, utilizando una tabla de predicción.

La evaluación mediante una Lluvia de ideas al inicio del proyecto para generar un gran número de ideas para asegurar un compromiso con las actividades y responsabilidad con el desarrollo del proyecto. Los organizadores visuales se emplearan al inicio del proyecto para sensibilizar al estudiante sobre la problemática mediante fotografías tomadas por los estudiantes

Durante el desarrollo del proyecto se empleara la tabla de predicción, reuniones para planificar, desarrollar y realizar visitas de campo para recopilar información y procesarla, también se considera una rúbrica sobre la actitud del estudiante frente al área. Y luego evaluar mediante una matriz de valoración de datos recopilados.

Al final del proyecto se evaluará la presentación de producto de los estudiante mediante una matriz de valoración sobre: Campaña de sensibilización pública, autonomía y datos recopilados.

Los estudiantes realizaron una campaña de sensibilización sobre el cuidado del agua de riego por medio de un blog, wiki, googledoc, skyps. mensajeria instantánea y pagina web.

Los conocimientos de cada área se desarrolló de acuerdo al horario de clase teniendo un total de 15 horas semanales (comunicación 6 h., matemática 4h., CTA 3h., arte 2h.)

Las reuniones de coordinación de docentes que integran al proyecto fue los días viernes a las 2:00 p.m., para evaluar el desarrollo de capacidades de los estudiantes y poder enriquecer el proyecto.

En el proyecto participo un estudiante con limitaciones para escribir y caminar por efectos de la poliomielitis, el integró en uno de los grupos de estudiantes, para el desarrollo del proyecto considerando su habilidad comunicativa utilizando utilizando simpletalk mediante el cual desarrollara sus destrezas

Para este estudiante el docente preparara mapas, gráficos y línea de tiempo.

Relacionar los conocimientos nuevos con los aprendizajes previos mediante la tabla de saber – preguntar – aprender, discusiones y cuestionamientos. Para una mejor comprensión de los textos se ampliara la pantalla y se resaltara y se utilizara los diccionarios parlantes que leen palabras y definiciones.

Las tareas serán dosificadas.

Las evaluaciones que se emplearán serán de acuerdo a sus posibilidades

Por lo tanto utilizando la tecnología y autonomía en el aprendizaje tratará de ser independiente

Crear un ambiente agradable para una estudiante que habla quechua, en todo momento hacerles presente a los estudiantes que respeten su lengua materna de dicha estudiante.

Para tener una comunicación con dicha estudiante utilizaremos un diccionario quechua en el siguiente link: http://www.educar.org/diccionarios/DiccionarioQuechua/quechuaespanol/M.asp

Para los trabajos en equipo se prepara material en quechua.

Observar constantemente el lenguaje corporal y las expresiones faciales que puedan dar indicios de confusión o duda.

Cada grupo creara una blog, wiki, red social en el cual dará a conocer su informe de investigación para plantear un debate en línea.

Finalmente se realiza un debate con alternativa de solución al problema de parte de los estudiantes a las autoridades del distrito con la presentación de periódico mural, gigantografias, maqueta en la municipalidad del distrito con la presencia del juez de paz, gobernador, estudiantes, docentes, director de la I. E. y se presentó un memorial con los acuerdos tomados.

5 Resultados

Lograron elaborar un biodigestor casero del cual pudieron extraer biogás (energía limpia), compost y biol.

El biogás es un gas producto de la fermentación del excremento de cerdo y agua que realizan las bacterias en el biodigestor. El biogás está compuesto del 53 al 70% de Metano (similar al propano comercial), del 25 al 45% de Dióxido de Carbono y de Sulfato de Hidrógeno. Su poder calórico es de aproximadamente 5 400,00 Kcal/m3, que puede ser usado para alimentar generadores eléctricos, cocinas, estufas, etc.

El compost es el abono formado por la mezcla fermentada de excremento de cerdo y agua.

Biol es un abono orgánico líquido, resultado de la descomposición de los residuos de los animales y vegetales en ausencia del oxígeno, contiene nutrientes que son asimilados fácilmente por la tierra el cual permite incrementar el rendimiento agrícola porque ayuda a disminuir las plagas y enfermedades de las plantas.

6 Conclusión

El desarrollo de proyectos y entornos virtuales web 2 nos permite fomentar un papel más activo de los estudiantes el cual mejora notablemente el rendimiento académico. Es interesante ver a los estudiantes como se organizan, lideran, crean, toman decisiones, construyen su aprendizaje, trabajando en equipo, colaborando para poder presentar propuestas de solución a sus problemas que le afectan.

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La experiencia de la participación en el equipo UPM Racing para el desarrollo de la competencia de resolución de conflictos en equipos multidisciplinares

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Abstract

Promoting personal and professional skills is becoming an issue of interest and major concern in university environments and this, in turn, is being driven by the demands of business. The INSIA (University Institute for Automobile Research), belonging to the Technical University of Madrid, participates in the Formula SAE international university competition, consisting in designing, manufacturing and competing in formula-type vehicles by a multidisciplinary team.

The aim of this paper is the description of the evaluation methodology for the competency "ability to identify, formulate, and solve engineering problems on multi-disciplinary teams", applied to the Formula SAE activity. Competency indicators have been proposed, and they have been run on a pilot testing using a ten-student sample. The main purpose of this pilot testing has been to catch potential problems before they become mistakes. Finally, it has provided information on how difficult items will be to complete.

Keywords: engineering education, engineer competencies, multi-disciplinary team problems, Formula SAE.

1 Introducción

La acción educativa en los próximos años, deberá ir encaminada a lograr una adaptación al EEES (Espacio Europeo de Educación Superior) (REAL DECRETO 1393/2007, de 29 de octubre, 2007), así como lograr la mejora de los programas formativos y la incorporación de objetivos dirigidos al desarrollo de competencias profesionales.

La creciente importancia que el mercado laboral está otorgando a las habilidades profesionales o competencias, ha hecho reflexionar sobre estas cuestiones y otras, acerca de la identificación de esas competencias tan deseables en un ingeniero en el campo de la automoción. Asimismo ha ayudado a reflexionar sobre las distintas maneras de complementar y mejorar la formación que hoy en día se imparte en el ámbito universitario.

Existe una preocupación en el ámbito educativo por lograr una mejora en las acciones formativas, que nos permitan ir incorporando nuevos objetivos y diseñar nuevas situaciones de aprendizaje que supongan una oportunidad para el desarrollo de competencias. Con la excepción de algunas iniciativas, la formación universitaria se ha centrado principalmente en la potenciación de los conocimientos y determinadas habilidades técnicas, siguiendo el sistema tradicional de clases magistrales, no constituyendo un objetivo generalmente perseguido el potenciar las competencias de los alumnos.

Desde este punto de vista y dada la necesidad de incorporar cambios en la cultura educativa y más concretamente cambios en las metodologías de enseñanza, surge el proyecto de la Fórmula SAE. Este Proyecto, que a continuación se describe, es una de las acciones educativas encaminadas al logro de dichos objetivos, cuyo reto va más allá del desarrollo de una nueva e innovadora metodología educativa.

El Proyecto de la Fórmula SAE constituye una experiencia única en la formación de ingenieros, en línea con las futuras reformas universitarias derivadas del acuerdo de Bolonia.

2 El Proyecto Fórmula SAE

En el año 2003, un equipo de profesores de la ETS de Ingenieros Industriales de la Universidad Politécnica de Madrid, con adscripción al Instituto Universitario de Investigación del Automóvil, INSIA, conscientes de la necesidad de potenciar las competencias de los estudiantes de grado, creó el primer equipo español universitario de competición Fórmula SAE, denominado UPM Racing.

Uno de los objetivos que se persigue con dicho proyecto es complementar la formación de los estudiantes de ingeniería de automoción, así como contribuir al desarrollo de determinadas competencias necesarias para un sector competitivo y complejo como es el de la automoción.

El proyecto consiste en concebir, diseñar y fabricar un vehículo de competición bajo las normas de la SAE (Society of Automotive Engineers) con el objetivo final de participar en alguna de las competiciones internacionales que se llevan a cabo en diferentes partes del mundo (Inglaterra, Alemania, Italia, España) y a la que asisten las más prestigiosas universidades de todo el mundo.

Lo novedoso de este proyecto va más allá del desarrollo de una nueva metodología educativa e innovadora; es el reto que supone para los alumnos asumir y participar en todo el proceso de fabricación de un vehículo, junto con la investigación y diseño del mismo. El producto final no es sólo la obtención de un vehículo con las mejoras prestaciones posibles para lograr el objetivo de la competición, sino el crear un equipo de trabajo entre todos los participantes, fomentando la participación activa e implicación en la consecución de un objetivo común entre todos, y cuyo incentivo es la satisfacción de poder llevar el vehículo fabricado (con su propio esfuerzo, tiempo y trabajo) a la realidad de una competición.

El proyecto de la Fórmula SAE ayudará al alumno a poner en práctica todos aquellos conocimientos adquiridos en el aula, además de favorecer el desarrollo personal y profesional del alumno.

2.1 Objetivos generales

Uno de los objetivos que se persigue con dicho proyecto es complementar la formación de los estudiantes de ingeniería de automoción. Su innovador método de trabajo permite al alumno tomar parte en todo momento de la cadena de fabricación de un producto, ayudándoles a poner en práctica los conocimientos adquiridos durante la carrera y además favorecer el desarrollo de determinadas competencias claves e importantes para el sector en el que tendrán que trabajar en un futuro próximo.

2.2 Método de trabajo

El proyecto multidisciplinar está dirigido principalmente a estudiantes de los últimos cursos de Ingeniería Industrial de todas las especialidades. Asimismo acoge a otros estudiantes de otras escuelas como, E.T.S.I. Aeronáuticos, E.U.I.T. Aeronáuticos, E.T.S. Arquitectos de Madrid, E.T.S.I. Telecomunicaciones, E.T.S.I. Navales y alumnos del Máster en Ingeniería de Automoción.

El equipo UPM Racing lo forman anualmente un grupo de alrededor 40 alumnos y un comité de profesores de ETSII-UPM y del INSIA-UPM. En la actualidad cuenta con una experiencia de 8 años y lleva fabricados 8 monoplazas, que han participado en las siete últimas ediciones en Inglaterra y este último año en Alemania. Son ya más de 200 alumnos los que participan o han participado en el proyecto, siendo el primer equipo que representó a España en tan prestigiosa competición. La estructura de funcionamiento del equipo se muestra en la siguiente figura (Figura 1).

El método de trabajo se apoya principalmente en 4 pilares, que serán los ejes claves en todo el proceso de aprendizaje:

- Permitir a los alumnos participar en el ciclo de vida completo de un producto. Concebir, diseñar, construir, ensayar y poner a punto un vehículo tipo Fórmula con la finalidad de competir.
- Tener una responsabilidad real. Los mismos estudiantes se encargan de conseguir los recursos económicos para construir el producto y son ellos mismos los que gestionan el uso de los recursos.
- Trabajar en equipo. Para lograr el éxito en un producto es fundamental la organización y la capacidad de trabajar en equipo durante todo el año.
- “Aprender haciendo”, logrando con ello una mejor asimilación de los contenidos por su vinculación con una experiencia real.

En su planificación, el proyecto está estructurado para que el alumno participe dos años en el equipo, donde el primer año es de formación y aplicación de las tecnologías de automoción aprendidas y el segundo año consiste en construir y evaluar con ensayos experimentales.

Para formar parte del equipo, los alumnos deben superar una entrevista personal, de forma que aquellos alumnos que resulten seleccionados, recibirán una formación inicial global e introductoria sobre las distintas áreas de conocimiento (frenos, motor, suspensión, transmisión, dinámica vehicular, organización y marketing) con el fin de que todos conozcan todas y cada una de las áreas que engloba la fabricación del vehículo y adquieran una idea de conjunto. Por otro lado recibirán una formación genérica sobre los distintos programas informáticos que utilizarán en el proceso de planificación y diseño del vehículo.

A continuación se les reparte y divide según las distintas áreas de conocimiento, formando así las áreas de trabajo, con el fin de recibir una formación más específica y formar el equipo de trabajo. Ésta formación específica será impartida por profesores especializados en las distintas áreas de conocimiento, e igualmente se recurrirá a la experiencia de alumnos que ya han participado en la competición. Durante todo este proceso de aprendizaje recibirán material de apoyo al estudio elaborado por profesores y alumnos del equipo (videos educativos, bibliografía específica, etc.) y se realizarán tutorías y sesiones de puesta en común entre los alumnos.

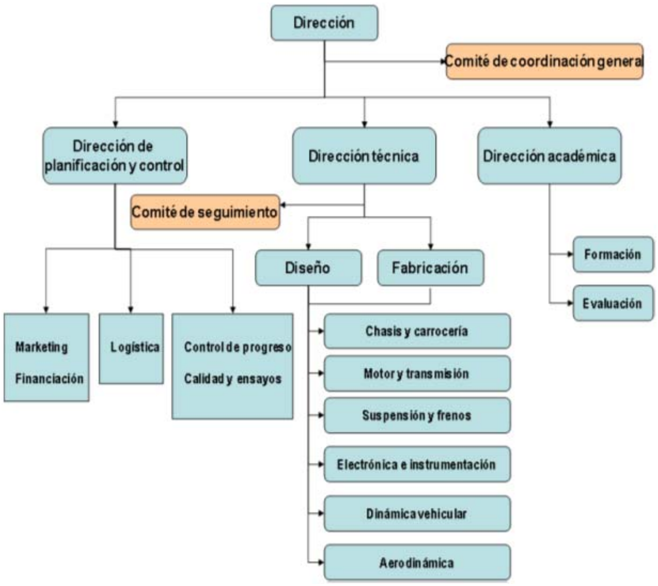

Figura 1: Organigrama General de UPM Racing

3 Desarrollo de competencias en la Fórmula SAE

Lo novedoso del Proyecto Fórmula SAE va más allá del desarrollo de una nueva metodología educativa e innovadora; es una de las experiencias innovadoras en la formación de ingenieros. Tras los enfoques didácticos más clásicos centrados en el aula y en la actividad del profesor, este proyecto presenta un método de trabajo en el que se impulsa la actividad autónoma del alumno, y le permite enfrentarse a determinadas situaciones de aprendizaje que favorecen la adquisición y desarrollo de competencias del Ingeniero Industrial.

Entre las definiciones que podemos encontrar sobre competencia se encuentra la capacidad de aplicar conocimientos, destrezas y actitudes al desempeño de la ocupación que se trate, incluyendo la capacidad de respuesta a problemas, imprevisto, la autonomía, la flexibilidad, la colaboración con el entorno profesional y con la organización del trabajo (REAL DECRETO 1393/2007, de 29 de octubre, 2007).

A modo de síntesis, de las múltiples definiciones existentes se puede extraer los elementos más reiterativos. Según esto, una competencia implica (Cano, 2008): integrar conocimientos, realizar ejecuciones, actuar de forma contextual, aprender constantemente y actuar de forma autónoma. En un trabajo precedente (Sánchez, Aparicio, Álvarez y Jiménez, 2009) y en la tabla siguiente (Quadro 1: Configuração das informações escritas pelo labirinto) se muestran 24 competencias frente a 16 situaciones distintas de aprendizaje relativas a distintos momentos o actividades del proyecto Formula SAE. Dichas competencias, dentro del proyecto, se estiman como las más deseables para un ingeniero que se prepara para trabajar en el sector de automoción.

Tabla 1: Fomento de competencias personales y profesionales según las distintas actividades y situaciones de aprendizaje

Situaciones de aprendizaje / Competencias	1. Formación inicial en todas las áreas de conocimiento	2. Material de apoyo y sesiones de tutoría durante el proceso.	3. División en subgrupos según áreas de trabajo.	4. Asignación de funciones, objetivos y responsabilidades.	5. Organización y planificación según costes/plazos generales	6. Cada alumno responde de su trabajo y colabora con el resto	7. Gran autonomía personal y posibilidades de innovación	8. Jornadas periódicas de presentación y puesta en común	9. Búsqueda de recursos y gestión de su uso	10. Todos participan en la fabricación del vehículo	11. Alumnos veteranos coordinan actividades de nuevos	12. Participación en una experiencia real	13. Puesta en práctica de conocimientos adquiridos	14. Se compite contra mejores universidades del mundo	15. Presentación y defensa del trabajo realizado ante un jurado	16. Necesidad de difundir la experiencia y los resultados
1. Trabajar en equipo			X	X	X	X		X	X	X	X	X		X	X	X
2. Liderazgo			X	X	X	X		X	X	X	X	X		X	X	X
3. Motivación			X	X	X	X		X		X	X	X		X	X	X
4.Responsabilidad y compromiso		X	X	X	X	X	X	X	X	X	X	X		X	X	X
5. Innovación				X		X	X			X		X	X	X		
6. Negociación			X	X	X	X	X	X	X	X	X	X		X	X	X
7. Automotivación	X	X	X	X		X	X		X					X	X	
8. Análisis	X	X	X	X	X	X	X	X	X				X	X		
9. Síntesis				X	X	X	X			X		X	X	X	X	X
10. Crítica y autocrítica		X	X	X	X	X	X	X		X	X	X	X	X	X	X
11. Autoaprendizaje	X	X	X	X			X						X	X		
12. Organización y planificación		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
13. Identificación de problemas			X	X	X	X	X	X	X	X	X	X	X	X	X	X
14. Resolución de conflictos				X	X	X		X	X	X	X	X	X		X	X
15. Creatividad				X		X	X	X	X			X	X	X	X	X
16. Emprender nuevas iniciativas				X	X	X	X		X	X		X	X	X		X
17. Adaptarse a situaciones de cambio	X		X	X	X	X			X	X	X	X	X	X	X	X
18. Trabajar de forma autónoma	X	X		X	X	X	X						X			
19. Tomar decisiones				X	X	X	X	X	X	X	X	X	X	X	X	X
20. Relación interpersonal			X	X	X	X		X	X	X	X	X		X	X	X
21. Asimilación y aplicación de los conocimientos	X	X		X		X	X			X	X	X	X		X	
22. Dinamismo				X	X	X	X		X	X	X	X		X	X	X
23. Disciplina y autocontrol	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
24. Comunicación oral y escrita en una segunda lengua	X	X							X			X		X	X	X

Como se puede observar en la tabla precedente, son varias las situaciones a las que el alumno se enfrenta a lo largo de su participación en el proyecto, situaciones en las que el alumno, además de poner a prueba sus conocimientos, trabaja en la construcción de las competencias. En este sentido, una de las competencias relacionadas con la formación que proporciona la participación en el equipo UPM Racing es la de aplicación de los conocimientos adquiridos para identificar, formular y resolver problemas dentro de contextos amplios y multidisciplinares, siendo capaces de integrar conocimientos, trabajando en equipos multidisciplinares, y es en ésta última en la que se centra este trabajo.

4 Indicadores para la evaluación de la competencia "Resolución de conflictos en equipos multidisciplinares"

Durante el presente trabajo se ha elaborado un instrumento de evaluación que permita medir el grado de adquisición de la competencia seleccionada, en este caso, resolución de conflictos en equipos multidisciplinares. El instrumento generado es una rúbrica, construida a partir de unos indicadores para lograr nuestro objetivo. Dada la complejidad que supone el diseñar una prueba y más concretamente el diseñar unos indicadores, se ha realizado una revisión de la literatura relacionada con la resolución de conflictos. Dicha revisión ha permitido extraer como información relevante para la construcción de la rúbrica las etapas que se siguen en la resolución de conflictos (Alzate, 1998; Funes y Saint-Mezard, 2000; Torrego 2000), siendo las siguientes:

a) Identificación del conflicto

b) Definición del conflicto

c) Análisis del conflicto

d) Generación de opciones

e) Selección de opciones

f) Seguimiento

g) Evaluación

Basada en dicha información, se ha elaborado una lista de indicadores y de descriptores que servirán para evaluar el desempeño del alumno en la competencia elegida.

Tabla 2: Indicadores y relación de descriptores de la rúbrica

Indicadores		Descriptores
1)	Identifica y analiza el problema	1.1. Reconoce adecuadamente e identifica cuando una dificultad supone un conflicto en el grupo.
		1.2. Expresa su opinión al grupo y busca conocer la opinión de los demás. Se interesa por generar el diálogo.
		1.3. Se preocupa de obtener, a través diversas fuentes de información, la máxima información de las posibles causas del conflicto, implica y hace partícipe a todos los miembros del equipo
		1.4. Reconoce cuando un problema surge como consecuencia del desarrollo de una tarea y cuándo surge como consecuencia de las relaciones interpersonales.
		1.5. Se preocupa de organizar la información obtenida y presentarla al equipo de una manera ordenada y estructurada.
		1.6. Obtiene información significativa para determinar el problema y el alcance del mismo.
2)	Identifica alternativas de resolución y selecciona las más adecuada	2.1. Identifica varias soluciones al problema
		2.2. Expresa su opinión al grupo y busca conocer la opinión de los demás. Se interesa por generar el diálogo.
		2.3. Selecciona, de las posibles soluciones, la más adecuada para resolver el problema.
		2.4. ¿Quién efectúa la selección?
3)	Metodología de aplicación de la solución escogida	3.1. Explica qué solución aplicaría y argumenta el por qué

5 Prueba piloto para la evaluación de la competencia "Resolución de conflictos en equipos multidisciplinares"

La parte final del presente trabajo ha consistido en la evaluación, mediante los indicadores propuestos, de una muestra de 10 alumnos integrantes del equipo UPM Racing. La metodología utilizada para la aplicación de la prueba, consistente en dos etapas, se describe a continuación.

<u>1ª etapa</u>

- Se reúne al grupo con el fin de mostrar la rúbrica y explicar el objetivo de la misma como instrumento de evaluación.

- Se opta por elegir como problema/conflicto el proceso de selección de los pilotos, tema con bastante controversia y que afecta a todos los miembros del equipo.
- A continuación se entrega la rúbrica a cada alumno.
- La única instrucción que recibe el alumno es la siguiente: una vez planteado el problema, se seguirán los indicadores y cada uno de sus descriptores, y se realizarán los comentarios que crean oportunos en cada uno de ellos con el fin de fragmentar el problema, estudiar sus partes, sus repercusiones, los agentes implicados, posibles soluciones, etc...
- Damos una semana para ejecutar la tarea asignada.

2º etapa

- El alumno entregará un informe, conforme al esquema propuesto en la rúbrica, sobre el proceso propuesto de resolución del problema planteado.
- El alumno debe llevar a cabo una presentación en grupo, conteniendo la defensa del proceso seguido en la resolución de dicho problema.
- El profesor planteará a cada alumno las cuestiones que considere pertinentes para la clarificación de las soluciones planteadas.
- Se evalúa esta actividad conforme a los criterios de la rúbrica, para lo cual el profesor evalúa si el alumno ha alcanzado el cumplimiento del objetivo marcado en cada descriptor.

6 Discusión

La prueba piloto realizada proporciona los siguientes resultados:

Tabla 3: Resultados de Respuestas

Descriptor	% respuesta	% respuesta coherentes al descriptor
1.1	64%	43%
1.2	64%	43%
1.3	55%	0%
1.4	64%	29%
1.5	18%	14%
1.6	27%	0%
2.1	45%	71%
2.2	64%	29%
2.3	27%	14%
2.4	55%	0%
3.1	64%	57%

Descriptor 1.1.- Los alumnos identifican el problema y no tienen ninguna dificultad en reconocer que existe un conflicto en el grupo. Sin embargo han faltado argumentos para justificar su respuesta. Estos argumentos son necesarios para poder entender cuál es la percepción y la visión del alumno de dicho problema. Por ello, se concluye que debería completarse la redacción del descriptor para que el alumno pueda desarrollar argumentos.

Descriptor 1.2.- El alumno expresa su opinión acerca del problema, comenta levemente haber buscando otras opiniones pero sin explicar qué alternativas encontró. No existe prueba que se organizara alguna actividad de grupo para expresar y conocer el resto de opiniones, lo que lleva a pensar que ha trabajado el ejercicio de forma individual como una actividad académica más. Para este indicador se plantea completar solicitando que separe y/o indique las opiniones personales del resto, permitiendo al evaluador determinar el nivel de búsqueda de información en este descriptor.

Descriptor 1.3.- Los alumnos, al no realizar ninguna tentativa de resolución en grupo, difícilmente han podido obtener la información de las diversas fuentes. El planteamiento para este descriptor se modificará para que el alumno explique cómo y de dónde obtiene la fuente de información.

Descriptor 1.4.- Todos muestran acuerdo en que el problema puede ocasionar conflictos interpersonales, dado que todos compiten con todos para la elección de los pilotos, lo que puede generar roces y controversias entre los miembros del equipo. Ninguno ha distinguido si el problema surge como consecuencia del desarrollo de una tarea o como consecuencia de las relaciones interpersonales. Por ello, se considera que debería completarse la redacción del descriptor para que el alumno pueda desarrollar argumentos y poder conocer la percepción del alumno.

Descriptor 1.5.- Pocos alumnos han realizado comentarios en este punto, por lo que dicho descriptor puede haberles resultado complejo. Por otro lado, el alumno no hace mención en sus comentarios que se haya reunido con el equipo y haya presentado dicha información de manera ordenada y estructurada. Este descriptor es de gran importancia, dado que el alumno debe realizar la labor de síntesis y de organización de la información que le ayudará a la toma de decisiones. El planteamiento para este descriptor se modificará para que el alumno explique qué información ha recogido y la pueda presentar de forma ordenada.

Descriptor 1.6.- Al igual que en el descriptor anterior los alumnos realizan pocos comentarios. Como en el punto anterior, si el alumno no realiza una labor de síntesis y de organización de la información obtenida, le dificultará más la tarea de extraer aquella información significativa para determinar el problema y el alcance del mismo.

Descriptor 2.1.- Los alumnos no tienen ninguna dificultad en indicar varias alternativas de solución al problema, y señalan que se debería conocer la opinión del equipo.

Descriptor 2.2.- Muchos de los comentarios hablan de la importancia de que el grupo se reúna y lo importante que es conocer la opinión de todos. Para este descriptor se propone que describa otras opiniones diferentes a las personales, obligando a describir puntos diferentes al suyo.

Descriptor 2.3.- Son pocos los alumnos que se deciden a seleccionar, de entre las posibles, la solución más adecuada; es más, el alumno en todo momento habla de una decisión democrática y consensuada entre todos.

Descriptor 2.4.- En este descriptivo se vuelve a hablar de decisiones democráticas y consensuadas y en la que todos participen.

Descriptor 3.1.- La mayoría de alumnos comenta este descriptor, sin embargo no todos los comentarios van dirigidos a explicar o argumentar algunas de las soluciones que se habían planteado. Asimismo, aquellos alumnos que completaron adecuadamente las tareas de recopilación, organización de la información e identificación de soluciones al problema, desarrollaron de manera más completa argumentos sobre cómo aplicarían dicha solución.

7 Conclusiones

La Formula SAE ha sido considerada como una de las actividades docentes más eficaces para la formación en competencias del Ingeniero Industrial. Esto le permite enfrentarse a determinadas situaciones de aprendizaje que favorecen la adquisición y desarrollo de dichas competencias.

El presente trabajo aborda la problemática de construcción de un instrumento de evaluación de la competencia de resolución de conflictos en equipos multidisciplinares, basado en indicadores. Estos indicadores presentan el modelo clásico de método científico: observación, investigación, hipótesis, y conclusión.

Para lograr este objetivo, se ha aplicado la herramienta desarrollada a una muestra piloto de alumnos del equipo UPM Racing, constituyendo éste un ejemplo óptimo de lo que se considera un equipo multidisciplinar. El análisis ha permitido recoger resultados que han ayudado a depurar la rúbrica inicial, y mejorar la definición de los indicadores y sus descriptores, con el fin de obtener un instrumento de mayor calidad.

El alumno está poco habituado a la metodología de evaluación propuesta, por lo que al no obtener información adecuada no puede responder coherentemente a los descriptores. El análisis permite concluir: falta de soluciones “creativas”; se confunde la “mejor solución” con la solución que ofrece el menor conflicto; y no se realiza una búsqueda exhaustiva de información para posibles soluciones.

Los próximos pasos de esta metodología consistirán en la aplicación de la herramienta desarrollada y ajustada a todos los alumnos integrantes del equipo.

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Nuevas herramientas docentes interdisciplinares: mecánica de medios continuos y expresión grafica

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Abstract

A high percentage of spanish students (signed up in engineering studies at university) did not choose the subject "Technical Drawing" at high school. This generates serious difficulties in other engineering subjects, such "Mechanics", where spatial compression of objects is required. In this sense, this paper introduces a new teaching tool based on an interactive virtual platform which aim is helping students to improve their three-dimensional viewing capacity. Specifically, the problems that are solved by this tool are related with the reduced spatial vision detected in students when, as a way of example, the visualization of the spatial position of a vector is needed for solving a typical problem of Mechanics. In this sense the proposed tool allows them to change interactively the spatial position of a vector, showing in *real time* the updated vector modulus and direction cosines.

Keywords: computer teaching tool, continuum mechanics, three-dimensional viewing.

1 Introducción

La habilidad espacial es una componente de la inteligencia humana muy importante dentro de ámbitos técnicos o ingenieriles. De hecho, sin una capacidad espacial bien desarrollada una persona puede encontrarse con graves problemas que afectan a su ejercicio académico o profesional (Martín et al, 2009). Investigadores del ámbito de la psicología (Pellegrino, Alderton & Shute, 1984; Carroll, 1993) y de la ingeniería (Olkun, 2003) simplifican la clasificación de la capacidad espacial en dos componentes: (i) *relación espacial o rotación mental*, definida por la velocidad con que se pueden rotar mentalmente formas simples, y (ii) *visualización espacial*, definida como la habilidad para gestionar mentalmente formas complejas.

Según estudios estadísticos (Hernández et al, 2008), un elevado porcentaje del alumnado que cursa estudios universitarios en carreras técnicas no escogió en bachillerato la asignatura Dibujo Técnico lo que, entre otras causas, induce a que dicha materia sea uno de los factores que provocan un retraso en la duración de los estudios universitarios del alumnado. De hecho, ya existen evidencias de las dificultades de capacidad espacial que presenta el alumnado al enfrentarse a asignaturas que necesitan una comprensión espacial de objetos (Vergara, Lorenzo & Rubio, 2007; Vergara, Rubio & Lorenzo, 2008), e.g., la asignatura Mecánica Técnica de titulaciones de ingeniería.

En el proceso de adaptación de las diferentes titulaciones de ingeniería al Espacio Europeo de Educación Superior (EEES) se debe favorecer la "*capacidad de visión espacial y conocimiento de las técnicas de representación gráfica*" de los estudiantes (BOE 20 de Febrero – Orden CIN/351/2009, de 9 de Febrero). Todo ello ha llevado a la elaboración de diversos recursos que permiten desarrollar las habilidades espaciales, siendo mejor aceptadas por parte del alumnado las que se basan en las nuevas tecnologías y crean una independencia del profesorado (Martín et al, 2009).

El impacto de la aplicación de las Tecnologías de la Información y Comunicación (TIC) en la sociedad actual es evidente y, debido a ello, la incorporación de éstas para conseguir una adecuada actualización de la enseñanza hace replantearse a los docentes los procedimientos didácticos a utilizar (Mena, Melero & Navarro, 1998). En este sentido, lo que se expone en esta comunicación es el desarrollo de nuevas herramientas didácticas, basadas en *plataformas virtuales interactivas*, que ayudarán a los alumnos a mejorar su capacidad de visión espacial a partir de ejercicios didácticos con aplicación directa en asignaturas relacionadas con la mecánica de medios continuos (e.g. mecánica técnica).

Los autores de esta comunicación ya han desarrollado previamente plataformas virtuales interactivas que sirven para favorecer las habilidades espaciales del alumnado (Vergara, Lorenzo & Rubio, 2007; Vergara, Rubio & Lorenzo, 2008) en otros campos o áreas, así que esta comunicación supone en realidad una continuación de esta línea de trabajo pero enfocada a asignaturas del área de Mecánica de Medios Continuos y Teoría de Estructuras (MMCyTE). Los problemas que resuelve esta nueva herramienta desarrollada están relacionados con las dificultades de visión espacial que los profesores de MMCyTE han detectado en el alumnado cuando trata de resolver ejercicios de mecánica técnica donde es preciso visualizar la *disposición espacial de un vector*. En este sentido la herramienta permite cambiar de forma interactiva la posición espacial del vector, pudiendo visualizar en *tiempo real* los cambios correspondientes a los valores del módulo del vector y de los cosenos directores.

Por lo tanto, en cierta manera, esta metodología garantiza un *aprendizaje de tipo productivo*, i.e., desarrolla el hábito de pensar, razonar y relacionar o explicar la información (Hernández, 1995), ya que el alumno, mediante un proceso de *autoaprendizaje*, no sólo ejercitará su capacidad de visión espacial sino que vinculará los cambios espaciales de imágenes a datos numéricos que proporcionará la propia herramienta. Los profesores implicados en el desarrollo de esta plataforma virtual pertenecen a diferentes áreas, MMCyTE y Expresión Gráfica (EG), y, a pesar de no haber puesto en práctica aún la herramienta en el aula, consideran que ésta va a tener una importante aplicación docente: (i) permite el desarrollo de actividades que establecerán *vínculos docentes interdisciplinares* entre ambas áreas (por un lado favoreciendo la capacidad de visión espacial, competencia del área de EG, y por otro fortaleciendo la comprensión física y matemática del cálculo vectorial, propio del área de MMCyTE), y (ii) supone un ejemplo de buena organización y coordinación docente entre diferentes áreas.

2 Plataforma virtual interactiva

Tal como se ha comentado en la introducción, los problemas detectados por los profesores del área de MMCyTE que se han tratado de resolver con este trabajo están relacionados con las dificultades de visión espacial que muestra parte del alumnado cuando trata de resolver ejercicios de mecánica técnica donde se requiere visualizar la disposición espacial de un vector. En este sentido, se determinó que la plataforma virtual interactiva desarrollada debía abarcar dos aspectos básicos de la asignatura Mecánica Técnica: (i) favorecer la *visualización espacial de los cosenos directores* de un vector situado en cualquier octante y (ii) favorecer la *visualización espacial de las coordenadas inicial y final de un vector* para determinar su valor unitario, a partir de la formulación pertinente.

Este último caso se planteó debido a varias situaciones vividas por los docentes en las que el alumnado, a pesar de reconocer perfectamente las coordenadas espaciales, fallaba a la hora de introducir dichos valores en la formulación matemática para obtener su valor unitario y no sabía interpretar correctamente lo que implicaba a nivel espacial un signo positivo o negativo. Debido a esto, con este trabajo no sólo se ha tratado de solventar el problema de capacidad de visión espacial –vincualdo al área de EG– sino también se ha procurado que el alumno aprenda a manejar correctamente las coordenadas de los puntos inicial y final de un vector para conocer sus componentes o proyecciones en las direcciones de los ejes coordenados.

La plataforma interactiva desarrollada se ha creado a partir del programa informático Cabri3D® y posteriormente ha sido implementada en Studium (plataforma moodle usada por la Universidad de Salamanca). Estando implementada en Studium, desde el momento que los profesores activen la aplicación, cualquier alumno matriculado en la asignatura correspondiente tendrá acceso a la plataforma virtual y podrá desarrollar y mejorar sus habilidades espaciales mediante un proceso de autoaprendizaje.

2.1 Visualización espacial de los cosenos directores de un vector.

Uno de los objetivos que se persiguen con el desarrollo de la plataforma virtual interactiva expuesta en este trabajo es favorecer la capacidad de visualización espacial de los cosenos directores de un vector cualquiera. Teniendo en cuenta este fin, la plataforma desarrollada permite representar espacialmente un vector, cambiando de manera interactiva y en tiempo real la posición espacial del punto de llegada de un vector (punto *R* en la Figura 1), siendo el punto de origen el origen de coordenadas. Este cambio permite detectar automáticamente en la pantalla del ordenador la variación de las coordenadas del punto *R* y los cambios correspondientes a los ángulos directores, con lo que el alumno puede comprobar, mediante los cálculos pertinentes, los nuevos valores que proporciona la plataforma virtual (aprendizaje de tipo productivo). El objetivo de favorecer las habilidades espaciales del alumnado se ha conseguido a partir de las siguientes aplicaciones de la plataforma interactiva:

(i) *Rotación*: permite cambiar fácilmente el punto de vista del objeto (botón derecho del ratón). Esto ayuda al alumnado a *auto*-comprender espacialmente la situación geométrica del vector (visión global en 3D del vector). En este sentido, en la Figura 1 se puede ver que la posición del punto final y los cosenos directores son los mismos que en la Figura 2, siendo el único cambio entre estas figuras que se ha visualizado el objeto desde diferentes puntos de vista.

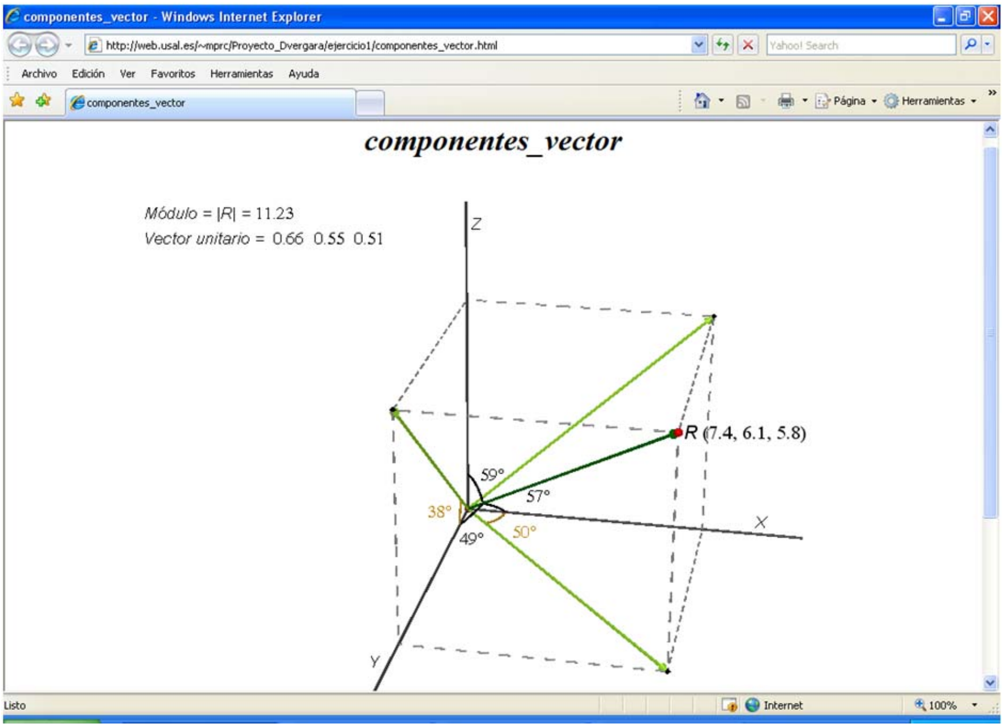

Figura 1. Plataforma interactiva que favorece la visualización espacial de los ángulos directores de un vector.

(ii) *Translación vertical* (resto movimientos impedidos): permite modificar verticalmente la posición del punto de llegada del vector (botón izquierdo del ratón más tecla Shift), i.e., se facilita la posibilidad de cambiar el valor de la coordenada *z* sin variar ninguna de las otras coordenadas. La plataforma proporciona directamente el nuevo valor de los cosenos directores y del módulo del vector (Figura 3). De esta manera, el alumno podrá mover espacialmente el punto *R* con perfecta libertad visualizando en *tiempo real* los cambios correspondientes en los valores del módulo y de los ángulos directores del vector, y además, comprobará que ni el valor de las otras coordenadas (*x* e *y*) ni la proyección de los ángulos directores en el plano *xy* varían.

(iii) *Translación libre*: permite cambiar la posición espacial del punto final del vector (botón izquierdo del ratón), de tal forma que el propio cambio proporciona en tiempo real los nuevos valores de la posición final de dicho punto, de los nuevos ángulos directores, de las proyecciones de éstos sobre los planos *xy* o *yz*, y del módulo del vector (Figura 4). Esta translación se puede efectuar a cualquier octante, lo cual facilita la comprensión espacial en posiciones más complicadas de visualizar mentalmente (Figura 5), más aún si la herramienta permite interactuar libremente con ella para alcanzar este objetivo. Además, con el fin de facilitar la comprensión espacial de los ángulos representados con esta herramienta se ha considerado importante y útil diferenciar el color de los ángulos directores con el color de las proyecciones de éstos.

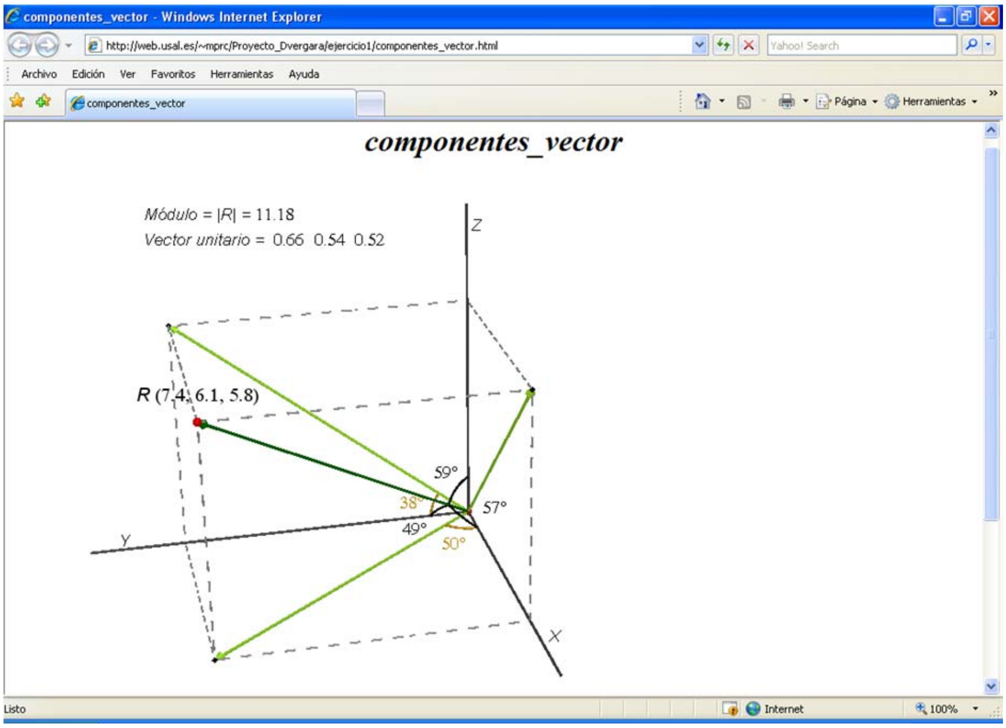

Figura 2. Visualización del mismo vector que la Figura 1 después de una rotación hacia la izquierda.

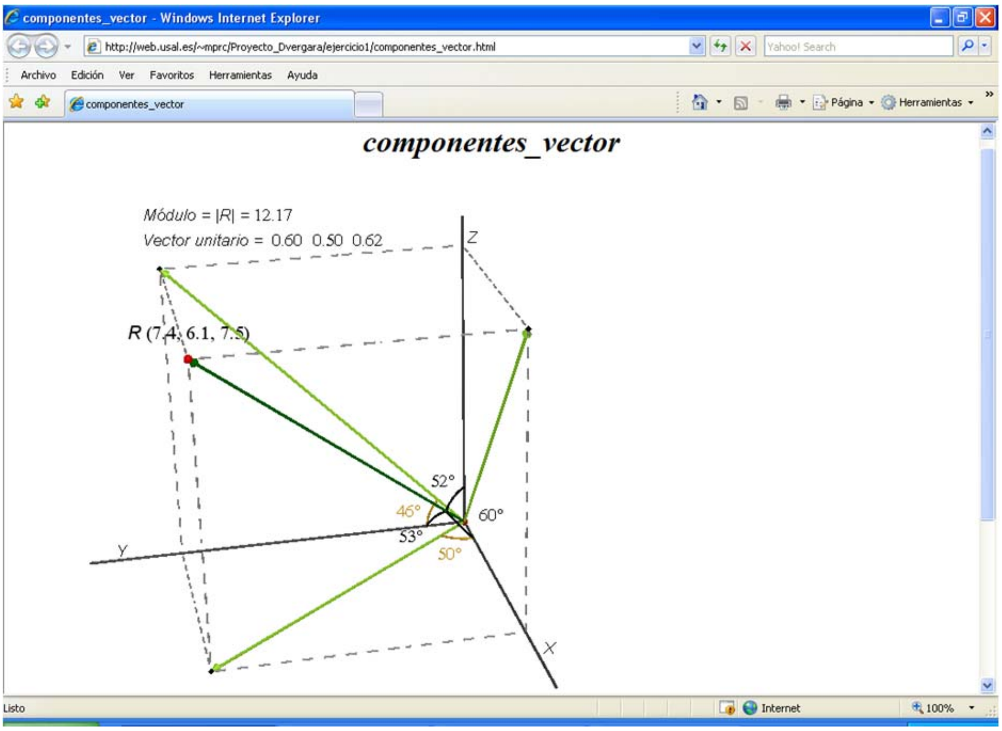

Figura 3. Visualización del mismo vector que la Figura 2 después de transladar verticalmente la posición del punto *R* (coordenada *z*).

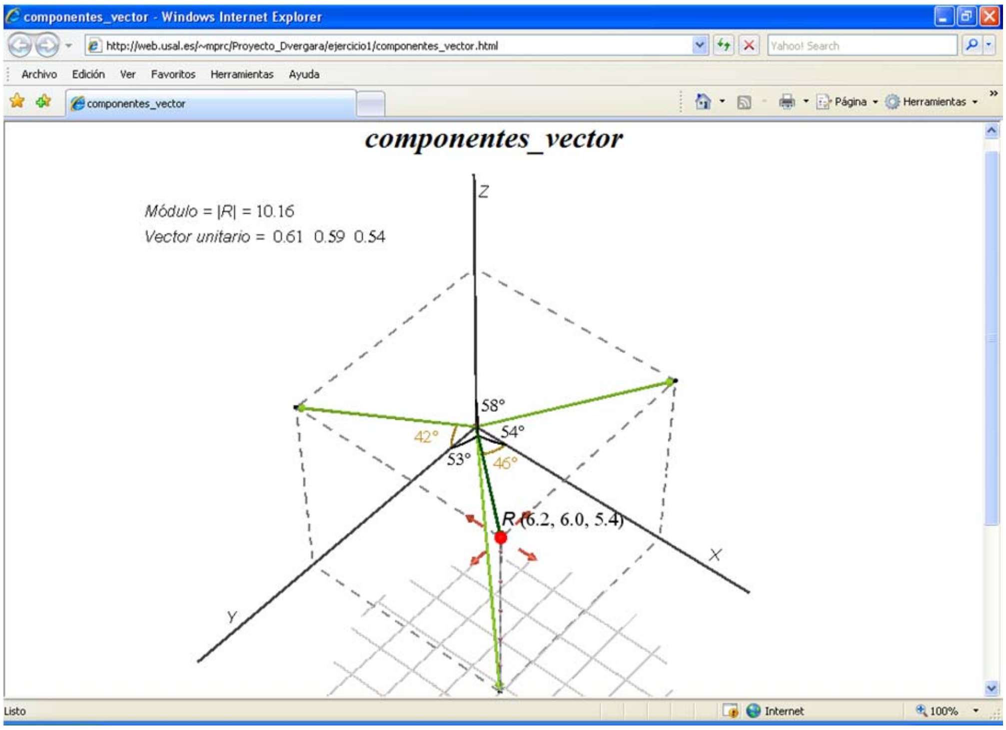

Figura 4. Translación del punto *R* dentro del octante I.

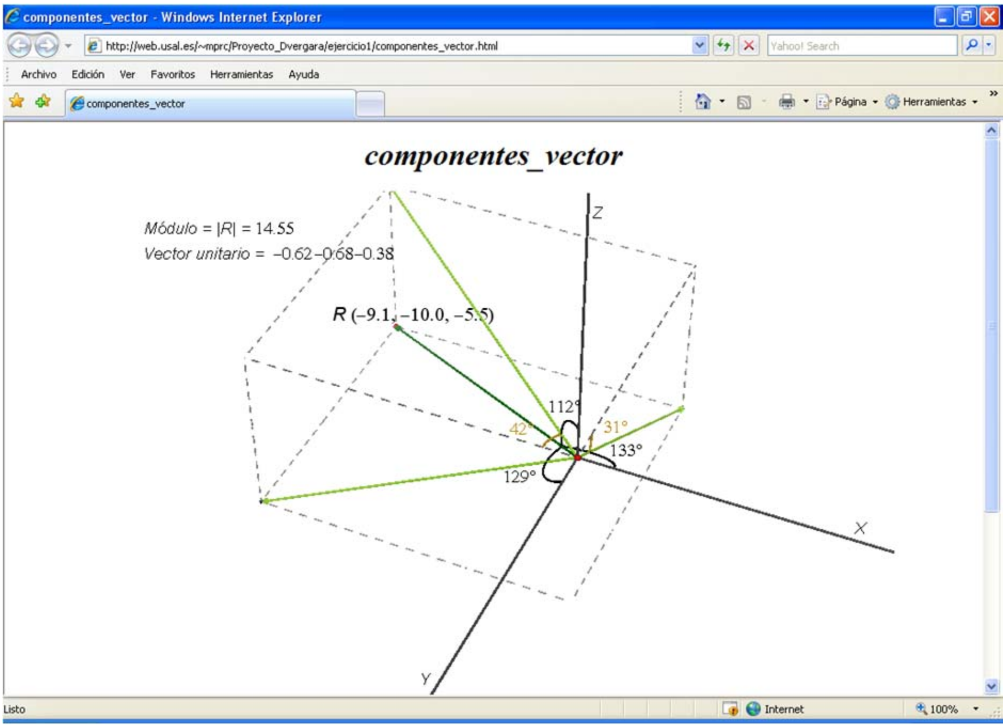

Figura 5. Translación del punto *R* al octante VII.

2.2 Interpretación de la posición espacial de un vector.

La plataforma virtual desarrollada también permite visualizar vectores situados libremente en el espacio, a partir de las coordenadas del punto de origen *Q* y del punto de llegada *R* (Figura 6), proporcionando en todo momento las coordenadas de ambos.

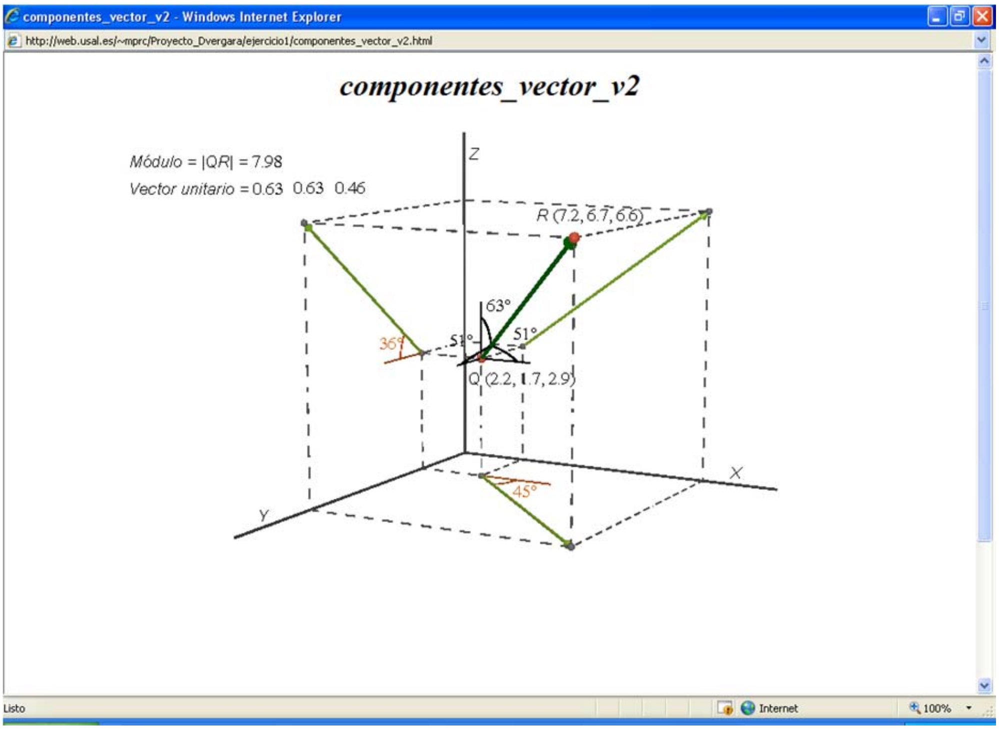

Figura 6. Visualización espacial de un vector cualquiera.

La herramienta ofrece, al igual que en el caso anterior, la posibilidad de realizar los siguientes movimientos: traslaciones libres, translaciones verticales y rotaciones. En función del cambio realizado, la plataforma indica en todo momento las coordenadas de los nuevos puntos, el nuevo valor del módulo del vector, las componentes del vector unitario y el valor de los ángulos directores y de la proyección de éstos sobre los planos coordenados. Esta herramienta permite mover libremente cualquiera de los extremos del vector –botón izquierdo del ratón– o introducir directamente las coordenadas de éstos. Así, el alumno puede representar espacialmente vectores que no consiga visualizar mentalmente y que necesite comprender para resolver algún problema de la asignatura. Aún así, aunque desde Cabri3D® este último recurso funciona perfectamente, al implementarlo dentro de la plataforma de moodle queda inhabilitado y sólo se pueden cambiar las coordenadas de un punto al moverlo con el ratón, sin poder introducir directamente unos nuevos valores.

3 Metodología docente

La metodología docente que los autores plantean, sirviéndose de la plataforma virtual expuesta en el punto anterior (Figuras 1-6), se basa principalmente en el *autoaprendizaje*: el problema de visualización espacial debe ser afrontado directamente por el alumno y, por lo tanto, esta plataforma virtual es simplemente una herramienta de ayuda para favorecer la capacidad de comprensión espacial de objetos. En muchas ocasiones los autores de esta comunicación han detectado que para que un alumno supere sus dificultades de visualización espacial no es suficiente con una explicación del profesor, sino que *es necesaria una representación tridimensional de lo que se desea visualizar*. En este sentido, esta plataforma virtual no sólo sirve para representar los vectores sino también para que el alumnado interactúe en tiempo real con ellos y los llegue a entender y asimilar completamente (autoaprendizaje).

El planteamiento metodológico, dentro de la asignatura "Mecánica Técnica" del área de MMCyTE, se fundamenta en el desarrollo de ejercicios basados en el cálculo vectorial de fuerzas (Riley & Sturges, 1995; Bedford & Fowler, 2008; Beer et al, 2010). En dicha asignatura se está empezando a trabajar con Mathcad® para facilitar la solución de problemas (Domínguez, Fueyo & Cabezas, 2008). Así, el uso de un programa matemático serviría para complementar la metodología docente planteada en esta comunicación: por un lado la plataforma virtual interactiva desarrolla la capacidad de visión espacial de vectores y, por otro, con el programa matemático (e.g. Mathcad®, Mathlab®, etc.) se puede corroborar el valor de las componentes vectoriales, de los vectores unitarios y de los ángulos directores. De esta forma, al cambiar las coordenadas de los puntos *Q* y/o *R* en la plataforma y consecuentemente variar los valores de los parámetros citados, el alumno podrá comprobar estos valores calculándolos él mismo con Mathcad®. Esto favorece que el alumnado piense, razone y sea capaz de explicar la relación existente entre el valor de dichos parámetros y el cambio de las coordenadas *Q* y/o *R*, i.e. se promueve un *aprendizaje de tipo productivo* (Hernández, 1995). Además la herramienta desarrollada puede ser útil para otras asignaturas habituales en cualquier carrera de carácter técnico, e.g. Física, permitiendo diseñar ejercicios que estén relacionados con dicha asignatura y presenten algún tipo de dificultad de comprensión espacial.

A modo de ejemplo, para el caso planteado en el apartado 2.1, a partir de las coordenadas del punto de llegada de un vector $P(x_1, x_2, x_3)$ se puede crear fácilmente un programa en Mathcad® o Mathlab® que sirva para obtener el valor del vector unitario $\vec{\mu}_P$:

$$\vec{\mu}_P = \frac{x_1\vec{i} + x_2\vec{j} + x_3\vec{k}}{\sqrt{x_1^2 + x_2^2 + x_3^2}} \quad (1)$$

y con éste se obtendrían las componentes vectoriales del vector $\vec{P} = P\cdot\vec{\mu}_P = \vec{P}_{x_1} + \vec{P}_{x_2} + \vec{P}_{x_3}$. De igual forma, el valor de los cosenos directores en los tres ejes coordenados ($\cos\theta_{x_i}$, siendo i = 1,2,3) se puede obtener fácilmente a partir de la siguiente ecuación:

$$\cos\theta_{x_i} = \frac{\dfrac{x_i}{\sqrt{x_1^2 + x_2^2 + x_3^2}}}{P} \quad (2)$$

4 Conclusiones

La plataforma virtual interactiva desarrollada parece ser una prometedora herramienta para solventar dos problemas encontrados en el alumnado de carreras técnicas: (i) la visualización espacial de los cosenos directores de un vector situado en cualquier octante y (ii) la interpretación espacial de la posición de un vector cualquiera. Esta herramienta, basada en el uso de las actuales Tecnologías de la Información y las Comunicaciones (TIC), proporciona al docente la posibilidad de desarrollar diferentes *metodologías activas* que favorezcan el autoaprendizaje de una manera amena e intuitiva. Además, el campo de aplicación de la herramienta desarrollada no se limita únicamente a un área de conocimiento sino que puede ser útil para varias asignaturas habituales en cualquier carrera de carácter técnico, e.g. Mecánica Técnica, Física, etc. Por último, los autores de esta comunicación consideran que las metodologías didácticas que se basen en el uso de esta herramienta permitirán conseguir una mejora en la organización y coordinación docente entre distintas áreas (e.g. MMCyT y EG), con la posibilidad de desarrollar actividades que establezcan *vínculos docentes interdisciplinares*.

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Ser profesor-tutor en el marco de los estudios universitarios de Ingeniería: análisis descriptivo de las necesidades formativas

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Resumen

El Espacio Europeo de Educación Superior destaca la relevancia del rol de tutor entre las funciones y competencias del profesorado universitario. Se busca que la tutoría se convierta en instrumento que favorezca y oriente el proceso de enseñanza- aprendizaje, facilitando el logro de competencias transversales que conduzcan al desarrollo integral de los estudiantes. Desde el convencimiento de que no es posible abordar la actividad orientadora sin previa formación del docente universitario en ella, el ICE de la Universidad Politécnica de Madrid realiza su oferta de formación en respuesta a las necesidades que el profesorado manifiesta a través de diversas consultas. Su análisis muestra que el interés en mejorar la función tutorial ha sido constante y se presenta en qué medida han sido atendidas, en los últimos cinco años, las dimensiones del perfil del tutor (ser, saber, saber hacer). Se sugieren propuestas de actuación para profundizar en la formación del profesorado.

Keywords: acción tutorial universitaria; formación docente universitaria; tutoría universidad; rol tutorial.

Abstract

The European Higher Education Area highlights the tutorial role among the relevant functions and competences for the teacher. The new guidelines are intended to foster tutoring as a useful tool to guide the teaching – learning process, so promoting the achievement of cross curricular competences and therefore contributing to the students' integral development. Since its beginning, the Institute for Education (ICE) at the Polytechnic University of Madrid (UPM) has always tried to offer the best preparation to the teachers. Several studies show the teachers' training priorities and the interest for developing tutoring skills has been a constant feature. We present how the different dimensions of the tutor's role (personal features, knowledge and know-how) have been taken into account to build the teachers' courses. Proposals to explore further actions for the teachers' training are suggested.

Keywords: university guidance, university teacher formation; university tutorial; tutor role.

1 Introducción

No cabe duda de que la labor de tutela, acompañamiento y orientación de los alumnos es vista como un valor añadido e indicador de calidad de las instituciones educativas y, por tanto, la acción tutorial ha de ser un tema clave en los planes formativos del profesorado universitario. La tutoría, en el marco de la nueva era digital, también será un factor clave en el proceso formativo de los estudiantes.

En las directrices que define el Espacio Europeo de Educación Superior se resalta la autonomía y responsabilidad del alumno en el proceso de aprendizaje, destacando la relevancia del rol de tutor entre las funciones y competencias del profesorado universitario, buscando así que la tutoría se convierta en un espacio que favorezca el proceso de enseñanza- aprendizaje en los alumnos. De ahí que los centros universitarios conscientes de su oportunidad y de las posibilidades que la Orientación Educativa comporta, en relación a su contribución al desarrollo integral de competencias transferibles, promuevan su implantación, dando lugar en los últimos tiempos a la planificación y puesta en marcha de Planes de Acción Tutorial Universitario (PATU) en muchas universidades.

Desde el convencimiento de que no es posible abordar la actividad orientadora sin previa formación del docente universitario en ella, el Instituto de Ciencias de la Educación (ICE) de la Universidad Politécnica de Madrid, ha promovido desde sus inicios la atención a las demandas que el profesorado ha manifestado a través de diversas consultas (estudios de necesidades en profesores, Directores de Departamentos, etc). A partir de estos análisis argumentaremos cómo, precisamente "la acción tutorial", incluyendo la modalidad telemática, ha sido un área de formación siempre presente, y no alejada de otros contenidos que han ido adquiriendo los profesores a través de las actividades de formación.

En esta ponencia vamos a abordar estos aspectos y además se revisarán las características y exigencias que conlleva el desempeño del rol de tutor universitario en el área de la ingeniería, sugiriendo también algunas propuestas de actuación que permitan profundizar en las necesidades de formación del docente universitario de Ingeniería. Conviene señalar que este profesorado precisa de formación específica en estos temas ya que, al menos en España, no corresponde abordar contenidos formativos en esta línea en las carreras de Ingeniería. Esta razón motiva su consideración en los planes formativos de postgrado para aquellos ingenieros que desean que su profesión se desarrolle en la docencia universitaria.

2 ¿Cómo se entiende la Tutoría en la Universidad?

La tutoría no es una "nueva función" ligada a las demandas sociales actuales, ni en respuesta al proceso de Convergencia Europea. La acción tutorial es inherente a la función docente, y quizás convenga recordar que la figura del tutor históricamente está presente en las Universidades ya a comienzos del siglo XI (Lázaro, 1997, pág. 240), siendo el profesor-tutor quien actuaba como garante de la verdad científica ante los estudiantes cuya formación tenía encomendada.

En España la labor tutorial se incorpora de forma explícita en los textos legales a mediados de la década de los años 60 del siglo XX, como ocurrió en etapas educativas previas. La Ley General de Educación, de 1970, es pionera en el establecimiento de tutorías para ayudar y orientar a los estudiantes y actualmente en la LOU (artículo 46, e) se reconoce el derecho de los estudiantes a recibir *"el asesoramiento y asistencia por parte de profesores y tutores en el modo en que se determine"*. Recientemente, el Estatuto del Estudiante Universitario (RD1791/210, de 30 de diciembre de 2011) dedica el capítulo V (artículos 19-22) a establecer los principios generales y abordar aspectos concretos en relación a la labor tutorial del profesor de Universidad.

Díaz Allué (1973) publica los primeros trabajos de investigación referidos a la Orientación Educativa en la Universidad. Poco a poco el tema será objeto de numerosos estudios que resaltan la necesidad de afrontar los requisitos de la acción tutorial en la etapa de educación superior (entre otros, Benavent, 1984; Castellano, 1995; Gallego, 1997; Lázaro, 1997; Valdivia, 1997). El replanteamiento metodológico que promueve el denominado proceso de Bolonia, así como la percepción de la acción tutorial como indicador de calidad educativa de las instituciones universitarias se refleja en el creciente número de estudios y publicaciones que abordan la temática desde distintas perspectivas tanto teóricas como prácticas (Álvarez Rojo, 2000, 2004; Durán, 2003; Gairín, Freixas, Gillamón y Quinquer, 2004; García Nieto, Asensio, Carballo, García y Guardia, 2004, 2005; Lázaro, 2003, 2008; Cano, 2009; Jiménez, 2010; Sáiz y Román, 2011, y un largo etc.). Conviene definir, antes de avanzar, qué entendemos por la acción tutorial, qué razones justifican su necesidad y qué modelos han sido establecidos en la práctica diaria de los alumnos universitarios y más concretamente en las ingenierías.

La acción tutorial referida a la Universidad puede definirse, en principio, en los mismos términos que en los niveles anteriores: se trata de *una parte de la responsabilidad docente, en la que se establece una interacción más personalizada entre el profesor y el estudiante, con el objetivo de guiar su aprendizaje, adaptándolo a sus condiciones individuales y a su estilo de aprender, de modo que cada estudiante alcance el mayor nivel de dominio posible* (García, Asensio, Carballo, García, Guardia, 2005, p.190). En otras palabras, implica toda *actividad formativa realizada por el profesor-tutor encaminada al desarrollo integral –intelectual, profesional y humano- de los estudiantes universitarios* (García et al. 2005, p.191).

Señalan Gairín et al. (2004) que el papel de la tutoría en la Universidad ha sido reconocido explícitamente en informes sobre la universidad ya que los modernos sistemas educativos resaltan el papel activo del estudiante, verdadero protagonista de su propio proceso de aprendizaje. Centrarse en la autonomía del estudiante (Alvarez y González, 2005, 2007, 2008) conduce a resaltar el rol del profesor como promotor, orientador, guía y dinamizador del proceso enseñanza-aprendizaje, potenciando el "aprender a aprender" y la motivación, a través de nuevos espacios de aprendizaje que favorezcan el máximo desarrollo de las competencias de utilidad para el desarrollo profesional de los estudiantes (García et. al, 2005). En este escenario, la tutoría ha de entenderse como una *estrategia pedagógica* que permite apoyar y asesorar a los estudiantes en su proceso de integración, desarrollo y formación (López Franco y Oliveros, 1999). Y, sin embargo, hay que reconocer que en España, como en la mayoría de los países mediterráneos, la atención e importancia de la tutoría integrada en la labor docente universitaria todavía no está, ni mucho menos, generalizada (Alvarez et al., 2008). A pesar de tener asignado, en general, un amplio horario semanal, por término medio se dedican 6 horas de obligado cumplimiento, es cierto que sus actividades y contenidos no suelen estar claramente definidos, quedando a veces a merced del voluntarismo del profesorado, no siempre formado para ello. Y no cabe duda de que actualmente diversos factores, acciones y responsabilidades resaltan su necesidad (García, et al., 2004), como, el número de alumnos que acceden a la educación superior, la ratio por aula, habitualmente mayor que en etapas educativas anteriores, la complejidad de la institución universitaria, la opcionalidad del curriculum universitario, alto índice de fracaso universitario, altas tasas de abandono y/o cambio de estudios, además de la orientación en el estudio de las materias específicas, aclaración de dudas, problemas para aplicar la teoría, etc..

Hoy día coexisten tres grandes modelos de tutoría (Rodríguez Espinar, 2004) asociados a los principales modelos de Universidad, que al tiempo permiten caracterizar los ámbitos de actuación, funciones y tareas básicas que el profesor-tutor ha de atender, y que se sintetizan en la tabla 1.

Modelo académico: más vinculado a la tradición continental en el que la acción docente se centra en el desarrollo académico de los estudiantes con el fin de informar u orientar sobre su asignatura, en un ambiente de máxima autonomía y libertad de todos los miembros de la comunidad universitaria. Este modelo permite estimular el desarrollo de la ciencia, con carácter profesionalizador. Implica ofrecer asesoramiento y apoyo técnico a los estudiantes universitarios, desde su ingreso hasta que completan su formación. Supone prestar atención a los métodos de aprendizaje, centrándose en el refuerzo para que el alumno adquiera y desarrolle las competencias propias de su titulación.

Modelo de desarrollo personal: más relacionado con el modelo anglosajón, en el que el objetivo es el desarrollo integral del estudiante y por tanto la acción tutorial abarca ámbitos más allá del estrictamente académico adentrándose en cuestiones profesionales y personales. En otras palabras, la Universidad presta atención al bienestar, la atención del alumno y al desarrollo personal, incluyendo orientación académica-profesional y personal.

Modelo de desarrollo profesional: basado en la colaboración para la formación de los estudiante entre la Universidad y las empresas, en el que la figura del tutor en la Universidad se ve complementada por la del tutor en el lugar de trabajo donde se desarrollan las prácticas en situaciones reales y en las que el principal objetivo es el desarrollo de destrezas y competencias personales, académicas y profesionales para que el perfil del estudiante se ajuste al máximo a los requerimientos del puesto profesional que se va a ver obligado a desempeñar al finalizar sus estudios.

Tabla 1.- Funciones y ámbitos de la Tutoría en la Universidad (García Nieto et al, 2004)

	AMBITO DE ACTUACIÓN PREFERENTE		
	PERSONAL (E. Inicial)	ACADÉMICO (E. Intermedia)	PROFESIONAL (E. final)
Objetivo	Integración en la vida universitaria	Ajuste a las exigencias académicas	Transición a la vida laboral
Necesidades del ALUMNO	Conocimiento y adaptación al medio	Configuración de un itinerario formativo personal	Transición al mundo laboral
	Inserción en el ambiente y estilo universitario	Autorregulación del proceso formativo	Inserción y búsqueda de empleo
	Conocimiento y reflexión sobre sus capacidades	Ampliación formativa: congresos, seminarios, actividades científicas	Búsqueda y ajuste a un puesto de trabajo
Tareas del TUTOR	Información general de la Universidad	Orientar a los estudiantes en cuanto al contenido del programa de trabajo	Asesoramiento a través del Prácticum y del Proyecto de fin de carrera
	Información específica sobre cuestiones académicas	Orientar en la metodología de estudio más adecuada	Información sobre formación continua, posgrados…
	Acompañamiento y asesoramiento en el desarrollo de su carrera	Información sobre acontecimientos extraacadémicos relacionados con los estudios	Información sobre organizaciones y requerimientos procedentes del mundo empresarial y empleadores

Otros autores consideran que es importante tener en cuenta “otras” modalidades de realización de la tutoría (García Nieto et al. 2004):

- *Tutoría burocrática o funcional*, en la que la atención se limita a aspectos administrativos, como la revisión de exámenes, reclamaciones, certificaciones, cumplimentación de actas y documentos oficiales.
- *Mentoría o tutoría entre iguales*, sistema en que la acción orientadora descansa en la labor realizada por un estudiante experimentado, que generalmente cursa últimos años de carrera, conocedor del medio universitario, formado específicamente para ello y que colabora y atiende las necesidades de los nuevos alumnos, recién incorporados a la dinámica de la Universidad y con menos experiencia que los mentores.

- *Teletutoría*, *tutoría virtual*, en la que la labor de apoyo (orientaciones, preguntas y respuestas, foros) se ofrece a través de las posibilidades que proporcionan las TIC's.
- *Tutoría individual vs grupal,* en función de la atención que precisen los estudiantes y de su posibilidad, o no, de agrupación.

3 El tutor universitario en las Ingenierías: Características y necesidades formativas

Actualmente, a todo profesor universitario se le suponen, al menos, tres competencias: dominio de los conocimientos que ha de transmitir y desarrollo destrezas sobre una determinada parcela del saber, contribuir a la búsqueda de nuevos saberes y estimular la formación de actitudes positivas hacia la ciencia y la profesión.

El perfil del tutor ha sido sintetizado por García Nieto (2005) en torno a tres dimensiones que, conjuntamente, le capacitan para desempeñar su cometido con eficacia: el “ser” del tutor, es decir, su propia personalidad; el “saber”, es decir, su preparación; y el “saber hacer”, que supone la capacidad técnica o aplicada. Cada una de estas capacidades forma parte de las características del tutor:

- En primer lugar, destaca el “ser” del tutor, su personalidad, y se señalan como cualidades deseables el hecho de contar con una personalidad equilibrada, sana y madura, mostrar sensibilidad para captar y entender los problemas de los estudiantes y capacidad para entablar relaciones cordiales con los demás. Las actitudes personales que ha de poner en juego el tutor pueden facilitar o dificultar, ya en un primer momento, la relación tutorial.
- El segundo aspecto, el “saber” del tutor contempla la preparación profesional y técnica del tutor que se convierte en una de las condiciones relevantes para garantizar la eficacia de su labor orientadora. Así, el tutor además de dominar su propia disciplina, precisa disponer de conocimientos sobre los aspectos psico-educativos: metodología didáctica y filosofía de la educación, sociología de la juventud, pedagogía diferencial, y buen conocimiento del sistema universitario... Este marco teórico le proporcionará claras referencias para la acción orientadora. Además, el tutor debe contar con conocimientos acerca de las relaciones interpersonales, dirección y animación de grupos y dominar ciertas técnicas de diagnóstico e intervención educativa, como la observación sistemática, la entrevista, el trabajo intelectual, la construcción de instrumentos de evaluación, etc.
- Por último, el saber-hacer del tutor, implica dominar y saber aplicar técnicas adecuadas: dirección del autoaprendizaje de los alumnos, dinámicas y técnicas de grupo, evaluaciones,... En el campo de las Ingenierías, además, deberá dominar la técnica del estudio de caso y solución de problemas.

En el trabajo elaborado por González Tirados (2005, p. 440) se propone un modelo de desarrollo de formación del docente universitario ajustado a las nuevas demandas que el profesor universitario de Ingenierías del siglo XXI deberá atender, definido por el tipo de tareas que deberá realizar para promover el máximo nivel de aprendizaje en sus alumnos, enmarcado en la sociedad del conocimiento. Lejos de querer provocar angustia y agobio por la amplitud de competencias a desarrollar, su análisis pretende promover la reflexión del docente ante la exigencia de su profesión, fomentando una actitud de actualización para mejorar su propia eficacia y actuación docente y tutorial.

4 La formación del profesor-tutor en la UPM

Convertirse en experto en el ámbito de la docencia (González Tirados, 2005; González Tirados y González Maura, 2007) implica un complejo proceso en el que formación psicopedagógica y experiencia práctica son la base de la mejora de las competencias del profesor universitario de Ingeniería. Desde su creación en el año 1972, ininterrumpidamente, el Instituto de Ciencias de la Educación de la UPM ha desarrollado una labor de formación y apoyo a la práctica docente, específicamente programada sólo para profesores de Ingeniería y Arquitectura, ofreciendo diferentes actividades dirigidas tanto a docentes consolidados, como a noveles profesores o investigadores que se inician en la docencia. Su propuesta se realiza a partir de estudios periódicos de necesidades formativas (1994, 2003, 2007), en los que los encuestados reclaman la atención de aspectos metodológicos y didácticos (dimensión saber), tecnologías aplicadas a las docencia universitaria (saber hacer), en menor medida, tópicos relacionados con el desarrollo personal (ser), solicitando, también, actividades relacionadas con la función investigadora, de gran relevancia y peso en los sistemas de acreditación.

Actualmente la acción formativa para el profesorado de Ingeniería y Arquitectura que se ofrece desde el ICE de la UPM se estructura en dos programas diferenciados:

- Formación Inicial, a través del curso "Formación Inicial en el marco del Espacio Europeo de Educación Superior": Este curso, con un desarrollo anual, comprende 8 módulos que suman 14 créditos ECTS, ofertando también la posibilidad de realizar un "Practicum" (4 ECTS), en el que un Tutor, profesor senior, ayuda, orienta y programa las acciones formativas de tipo científico. Los contenidos del curso versan sobre temas psicopedagógicos básicos para afrontar la docencia universitaria. La Acción Tutorial tiene su propio lugar entre ellos, aunque no cabe duda de que en todos los módulos se consideran aspectos fundamentales e imprescindibles para completar la formación del profesor de Ingeniería y Arquitectura atendiendo específicamente las dimensiones "saber" y "saber-hacer", esto es su preparación como docente en todos los aspectos. Para facilitar su seguimiento, cada módulo mantiene su autonomía, en relación a su desarrollo y evaluación. El los últimos cuatro años, han participado, de forma completa, 114 profesores noveles, becarios o investigadores vinculados a la UPM. Considerando un seguimiento parcial, por módulos, el número de participantes asciende a 137.
- Formación Continua: En este programa se incluyen las actividades que se ofertan presentan de una duración menor y contenidos, habitualmente, más específicos. Se centran en diversos y variados aspectos formativos que aportan conocimientos teórico-prácticos relacionados, concretamente, con estrategias metodológicas, incluyendo tecnologías aplicadas, desarrollo personal del docente y formación básica para la labor investigadora. No cabe duda que su amplitud intenta responder a demandas concretas de cada una de las dimensiones identificadas (ser, saber y saber hacer del profesor-tutor).

Tabla 2: Resumen de actividades formativas en respuesta a las necesidades de formación del profesor-tutor en Ingeniería y Arquitectura

Cursos		2006-07	2007-08	2008-09	2009-10	2010-11*	Total
Formación para el desarrollo personal -SER-	Actividades	-	2	6	5	8	21
	Asistentes	-	41	99	109	209	458
Estrategias metodológicas en el marco del EEES -SABER-	Actividades	24	19	9	17	9	78
	Asistentes	39	186	146	343	199	913
Tecnologías aplicadas a la docencia universitaria -SABER HACER-	Actividades	22	8	11	16	11	68
	Asistentes	383	111	203	289	190	1176
Otros	Actividades	25	19	25	26	13	108
	Asistentes	820	474	583	694	220	2791
	Actividades	71	48	51	64	41	275
TOTAL	Asistentes	1242	812	1031	1435	818	5338

* Se han contabilizado las actividades formativas realizadas hasta el 30 de abril de 2011

La lectura de los datos de participación en actividades formativas del profesorado de Ingeniería y Arquitectura de la UPM en estos últimos cinco años (tabla 2) muestra una distribución diferenciada atendiendo a las dimensiones propuestas, tanto por el número de actividades celebradas, como por su seguimiento. El 60% de las actividades realizadas dan respuesta a alguna de las dimensiones de formación del profesor-tutor identificadas, al tiempo que un 40% se centran en otras demandas formativas, que incluye las relacionadas con la formación básica para la labor investigadora (además de conferencias y mesas redondas sobre temas relevantes de actualidad para la comunidad universitaria de la UPM).

La distribución de profesores participantes por dimensiones formativas resultó como sigue: el 8,6% asistieron a cursos de formación centrados en la dimensión "ser", el 17,1% en la de "saber" y el 22% en "saber hacer", siendo la categoría "otros" la que acumula mayor porcentaje de participación, con un 52,3% de la totalidad de participantes.

Además de la programación, organización e impartición de los cursos de formación, el ICE realiza estudios monográficos en respuesta a demandas concretas de centros de Ingeniería, por los que también recaba información sobre las actividades de tutoría realizada por los profesores de la UPM (ICE, 1997, 2003, 2004). En ellos se observa que no siempre coincide la perspectiva de docentes y alumnos. Se pone de manifiesto la limitación de la acción tutorial al aspecto académico, casi burocrático y a demanda de los estudiantes (resolución de dudas y revisión de exámenes), concentradas al final del período lectivo, poniendo de relieve una clara infrautilización de las posibilidades formativas y orientadoras de la tutoría. Muchas veces se justifica por la falta de tiempo de los alumnos, en ocasiones por la gran carga horaria de las carreras y otras por compatibilizar estudio y trabajo, que –lógicamente- reduce el tiempo disponible. Es necesario señalar que, a veces, los alumnos refieren situaciones en las que la atención que reciben por parte del profesor-tutor no resulta satisfactoria, demandando mayor dedicación personalizada e incrementando la disponibilidad del profesor-tutor. El Estudio de Evaluación de satisfacción de los estudiantes (UPM, 2009) refleja que consideran importante la tutoría, situándola en el puesto 22 de 81. Del 84% de los alumnos que refieren utilizar la "tutoría de asignatura", el 58,6% se muestran satisfechos; el porcentaje de alumnos que utilizan la "tutoría currícular" o la modalidad "on-line" desciende considerablemente –hasta valores del 55%-, incrementándose notablemente los niveles de insatisfacción. El trabajo reciente realizado por del Álamo, Cuadrado, Fernández, Malagón, Trapero y González Tirados (2011) pone de manifiesto carencias formativas en temas de liderazgo en los profesores tutores del Proyecto Fin de Carrera, aunque la valoración del nivel de satisfacción de los tutelados, en general, es elevada (en una escala de 1 a 5, el 77% de los profesores-tutores fueron valorados en las categorías 4 y 5).

También en los proyectos de Innovación Educativa, que suponen un nuevo cauce para promover y reforzar la innovación metodológica en el aula, el último informe del Vicerrectorado de Ordenación Académica de la UPM (2011) refleja un claro interés de los grupos de innovación por promover acciones tutoriales, de manera que de un total de 16 proyectos de Centro aprobados en la última convocatoria, 5 responden a las necesidades de los estudiantes en el momento del acceso a los estudios superiores. Teniendo en cuenta que en la UPM varias Escuelas ya han consolidado su programa de atención al estudiante, como la ETSI Industriales, la ETSI Telecomunicaciones, la ETSI Caminos, Puertos y Canales, etc. y conociendo las medidas señaladas en el Modelo Educativo de la UPM (2011), cabría esperar que en un breve espacio de tiempo sea una práctica generalizada en todos los Centros. Conviene resaltar, también, que el 85% de los proyectos de Innovación realizados en asignaturas concretas, hasta un total de **56**, contemplaron la realización de tareas de tutela: resolución de problemas, proyectos, supervisión de trabajos, orientación al estudio y orientación profesional de los alumnos matriculados en la materia. Esta profundización práctica en las posibilidades pedagógicas de la tutoría, en general, fue valorada de forma satisfactoria por los alumnos participantes en las experiencias y son un paso más hacia el descubrimiento de otras formas de enseñar en los estudios de Ingeniería.

5 Conclusiones

Hace tiempo que Elton (1987) se lamentaba de que la Universidad no formara a sus propios profesionales (sus docentes) con el esmero y nivel con el que forma a los profesionales de las diferentes titulaciones específicas para otras profesiones. Además, se da la circunstancia de que el docente universitario participa de forma voluntaria en actividades formativas, y en muchas ocasiones no está suficientemente valorada, a pesar de reconocer la dificultad que conlleva la docencia, sobre todo en los primeros años de desarrollo (González Tirados, 2005), y de valorar las posibilidades formativas de las tutorías (García Nieto et al 2005), ya que los procesos de valoración resaltan el perfil investigador, más que mimar y potenciar los aspectos relacionados con la mejora de las competencias docentes.

Una universidad que pretenda responder a los retos que el nuevo EEES propone ha de reflexionar acerca de las nuevas competencias del rol de profesor-tutor y plantearse tanto estratégica como pragmáticamente cómo articular su organización. La comunidad educativa universitaria parece compartir la convicción de que la función tutorial supone una estrategia fundamental para promover e incrementar la calidad educativa, y la excelencia formativa implicaría el establecimiento de una "red tutorial" institucional, con espacios, tiempos y acciones coordinadas institucionalmente. La acción tutorial, para ser eficaz, no puede ser improvisada sino que ha de ser planificada, impulsada, programada y evaluada, contando con medios y recursos suficientes y necesarios para responder ante los retos que la atención a la diversidad de los estudiantes requiere (Lázaro, 2003; García Nieto et al., 2005).

El EEES ofrece una nueva oportunidad para replantear la actividad docente, sus requisitos, sus posibilidades. Y parece necesario plantear nuevos cauces de formación del docente universitario para poder incorporar realmente la tutoría y la atención a los estudiantes de forma eficaz y adecuada.

También se debe producir un apoyo institucional real traspasando la línea de la recomendación, con el fin de incentivar con reconocimiento claro la labor tutorial realizada. Sin duda, un primer paso es la elaboración del

Plan de Acción Tutorial Universitaria, como marco general de actuación. Pero, los documentos sólo son eficaces con una puesta en práctica real, eficaz y concienzuda.

Sería conveniente realizar un estudio exhaustivo de las acciones tutoriales en nuestra universidad obteniendo resultados empíricos que nos permitan profundizar tanto en las carencias como en la nuevas estrategias.

Además, para favorecer la formación en materia de Acción Tutorial proponemos la realización de seminarios de reflexión conjunta, abiertos a la participación de docentes de diferentes áreas y con distintos grados de experiencia, con los que realizar intercambio de experiencias que resalte el trabajo colaborativo entre profesores que conduzcan nuevos proyectos de innovación educativa, a la búsqueda de procedimientos más eficaces para integrar la tutoría, de forma real, en los estudios universitarios de ingeniería. Por ello convendría profundizar en el conocimiento de qué acciones tutoriales están siendo realizadas en la actualidad por los profesores de Ingeniería de la UPM, en la reflexión de cuáles podrían ser puestas en marcha y analizar, si fuera el caso, las nuevas necesidades formativas derivadas.

Compartimos con Raga (2003, p. 46), que "no cabe docencia sin vocación, no cabe investigación sin respeto al saber y no cabe tutoría sin interés por la persona".

La acción tutorial ha de ser comprendida como uno de los pilares para afrontar las demandas formativas que la nueva era digital plantea, factor clave en el proceso formativo de los estudiantes y un valor añadido e indicador de calidad de la institución educativa. La tutoría, la implicación real y efectiva del profesor-tutor con el alumno, debería ser una seña de identidad de nuestro sistema universitario y su formación, una prioridad.

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Una Propuesta de Desarrollo del Área de Formación en Optimización en Ingeniería Industrial: Hacia la Vinculación del Currículo con la Investigación

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Abstract

This paper aims to present a proposal to coordinate educational processes in the area of optimization of industrial engineering curriculum at the Universidad Pontificia Bolivariana, in the process of formative research, applied research and advanced training in the area, so that presents a proposal for curriculum integration where from the development of skills and competencies of both teachers and students in the area will enhance the knowledge sets and acquired a new dimension in the creation and development of research proposals from undergraduate training to advanced training in graduate school. Thus providing not only the discussion of the relevance and validity of curriculum focused on the development of skills and competencies of the learner and teacher if not in the development of formative research in the area as an articulating for a given context in the curriculum transformation models for teaching with research universities.

Keywords: Investigative Skills; Curriculum; Formative Investigation; Industrial Engineering.

1 Introducción

Existe una necesidad inherente a la innovación, investigación y desarrollo de procesos en la industria, ya que la globalización ha generado cambios drásticos que hacen necesarios diferentes tipos de estudios e implementación de técnicas que permitan reducir la incertidumbre al máximo a la hora de la toma de decisiones. Autores como (Parra C, et al., 2006) y (Zapata J, Peña G., 2006), cuyos objetivos fueron mostrar soluciones factibles vía simulación para minimizar las demoras y tiempos de cola que afectan el tiempo total de producción de las órdenes como también entender las relaciones entre los elementos del proceso, permiten establecer políticas que lleven a los resultados más deseados para la industria.

En este trabajo se muestra una metodología para el desarrollo de competencias investigativas que integren los procesos de investigación con el currículo de formación en el pregrado de ingeniería industrial articulado al proceso de formación integral con énfasis en un orden científico de cara a un proceso de formación avanzada.

En la segunda sección se muestran los antecedentes teóricos más relevantes como soporte al esquema propuesto, en la tercera y cuarta sección se muestra la metodología utilizada en el proceso de construcción de esta propuesta con una descripción sobre la aplicación y proyección del esquema metodológico propuesto y casos de estudio.

2 Antecedentes

Una mirada al estado actual sobre los elementos conceptuales propuestos en el marco de una metodología para la articulación y el desarrollo de competencias investigativas en el currículo del pregrado de ingeniería industrial en aras de su fortalecimiento hacia la formación avanzada, nos muestra lo siguiente:

2.1 Antecedentes conceptuales

Existen cuatro conceptos de relevante importancia a la hora de proponer un marco metodológico que nos sirva de fundamentación a la propuesta, estos son: Investigación, Competencias Investigativas, Currículo y Formación Avanzada, veamos:

2.1.1 Acerca de la Investigación

La Investigación, según (Tamayo, 2002) se define como: "la búsqueda intencionada de conocimientos o de soluciones a problemas de carácter científico", en este sentido, se entenderá como proceso de producción, apropiación y utilización o uso racional de los desarrollos generados por el conocimiento para la solución de problemas, es si se quiere, como lo presenta (UPB-CIDI, 2010) "La investigación, tanto la científica como la formativa, en su relación con la producción de conocimiento, es una de las funciones sustantivas de la Universidad. Tanto la investigación externa, aplicada a proyectos de transferencia tecnológica y de conocimiento, como la interna asociada a la docencia, se articulan con las necesidades del entorno y con las cadenas productivas y de competitividad".

2.1.2 Acerca de las Competencias Investigativas

Los trabajos de (Tobón et al. 2010) nos definen las Competencias Investigativas como: " actuaciones integrales para identificar, interpretar, argumentar y resolver problemas del contexto con idoneidad y ética, integrando el saber ser, el saber hacer y el saber conocer ", en este sentido, las competencias investigativas se articulan al quehacer de la investigación en tanto reconoce en esta el fundamento de su formación como objeto instrumental del conocimiento, definen el carácter epistemológico de la formación en el aprender-haciendo para la transformación del saber en el resultado tangible de la cosa enmarcada en el contexto de la investigación científica o investigación instrumental del saber.

En este sentido, en (UPB-CIDI, 2010) se reconocen las Competencias Investigativas como: "aquellas propuestas para planear y ejecutar proyectos que permitan la indagación sobre los conocimientos. Estas deben ayudar a solucionar los problemas que se presenten y se prevean en los procesos de intervención del estudiante y del profesional".

2.1.3 Acerca del Currículo

En (Stenhouse, 1998) se define el Currículo como: "Un instrumento potente e inmediato para la transformación de la enseñanza, porque es una fecunda guía para el profesor…. Que expresa toda una visión de lo que es el conocimiento y una concepción clara del proceso de la educación. Proporciona al profesor la capacidad de desarrollar nuevas habilidades relacionando estas, con las concepciones del conocimiento y del aprendizaje", en este sentido hemos querido rescatar el concepto de Currículo como articulación del quehacer docente centrado en un dialogo permanente de reflexión acerca de su papel como "insinuador" del conocimiento.

Así mismo, en (MEN, 2010) se plantea del Currículo que este se debe "centrar en establecer parámetros claros, que definan lo que los sujetos tendrían que saber y ser capaces de hacer con base en su preparación para la ciudadanía, trabajo y realización personal".

2.1.4 Acerca de la Formación Avanzada

Se infiere por formación avanzada lo que respecta a (MEN, 2010), cuando plantea que es aquella formación que "tiene como propósito la cualificación del ejercicio profesional y el desarrollo de las competencias que posibiliten el perfeccionamiento en la misma ocupación, profesión, disciplina o en áreas afines o complementarias", cuando se refiere a la formación en especializaciones y la formación que "prepara en las capacidades cognitivas superiores: capacidad de identificar, delimitar, jerarquizar y resolver problemas, capacidad de resumir, sintetizar, abstraer, conjeturar; plantear hipótesis, relacionar, asociar, agregar, disociar, argumentar, comprender y explicar; expresarse correctamente oral y por escrito; capacidad de trabajar de manera interdisciplinaria y en equipo; capacidad de enseñar, planificar, prever y de pensar para el corto y largo plazo; para lo estructural y para lo coyuntural, para lo operativo y para lo estratégico, entre otras. En conclusión para formarse como, lo que denominan algunos autores, un analista simbólico", cuando se refiere a la formación en maestrías.

En este mismo sentido, concibe (UPB-CIDI, 2010) la formación avanzada "hace parte del proyecto educativo y de la propuesta curricular universitaria. Brinda al país la generación y aplicación de conocimiento en los programas de Especialización, Maestría y Doctorado, perfeccionando y adecuando los perfiles de los profesionales con miras al mejor desempeño de sus disciplinas, con tres propósitos de formación: Científica: análisis crítico de los principales problemas epistemológicos, teóricos, metodológicos y técnicos de la investigación. Profesional: profesionales formados con capacidad de articular su profesión a las transformaciones sociales y a las demandas del medio. Curricular: profesionales formados para promover el desarrollo de su disciplina, con una mirada crítica, abierta a la discusión, a la interacción y al trabajo con otras profesiones".

Este marco conceptual nos ubica frente a un interrogante fundamental de ¿Cómo articular el desarrollo de las competencias investigativas en la investigación con el currículo de formación en el pregrado de ingeniería industrial en el área de optimización y sus posibles articulaciones con el proceso de formación integral en competencias investigativas del orden científico de cara a un proceso de formación avanzada a nivel de posgrado?

Interrogante este que fue abordado desde la propuesta de Construcción de una Metodología Unificada para la Adquisición de Competencias Investigativas desde el Currículo hacia la Formación Avanzada, la cual se explica a continuación.

3 Propuesta Metodologica

La propuesta metodología se enfoca en el desarrollo del siguiente esquema por Fases o Momentos:

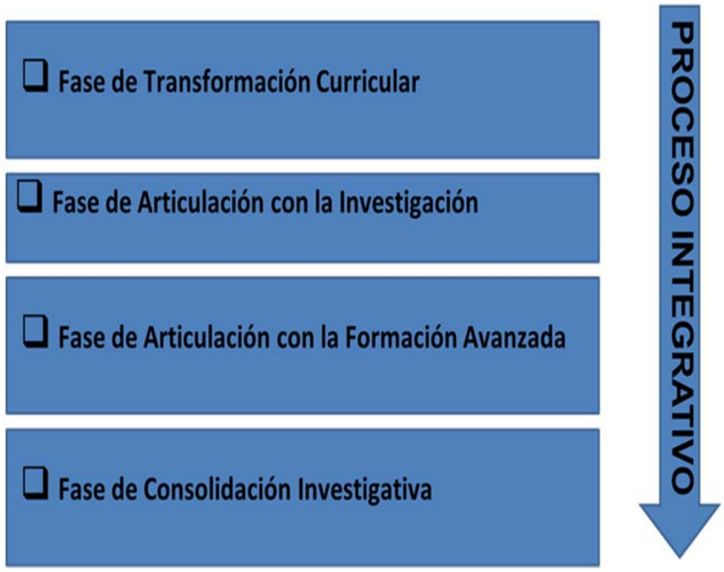

Figura 1: Esquema de la Metodología Unificada para la Adquisición de Competencias Investigativas desde el Currículo en el Área de Optimización Fuente: Autores

3.1 Fase de Transformación Curricular

En esta fase o primer momento se plantea el modelo de transformación curricular centrado en la docencia con investigación, en nuestro caso el Programa de Ingeniería Industrial de la Universidad Pontificia Bolivariana y su área de Formación en Optimización ha adoptado un Currículo de Formación centrado en los siguientes aspectos: la disminución de créditos, la inclusión de la investigación soportada por dos grupos de investigación, GISAI (Grupo de Investigación en Sistemas Aplicados a la Industria) y Política y Gestión Tecnológica y la articulación con los programas de formación avanzada en general y en particular, con la Especialización en Gestión de la Innovación y la Maestría en Gestión Tecnológica.

En este orden de ideas, concibe su objeto de estudio, según (PEP INGENIERIA INDUSTRIAL UPB, 2010) en: “los procesos industriales, de servicios, comerciales y de gestión, ampliamente interdisciplinar, con una base teórica importante que parte de las ciencias experimentales, especialmente la física, la química y las matemáticas para acabar estudiando tecnologías generalistas e intensificándose en las de su propia especialización, para así dar solución a situaciones problemáticas en áreas como producción, optimización y gestión”. Formación esta que se enmarca en cuatro grandes ciclos formativos propuestos en (PEP INGENIERIA INDUSTRIAL UPB, 2010): “Ciclo Básico Universitario que comprende toda la formación socio humanística, ética y de emprendimiento que dispone la UPB para todos sus programas, Ciclo Básico Disciplinar que comprende la fundamentación matemática, física y química, así como de ingeniería básica, Ciclo Profesional este ubica al estudiante en los aspectos profesionales de cada una de las áreas de la ingeniería industrial: producción, gestión, optimización. Ciclo Avanzado o de Integración que trata de ubicar al estudiante en la perspectiva de los temas avanzados de la profesión y le permite incluir cursos que formen parte de un postgrado que posteriormente el estudiante pueda iniciar”. Este último adopta en la nueva propuesta curricular la denominación de Transición a la Vida Laboral y en él se centra la propuesta de desarrollo de Competencias Investigativas Articuladas a la Formación Avanzada.

3.2 Fase de Articulación con la Investigación

El Programa de Ingeniería Industrial y su área de Optimización de la Universidad Pontificia Bolivariana ha propuesto el desarrollo de actividades de formación y fundamentación investigativa, donde la interacción alumno-docente a través del diálogo permanente en el aula genera las necesidades de formación, capacitación y saber sobre el componente investigativo del currículo articulado al desarrollo de sus proyectos de aula, el cual permite desarrollar las siguientes competencia investigativas referidas en (PEP INGENIERIA INDUSTRIAL UPB, 2010): Capacidad de aplicar el método científico en la identificación, búsqueda y solución de problemas de la industria, con dos componentes fundamentales: Investigar problemas y necesidades de los productos, los procesos de producción y de servicios, teniendo en cuenta criterios tecnológicos, de rigurosidad científica y con objetivos económicos e Investigar problemas y necesidades de la empresa dentro de la cadena de valor, teniendo en cuenta criterios de beneficios económicos y sociales".

Ahora bien, una vez definidas y desarrolladas las líneas de investigación y los objetos de investigación de los semilleros y grupos de investigación con asiento en el área de formación en optimización, se generan los espacios institucionales como semilleros, foros, encuentros, donde el dialogo transdisciplinar de la relación alumno-docente genera las inquietudes o el "tanque de ideas investigativas", que se materializaran luego en la forma de trabajos de grado, practicas, laboratorios de investigación o productos intermedios de formación investigativa, sean estos al nivel de documentos o artículos sobre el estado del arte o de la técnica de una área investigativa especifica.

En esta fase se consolidan los primeros espacios de construcción del quehacer investigativo, vinculando al docente y al alumno en propuestas de investigación que recojan las inquietudes investigativas de los Grupos de Investigación y su relación con el conocimiento específico o multidisciplinar del área de formación en optimización y los problemas del contexto investigativo al cual se asiste.

3.3 Fase de Articulación con la Formación Avanzada

Dentro de la propuesta desarrollada, se pretende dejar implícita la articulación con los postgrados que la institución ofrece en sus diferentes escuelas, sin embargo, es claro hasta el momento la articulación con Formación Avanzada de la Escuela de ingenierías en general y en particular con la Especialización en Gestión de la Innovación y la Maestría en Gestión Tecnológica. El objetivo de esta articulación es ubicar al estudiante en la perspectiva de los temas avanzados de la profesión, permitiendo incluir cursos dentro del currículo que formen parte de la oferta de postgrados que el estudiante posteriormente pueda iniciar y homologar.

El objeto de estudio de la gestión tecnológica se basa en el análisis de las innovaciones tecnológicas de productos y procesos, así como la innovación organizacional, temas estos concordantes en su totalidad con el objetivo del programa de Ingeniería Industrial, el cual es formar profesionales capaces de hacer innovación y desarrollo tecnológico con proyección social y humana, con imaginación, con capacidad de desarrollar nuevos productos, procesos y servicios para el mercado, con altas capacidades de gerencia de proyectos, de trabajo en redes de innovación y de interacción; así como con capacidades para participar en la construcción de una nueva sociedad más equitativa (PEP INGENIERIA INDUSTRIAL UPB, 2010).

Es importante resaltar que en la Facultad, existen programas del postgrado que están diseñados con énfasis en competencias de Gestión Tecnológica, aspecto clave en la transformación curricular que se está llevando a cabo en la carrera. Dichos postgrados poseen un mayor énfasis en Estrategias de Investigación, Desarrollo e Innovación y su plan de estudio ha sido diseñado para quienes tienen responsabilidades estratégicas en el ámbito tecnológico y de innovación. Por lo anterior, se propone una articulación inicial de la Facultad de Ingeniería Industrial y del área de formación en Optimización, la cual más adelante será extensiva a la Escuela, con los Postgrados de la misma, ofreciendo dos cursos en una línea de profundización que lleva el mismo nombre del postgrado.

En este orden de ideas, las Competencias Investigativas desarrolladas por los alumnos en el proceso anterior, permiten la articulación de sus trabajos de grado o prácticas empresariales con el quehacer de los grupos de investigación y las propuestas de monografías a nivel de especialización y tesis a nivel de formación en maestría, con resultados tangibles en términos de ponencias, productos, modelos y prototipos que permiten la visibilización del quehacer investigativo en el programa.

3.4 Fase de Consolidación Investigativa

Finalmente es el espacio de la visibilización, en la cual la relación alumno-docente muestra los resultados del logro de las Competencias Investigativas generadas en las fases anteriores y se consolidan los programas de investigación y las estrategias de sostenibilidad del quehacer investigativo articuladas a las propuestas de Formación Avanzada. Esta fase aún se encuentra en proceso de estructuración para mostrar resultados en el corto plazo.

4 Casos de Estudio

La investigación en formación es un aspecto trabajado desde diferentes ópticas en el área de Optimización de la Facultad de Ingeniería Industrial, en la medida en que se desarrollan procesos de investigación utilizando el esquema del método científico aplicado en casos empresariales, buscando resolver aspectos como por ejemplo, la determinación de factores influyentes en salidas de procesos productivos, la elección de las mejores alternativas según la representación de la realidad por medio de la simulación de procesos, el diseño de experimentos, el uso de métodos de pronóstico que mejoren la gestión de los inventarios, metodologías desarrolladas en trabajos académicos que pueden dar respuesta a esas preguntas de investigación como los dos casos expuestos a continuación, desarrollados por estudiantes de la facultad con asesoría de los docentes.

4.1 Productividad de colchones Pétalo

En la fábrica "Colchones pétalo" han buscado alternativas que permitan mejorar la productividad, para ello, se realizó un estudio teniendo en cuenta las variables más críticas en el proceso de elaboración, como unidades producidas, tiempo de procesamiento y el número de operarios. Para dicho estudio se utiliza el software ARENA en donde se modela un proceso productivo de esta empresa, y plantear escenarios al alterar diferentes variables que permitan observar el comportamiento de la producción, escogiendo finalmente el mejor escenario que disminuya al máximo los costos y tenga una mayor utilización de los recursos.

Colchones Pétalo es una empresa dedicada a la fabricación y comercialización de artículos para el descanso y el confort, a lo largo de su trayectoria ha venido convirtiéndose en el productor de sus propios insumos, mejorando sus procesos, generando una mayor calidad, satisfacción y confianza para el cliente. La organización con los insumos, mano de obra y maquinaria implementados hasta el momento ha podido responder a la demanda existente, sin embargo, existe un posible cliente extranjero que necesita gran cantidad de sus colchones, por ello en este momento la empresa necesita aumentar su producción por lo menos en un 60% de lo producido actualmente en la planta, conservando las cualidades que los identifican, comodidad, confort y confianza.

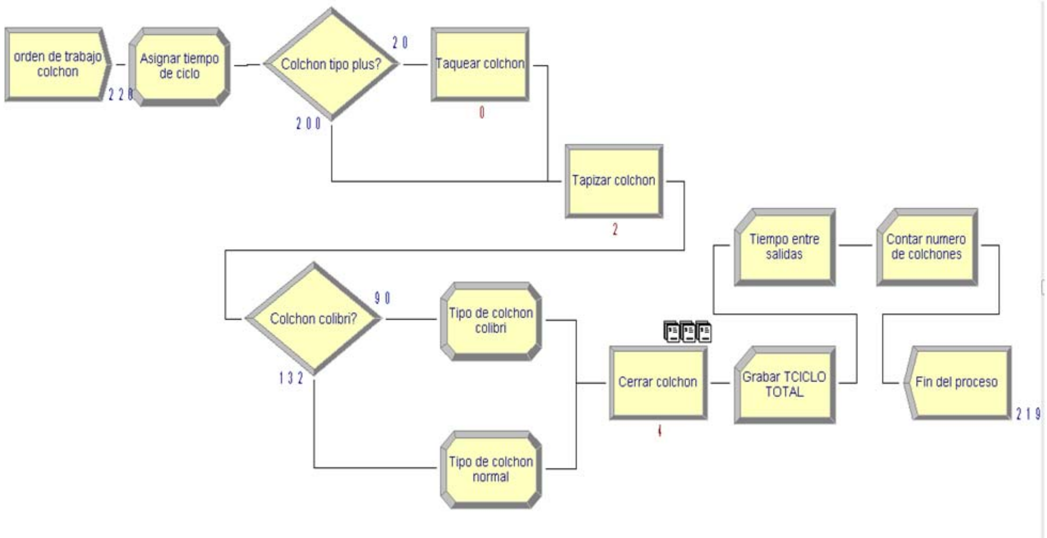

Figura 2: Modelo de aplicación en Colchones Pétalo Fuente: Autores

A partir de este modelo mostrado en la figura anterior se logran objetivos como la mejor comprensión del proceso industrial de los estudiantes, así como la identificación de mejores alternativas, que para ellos, lleva a una satisfacción de la demanda requerida en el proceso, con el mínimo de recursos.

4.2 Caso Euroautos-Renault.

El siguiente modelo se llevo a cabo siguiendo las etapas de: Planeación general del proyecto y formulación del problema en Euroautos. Conceptualización del modelo de reparación de vehículos. Recolección de los datos del sistema de reparación de vehículos. Construcción del modelo de simulación para Euroautos. Verificación, validación y prueba del modelo. Diseño experimental del modelo. Simulación y análisis. Documentación y reporte e Implementación. Debido a que el modelo debía ser simplificado se consideró en consenso con el cliente que el proceso más apropiado para simular era el de los vehículos que ingresaban por Aseguradoras, pues este es uno de los clientes más críticos de Euroautos, ya que se presentan algunas dificultades en tipo de proceso debido a las condiciones que presentan las aseguradoras para reparaciones y otros aspectos relevantes. El diseño y desarrollo de la simulación del modelo para dicha empresa se hizo en el software ProModel®.

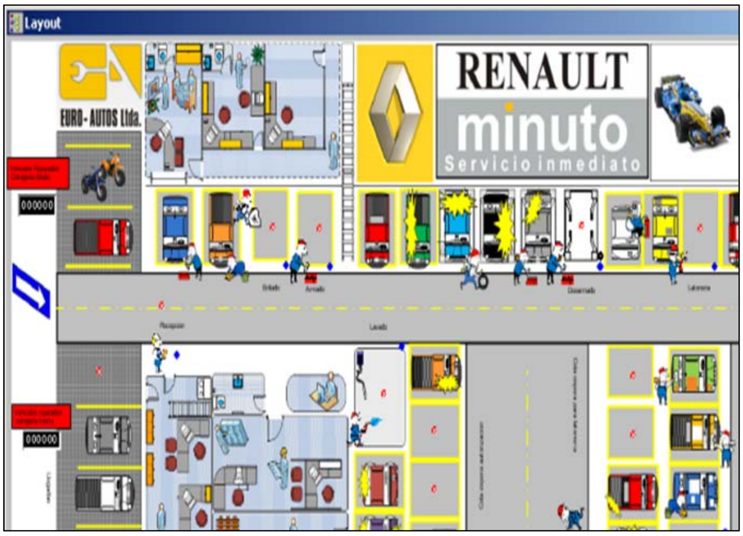

Figura 3: Gráfica de la plantilla del modelo de simulación propuesto. Fuente: Fernández, J. Ceballos, J. y Restrepo, D. Guía metodológica para la aplicación de un modelo de simulación discreta en el sector del servicio automotriz. Euroautos LTDA. Tesis de grado. Universidad Pontificia Bolivariana. 2010.

En este modelo mostrado en la figura anterior se obtiene un valor de gran importancia para la empresa y es el número de vehículos facturados o reparados en el periodo de tres meses hábiles; con la salida de 9 Twingos que ingresaron con choque medio, y 7 con choque, que representaría 3 con choque medio por mes y 2 con choque fuerte. Al realizar el análisis de sensibilidad al modelo desarrollado, se plantearon las siguientes alternativas de solución: Disminución en el tiempo de autorización por parte de las compañías aseguradoras, Disminuir en una unidad la capacidad de cada una de las colas que se incluyen en el modelo, donde la cola de llegadas quedaría con capacidad de dos, mientras la de autorización y de latonería tan solo con capacidad de uno, Disminución del tiempo de aseo y lavado a la mitad del actual. Lo cual permitió mejorar los resultados del modelo.

5 CONCLUSIONES

- El área de optimización ofrece múltiples aplicaciones en el entorno empresarial e investigativo, no solo a nivel exploratorio de los datos sino también en otras áreas de mayor impacto para la industria. Entre las principales aplicaciones tenemos: aumento de la productividad, caracterización de productos y automatización de procesos. Entre las principales técnicas utilizadas, encontramos: modelos lineales y modelos de teoría de restricciones para la toma de decisiones, modelos de distribución con teorías de grafos y simulación numérica o métodos numéricos.
- Las competencias investigativas requieren su articulación desde las etapas tempranas de la formación académica.
- Los logros en el desarrollo de las competencias investigativas requieren una fuerte fundamentación teórica en: Metodología de la investigación, diseño experimental y gestión de proyectos. Así como la enseñanza de técnicas cuantitativas para dar respuesta a diferentes interrogantes, como la elaboración de modelos estadísticos para la asociación de variables, modelos de redes, de optimización, entre otros y la gestión de proyectos investigativos.
- Nuestra propuesta se centra en la “INVESTIGACION CON EL EJEMPLO”, si el docente no es un referente obligado, el estudiante no se sentirá estimulado tanto a nivel de formación avanzada como de investigación.
- La propuesta señala la importancia de fomentar la investigación aplicada a la industria, para que exista un beneficio mutuo de formación y mejoramiento empresarial, en aras de la integración del currículo a la investigación y su proyección externa.
- Se deben crear mecanismos de visibilización del quehacer investigativo en el Aula, en el Laboratorio y en general en el circuito académico con externalidades que propicien un reconocimiento a la labor docente y estudiantil.

- Reclamamos definir nuestro “Valor Diferenciador” en el panorama investigativo Local, Nacional e Internacional.

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Paper Session B1

Learning assessment based on active training methods for competence in education using engineering projects

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Abstract

At the School of Industrial Engineering, University of Vigo, the instructors from Engineering Projects Area, which is part of the Design in Engineering Department, have been involved for two years in pilot courses aimed at gradually change the traditional education system to the new framework in the Projects subject of the final year, common to the Industrial Engineering degrees, that will come into force in two years for this subject, in the academic year 2012/2013. Currently, and as part of the design process of the new curriculum according to the learning-centered and competence-based teaching method, several doubts are arising about how generic or cross-curricular competences are to be distributed and assessed. This document will develop the work, the experiences that we had over the past two years and the results obtained in this subject, from the viewpoint of the students' development of general or cross-curricular competences, including activities and assessment procedures used. Having this aim in mind, we have tried, on the one hand, to use the Information and communication technologies as widely as possible as tools to achieve the objectives set, and on the other hand, aligned with the main objective, to implement the project-based education model.

Keywords: competences; Project-Based Learning; e-working platform; TIC.

1 Introduction

Since the Bologna Process was first applied to the University in Spain, the University system has undergone a significant change. The different innovations and reforms being carried out to integrate it into the European Higher Education Area (EHEA) are focused on Competency Based Education (Miguel Díaz, M. 2006). Instruction has shifted from teacher-centered approaches into student-centered approaches promoting active learning behaviors. The new active teaching methodologies propose a change in focus, the main role being given to the student, always followed and motivated by the corresponding instructor. In this new scenario the student's direct involvement is sought in the preparation of the teaching contents that will have a bearing on his education (Benito A. y Cruz A., 2005).

This change of model entails an important effort from the instructors' side to adapt from the traditional knowledge-based teaching method to this new approach. This is about being able to create knowledge as opposed to transmitting it. The arousal of these new keys for teaching require adaptation of instructors so that students' learning can be enriched (Knight, P. y Manzano, P., 2005). Even more, the new social role of universities, as lifelong education and learning centers, requires faculty and students to achieve more competencies, thereby forcing an academic synergy leasing to best results.

Active methodologies, in particular Project-Based Learning (PBL), present a perfect adaptation in engineering teaching, since the future engineers will have to adopt similar methodologies once they join the workfoce. Project-Based Learning is a learning method in which students plan, implement and evaluate projects that have real-world applications beyond the classroom (Blank 1997; Dickinson, 1998 and Harwell 1997). This model has its roots in the constructivism views that evolved from the work of psychologists and educators such as Lev Vygotsky, Jerome Bruner, Jean Piaget and John Dewey. The PBL has been found to be advantageous for higher education institutions as regards students' learning and competence acquisition. As for learning, students are motivated when engaged in project and group-based pedagogy practices. Specifically, this means shorter study time for students, as well as lower student drop-out rates. Regarding competencies, students acquire competencies that align with the knowledge-based society.

In this context, e-learning or distance learning is understood as stated by Buzón (2005), not simply as distance learning, but as a distance learning teaching method, supported by TICs, combining different pedagogic resources. The attendance and non attendance of this method, as well as the ideas about the use of learning times, individual work capacity and group learner capacity, information structuring and instructor's new working methods are qualities that distance learning brings about to teaching-learning processes. These new systems offer users a personalized education, as well as the possibility of establishing a continuous tracking on students, of their progress, optimizing learning processes and removing some problems related to classroom instruction, such as lack of time and space. At our program, we propose an educational environment that aims at fostering cooperative learning, among students and instructors, among instructors themselves and among a class and wider, academic and non-academic communities.

This study is focused on the experience of applying a competency-based education model to project-based teaching launched through the virtual platform Claroline used in the Project subject at the School of Industrial Engineering, University of Vigo. This model design will be presented; the different experienced training activities; the solutions that allowed for capacities, abilities and attitudes, that is, both general and specific competencies; organization criteria and some thoughts derived from its development within the mentioned virtual learning platform.

The paper is structured in five sections. Section 1 introduces the context, the problem and the objectives of the paper. Section 2 briefly characterizes the PBL and the e-learning approach. The case of study is described in section 3 along. Section 4 develops the results, and finally, on section 5, some concluding remarks are outlined.

2 PBL and E-Learning Characterization

Our program has tried to adapt to Bologna Process and we seek to use a lessons learned approach to change the working method and instructor's assessment. The two pillars in which the experience has been based are:

- Conducting a project applying gained knowledge and abilities. Broadly speaking, instruction is provided about theoretical aspects applicable to any aspect of the project and that knowledge is applied in the form of a practical project supervised by the tutor instructor assigned to each group.
- The use of the FaiTIC distance-teaching platform based on the Claroline platform with the aim of virtually completing classroom teaching.

2.1 Project-Based Learning Methodology

PBL has been progressively applied to higher education since 1970s. One of the first applications of PBL to higher education was carried out in McMaster University (Ontario, Canada) for use with medical students (Woods, 1994). Also, a very important application of PBL has been performed in the Aalborg University (Denmark) known as the Aalborg PBL Model (Kjersdam & Enemark, 1994). This institution has developed and adopted a systematic framework for the PBL to education since all university programmes have been base on PBL. Another interesting examples of PBL application to European higher education are: Roskilde University (Denmark); Maastricht University, Delf University of Technology, Eindhoven University of Technology and University of Twente (Holland); Linköping University (Sweden); and Norwergian University of Science and Technology (Norway).

PBL can be applied in different scenarios, i.e.: single subjects, group of subjects, the whole program of studies, or even more all university programmes (as the mentioned Aalborg University). Even so, subjects with a significant number of ECTS (European Credit Transfer System) are more suitable scenario for PBL since students' skills can be developed more appropriately (Valero-García, 2010). Recent and innovative experiences applying PBL in different contexts can be found in Spanish universities. On the one hand, Universitat Autònoma de Barcelona has applied PBL to single subjects in the field of computer science achieving successful findings (Martí, Gil, Vivet & Julià, 2009). Also, in the context of computer science at the University of Alicante, PBL has been applied to group of subjects showing that more complex projects can be designed when different subjects are involved (Reverte, Gallego, Molina & Satorre, 2007). On the other hand, an example of PBL applied to the whole program of studies can be found in the Escola d'Enginyeria de Telecomunicació i Aeroespacial de Castelldefels (Universitat Politècnica de Catalunya) (Alcocer, Ruíz & Valero-García, 2003). In summary, PBL has shown to be a very useful learning model applied to higher education and, more specifically, in the context of engineering studies.

Engineers are traditionally trained to solve both general and highly technical problems. A widely used tool used to solve complex problems is a project-based approach since it forces a working methodology in which creativity, innovation and imagination are given priority for approaching the problem and evaluating potential solutions. In a project-based environment procedures' systemization is forced, since the intention is that a project written by an expert author can be carried out in full by an expert author different from the author.The vision offered by a Project, as a point of implementation of the overall knowledge and abilities acquired throughout the degree is global from this point of view. Figure 1 shows this process schematically.

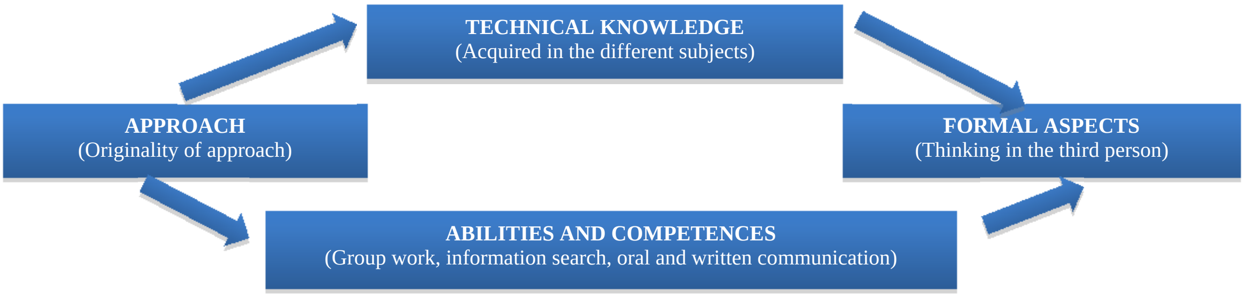

Figure 1: Project Process Diagram

Therefore, instructors of the subject of study think that the best way to "learn" that working sketch is by combining the acquisition of theoretical knowledge and a project's implementation, in order to face the most complex problems and at the same time to facilitate the acquisition of group working competences. These objectives are encouraged by means of developing a practical project, as a learning method.

Through the PBL, the student learns to learn, and the instructor coordinates and supervises the students' work. After an initial introduction of the most important theoretical concepts, the student undertakes the carrying out of a "Project". This is basically a work, mainly practical, in which both the subject's specific and cross-curricular competencies are developed.

2.2 E-Learning platform

Claroline is an Open Source eLearning and eWorking platform that allows to build effective online courses and to manage learning and collaborative activities on the web. It was initiated in 2001 by the IPM, University Pedagogy and Multimedia Institute from the UCL (Catholic University of Louvain, Belgium). The Claroline Consortium was born in 2007, the University of Vigo being one of its 5 founder members.

We have decided to use this platform called FaiTIC since it gathers specific and particular characteristics of the Content Management Systems, best known as CMS, such as being totally dynamic, highly configurable, versatile and simple when it comes to modifying its contents. It allows for almost instant administration of e-Learning courses and to undertake the control of the following tasks: to publish documents in any format (.doc, .odt, ppt, pdf); administrate and model discussion forums, both public and private; to administrate listings of reference links; create study groups; make practice exercises; structure and administrate an agenda of events, tasks and deadlines; control course users or students; administrate each course instructors; handle students' deliveries (documents, tasks, works, etc.); manage and store the Chats that instructor and students can establish; complete follow-up by means of statistics of the students in the classes; and assess through multiple choice system.

As it has been exposed, this platform where our online education method is developed allows us to set up different and varied activities and learning methods (individual and group) that will imply overcoming fear regarding the use and command of TICs and to put the learned concepts into practice. Apart from its tools, both synchronous and asynchronous, the platform allows us to track each student individually, as well as to set up group or individual virtual tutorials, thus serving each student's needs and respecting their learning pace. The use of a virtual environment for teaching the Projects subject is aimed at reinforcing traditional teaching, making use of the possibilities available to spread teaching material, to temporary link theoretic concepts and its practical application, to foster students' interest and to monitor their learning. In order to achieve these objectives, the teaching platform Claroline platform is established as the main virtual space containing different components linked to teaching the subject. It stands out for being user-friendly as opposed to other kinds of platforms (Casar, 2006; De Henao, 2007); it has been adapted to the instructors' needs by the University of Vigo and its maintenance is assured by a specific university service (FaiTIC) (Casar, 2006).

3 Case study

Background: until 2001, the Degree in Industrial Engineering, University of Vigo had the former 6-year long Study Program. In that Study Program, dated 1982, the Projects subject had 6 theory credits. When the new Study Program came into force in 2001 at the Industrial Engineering Schools, the degree went from 6 to 5 years, and the Projects subject has 3 theory credits and 3 practice credits. This Study Programme is still in force until the 5th course, where the Projects subject is taught, and degrees are being gradually introduced year after year, this year 2010/2011 being its first time at the University of Vigo. Each degree will last 4 years and the subject object of study will be taught in the 3^{rd} year in some degrees and in the 4^{th} in others.

This work introduces the way to adapt to this new approach in the Project subject, which has been chosen by a significant number of students, about 250 from different specialties and 6 instructors to evaluate them. About degrees, the situation changes significantly, since the students are already in different degrees by specialty from the 1st year and years are not so heterogeneous; furthermore, the number of students goes down considerably. This paper reports on the results obtained regarding approximately 50 students enrolled in a course. The name of the subject was *Technical Office and Projects* and will become a compulsory, common subject of the Industrial specialty of the 4th year, and will have 6 credits ECTS distributed as follows: 3 credits for lectures, 2.5 to lab classes and 0.5 for tutorials. Compulsory classroom activities will represent 35% of the student time, whereas distance-learning will do 65%. The above-mentioned are the essentials of this experience.

The study presented here has a 4-year time frame and is still developing. It is currently in its third year, even though only the first two years' experience will be analyzed in this paper. The final aim set for this experience, after the 4-year study, is the achievement of the competences included in the Verifica Datasheet (table 1).

Table 1: Competences to be accomplished by the student

Specific competences
Knowledge and capacities to organize and to manage projects
Becoming familiar with a Technical Office organization and working
Cross-curricular Competences
Analysis and summary
Problem-solving
Mother tongue oral and written communication knowledge
Information management
IT applied to curriculum
Capacity to organize and plan
Decision making
Application of nowledge
Autonomous learning and work
Planning changes that improve global systems
Adaptation to new situations
Creativity
Objectification, identification and organization
Critical thinking
Team work
Ability to communicate with experts in the field
Leadership

In order to ilustrate the educational methodologies used, the project carried out in the academic years 2008/2010 are presented next. With this aim the experience realized in each of these two years will be described:

3.1 First Stage: Project-Based Learning

The pilot experience of the Projects subject started in the academic year 2008/2009; it was taught to all specialties in the second term of Industrial Engineering. It was decided that all specialties started at the same time because the four instructors divided the subject by topics and the topic was taught to all specialties. In the current Study Program, this is a core, 6-credit subject (3 for theory and 3 for practice). The 230 students enrolled in the Industrial Engineering School were simultaneously assigned to one pf four groups for traditional classroom instruction (one by specialty), and and one of 12 laboratory groups for laboratory instruction carried out in the computer lab. Number of students per group varied greatly from between specialties. In the labs each student has a computer, which has supported students to complete their project.This first year the teacher-centered education model was changed to the learning method based on the PBL. This change implies that the student assumes more freedom of action and responsibility and the instructor makes the pace for the student learning process. An initial question was to explain the new teaching methods to the students so that they could understand and accept it despite being used to a traditional learning method. In order to do that, we tried to make the students aware of the objectives pursued and of the benefits to be attained.

Working groups of 4-5 students were established, the group setup being free; the intention was to facilitate class attendance in different groups independent of the working group, since most of the students in these degrees are enrolled in subjects from other years and it is therefore very common that lectures overlap.

We bore in mind that the proposed project fulfilled the characteristics that an appropriate PBL project should have: must be relevant and of interest for students, have clear objectives and stages and be complex in the sense of having different solutions and being interdisciplinary. Many situations of professional real-world can meet these characteristics. We considered making a planning and execution of an industrial building during the whole four-month term. The requirements had to be chosen by the group: they had to choose a town in Galicia, to get urban planning regulations, to choose the activity of the building, its classification, they also had to select a plot available for building, design the building, measurements, structural elements, budgets... Although they had to be validated by the instructor. Once defined, they were to be kept throughout the project.

The material resources available to conduct the project in practical classes were chosen by the instructors proposing, as an important methodological aspect, to foster students' participation in the development of the lectures, and therefore we chose commercial software, easily accesible by students so that they could work with them in class and during the hours assigned to them outside the class schedule.

A relevant fact is that the basics of project management and planning are developed in the first topic both practical and theoretically and it is that first topic where the work plan was established with several targets to be attained; for each target some documents reflecting carried out actions and obtained results were to be handed out. Groups were asked to use a common format in all documents containing at least: author, date, project, matter, version.

The Work Plan included:

- Delivery of documents regarding the project chosen and the responsibilities of each of the group's member on the specified dates. Some were individual and some group deliveries both clearly defined and planned. Preliminary design and prototype were defined by these partial deliveries.
- Final document delivery and public presentation of project by group including requirement specification, project planning, as well as tools and technologies chosen for the development with its corresponding justification.

The functions represented by the instructor in formal education and corresponding tutorials have been as follow:

- Propose the problem to be solved.
- Initially provide basic knowledge about topics.
- Play the role of the client commissioning the project.
- Critically assess the documents supplied in public presentations.
- Make interviews with the following aims: observe the correct development of the different project stages; check task distribution within the groups; make learning easy for students by asking questions or alternatives, trying to make students find possible solutions by themselves.

3.2 Second Stage: Virtual Learning

During the academic year 2009/2010 a further step was taken regarding the achievement of general or cross-curricular competences by students, including the use of TICs as tools to get the objectives set. The second year there were 219 students enrolled, group and student allocation followed a similar model as the previous year. The number of instructors has also been the same, four.

The instuctors apply various educational methodologies and teach them in such a way that the students can apply them in the rest of the disciplines. The methodological strategy was organized around a core of communication between instructor and students and also around the common work among students. Each student was assigned individual tasks, supplemented by additional group tasks that required collaboration. All these activities were assessed through different methods that will show the level of achievement of the targets reached (evidence) and that will be taken into account by the instructor, together with other factors such as participation. Working groups was the proper tool for the exchange of files and the distribution of support materials and in general for carrying out work in teams. Teamwork allowed the discussion, the constructive criticism and the search for joint solutions for the study of cooperative and the dynamics of group that was developed in the classroom.

Doubts common to the group were solved in the classroom and simulation techniques, laboratory practice, group dynamics, film-forum, role-playing activities, among other activities, were carried out as a supplement to the theoretical content. Furthermore, students have access to computer data searches and libraries collections through the platform.

These strategies imply learning through discovery in which instructors will act as guide and support, mainly bibliographic, combined with expository works, both by instructors and learners.Theoretical material was found on the platform and students could discuss about doubts, suggestions to broaden topics or any administrative procedure with other students or with the instructor through the forum. Also, students can individually access instructors by e-mail to solve any personal issue that may arise.The presentation of objectives, methodologies and procedures for following up on the subject was done the first day of the course in the classroom. The calendar of teaching and assessment activities is included in the tutorial published in the virtual learning environment, as well as the rest of teaching and assessment material that was followed from that first on-site class through the Claroline online learning management system.

Since 2005, the platform has been used in this subject only as a repository or for students to upload their works. The subject is split into fifteen modules of 2 hours each and four practice modules, 3-hour and two 9-hour respectively. The theory lectures last 2 hours and lab practices last 3 hours. Materials for study and complementary reading can be found on the platform in an organized way with the following formats: presentations, text files, rules, standards, latest news, drawings, images, videos, websites, etc. Also included is a series of activities related to competency assessment that will be explained in detail in the next section, as well as a forum to clear up any doubts. They can also be asked by e-mail or in person to the subject instructors. Figure 2 shows a screen shot illustrating the website at the end of the course the subject's presentation on the left and first teaching unit's contents and activities on the right. screen shot illustrating the website at the end of the course.

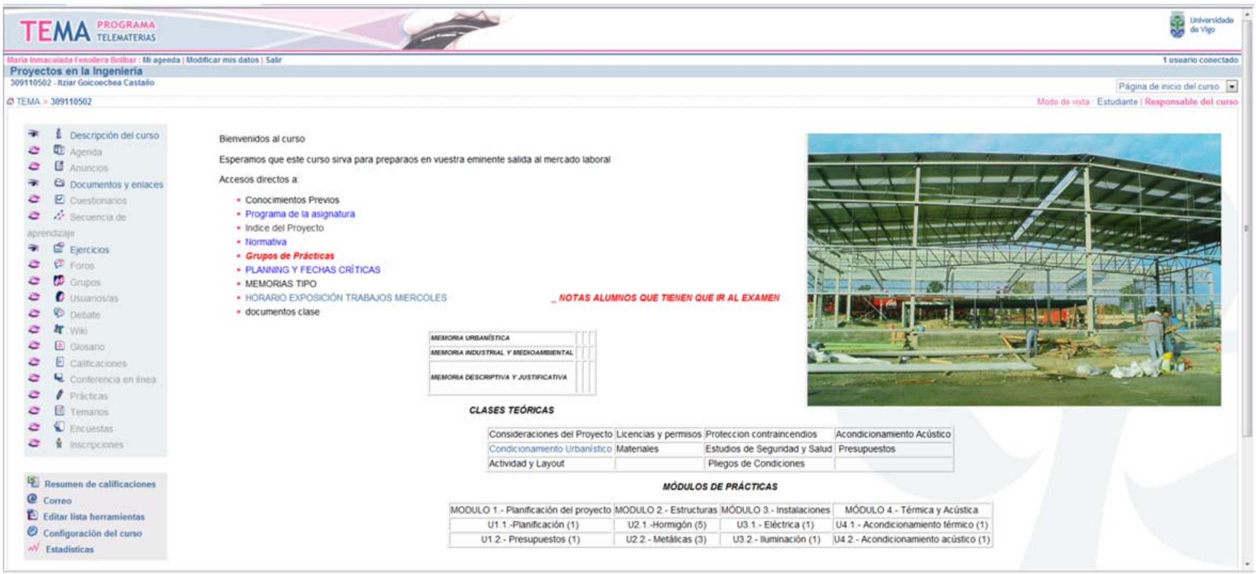

Figure 2: Virtual environment of the Projects subject. Year 2009/2010

Some assessment procedures have been established to check that competencies are attained:

- Multiple-choice test in labs, regarding key topics. Enable on-line assessment for a limited period of time and for all students at the same time. The aim is both to confirm the acquisition of specific knowledge and to attain some information searching and selection skills.
- Written report about a topic for study proposed by the instructor made through cooperative group work. It basically involved searching for information and creating a document in electronic format in which all group members participated through a suitable task distribution and keeping a uniform format and structure. The aim is to train students in group work competencies by using the Internet. The estimated time was 35 hours and a proportion was allocated in the final mark.

4 Results

Very good academic results have been obtained in this subject at the end of these two years, as it can be observed in Figure 3, with a follow-up and success rate close to 95%. The percentage of students that did not take the final test is in keeping with those students not following the continuous assessment procedure proposed in this experience suggesting that the change in the teaching method has been positive. Although it is true that the students complained (during their personal interviews in tutorials) about this new way of working requiring a bigger effort. This can be due to the students not being used to this and being more familiar with more structured works, with less freedom of action and responsibility.There was not a specific tutor by group, the four instructors tutored all the groups; this partly arose from teaching by topics instead of by groups. This implied a good coordination among them, which was hard in the beginning, since the students tended to repeatedly ask all the instructors about the same topics, searching for the one that made their work easier. Instructors' weekly meetings were set to sort these initial difficulties out.

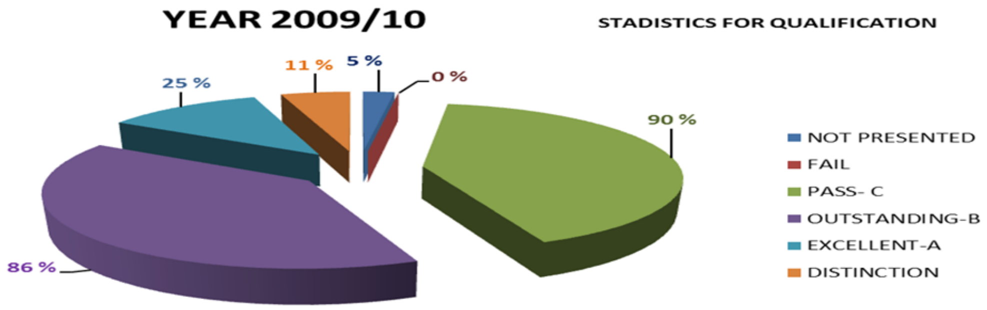

Figure 3: Year 2009/2010 academic results after a 2-year experience

The change in the tutoring method (the instructor contributes orientations, references, bibliography, aiming for the student to obtain answers himself) was regarded by some students as lack of involvement. Participating faculty expect that such feeling would diminish with more practice from the instructors and making more use of these active learning methodologies.

Another aspect that came to light was that some students felt distressed at not being able to do the project, mainly during the first year, because they saw the project as their first work of some magnitude, and this caused insecurity. However, from that year, the increased number of students requesting to do their final-year thesis with these instructors suggests they viewed the experience positively.

In the personal interviews, the students mentioned the problem of not having enough time. The beginning of the project was delayed in many groups, either because the project size was not correctly estimated and therefore there was a wrong planning, because the planning done was not properly conducted, or because the documents included in the virtual environment could seem excessive when compared to those of the traditional method. As positive, they mentioned continuous assessment, that is, the possibility of passing the subject with only one work, thus freeing themselves from the much feared final test. It could also be checked that the learning goals from previous years were not achieved, or that students were not capable of integrating and applying different concepts.

5 Conclusions

Instructors of the Projects subject are aware that drawing definitive conclusions from a first experience in a field can be risky and that most of the difficulties arisen were mainly due to students and instructors being unaccostumed. Anyhow, we would like to make the following comments:

- For the students, the proposed change is a step previous to the final-year thesis where they are expected to integrate their knowledge on a variety of subjects learned throughout their degree. Contribution has been made to stop seeing subjects as isolated, situation that is far from professional reality in which projects and problems require an interdisciplinary approach.
- Learning, group work, time management, oral and written communication are practised. Work is also distributed along the whole four-month term, avoiding typical end-of-term efforts.
- For the instructors, even though it has been a huge effort, particularly when it came to do group work for teaching, we consider this a good pilot preparing us to the goal set for developing and assessing the necessary competencies. The good results obtained encourage us to make a positive assessment.
- The scheduled three-hour working sessions, particularly for practical lectures, makes it easier for students to be immersed in the problem for longer periods. These experiences made them more aware of the context in real projects, where there is no jumping from one issue to another every hour..
- As it has been shown by this study, the use of virtual learning platforms is useful not only as a repository of material and learning elements, but also to enable class management, planning and competence-based assessment.

Despite the difficulties, the final result was very satisfactory. Although we are halfway toward the objectives set, we plan to use what we learned so far to make improvements to reach those objectives. Thus, this academic year 2010/2011 several online initiatives are being carried out, such as discussion and doubt forums, work and presentation templates and self-assessment tests. Aditionally, an assessment table or rubric is being conducted in order to assess cross-curricular competencies sought.

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Planning, Communication and Management tools for project-based learning using virtual teams.

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Abstract

The corporate world is being transformed into a virtual environment in which projects require collaboration among individuals located in different countries, with different cultures and time zones. The skills and abilities necessary for successful completion of projects in this virtual setting is a key requirement for graduates in technical areas such as engineering. How are universities preparing students for this environment? This article presents a project-based learning initiative implemented through the last three years as a course requirement for graduate students at the Master of Engineering Management imparted at the Department of Engineering Management and Systems Engineering at Old Dominion University in Norfolk, VA. The objective of the described activity was the integration of authentic experiences into the learning process through the use of technologies as part of a virtual team. Information and communication technologies offer tools that can help teams overcome communication barriers, geographic separation, and cultural and time differences. A good understanding and application of communication technology tools is critical in order to be a competitive asset in a global market. Technologies such as web collaboration platforms, shared web spaces, videoconferencing, instant messaging and discussion forums among others, allow teams to collaborate from distant locations. The initiative presented provides students with a unique learning experience aimed at supporting the development of team relationships, improving team communication and coordination, as well as learning the tools to support successful collaboration.

Keywords: virtual teams, collaboration tools, project-based learning.

1 Introduction

Current organizations face the challenges of a turbulent environment characterized by increased globalization and rapidly changing technologies. Successful adaptation to this environment is critical for sustainable success, and a workforce prepared to meet this challenge is key in maintaining a competitive advantage. Work teams in organizations are often globally distributed and comprise participants from multiple disciplines and cultures who rely on communication and information technologies. Organizations increasingly embrace these virtual teams and use a variety of information and communication technologies to support synchronous and asynchronous team interaction (e.g., chat, videoconferencing, email, group support systems, instant messaging, and forums). The change toward increased remote team-based activities has paralleled the growth of communication and information technologies that can be used to support those teams. Communication and information technologies are continuously emerging to support communication and collaboration among team members (citation).

Engineering programs across the world are being challenged to respond by developing programs that provide engineering students with the knowledge, skills and abilities necessary to succeed in this global and technology-intensive environment. Higher education institutions have been addressing these requirements with project approaches to engineering education. However, most project-based approaches have focused on face-to-face interaction among students. This paper describes an innovative approach to training students by using hands-on experiences that involve the completion of a project using solely online interaction and online collaboration tools.

Organizations hiring graduates expect engineering students to have a high level of technical skills, but also demand interpersonal, communication and cooperation skills, flexibility to work in different contexts and the capacity to manage projects with individuals in remote locations. Institution of higher education must meet these demands through pedagogies that foster these skills inside the classroom. This paper describes the development of a project-based course aimed at enhancing those skills through the understanding of organizational analysis and design and the development of skills necessary for successful remote collaboration as part of a virtual project team.

2 Context of the study

The course described in this study is a core requirement of a Master of Engineering Management (MEM) program that has been recognized several times, most recently in 2010, with the American Society for Engineering Management's award for Excellence in Academic Leadership. The MEM delivered courses to approximately 275 graduate students in the Fall 2010 semester. Most students are working engineering professionals and courses are offered mostly in the evenings (4pm to 10 pm). Although some students come to the main campus for instruction, many of them attend via web-conferencing from their own homes or work and from satellite campuses in several locations across the Commonwealth of Virginia, Washington State, Arizona. There are also students unaffiliated with a site who come to ODU for the flexibility of distance learning course offerings, some as remote as Iraq, Afghanistan, Djibouti, and Japan.

Activities described in this paper are part of a course in a master of Engineering Management program that focuses on organizational analysis and design. Some core areas in the course include organizational structure, organizational rewards and organizational learning. The course describe takes a project-based approach and one of the main course assignments is a group project as part of a virtual team (50% of the total grade). The product the students deliver is an individual project report, a group final project report, a project website and a presentation.

The objectives of this educational approach are:

(1) to provide the students the opportunity to work on a project with a similar level of complexity to that they might encounter after they graduate;

(2) to experience working remotely on a project as part of a virtual team;

(3) to select and use a range of communication media to complete the tasks of their virtual team project.

This experience enables students to plan a project, deliver a product, and deal with timelines from distant locations with the support of information and communication technologies (ICT).

Students are assigned to a virtual team of 4-5 students that collaborates remotely. They create a team website that includes all relevant project information such as: team charter, project plan, timelines, updated documents, resources, etc. This space is used for asynchronous collaboration during the project as well as a project document repository. The website development is scaffolded to insure that all necessary elements of the site are included. Figure 1 shows a screen shot illustrating a sample team website. Each site typically includes a discussion board, a project document folder, team members' information, project plan and activity tracking. Students receive a set of instructions on the required website features and instructions on web site development.

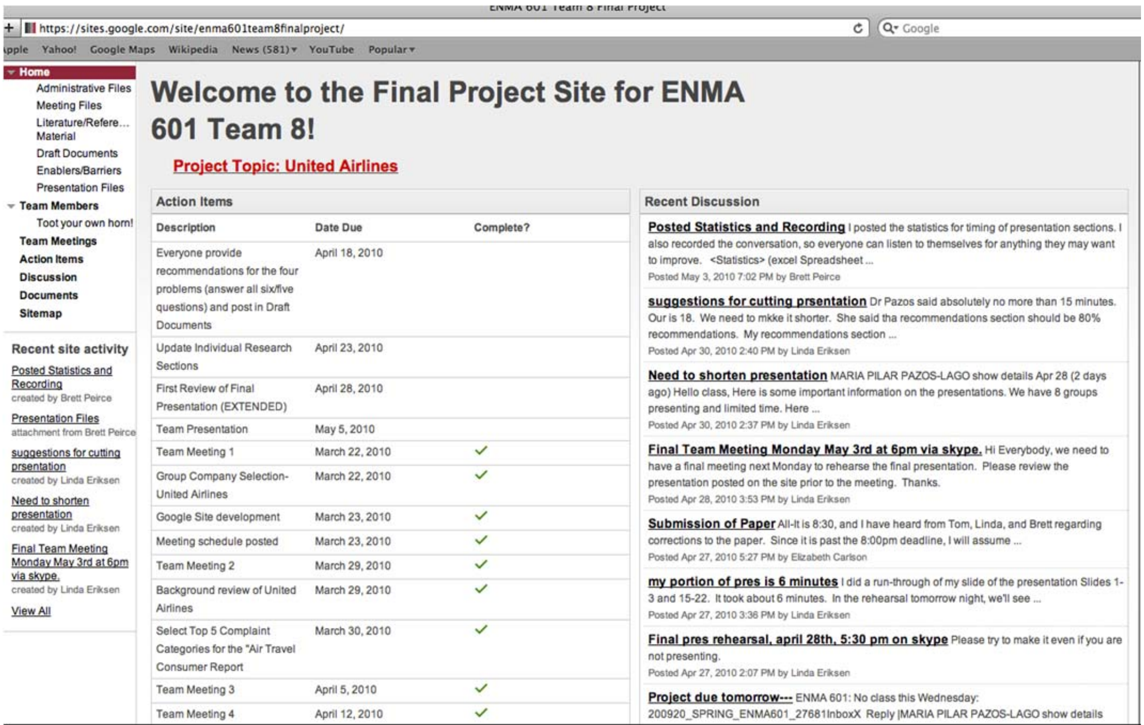

Figure 1. Sample team website

The technologies used in the course include the team's website, web conferencing, email, and a learning-management platform (Blackboard) that describes project requirements. Web conferencing is used for weekly team meetings. The technology allows for document and application sharing, text and voice communication and whiteboard among others. The students use the team website as the central repository for all the work related to the project. The learning management platform has the typical elements of course management and information including syllabus, course materials, project requirements, etc.

Portfolio of Technology It is especially important to provide a portfolio of ICTs from which the students can choose those that best fit the needs of the task they need to undertake. By so doing, the ICT does not get in the way of the team dynamic, and the team and subgroups within the team can maximize their productivity across time and space.

2.1 Assessment

The class lectures are available on-campus but also delivered via distance mode using Adobe Connect software. Critical skills are developed and applied during the project work. The objective of the team project is to conduct an analysis of the company, identify systemic problems and propose recommendations to address the problems.

Learning and assessment processes are integrated throughout the semester. The assessment consists of project team-based work, peer assessment, individual reflective reports, project updates and final presentation.

Grades were awarded for individual and group work as follows:

• a team final report grade based on the quality of the report based on a rubric with a fixed criteria;

• a peer assessment mark, calculated as the average of each the team members score. This encourages students to carefully consider their role and contribution in relation to the others while working in a team.

Essential features of the class environment include scaffolding so that students use different tools to interact with each other and with the class material. Cooperative interaction was achieved through bulletin board communication synchronous team meetings, collaborative planning and execution. As part of their tasks, teams have to develop a project plan and execute it, be able to elaborate their ideas and negotiate project terms with fellow team members as they would in a work project. This pedagogical approach fully aligns with social constructivist theories which suggest that learners build knowledge through interaction and conversation with others, enabling articulation, negotiation and reflection (English and Yazdani, 1999; Abrami and Chambers,1991).

2.2 Course tool and skill development

The described course used group-based project for its alignment to the learning outcomes that were sought. Project-based learning has been recognized for its role in enhancing professional and vocational skills and is has been described as a successful instructional strategy in a variety of contexts (Collis, 1997; Klemm and Snell, 1996; English and Yazdani, 1999).

The described project-based learning initiative involves a number of activities and tasks that are aimed at supporting the development of a number of key skills. Some of the activities involved include:

- Team charter development. The team works together to establish a team charter outlining expectations, behaviors and team norms. The charter is composed and signed by all team members.
- Project planning. Students are required to develop a team project plan outlining all activities, deadlines and responsible parties using a project planning software tool. The project plan is posted on the team's website.
- Peer evaluation. Having completed the project, the students are required reflect on every team member's role in the project (including themselves) and apply a given criteria to evaluate contributions by every member. The students are requested to provide a score in a number of criteria along with specific supporting information used to arrive at the scores.
- Collaboration. Each group consists of 4–5 members. The project requires members to organize themselves into teams who share the workload, undertake separate and collaborative tasks and maintain tight deadlines to fulfil project requirements.
- Communication. Team members are required to select and use the appropriate media to communicate based on the task on hand.
- Personal reflection on task and process. Each student develops a journal reporting their experience by describing the main barriers and enablers for accomplishing their goal, skills they have applied and developed, communication and coordination processes, and plan to apply what they learned.

Table 1: Course features

Course Tool	Elements and communication capabilities
Team shared website	Asynchronous communication Posting board for discussion topics or questions Announcements and Updates Document repository Task tracking Team member information RSS feed (inform team members of site updates)
Web conferencing	Synchronous communication Video, audio and text- based communication Application and document sharing (drafts, agendas, etc.) Pod to record meeting minutes
Course management software	Project requirements Course Materials Project expectations Project deadlines

2.3 Students' Perception on Project Experience

This section describes students' satisfaction with the project-based experience based on a 4-item survey. 103 subjects from four sections of a graduate level Engineering Management course participated in the study. Participants' gender was 75% male and 25 % female and ages ranged from 22 to 55.

Satisfaction. We used a measure of satisfaction based on the work by Van der Vegt, Emans, and Van de Vliert (2001) and Flynn, Chatman and Spataro (2001) to assess the overall team satisfaction with processes and outcomes. The questions were on a 1 to 5 Likert scale anchored with strongly disagree (1) strongly agree (5). The average of all questions was used to assess satisfaction at the individual level. We assessed the resulting reliability of the measure which was = 0.93 indicating a high level of reliability. The average level of satisfaction reported by the students was 4.18 with a standard deviation of .46. These results suggest the overall satisfaction with the process and the outcomes of the team project was generally high among participating students.

2.4 Lessons Learned

Many tools are available to virtual work teams that can be used to support goal setting and role clarity during the early planning stages and over the project lifecycle. During the three years of using this educational approach several tools have emerged as critical elements to support goal accomplishment for the teams. For instance, tools such as team charters have been extremely valuable in supporting team goal setting, and clarifying norms and expectations. Those charters should be developed and agreed on by all team members, visible, accessible, and ever present during the life of the project to increase goal clarity and commitment. Virtual teams should focus on creating a unified sense of purpose and identify available tools and technologies that can support them to accomplish that in the virtual environment.

One element of the project that was observed to support team members individual accountability was the used of a peer review system by which team members rated each other and themselves on a series of items dealing with project contribution. The peer review was incorporated as part of the grade in the final project.

Weekly project meetings were another critical element that supported teams' success. Meetings that included a clear predefined agenda and where meeting minutes were shared timely with the team were amongst best team practices. Most teams also had predefined roles as this was scaffolded as part of the project requirements. Most teams had a leader, a chief editor, a meeting manager and a web site designer. Typically students volunteered for these roles.

Even though team members worked remotely from their own locations, the researchers were able to track the team activities and progress on the team website. Teams were required to upload all project documentation on their site, which was also accessible to the instructor. This observation supported the idea that team members collaborated to accomplish the final outcome rather than dividing up the report in parts and piecing them together at the end. Teams were required to jointly identify the organizational problem and come up with an improvement plan and all teams followed that guideline.

3 Conclusion

This paper presents a project-based educational approach and discussed the key elements for the course design. The use of a hands-on project based approach to learning was used to add authenticity to the students experience and prepare them for future challenges in a team environment. The course described used synchronous and asynchronous collaborative tools, supporting a range of learning activities within a classroom environment. The main tools used by the teams and the activities supported by the team are described. We also outline some of the lessons learned from three years of experience in this project-based course.

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Model of project and design competences development in conditions of multilevel system of technical education

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Abstract

The article analyses the international and national requirements for professional competences of bachelors and masters in engineering and technology. The structure of key competences needed for successful project and design activity is formed. The model of project and design competences development implemented in Tomsk Polytechnic University is presented. The technology of technical bachelor training for project and design activity based on the principles of problem-based and project-organised learning aimed at active cognitive activity of students is described.

Keywords: training technology, project and design competences, structural and functional model

1 Introduction

Modern engineering field is characterized by development of high-tech industries and requires specialists of qualitatively different level, creative, able to independently solve production tasks that go beyond the prescribed standard situations and to consciously evaluate their performance, and having high communication skills.

According to the international requirements (Washington Accord Graduate Attributes and Professional Competencies, EUR-ACE Framework Standards for Accreditation of Engineering Programmes, CDIO Syllabus) for professional and general competences, graduates of educational programs in engineering and technology should be prepared to solve complex engineering tasks (preparedness to formulation, research, analysis of complex engineering problems and design of engineering solutions) and to conduct independent professional activity (execution of an important engineering project) (Boev, Gerasimov, Chuchalin, Kriushova, 2009; Chuchalin, 2008).

Modern concept of bachelor engineering education is so-called CDIO Initiative (Conceive, Design, Implement, Operate) developed at Massachusetts Institute of Technology (MIT) and containing a comprehensive list of requirements to the learning outcomes for technical bachelors. CDIO Initiative is based on the initial point that graduates of engineering programs should be able to “conceive-design-implement-operate” integrated engineering solutions in modern engineering environment based on teamwork, in order to create competitive programs and technical systems. In other words, graduates should understand engineering processes, be able to design and develop engineering products (Crawley, 2001).

In Russian higher professional education, standards that contain the requirements to learning outcomes for graduates of educational programs in engineering and technology are the Federal State Educational Standards (FSES HPE), criteria of the Association for Engineering Education of Russia (AEER) and the National Qualifications Framework of the Russian Federation (NQF). It is worthwhile noting that the FSES HPE and the AEER criteria fix preparedness of graduates for professional activity in accordance with the level of acquired competences, while NQF takes into account knowledge and experience that can be acquired through practical activity and additional education.

2 Project and design competences

Through comprehending the national and international requirements for bachelors and masters in engineering and technology, it can be asserted that project and design competence should become necessary and important component of outcome of professional education in technical university, including:

- ability to formulate and analyze problems in the sphere of professional activity , to develop generalized variants of problems solutions;

- ability to use modern project methodology (to carry out project activities): to formulate goals and objectives of a project, analyze and build structure of their interconnections; identify priority tasks of a project; choose grounded project solutions; conduct scientific and technical calculations taking into account constructive parameters of a projectable object or process; design integrated technical systems or devices with the use of modern computer-aided design; use methods of projection drawing; perform and analyze drawings and diagrams;
- ability to use modern design methodology (to carry out design activities): design sketches, technical and working drawings of products or technological schemes; draw up a specification; draw up project and technical documentation; draw up a finished project and design work in accordance with the applicable standards, regulations, technical requirements and other guiding methodical and normative documents in a professional field;
- ability to use modern information technologies for effective solution of project and design tasks;
- ability to assess economic efficiency (innovation capacity) of a projectable object or process.

Under these conditions, the major objective of modern system of technical bachelors and masters training is to form the set of “universal learning activities” that ensures mainly the “learn to learn” competence, ability of a person for self-development and self-improvement through conscious and active assimilation of new social experience, and not just development by learners of specific subject knowledge and skills within particular disciplines. And knowledge and skills are regarded as derivatives of the respective types of purposive actions, i.e. they are formed, used and maintained in close connection with the living activities of the learners. All these make serious demands on the organisation of educational process in university, including selection and implementation by teachers of appropriate teaching technologies based on activating, developing, problem, intensifying forms and methods of training.

3 Model of project and design competences development implemented in Tomsk Polytechnic University

To prepare students for future project and design activity, a structural and functional model (Figure 1) as the basis of technology of project and design competences development is implemented in Tomsk Polytechnic University. The model consists of the following units:

- organisation and methodical unit which includes competence-oriented educational and methodical package of documents on a discipline, using both traditional and active teaching and learning methods (problem-based lectures, practice-oriented classes, seminars-discussions, business games, intra- and interdisciplinary projects, including team projects);
- information and developmental unit which includes theoretical material of problematic and developmental character aimed at stimulating intellectual activity of students;
- practice-oriented unit which includes the system of educational and creative, professionally oriented heuristic tasks related to future professional activity of a graduate;
- project-organised unit which includes solving real production tasks with the use of computer programs of three-dimensional modeling, as well as methodical guidelines with definition of projecting goals, milestones and criteria for project work results evaluation;
- unit of independent work organization which includes materials for independent work including electronic educational resources (electronic media for educational purposes, lectures abstracts, methodical and control materials, etc.) that are posted on the corporate portal of the university;
- control and diagnostic unit which includes control materials bank including test tasks.

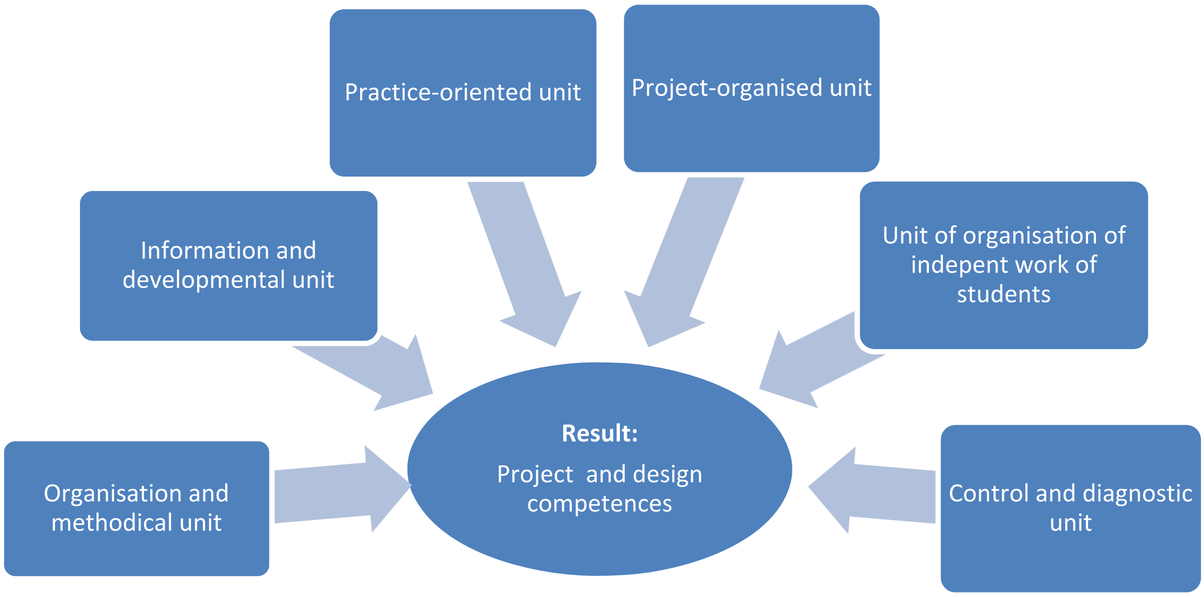

Figure 1: Model of project and design competence development

4 Technology of training of specialists in engineering and technology for project and design activity

The organisation of educational process in some TPU subdivisions is based on the principles of problem-based (orientation on solving of a specific problem through a project, student-centred learning, interdisciplinary, teamwork, experience learning) and project-organised learning in conjunction with various kinds of educational and cognitive activities (Lavrentieva, Fyodorova, 2003; Kolmos, 2002).

The main idea of the proposed technology is in the attempt to provide close connection of production and continuous process of students training for project and design activity (Figure 2).

From the study of general professional disciplines of the first year till the preparation of a graduate qualification paper, activities of students are connected with solving of practice-oriented professional problems that they are trying to solve on their own or in teams through project work (Safyannikov, Vehter, 2010).

Imparting of project activity culture from the first year of study allows students in the sequel to work productively both in interdisciplinary and integrated intra-university projects. At every stage of training the interconnection of different levels of preparedness of students for project activity by adjusting of goals and content of general professional and special disciplines is ensured.

The use of modern information technology is principal in the development of project and design competences. It allows expanding the scope of application of acquired technical knowledge in programming using systems of computer-aided design. The process of designing on a computer allows constructing necessary combinations easily and mechanically simple providing modularity of knowledge presentation. It is particularly widely reflected in the project-organised unit when projects are carried out by students with the use of modern computer-aided design facilities (Autodesk AutoCAD Inventor, 3D-MAX, Solid Works, CATIA) that makes it possible to automate the development of project and technical documentation as well as to perform 3D models of future products.

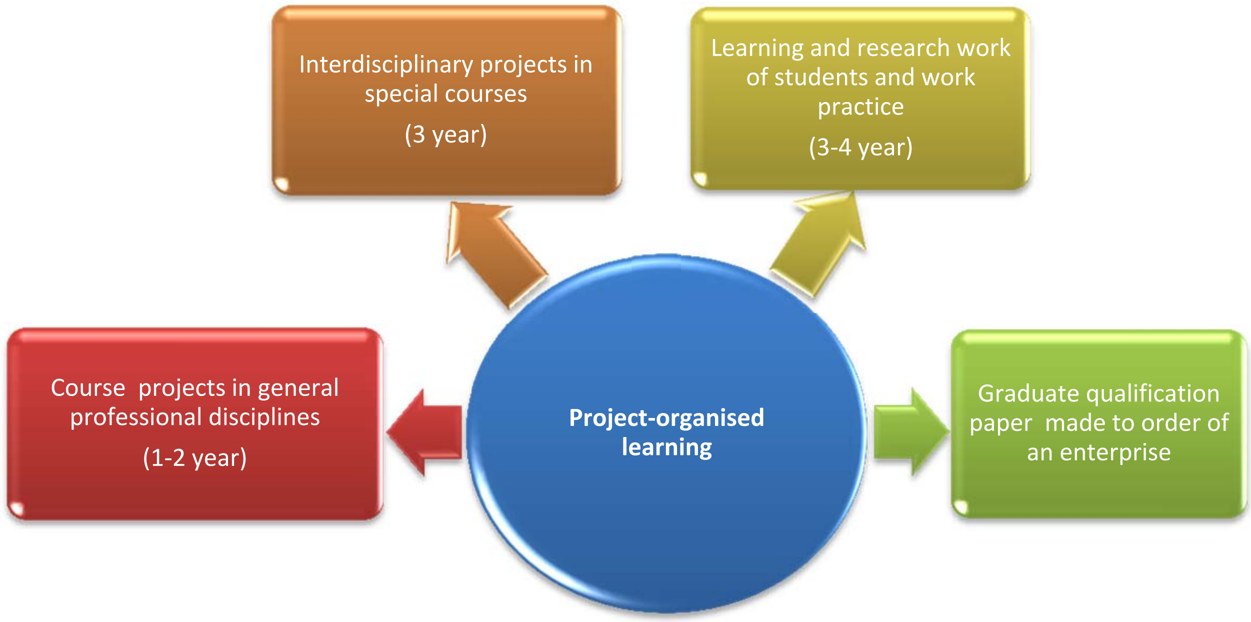

Figure 2: Kinds of learning activities oriented to preparation for project and design activity

The training on bachelor programs 130100 “Geology and Mineral Exploration” and 230400 “Information Systems and Technology” based on the integrative approach that supposes realization of three main provisions reflecting three sides of educational process - learning content, teaching and learning methods, and organizational aspect - is instanced (Gricenko, 2008).

Ensuring the process of prospecting, exploration and development of oil and gas fields is impossible in modern conditions without the use of complex, high information technology and digital three-dimensional models. Creation, maintenance and use of such models requires specialists who are highly qualified both in the field of geology and development, and in computer software complexes and systems. Therefore, inter-discipline integration is rather topical in the process of graduates training for future professional activity.

The basic discipline of the general professional series “Descriptive Geometry, Engineering and Computer Graphics” forms the basis of project and design activity. Practice-oriented educational projects and creative tasks of different complexity that allows determining the degree of student preparedness for project and design activity are used for project and design competences development. Graphical presentation of information due to a number of properties is unique in engineering communication process as professional information in engineering is presented through projects, schemes and models providing visualization of the studied materials. Therefore, descriptive geometry and engineering graphics is one of the basic general professional disciplines that develop representational spatial thinking and design competence of a future graduate, form knowledge and skills of “reading” drawings of parts and subassemblies of machines and apparatus, without which further training of bachelors in engineering and technology is impossible (Vehter, 2010).

In senior courses of the specified bachelor programs, knowledge from various subject areas - information technology and geology and mineral exploration - is constructively synthesized in the learning content. Integration of the concepts of productive and activity approaches is used in teaching methodology. TPU Scientific and Educational Laboratory of 3D Modeling is a link in the organization of educational process, serving the basis for real project work (Fyodorov, Ostankova, Zakharova, Chernova, 2006). Such projects teams involve students of two TPU institutes: Institute of Natural Resources (INR) and Institute of Cybernetics (IC) (Figure 3).

Training takes place through the process of modeling of oil and gas fields when digital 3D geological and 3D hydrodynamic models are designed on the results of data collection and analysis (Zakharova, Yampolskiy, 2009; Zakharova, Yampolskiy, 2010). As a result, a complete set of project and design documentation in accordance with industry regulations and instructions is developed.

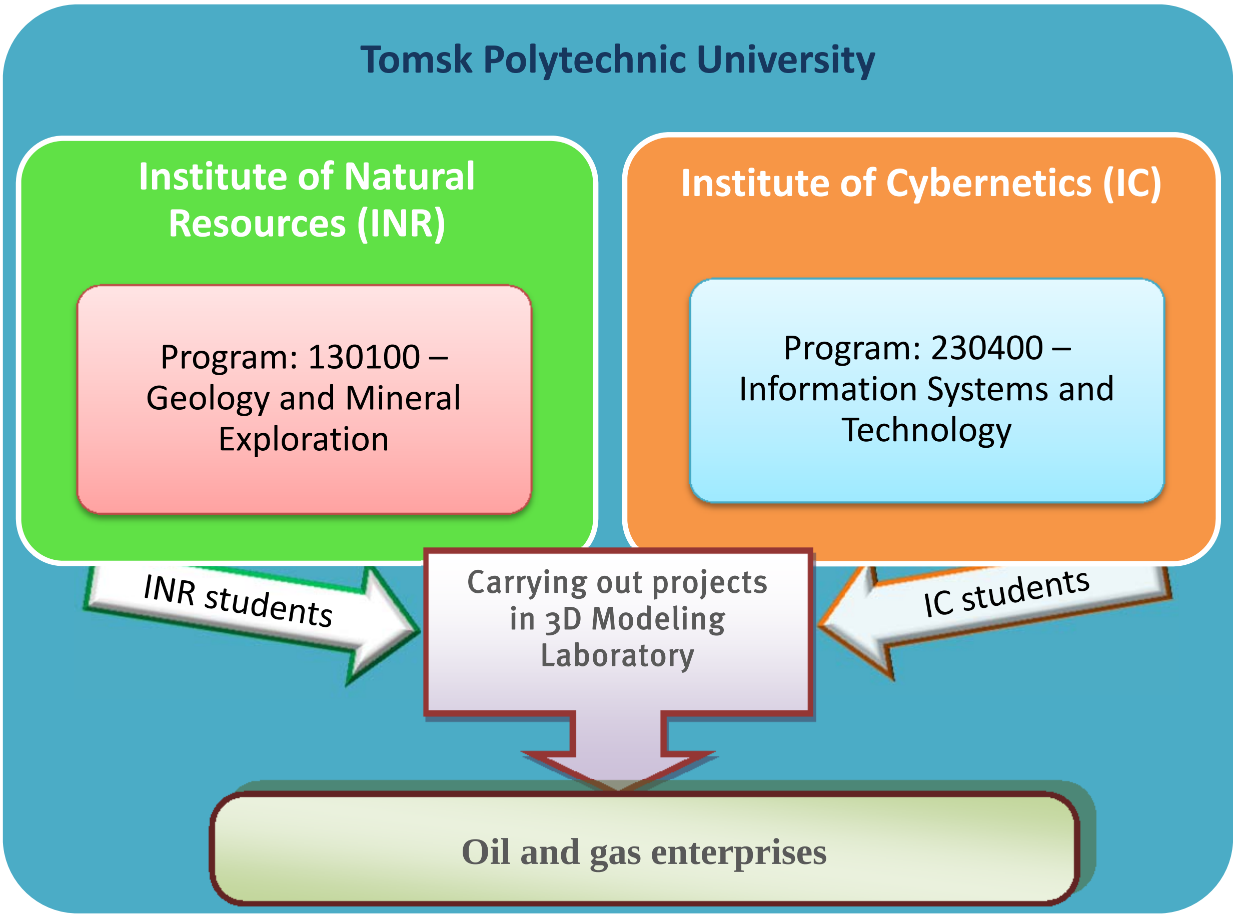

Figure 3: Integrative approach to TPU students training

Implementation of the proposed technology is achieved in stages. On the first stage students are offered an integrated information block: INR students study courses in information systems and technologies, and IC students – core courses in the field of geology and development of oil and gas fields.

On the second stage, students of both programs study complex information technologies applied in industrial oil and gas companies, and on the third - apply their knowledge and experience on the basis of real data in such projects as the calculation of hydrocarbon reserves, projects of development of specific oil and gas fields, etc.

5 Results

Students (student teams) work results in student scientific research work and graduate qualification papers. Efficiency and quality of such training is confirmed by the active participation of students in conferences and seminars of various levels, diplomas, certificates, grants, scholarships, etc. Implementation of the proposed approach to educational process organization develops student professionally significant competences as well as such universal ones as critical thinking, teamwork skills, ability to competently set goals and make independent decisions, to communicate with the specialists of other subject areas in the process of cooperation, etc.

To combine knowledge and skills of students of two programs already at the stage of basic professional education is very promising approach that allows in the modern conditions to prepare the teams of highly qualified specialists in demand of oil and gas companies, providing their fast adaptation to the professional activities in the workplace.

The implementation of this approach has already given positive results:

1. With participation of Scientific and Education Laboratory of 3D Modeling in the educational process, more than 40 projects for oil and gas companies were carried out at high technical level. All projects are the development of real oil and gas fields that were examined by relevant scientific and technical

divisions of oil and gas companies and state commissions on resources and development, and transferred to the customers for practical use, thus ensuring high professional level of these specialists.

2. Functional relations between teachers of different disciplines working together to achieve common goals contribute to formation and development of professional and pedagogical competences of teachers in development and implementation of original methods in educational process. And training is conducted within the framework of the adopted regulated state educational standards and programs.
3. Base for further research and development within the framework of master theses and dissertations preparation is being created.
4. Teamwork under the supervision of teachers from different areas allows organizing quality training of students for future project and design activity considering all industry requirements and standards.

In any industry there is a need for highly skilled personnel with competences in interdisciplinary areas. These areas include oil and gas area that requires from a modern specialist both competence in management of prospecting, exploration and subsequent development of oil and gas deposits and abilities to use modern information systems and technologies for modeling each stage of development of oil and gas fields.

On the other hand, specialists in the field of information technologies graduate from many universities every year with mastery of mathematical apparatus, easily and quickly mastering latest information facilities, but not able to adapt quickly at the enterprises due to lack of practical knowledge and experience in solving industry production problems.

It necessitates formulating and formalizing a wide range of topical problems that a specialist in one subject area is not able to handle. Moreover, because works under way are real industrial problems, students interest to them greatly increases, understanding of importance and demand for the complex of knowledge that is offered to students in the all course of study at university arises; this knowledge is consolidated and considered by example of real and not abstract tasks.

6 Conclusion

Thus, from the foregoing follows that the integrative technology of training of bachelor in engineering and technology for future project and design activity based on the principles of problem-based and project-organised learning contributes to successful professional activity of a technical university graduate. The statement is based on the point that it takes into account the characteristics of future professional activity of specialists and is aimed at development of their abilities to natural and quick adaptation to fellow employees and quick mastering of the most advanced high technologies.

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INTERNATIONAL SYMPOSIUM ON PROJECT APPROACHES IN ENGINEERING EDUCATION

Students' Judgment in Initial Phases of Industry Projects

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Abstract

This paper presents an investigation into the Cognitive Apprenticeship (CA) model of applied learning and evaluates its application in the development of student judgment from the supervisors' point of view undertaking an analysis project in final year. The research for this paper is performed through the use of reflective journals where the students are required to answer a wide ranging set of questions. These questions are designed to encourage students to reflect on their understanding of both the project and the process of systems analysis. This paper reports on the supervisors reflections on the journal submission by students shortly after initial client interviews in which they reflect on their understanding of the project problem and goals, team interaction, team management and interaction with their supervisor.

Keywords: Industry Projects; Cognitive Apprenticeship; Information Systems; project approaches.

1 Introduction

The term "cognitive apprenticeship" was used by Collins, Brown and Holum to describe the idea of synthesizing the more traditional apprenticeship model of instruction with the teaching of more conceptual subjects in the educational environment (Collins, Brown, & Holum, 2006). They provide a general framework to guide the development of teaching using the cognitive apprenticeship approach. The cognitive apprenticeship model is a set of guidelines and suggestions on how teaching can be approached. It is more appropriate in areas of complexity and judgment and not in areas where the learning matter is relatively straightforward. This research is based on this model and applied to final year industry project. The aim of the project is to develop students' expertise in information systems analysis by exposing students to realistic environments, working with supervisors experienced in systems analysis. Students are formed into teams and work in the role of information systems analysts with industry clients on real world organizational problems. The learning environment created aims to be as close to professional practice as possible so teams deal directly with their assigned industry clients. Academic supervisors regularly meet with the student teams throughout the project and following the cognitive apprenticeship philosophy, encourage students to verbalize and explore their understanding and misunderstandings across all aspects of the project. This provides an opportunity for the supervisor to offer appropriate advice and guidance.

Requirements analysis and design (RAD) for information systems development projects involves defining the problem, analysing and determining the requirements and proposing high level solutions. RAD in real world projects is described as a "wicked problem" because it is likely to be complex and often "characterized by incomplete, contradictory and changing requirements, and solutions that are often difficult to recognize as such because of complex interdependencies" (Collins, Brown, & Holum, 2006). It is unlikely that their previous academic experiences have prepared students very well for real world projects.

The methodologies taught in information systems courses are suitable to teach beginners but, in practice, experienced developers adapt and modify these methodologies or develop new ones as required by the project based on their expertise and experience. Several authors involved in education haven noted that students "have difficulty handling ambiguity and vagueness, which can arise during knowledge elicitation". They also "have difficulty analysing problems where there is no single, simple, well-known, or correct solution" (Degrace, & Stahl, 1990; Fitzgerald, 1998). Analysis and design subjects challenge students to think at a metacognitive level (e.g. thinking about thinking) but many students struggle to understand such abstract concepts (Hadjerrouit, 1999; Yazici, Boyle, & Khan, 2001; Chilton, Mchaney, & Chae, 2006).

Schon makes several points about design which is relevant to teaching. Firstly, he suggests that it cannot be taught by describing the process but instead must be learned through practice. Secondly, it is a holistic skill and the parts cannot be learned in isolation. Thirdly, it depends on having an understanding of which properties are desirable and undesirable in the context of the problem space and this can only be learned by doing (Schon, 1983). Design is a creative process and as such requires seeing and doing things in new ways.

Given the arguments above, a suitably supportive learning environment is required which recognises the particular challenges and difficulties faced by students learning RAD. One such approach is that of Cognitive Apprenticeship (CA) which uses the idea of synthesising the more traditional apprenticeship model of instruction with the teaching of more conceptual subjects in the educational environment, hence the descriptor "cognitive" (Brown, Collins, Holum, 1991). They provide a general framework to guide the development of teaching using the cognitive apprenticeship approach. The framework addresses four areas: content, methods, sequencing and sociology. The area of content is broken down to domain knowledge, heuristic strategies, control strategies (also called metacognitive strategies) and learning strategies. Methods relate the possible teaching strategies which can be employed for teaching and these include, for example, modeling, coaching, scaffolding, articulation, reflection and explanation. Key features of the cognitive apprenticeship approach are the provision of learning in realistic settings, the supervision of students by someone with practical experience and recognised competency and an interactive environment of mutual dialogue in which students and supervisors try to make explicit their understanding and thought processes so that tacit knowledge and assumptions are made explicit.

This research involves providing a learning environment aligned on CA principles to students doing final year industry projects predominantly involving RAD information systems development. Students are formed into teams and are required to address real world problems with clients from industry. This provides an appropriate context for learning about RAD. The aim of the research is to study the development of students' understanding and skills in RAD as they progress through their projects and the usefulness of the CA environment in this development. The research for this paper is performed through the use of reflective journals where the students are required to answer a wide ranging set of questions. These questions are designed to encourage students to reflect on their understanding of both the project and the process of systems analysis. The focus of this paper is on the supervisors' reflections on the students' judgment in the initial phases of their industry projects. In the following sections the research methodology and the final year industry project unit of study are described. This is then followed by analysis of responses by the supervisors achieved through interviews.

2 The Industry Project

Students are provided a project provided by a client working for a real organisation with a real problem to be addressed. The client provides a description outlining the client's perception of the problem and expected outcomes. The problem and its scope is almost certain to need a great deal of clarification and may well change, the expected outcome will need to be negotiated between the client and the team. These descriptions are not modified in any way by the subject convener. The projects are initially screened and chosen by the subject convener to ensure that they are broadly appropriate in terms of type of project, scope and time frame for completion. The problems require analysis, investigation and recommendations but do not require implementation since teams take on the role of analysts and not developers. Experience with previous projects demonstrates that many clients find students' work of significant value to them and act upon the reports provided by students. Students work in teams of three to five. There is a common lecture time of up to two hours per week which discusses topics such as presentation skills, report writing, small group dynamics, personality types, client interaction, interviewing and so on. Each team has an allocated time with their team supervisor which students must attend every week and which typically runs for around 30 minutes.

Students are allocated to teams by the subject convener at the start of semester. The subject convener tries to align the skills sets of students to those required in a project but, in practice, it is probably more accurate to suggest that obvious mismatches are avoided.

2.1 Student Backgrounds

Team projects are used to prepare students for the IT industry. These projects are offered to students from a wide variety of undergraduate and postgraduate courses but in every case students take the project in the last year of their course. The project runs for one semester only (12 weeks) and counts as one subject in their course of study. As a guide, a student enrolled in the (undergraduate) Bachelor of Business Information Systems is required to complete 24 subjects in total in order to qualify for the degree. For a postgraduate student it will be one subject of a 12 or 16 subject course. Depending on the student's course and personal situation a student could be doing up to four other subjects at the same time in which the time that can be spent by a student on their project can be quite limited.

There were 35 students enrolled in industry projects. Students are enrolled in a variety of degree programs. Some programs have a strong Information Systems emphasis (e.g. Bachelor of Business Information Systems) while most others typically have some combination of Information Systems type subjects and more technologically based subjects. There were 19 students in the undergraduate courses and these were mostly local with a few international students. Some students have had approximately 10 months placements in industry in IT roles as part of their degree program. There were 16 postgraduate students and the great majority of these students were international students and had a prior degree which was very often technical (e.g. programming, networks) in nature. All international students have been studying for at least a year at Swinburne but that does not mean that they will necessarily be totally familiar with Australian culture and norms. Overall, there were 29 male and 6 female students.

2.2 Supervisor’s Role

The supervisor’s primary role is as a coach and, according to cognitive apprenticeship principles, oversees the students by “choosing tasks, providing hints and scaffolding, evaluating the activities of apprentices and diagnosing the kinds of problems they are having, challenging them and offering encouragement, giving feedback, structuring the way to do things, working on weaknesses”. Teams are expected to be proactive and largely self-managing so supervisors should expect to adopt a fairly passive style by acting more as mentors or guides. Supervisors also act as role models, at least from a professional perspective. It is well known that espoused views of professional practice do not necessarily match actual behavior (Schon, 1983).

Assuming it is not deliberate deception, this may be because it is difficult if not impossible to prescribe what one should do in every circumstance; it may reflect that a person may know how to do something but is not able to articulate it effectively; or it may be an attitude of mind or intuitive reaction to events of which a person might not be aware. People learn more than they might imagine through simple observation. While much learning will be conscious, there is also a subliminal aspect as well. Students observing supervisors as they discuss situations, react to events and handle particular situations will pick up behavioral cues which may be assimilated unconsciously.

3 Research Methodology

Given the interactive nature of the researchers as participants in the learning process, the focus on problem determination and aim to improve the outcomes of students undertaking this type of industry project in the future this is action research. The research methodology uses a qualitative interpretive approach in which analysts (supervisors) describe their thought processes, attitudes and approaches to addressing problems. Students’ behaviour and artefacts produced through the journal submission are observed and examined by their supervisors. Supervisors then provide their own interpretation and understanding of events by comparing and contrasting students thought processes, attitudes and approaches to addressing problems with their own. The research makes use of multiple data gathering techniques (Denscombe, 2007; Yin, 2009). The data collection methods include students structured journals, documents submitted by teams, interviews with project team supervisors, peer assessments and observations by the action researcher. Of these only the supervisor interviews are relevant. Three main research blocks comprising of a number of question in each block were investigated through supervisors’ interviews. Each block was setup around a particular theme to encourage the supervisor to explore the issues. The first block is based around the students' first interview(s) with the client, the second block is about the students' understanding of the task and standards, and the third is about the supervisors' interpretations of "professional attitude" as a requirements analyst. The three blocks of questions are shown in table 1 below.

Table 8: Interview question blocks

Block 1	Block 2	Block 3
How well did the teams handle the first interviews? Consider how they prepared for, executed and followed up. What appeared to be lacking or poorly executed? How well do they appear to understand the problem, scope, requirements and the business context? What principles or values do you apply when deciding how well the teams are doing on this issue?	Do students appear to have a satisfactory idea of the task, how to go about it and standards to be achieved at this stage? If not, what aspects do they appear unsatisfactory or misguided?	We aim to develop a “professional attitude” in students meaning a number of qualities regarded as appropriate and effective in a particular field. What are your observations about students’ attitudes to the project and team work at this stage and are these attitudes significantly at variance from what you would regard as professional?

4 Result & Analysis

This section reflects on the student experience and supervisor's reflections on the student's judgements in the initial phases of the industry projects. The reflections are grouped into eight categories as shown in figure 1 below.

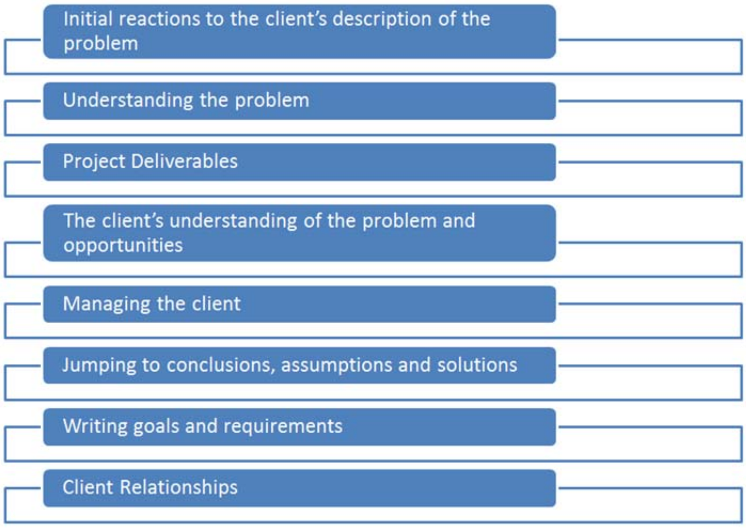

Figure 2: Reflections Categories

4.1 Initial reactions to the client's description of the problem

Expert supervisors approached the problem description by placing it into one or more broad problem categories, such as business process improvement or software package selection with which they associated various approaches and issues. Thereafter, while they might be aware of vagueness or ambiguity in the problem description they were not overly concerned by this and saw it as something to be resolved later. All expert supervisors flatly refused to consider potential solutions. Students were less able or slower to categorise the problem and less aware of the most appropriate approaches and issues that might arise. Students' early emotional reactions to their project varied. Some became very apprehensive because they couldn't see an immediate solution or because they didn't understand the problem description or because they couldn't see precisely what needed to be done. One supervisor for example described the following situation: "*I had one group and the girl went into panic mode after the first meeting with the client. It was a good group they were quite good students but she just went off the deep end in terms of 'I don't know what they want; they don't know what they want'.*" Some became very confident if they believed they had a solution to the problem or how to approach it. Students were less likely to see the project as a journey with an imprecise endpoint and more likely to see it rather like exam question with a "correct" answer.

For those students that became particularly apprehensive supervisors would try to reassure them that the difficulties they perceived were a normal part of the project. Generally supervisors did not attempt to deflate students' confidence but would warn against coming to conclusions without having obtained all the facts.

4.2 Understanding the problem

Prior to meeting the client supervisors read the client's problem description carefully gathering as much information as they could from it and expected to have to do some preliminary background research on the client, their organisation and the problem domain. They had a good awareness of what they knew, what they had to find out and actively explored for as yet unknown factors which might be relevant to the project. The majority of students were not as diligent in their reading of client's problem description nor did they appreciate the value of doing some preliminary research prior to approaching the client. Many teams perceived their first meeting with the client as the start of their project and would have been poorly prepared if not for their supervisors. One supervisor for example commented, *"You have to ask the right questions. You have to show an element of understanding of the industry. I always tell the students before you go to see the client look at the website. See if they've got a website. Get an understanding of what the business is all about. If there's no website find similar organisations just to get an overview of what they're trying to do".*

Sometimes students realise that they don't understand the problem as posed by the client but they don't have the appropriate strategies that allow them to come to the understanding. One of the supervisors had a team that was in such a position and the supervisor was able to guide them by suggesting what sorts of questions needed to be asked and what research needed to be undertaken. Expert supervisors have developed very good strategies in this area and this is where the supervisor can provide invaluable guidance to students many of whom would be floundering without this guidance. After teams interviewed their client, the same supervisor commented that students may believe that they understand the client's problem but this is not necessarily matched by their actual understanding. This lack of understanding can sometimes be found out when the supervisor discusses the teams' interview with the client or possibly when reviewing the interview questions and answers which teams are expected to provide. One supervisor's observation was also that some students didn't know the more fundamental questions that they needed to ask the client and their questions were superficial and potentially off track. For example, if a client indicated that they wanted to survey staff then questions about who they wanted to survey and what they wanted to achieve by surveying them were more fundamental questions than how many staff were to be surveyed and the questions to be asked. To help them with understanding the problem and asking the right questions the supervisor encouraged his students to provide a draft of the students' proposed interview questions which he would review with them and explain how to rewrite or restructure them as necessary.

The same supervisor viewed difficulty determining solution scope as symptomatic of lack of understanding of the problem. PK described the situation in which students in one team could not determine an appropriate solution scope and traced this back to the fact that they did not fully understand the problem. He determined that the team had not asked the right questions in their interview and then had to go back to the client to clarify the problem.

4.3 Project deliverables

Sometimes teams understood the client's problem but had difficulty grasping or appreciating the project deliverables. For example one of the supervisors worked with one team that was focused on issues related to building software even though their project deliverable was to establish the requirements of the software. As the supervisor mentioned "*They certainly had the issue with it being a requirements type analysis unit and not build… No matter how many times I told them. The ramifications of that took a while to actually sink in…. They had to be dragged back and hammered that this is a requirements analysis*".

4.4 The client's understanding of the problem and opportunities

All supervisors saw the analyst's role as one of helping the client to determine and solve their business problems and not blindly implementing clients' requests. Students often approached the client's problem description as being definitive. On the other hand, supervisors tended to approach it more as starting point potentially subject to further (and perhaps heavy) revision or even rejection. For example, one of the supervisors stated that *"the problem statement given to them by the client is from the client's perspective but often what happens is that buried underneath [is] that the problem statement given by the client is superficial"*. As an illustration of this, this supervisor described the situation with one of his student teams in which the team was requested to research and to recommend a particular type of software package. From this supervisor's perspective, in this particular case the client had described a solution to a business problem rather than the problem itself which had not being articulated. This supervisor saw his role as analyst was to dig a bit deeper and to determine why the client wanted to implement the proposed solution. As it turned out, what the client asked for would not have solved the client's underlying business problem and thereafter alternative solutions were explored. As his supervisor put it, you need to ask the "Why?" questions.

At times supervisors saw their role as an educative one. Particularly in the case of small to medium enterprises, clients may have a limited understanding of the capabilities of the latest information technology and application software. This may mean that they are unaware of potential opportunities or describe a very limited scope in their problem description. Another supervisor, in a common situation, described one project in which a small retailer requested a very modest website enhancement in the hope of increasing his sales. This supervisor however encouraged his team to explore further possibilities and together with the client developed a more ambitious plan which included online sales and marketing with which the client was delighted.

4.5 Managing the client

A consistent theme across all supervisors was the idea of managing the client. Supervisors viewed managing the client not as telling them what they needed but rather one of helping them clarify their needs so as to develop a clear problem description which could be used to then formulate achievable project goals. Managing the clients could happen in a variety of ways. DB for instance mentioned that the client could be vague and was not able to articulate clearly defined tasks and standards. In this case managing the client related to working with them to develop a clear description of the problem, deliverables and standards. Sometimes the client could be solution focused as mentioned earlier and needed to be guided back to describe the business problem or opportunity. From there requirements could be established and suitable solution found. Sometimes a client can have grandiose plans that are in no way achievable given the time and resources available to the students. In this case a common approach is to accept the client's vision but to reflect it back to them in the context of a long-term strategy and what could be achieved in one semester was one step towards implementation of the client's vision. One team had a client whose original plan would have taken several experienced developers several months of full time work to develop. In another example, one supervisor described the situation where the client attempted to increase substantially the originally agreed scope of the project and again the approach was to accept the client's vision and put the original agreed scope as a step towards that larger vision. All supervisors agreed that it was important to show tact and diplomacy toward the client and to demonstrate that they had heard what they had had to say. One supervisor pointed out that it was dangerous to simply ignore the client’s wishes because then "*the clients will believe that the project is a failure because you haven't delivered what they wanted*".

If clients do not take the students very seriously, managing the client can be more difficult even if students are saying and doing the right things. One supervisor for example described the situation where a client insisted on being given cost estimates for a solution to his problem. The students were clearly not in a position to give since they had not even properly established the requirements yet. The supervisor explained what they needed to tell the client however the client still insisted on cost estimates and students were at a loss as to how to handle this situation. However, when the supervisor met the client and gave the same explanation, the client accepted it immediately. The youth and inexperience of students can sometimes be an issue with some clients as they perceive them as lacking authority (or as one of the supervisors stated “gravitas").

As the one of the supervisors pointed out, “*it was not the job of the analyst to criticise a client's business plan even though it might appear ill-conceived. In this case one has to proceed and still do the best job possible”*.

4.6 Jumping to conclusions, assumptions and solutions

Supervisors were good critical thinkers in that they emphasised the importance establishing clear goals, gathering evidence, considering the reliability of any evidence, were very aware of potential biases in whatever they read and heard, looked for and tested assumptions and regarded that coming to conclusions or recommendations should be the result of well-reasoned argument. Students varied in their critical thinking skills. Some struggled to establish clear goals when they were not provided them. Some didn't appreciate the importance of gathering evidence or possibly did not have the experience to appreciate the reliability or importance of particular evidence. Often they did not appreciate the extent to which what they heard or read was biased by the interests or the perspective of the source. Often they were unaware of their own assumptions or those of the client until it had some impact (typically negative) on the project. Finally, while some clients were willing to trust the recommendations or conclusions of students on the assumption that they knew what they were talking about, the supervisors themselves expected high standards from the students in terms of being able to justify their recommendations or conclusions.

With regard to interviewing, one of the supervisors commented that it was important to ask the more fundamental questions first and then proceed to ask further questions in the light of what was learned. One of the teams that he supervised made an incorrect assumption about the nature of the project and based their entire first interview with the client around that assumption. This assumption was not tested until the end of the interview and so the interview turned out to be largely a waste of time because of irrelevant questions and misinterpreted answers.

A problem encountered by another supervisor with one of his teams was that of becoming “solution bound”. As he described it “*When I first met them from their perspective they had already solved the problem. They were solution bound. They hadn't thought very deeply about the problem. They had a solution and they were trying to make the solution fit the problem.”* From this supervisor’s perspective the problem was not that their solution was necessarily wrong but that they had stopped absorbing the issues related to the problem which might have caused them to look more widely at alternative solutions. In this situation, the supervisor made clear to the team leader that he disagreed with their approach and why.

4.7 Writing goals and requirements

Supervisors were very particular that writing goals and requirements must be as clear, precise and measurable as possible. From their experience in industry, the goals and requirements were essentially contracts with the client. Poorly written goals and requirements can easily become a source of dissatisfaction, disagreement and possibly legal action. One supervisor found it was common that students wrote scope statements that were vague, did not reflect what the students actually intended to do or too ambitious to complete in one semester. “*The way you word it [the scope statement] becomes very, very important particularly in a contractual arrangement because this is what you are committing to do. … What I do is I won't allow it to go to the client until I've been through it”*. In these cases he would point out what it was that they were in fact agreeing to do for the client and then worked with them to write more appropriate scope statements which they would then have to negotiate with their client. Similarly, another supervisor often found that requirements statements were vague or subjective. As an illustration he mentioned that a common requirement of this type was that software be “user-friendly”. Whether a piece of software is user friendly is very subjective and so he would require students to either provide some sort of standard or agreed test that could be applied or if that was not feasible then to nominate who would decide whether the software was user-friendly or not. One supervisor believed that writing goals and requirements was not something that was easily taught. “*In terms of learning things like scope statements and business reports I don't think you can really teach that - it's very hard to teach. You can provide exemplars but part of the learning is learning on the job … To some extent certain things must be learned on the job.”*

4.8 Client relationships

Supervisors adapted their approach or role to the clients depending on what the client wanted and also on the evaluation of the client. One supervisor stated that “It is necessary to evaluate the client and determine their understanding of the problem. From there you need to determine your relationship with them” This role might change as the project developed. This supervisor suggested several possible roles for the analyst. At times they might be "experts" providing specialist knowledge and skills, at other times "doctors" diagnosing problems and suggesting solutions and at other times "educators" teaching the client about the state and possibilities of relevant information technology. Students had little, if any, experience and had to rely on their own preconceived mental model of the client-analyst relationship. The most common role model that students appeared to have was that of the expert who would talk to the client and, with relatively little effort, be able to come up with the right answers. Although students were, at this stage of their course, actually quite knowledgeable and did have some reasonable skills, this model of the analyst meant that they put themselves under a great deal of pressure and was unrealistic (seen in the light of the experience of their supervisors). Their lack of experience dealing with real business problems meant that they were not well prepared to handle this type of role. Some students were disinclined to take on the role of educator. Those that were disinclined to take on this role might do so because they perceived the client as socially superior to themselves and trying to “teach” the client was uncomfortable or perceived as potentially rude. On the other hand, some students had no such inhibitions and had to be warned by their supervisor not to “lecture” the client. One supervisor, for example, mentioned situations when students “tried to demonstrate their superior knowledge and skill [in IT related matters] in a blatant and possibly condescending manner”. All supervisors emphasised the importance of developing a good relationship with the client if the project was to have any chance of success. As one supervisor mentioned *“there is an element of trust that has to be built up between the client and the group and … the client won't just open up and do a complete dump of everything. They will hold back until that element of trust has been developed.”* Being respectful and maintaining a professional attitude toward the client at all times (whatever their personal feelings about the client) was essential if the client was to develop trust. Some of the points made by supervisors to students were to dress appropriately when meeting clients, being punctual, ensuring that all written communications were well thought out and checked used appropriate fonts, formatting, and logos, following up on undertakings to the client and that students kept in regular contact with their client. This same supervisor states: *“If you act in an unprofessional way with the client you lose credibility with the client.”* Another supervisor described the relationship of the analyst as that of working with the client in order to help solve the client problem. Part of this attitude was to "bring them along" as the analyst worked through the project with the client.

Finally, all supervisors demonstrated a great commitment to helping the client. For example, one supervisor stated “a professional attitude is about achieving effective results and not just trying or going through the motions”. He was particularly opposed to students who looked at their project in the same light as a university assignment and satisfying the client as secondary to satisfying their assessors. Another supervisor emphasised certain personal values that he found important as an analyst. These values were honesty, integrity and caring but, as he put it, “how do you teach honesty, integrity and caring?”

5 Conclusion

The interaction between students, industry, and supervisors is a key component of the cognitive apprenticeship model. What this research suggests is that it is important that supervisors and students play their roles appropriately and effectively. At the same time, it is important that industry, students, and supervisor have clearly defined roles in the project life cycle. In order for this to happen, the roles to be played need to be explicitly stated from the beginning so that there is no misunderstanding which we have observed can lead to conflict or inhibit students interacting effectively. Furthermore, supervisors in consultation with the industry partners must adopt strategies and techniques which will create and maintain the free sharing of ideas which underpin the cognitive apprenticeship model.

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INTERNATIONAL SYMPOSIUM ON PROJECT APPROACHES IN ENGINEERING EDUCATION

Project Management Guide for Student Project Teams

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Abstract

Project based learning is a methodology based on students' teams developing interdisciplinary work to deliver an outcome as a result of a project. The engineering students' teams when performing project work have to adopt project management methodologies. Assuming that the quality of the results on project work is also dependent on the project management methodology applied and that project management is one of the competencies to be developed during engineering degrees, this paper presents a project management guide to be followed by students' teams involved in large projects. This project management methodology is the result of the experience of students and teachers involved in project based learning practices in the last 6 years in the engineering school at the University of Minho.

Keywords: Project based learning (PBL); Project management methodology; Team work; Engineering Education.

1 Introduction

The Portuguese Ministry of Science, Technology and Higher Education (MCTES) refers as essential the adoption of an educational system favoring the development of experimental work and project work competencies (MCTES, 2008). They are also in favor of adopting active learning methodologies in cooperative and participative environments and focused on problem solving. The learning outcomes expected in engineering education go beyond the technical competencies listed in traditional engineering programs. Besides the specific technical competencies associated to a professional area, the transversal competencies related with communication, project management, team work, autonomy, etc., are also relevant competencies to be achieved by engineering students. Project Based Learning (PBL) is one of the learning methodologies more effective in creating this range of competencies (Helle, Tynjälä, & Olkinuora, 2006), (Lima, Carvalho, Flores, & Hattum-Janssen, 2007) and (Powell & Weenk, 2003). PBL is becoming a quite popular learning approach in many Engineering universities across Europe and in many other countries in the world because is an effective way of motivating students to work while promoting cooperative learning, critical thinking, communication competencies, project management competencies, learning by doing, autonomy research and engage students in investigating authentic problems. All these competencies are more than welcome in the organizations.

The quality of the deliverables in project work and the learning effectiveness associated depends on a great deal on the project management methodology adopted by the students' team as well as on the team member project management competencies. The size of the projects that we are considering in this article is large enough to be highly dependent on the project management effectiveness.

When a project is assigned to a team of students without appropriate project management training, which is normally the case in many engineering education institutions, students' teams tend to assume intuitive approaches resulting normally in poor results. The students' teams from the department of Production Engineering and Systems at the University of Minho normally perform typically quite well in the first 2 or 3 weeks and then they tend to lose part of the control of some tasks and of what every member is doing. Some of the problems that we recognise as common among student teams undergoing large projects are:

- The motivation, although starting with high levels in the beginning of the project, gradually decreases along the semester. Sometimes the motivation increases again at the end of the semester.
- Very frequently the objectives are not clearly understood by every member.
- Very little effort is given to planning.
- Very little effort is given to monitoring.
- The work load is not levelled along the semester.
- The work load is not assigned equally to every team member.
- The initial plan is not followed nor adapted along the semester.

- The focus on the original objectives is frequently lost.
- The tasks descriptions and assignments are frequently fuzzy.
- ...

Assuming that all these difficulties that are typically connected to project work carried out by student teams and also assuming that it negatively influences the results and team performance a project management methodology was developed aiming to lead students' teams to achieve better project results.

The objective of this paper is to present a project management guide proposal specially oriented to teams of engineering students involved in relatively large interdisciplinary project following the Project Led Education principles (Powell and Weenk 2003). As a relatively large project we consider a team of 6 to 8 students involved in a project corresponding to half of the semester total work. In the context of the Bologna process a new credit system was defined based on total learning work, including the work developed in direct contact with teachers and work developed in autonomously way: European Credit Transfer System – ECTS (European Commission, 2009). Considering that in our Engineering Scholl 1 ECTS is equivalent to 28 hours of work, a half semester project has 15 ECTS and corresponds to a minimum of 2520 hours*man. This methodology will allow the teams of students to be more effective in project work as well as developing solid project management and team management competencies.

2 Project Management Guide Proposal

For MIEGI's students have contact with practices and develop competencies in project management, it is intended to present a project management guide designed for supporting teams with a set of forms. This guide will allow students to apply project management techniques, guiding them in this process. In the creation of this guide, there was the concern to provide a tool, easy to understand, little bureaucratic and easier to use by students teams.

The proposed guide is supported by forms, guidelines and procedures in order to help students in the project management process as well as in the inherent records during the project life cycle as can be seen in Figure 1. In this work a project life cycle for students was developed that is based on three fundamental phases: initial, intermediate and final.

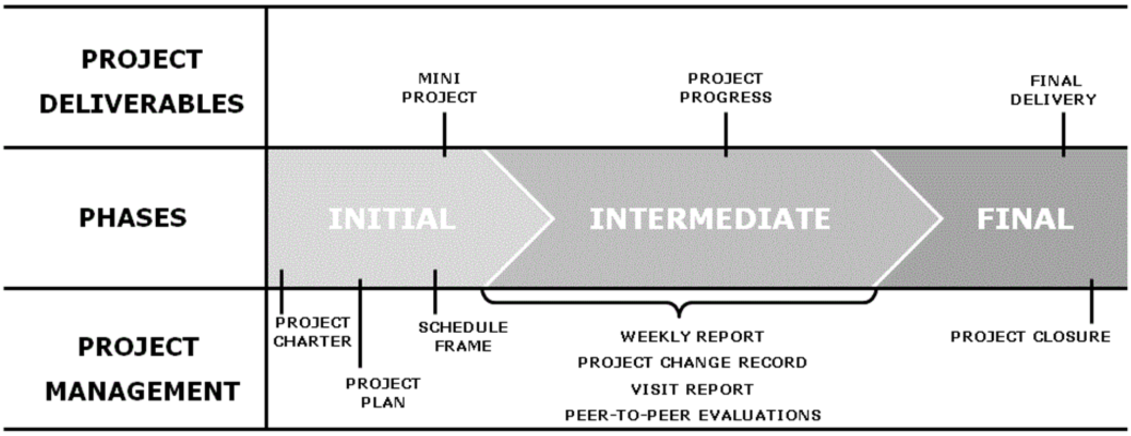


Figure 1: Students' Project Management Framework – based on PMI (2004).

The forms are categorized as follows: General Information, Project Charter, Project Plan, Schedule Frame; Weekly Report; Visit Report, Project Change Record, Peer-to-Peer Evaluation and Project Closure. In parallel with the forms, students have access to detailed explanations, including examples, of how to fill them and when they are required. Thus, students can apply project management techniques designed specifically for these kinds of projects.

2.1 Initial Phase

Project Initiation phase is characterized by the project approval and by project planning. For this purpose, it is necessary that students understand how important it is to spend time and effort in project planning, mainly to define activities and refine the project objectives.

The coordination team starts the semester presenting objectives and general guidelines of an open project. After this presentation, the teams should meet to share ideas and experiences, to choose the team Leader, if necessary, and look for support from teachers and tutors in order to fill the GENERAL INFORMATIONS form. This form contains general information about the project, such as the project theme, the team members, the team leader and the team tutor, the courses involved in the project and the coordination team, as well as the identification of the company when applicable.

Throughout the first week, team members should meet several times to discuss and reflect about the project and related issues in order to complete the PROJECT CHARTER form. Thus, teams should identify the project stakeholders, the general and specific objectives, the project scope and its milestones. Figure 2 shows an example of the specification of general objectives and scope contained on PROJECT CHARTER form. The PROJECT CHARTER is a document intended to formalize the beginning of the project and it must be filled in a meeting and approved by the team leader and team tutor.

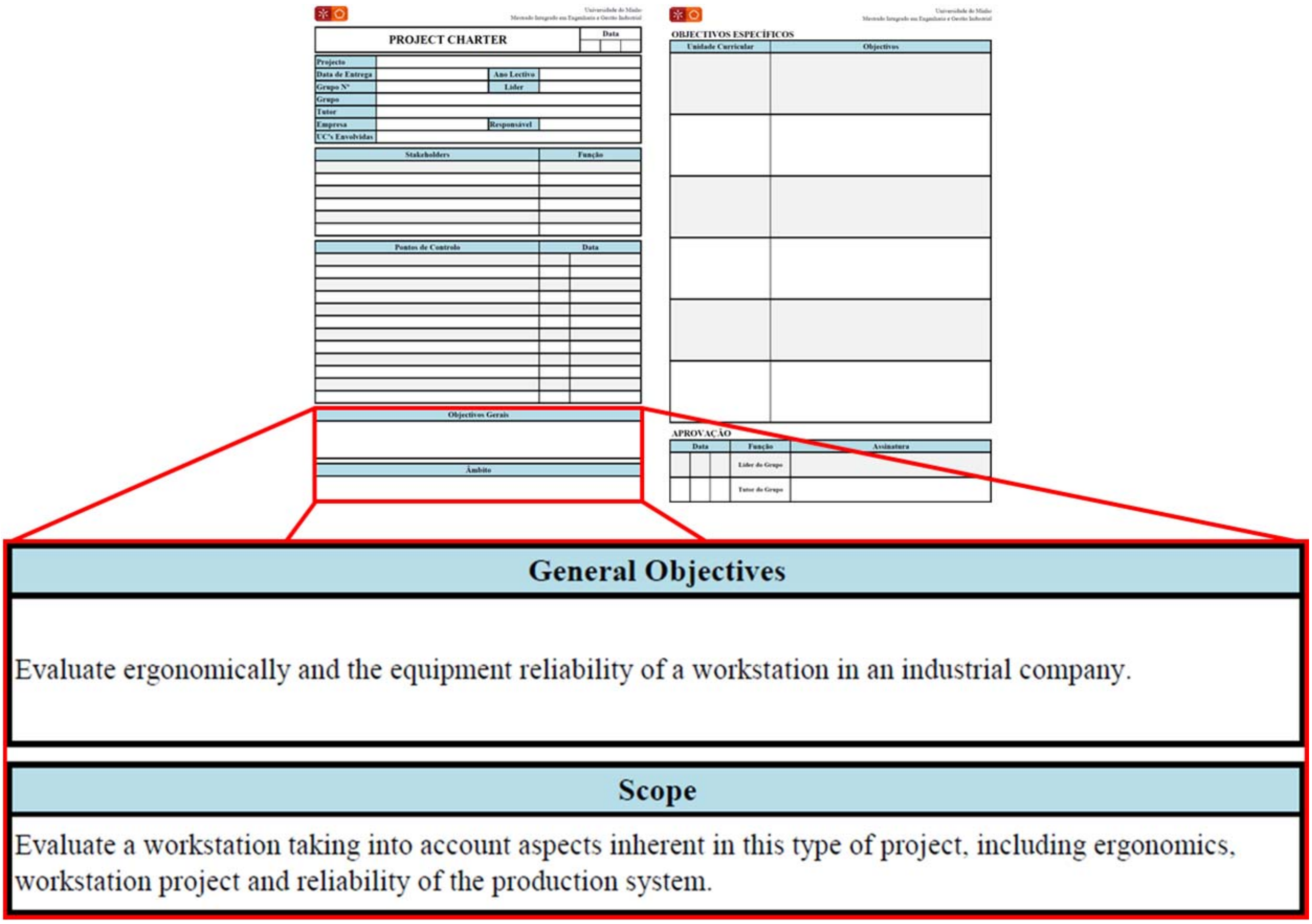
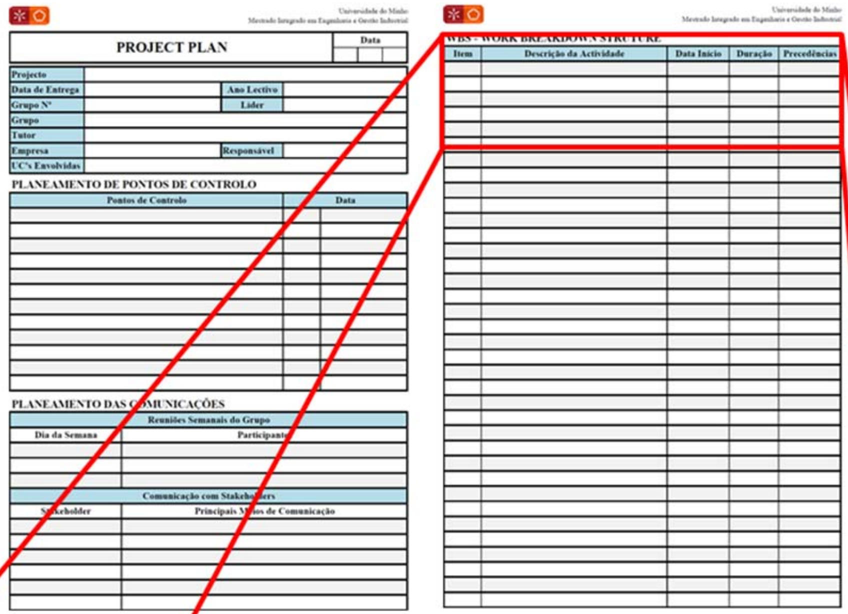


Figure 2: Extract from Project Charter form - example of Project General Objectives and Scope

In the same first week, teams must also dedicate time to make a plan for project and fill the PROJECT PLAN form. This form aims to support different planning aspects: milestones, communication between stakeholders, schedule meetings and create the WBS (Work Breakdown Structure). Figure 3 presents an extract of WBS included on PROJECT PLAN form. During the project, there are expected changes and updates of this form whenever is necessary.



WBS - WORK BREAKDOWN STRUTURE

Item	Activity Description	Start Date	Duration	Precedences
7	Ergonomic analysis of workstation	23-03-2011	8 days	-
7.1	Illuminance analysis	23-03-2011	2 days	-
7.1.1	Measurement of illuminance in the workstation	23-03-2011	1 day	-
7.2	Noise analysis	26-03-2011	2 days	-
7.2.1	Measurement of noise in the workstation	26-03-2011	1 day	-
7.3	Thermal environment analysis	30-03-2011	2 days	-
7.3.1	Measurement of temperature in the workstation	30-03-2011	1 day	-
7.3.2	Measurement of relative humidity in the workstation	31-03-2011	1 day	-
...	...	...	...	...
11	Study of proposed ergonomics improvements	25-04-2011	5 days	7

Figure 3: Extract from Project Plan form - example of WBS (Work Breakdown Structure)

Alternatively, the WBS can be created with suitable software, for example, Microsoft Office Project. To create the WBS, the team should identify all the activities that should take place throughout the project, although the project progress may cause several changes in the WBS.

Within the context of the PROJECT PLAN it is suggested the filling of the SCHEDULE FRAME, which consists of a tabular board where information can be printed and where team members can stick small pieces of paper (post its) with relevant information such as the identification of activities, responsibilities and deadlines, as shown in the Figure 4. Being a visual tool presented on the team project area (where the team spends most of the working time) this board aims to keep a permanent overview of the progress of the project. This visual tool aims a more effective planning and control of all project activities.

In this framework, the milestones, vacations and holidays must previously be filled with highlighted colors. Alternatively, those who create the WBS and a Gantt chart using project management software application can print it and use it as the tabular board background with a similar effect as the board suggested above.

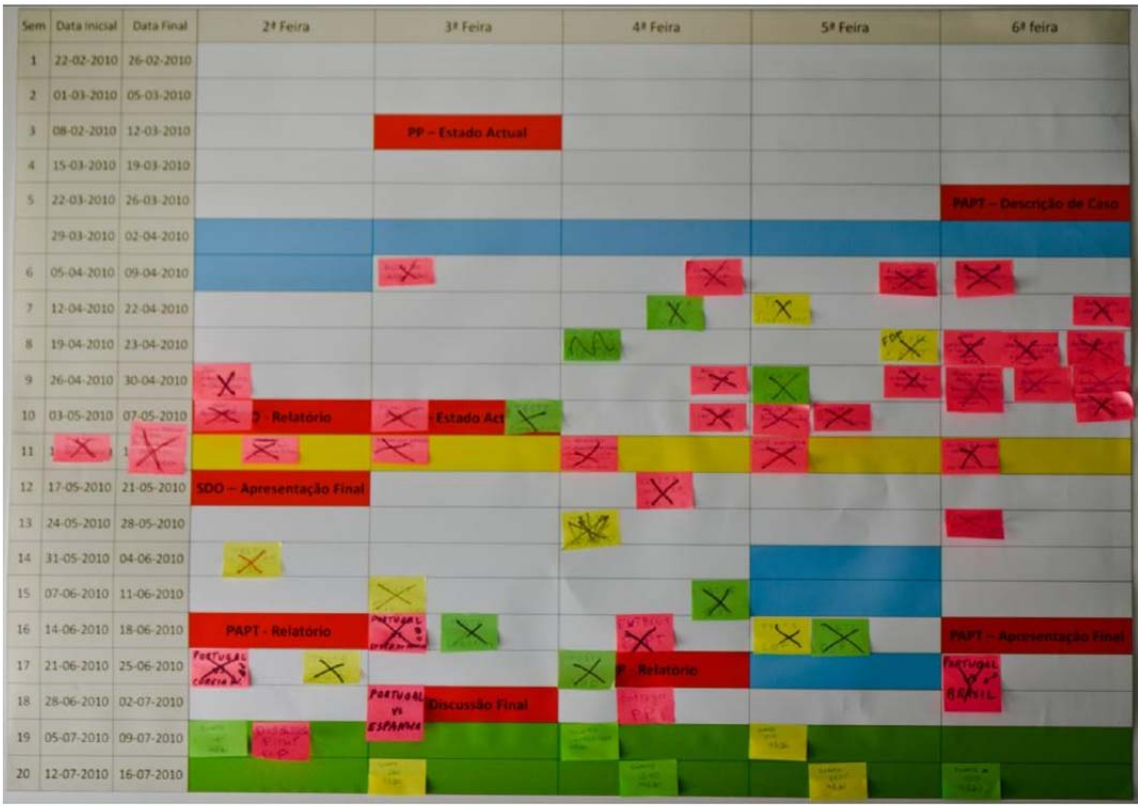


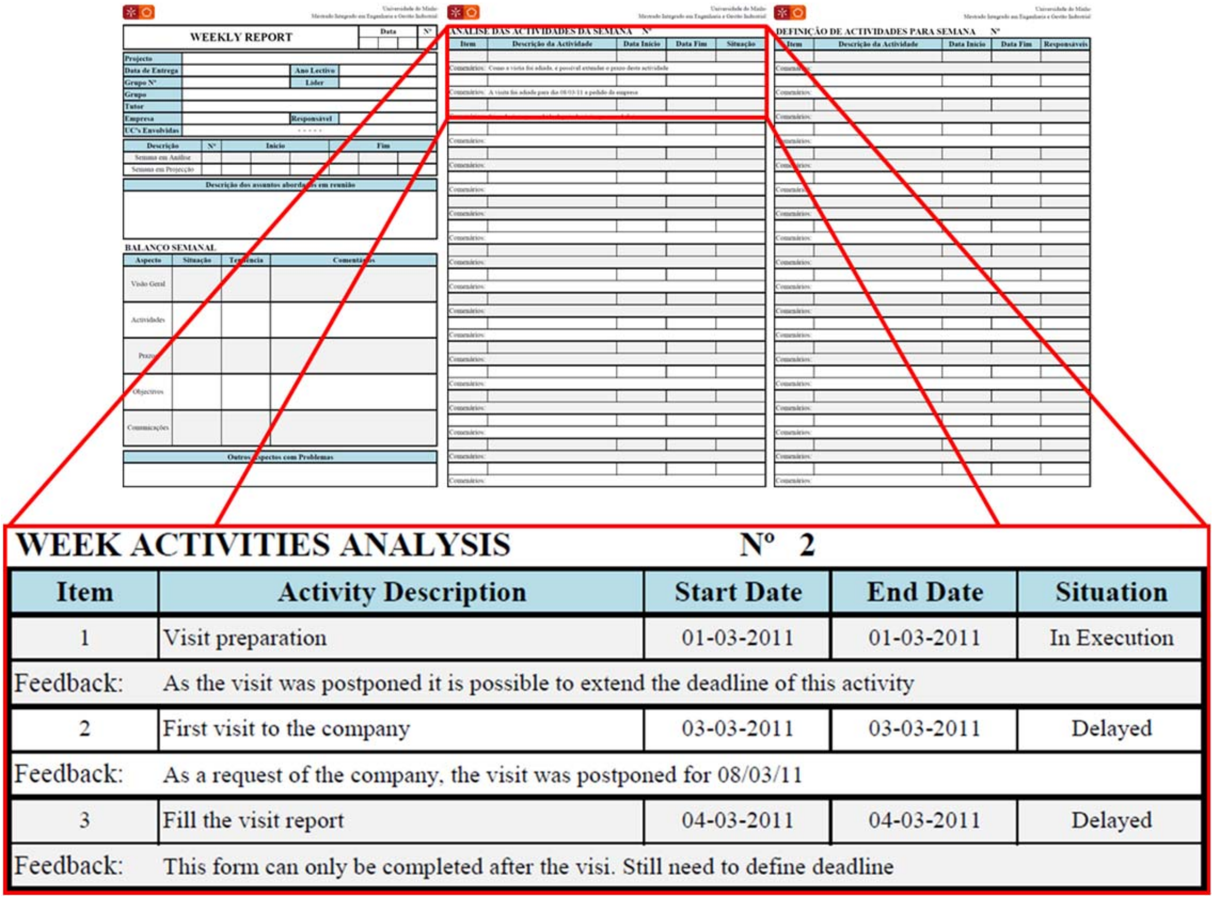
Figure 4: Example of Schedule Frame used by a team last year.

2.2 Intermediate Phase

The intermediate phase of the project life cycle is characterized by execution and continuous planning and control of the processes, so teams should monitor the progress of the project and introduce changes to ensure that the objectives will be reached. As shown on the framework of figure 1 we assume that the same management routine should be followed every week. In this way and in weekly terms, teams must fill in the WEEKLY REPORT form, which is designed mainly to focus and record relevant information from the previous week and plan activities for the following week, providing an overview of the project progress and performance.

The teams should reflect on the week under review and conduct an evaluation on the following aspects: Overview, Activities, Deadlines, Objectives and Communications. For each aspect the teams should refer its situation (Without Problems; Under Risk to have problems; with problems) and its trend (Stable; Improving; Getting Worse), in order to characterize each one of the aspects in evaluation. Moreover, teams should analyze in detail the activities undertaken in the previous week as shown in the Figure 5 and refer the situation of each of these activities (Done; In Execution; Delayed; To Begin).

Concerning to the next week, the teams should reflect on the activities to be undertaken in the same week, indicating who is responsible for each activity and its deadline.



WEEK ACTIVITIES ANALYSIS Nº 2

Item	Activity Description	Start Date	End Date	Situation
1	Visit preparation	01-03-2011	01-03-2011	In Execution
Feedback:	As the visit was postponed it is possible to extend the deadline of this activity			
2	First visit to the company	03-03-2011	03-03-2011	Delayed
Feedback:	As a request of the company, the visit was postponed for 08/03/11			
3	Fill the visit report	04-03-2011	04-03-2011	Delayed
Feedback:	This form can only be completed after the visi. Still need to define deadline			

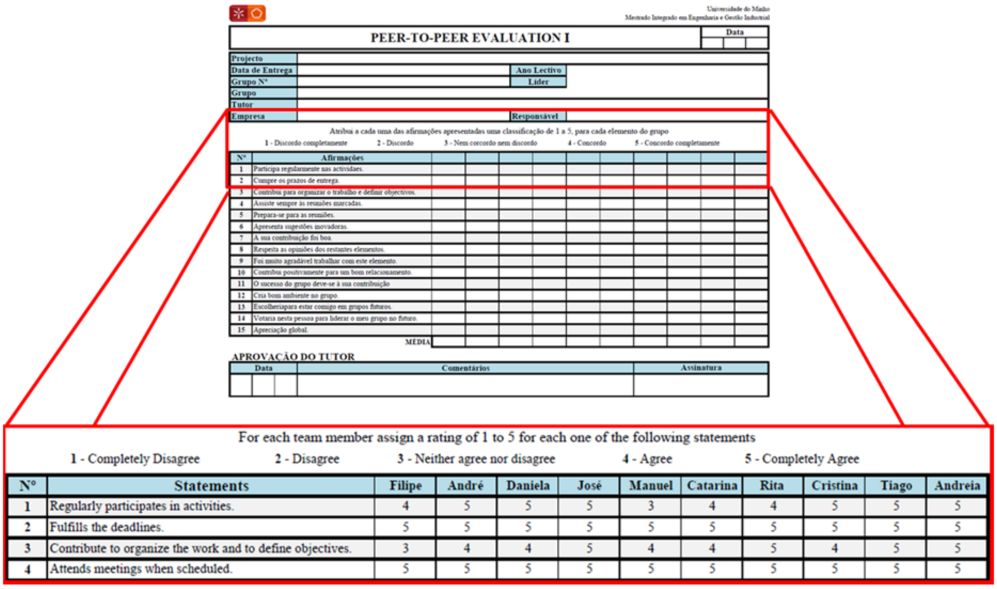
Figure 5: Extract from Weekly Report form - example of activities analysis from week under review.

There is also the PROJECT CHANGE RECORD form to be used whenever the project scope changes. Besides the change description, in this form, the teams should consider if such change will cause some impact on the project activities, deadlines, resources, objectives and communications. The teams should also describe the necessary actions to implement this change. It is important that the teams properly update the PROJECT PLAN, the SCHEDULE FRAME and other documents that may suffer changes.

The VISIT REPORT is another form that aims to control the activities of the project. This form should only be filled if applicable to the project in question and whenever the teams conduct a company visit. In this form it is possible to record important general observations, for example, visited departments, meetings with officials, a factor that prevented the completion of planned actions, planned actions and their evaluation according to their status: Done, to repeat or not taken place, major issues discussed in the company and schedule future visits.

Still regarding the project control, teams must accomplish peer-to-peer evaluations, for such, there are presented two possible forms, each team should choose one, even if it is different from those presented. These evaluations should be performed periodically and according to the official dates and milestones or anytime the teams considers it is necessary. This process must be performed in the presence of all team members and, if possible, the Team tutor as well.

In one suggested form for peer-to-peer evaluation, each team member is evaluated by the remaining members and by him/herself, assigning a rating of 1 to 5 for each one of the fifteen statements presented in the form, as can be seen in Figure 6. In this rating, 1 corresponds to *Completely Disagree* and 5 to *completely agree*.


PEER-TO-PEER EVALUATION I

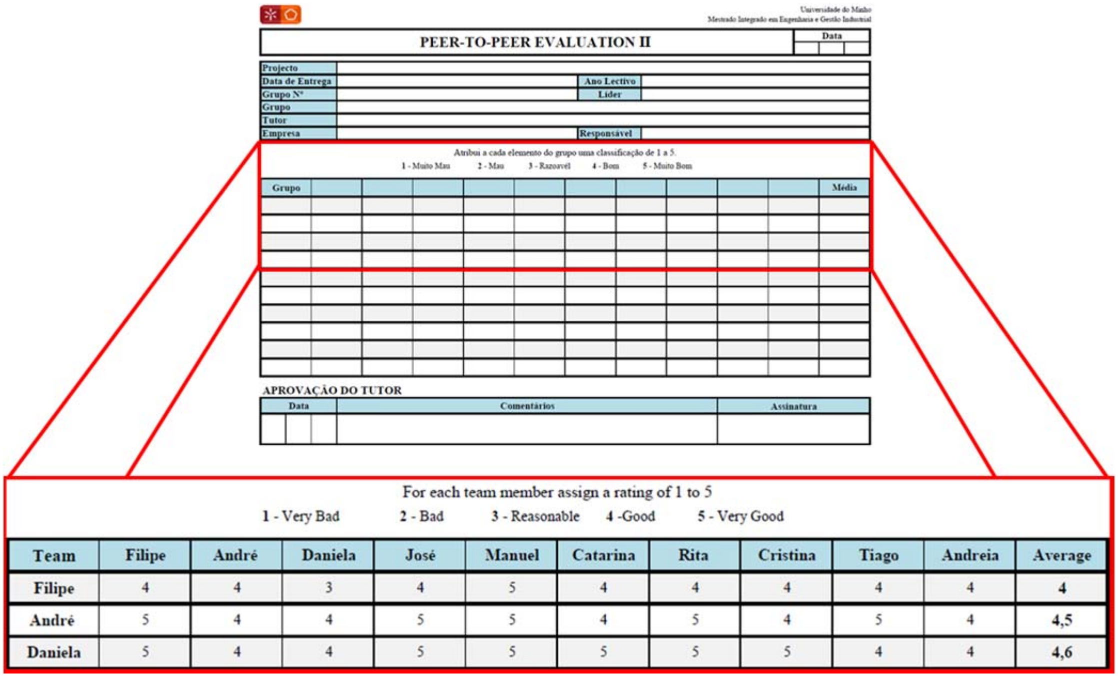
For each team member assign a rating of 1 to 5 for each one of the following statements

1 - Completely Disagree 2 - Disagree 3 - Neither agree nor disagree 4 - Agree 5 - Completely Agree

Nº	Statements	Filipe	André	Daniela	José	Manuel	Catarina	Rita	Cristina	Tiago	Andreia
1	Regularly participates in activities.	4	5	5	5	3	4	4	5	5	5
2	Fulfills the deadlines.	5	5	5	5	5	5	5	5	5	5
3	Contribute to organize the work and to define objectives.	3	4	4	5	4	4	5	4	5	5
4	Attends meetings when scheduled.	5	5	5	5	5	5	5	5	5	5

Figure 6: Extract from Peer-to-Peer Evaluation I form- example of statements included in form and its respective evaluation.

The other suggested form is more simple and direct. Each team member evaluates his own performance and the others performances by assigning a rating from 1 to 5, as shows Figure 7. In this form, 1 corresponds to Very Bad and 5 to Very Good.


PEER-TO-PEER EVALUATION II

For each team member assign a rating of 1 to 5

1 - Very Bad 2 - Bad 3 - Reasonable 4 -Good 5 - Very Good

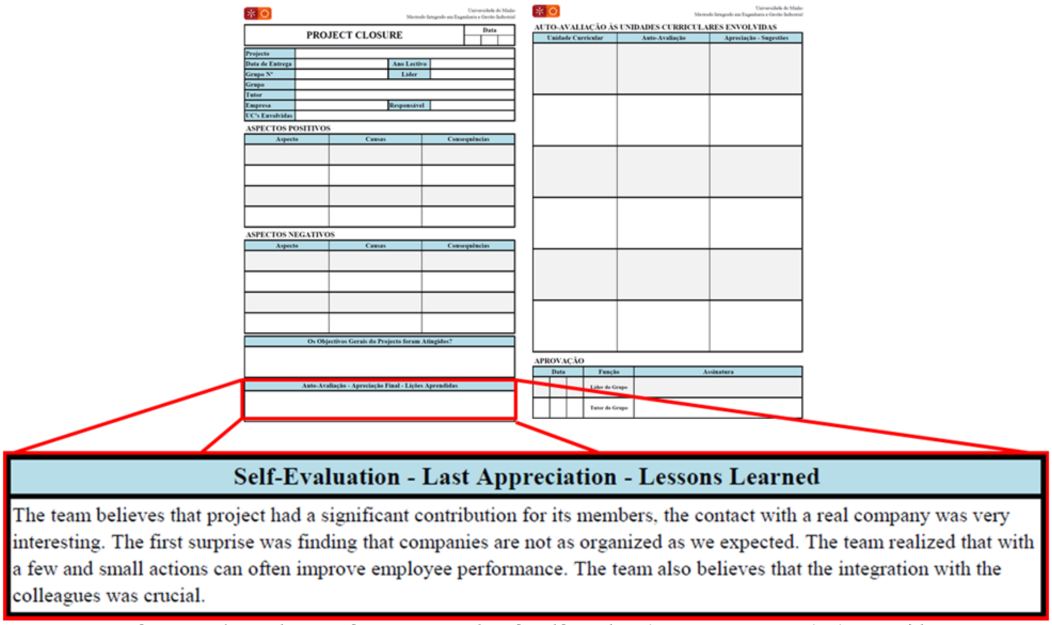
Team	Filipe	André	Daniela	José	Manuel	Catarina	Rita	Cristina	Tiago	Andreia	Average
Filipe	4	4	3	4	5	4	4	4	4	4	4
André	5	4	4	5	5	4	5	4	5	4	4,5
Daniela	5	4	4	5	5	5	5	5	4	4	4,6

Figure 7: Extract from Peer-to-Peer Evaluation II form- Example of evaluation.

Both forms must be signed and commented by the Team Tutor as a sign of approval.

2.3 Final Phase

The last phase of the project life cycle is characterized by formalizing that the project reached the end. Thus the form PROJECT CLOSURE must be filled when the project objectives are achieved, or when the project ends for other reasons. This form is intended to formalize the ending of the project and leads the teams to accomplish a final reflection about the project success or failure. Therefore, the teams should accomplish a closing meeting to discuss, through a self-evaluation: if the general and specific objectives of the project had been reached, compile lessons learned, analyze the problems that occurred during the project, for example, communication failures, deviations on deadlines, if the scope was respected, and other problems/issues that may be discussed. Figure 8 exemplify a record of self-evaluation, last appreciation and lessons learned, contained in the PROJECT CLOSURE form.



PROJECT CLOSURE

Self-Evaluation - Last Appreciation - Lessons Learned

The team believes that project had a significant contribution for its members, the contact with a real company was very interesting. The first surprise was finding that companies are not as organized as we expected. The team realized that with a few and small actions can often improve employee performance. The team also believes that the integration with the colleagues was crucial.

Figure 8: Extract from Project Closure form- Example of Self-Evaluation, Last Appreciation and lessons Learned

3 Conclusion

This paper addresses the problem of project management practices adopted by engineering students when doing project work. Since student teams tend to assume very relaxed project management methodologies with relatively bad performance, a project management methodology is proposed to be followed by student teams when involved with relatively large projects. This methodology assumes three project phases: initial phase, intermediate phase and final phase. The initial phase is focused on formalization of the project as well as on the initial planning. The intermediate phase is the most crucial phase for student teams since it is on this phase that there exist a higher risk to fall on relaxation losing objectives scope and control. This methodology proposes a week routine to be followed in terms of auto-monitoring and auto-control with forms to be filled in about week activity analysis as well as peer-to-peer evaluation. The final phase includes the final delivery followed by a team reflection on lessons learned. This methodology is based on the experiences gained along the last 6 year by students and teachers involved on project based learning activities taking place in the engineering school at the University of Minho.

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Paper Session B2

INTERNATIONAL SYMPOSIUM ON PROJECT APPROACHES IN ENGINEERING EDUCATION

Tipo de Proyectos Desarrollados por Estudiantes de Ingeniería y sus Percepciones sobre la Experiencia. Un caso en México

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Abstract

Project based learning and situated learning enable engineering students not only to mobilize and transfer knowledge but also to enter actual work scenarios as opposed to artificial ones. This work describes the type of projects developed by engineering students at Universidad Iberoamericana and some perceptions about the experience. From some teaching standardized portfolios we classify projects. Then we applied a questionnaire to 108 students and summarize some of the perceptions about topics in which they must develop projects. Of 28 papers of third semester, 19 are related to environmental technologies and proposals, 22 of 25 senior projects were linked to a local company or industry. Sophomore students give more importance to methodological aspects and communication to disciplinary knowledge, as opposed to senior students.

Keywords: Project based learning; situated learning; engineering students; perceptions.

1 Introducción

En una investigación relativamente reciente, sobre las nuevas tareas de los ingenieros en México (Ruiz 2004), se reporta que en las instituciones de educación superior de mayor tradición en la formación de ingenieros, existe controversia sobre si hay que formar ingenieros con el clásico perfil relacionado con el dominio de “conocimientos tecnológicos y científicos para la operación tecnológica y la ejecución de proyectos” (p.58) apegados al paradigma de racionalidad científica o formar ingenieros que respondan a las necesidades de la industria mexicana que demanda conocimientos menos relacionados con la producción: como administración, finanzas y comercialización.

Además en la misma investigación se reporta que, por encima de las competencias técnicas, los empleadores industriales demandan capacidades emprendedoras y de relación social: “capacidades para interpretar el entorno social, iniciativa y toma de decisiones, habilidades comunicativas en varios idiomas, manejo de relaciones humanas y liderazgo y trabajo en equipo, disposición de adaptación al cambio constante y auto aprendizaje, por citar algunos” (p.60).

Se analiza una propuesta educativa de aprendizaje basado en proyectos, con la cual se pueden desarrollar competencias en las que se ponga en juego el dominio de conocimiento tecnológico científico, propio de la ingeniería, y de las áreas económico-administrativas, el desarrollo de las capacidades emprendedoras y de relación social.

El enfoque, en la práctica, no es nuevo. Muchos profesores solicitan a sus estudiantes que desarrollen un proyecto relacionado con la aplicación de los conocimientos de su asignatura y no hay que olvidar que, normalmente, un estudiante de ingeniería, como muchos de otros campos, finaliza sus estudios desarrollando un proyecto recepcional. Con esa práctica casual, en el primer caso, porque depende totalmente de la forma en que trabaja el profesor, y con la práctica obligada en el segundo caso, se asume que la competencia profesional para desarrollar proyectos ya se logró. Hecho no precisamente cierto ya que, en muchos casos, los profesores centran su atención en el dominio de conocimientos disciplinares necesarios para desarrollar el proyecto y descuidan las habilidades superiores que se requieren para la conceptualización y aplicación de éste.

En este entorno, en el Departamento de Ciencias e Ingenierías de la Universidad Iberoamericana Puebla (UIAP) en México se decidió que, en los nuevos planes de estudio (ofrecidos desde 2005), se trabajara con un enfoque de aprendizaje basado en el desarrollo de proyectos de manera curricular y no de manera casual o solo en los últimos semestres.

Quedó entonces establecido en los programas de siete asignaturas que, de manera obligada, un estudiante de ingeniería debía desarrollar un proyecto en su paso por la universidad en los semestres: primero, segundo, tercero, sexto y octavo del plan de estudios ideal.

El enfoque por proyectos adoptado está inserto en la concepción de aprendizaje situado pues se pripicia la transferencia de los aprendizajes y movilización de conocimientos ante situaciones problemáticas, en un contexto físico y social determinado (Marco, 2008).

Las premisas operativas que permean el trabajo en las aulas son:

- Los estudiantes deben trabajar en escenarios o en situaciones vinculados a la realidad y no artificiales, lo que implica que interactúen con personas de carne y hueso que trabajan en las empresas en donde se desarrolla el proyecto o con personas que tienen necesidades reales identificadas por los estudiantes, como los beneficiarios de alguna prótesis o un dispositivo para los hogares.
- El desarrollo del proyecto es una experiencia breve (normalmente de un semestre), pero estructurada en la que se aplican conocimientos matemáticos, de las ciencias básicas y herramientas propias de la ingeniería.

La relevancia de esta experiencia radica en dos aspectos: se trabaja la misma estructura conceptual y contextual en los tres primeros semestres; y, el desarrollo del proyecto no se deja a criterio del profesor.

Pero ¿cómo se expresan en la práctica estas intencionalidades?, ¿qué tipo de trabajos desarrollan los estudiantes?, ¿en qué lugares?

En este trabajo se describen el tipo de proyectos que desarrollan los estudiantes de ingeniería de la UIAP y algunas percepciones que tienen los estudiantes sobre estas estrategias educativas.

2 Descripción del diseño y del desarrollo curricular

A la fecha, las asignaturas en las que todos los estudiantes de ingeniería de la UIAP deben desarrollar un proyecto son:

- En el primer semestre "Procesos productivos básicos" y "Procesos metodológicos básicos". En las que los profesores de las dos asignaturas asesoran un proyecto relacionado con el diagnóstico de la vulnerabilidad de un proceso productivo.
- En el segundo semestre "Sustentabilidad y calidad de vida" y "Procesos metodológicos". En las que los profesores de las dos asignaturas asesoran un proyecto relacionado con el diagnóstico de la sustentabilidad de un proceso productivo.
- En los semestres tercero, sexto y octavo, las asignaturas están relacionadas con un área curricular denominada Área de Síntesis y Evaluación (ASE). Área común en todas las Universidades confiadas a la Compañía de Jesús en México, que sustituye al tradicional proceso de titulación por tesis. En estas asignaturas se pretende que el estudiante integre, aplique y evalúe las competencias genéricas y profesionales que ha desarrollado en su paso por la universidad (SEUIA, 2003).
  - En tercer semestre, en ASE I, los estudiantes formulan un proyecto relacionado con su profesión, con el que se evalúa la síntesis de su formación básica. Un profesor titular dirige el proyecto y tres profesores acompañan el proceso en calidad de asesores. El trabajo se realiza en equipos de cuatro o cinco estudiantes de todas las carreras del departamento; los cuales presentan sus avances en dos momentos intermedios para que los profesores acompañantes retroalimenten; y al final del semestre presentan públicamente su producto para que sea evaluado por los cuatro profesores.
  - En sexto semestre, en ASE II, con el proyecto que desarrollan los estudiantes es evaluada la síntesis de su formación profesional. La mecánica que se sigue es similar a la de ASE I, pero los grupos están conformados, la mayoría de las veces, por estudiantes de una sola licenciatura.
  - En el octavo semestre, en ASE III, se evalúa con un proyecto el logro del perfil de egreso; pero la mecánica tiene un giro interesante. Especialmente, en el caso que se presenta en este trabajo, el estudiante selecciona o consigue prácticas profesionales (trabajo normalmente no remunerado) en una empresa privada, en una dependencia gubernamental o en una organización no gubernamental.
    Casi todos los proyectos son desarrollados de manera individual y son asesorados y evaluados por una persona de la entidad en la que se realizan las prácticas y un profesor de la universidad que asesora, dirige y acompaña. El proyecto se define en la entidad de acuerdo a sus necesidades.
    Además, en un momento intermedio, el anteproyecto es asesorado por un equipo de ingenieros, sin relación laboral con la universidad, que se desempeñan en alguna empresa o institución diferente al lugar en que se desarrolla el proyecto.
  - En los tres momentos de ASE los profesores titulares acompañan el proceso y se prescinde de la cátedra típica en la que el profesor expone y los estudiantes escuchan y anotan. El profesor es un guía que sigue de cerca, con base en el diálogo permanente: el proceso de problematización, la conceptualización del proyecto y la formulación del protocolo. Se revisa la pertinencia técnica y social, la viabilidad, la selección de herramientas de ingeniería, la ejecución y la congruencia metodológica de la propuesta.

- Los productos generados en las asignaturas comentadas y en otras en las que distintos profesores, por decisión propia solicitan el desarrollo de un proyecto, se exponen en una muestra de trabajos de toda la universidad. Las modalidades de presentación para los estudiantes de ingeniería son: cartel, presentación oral, mesa de trabajo y prototipos en piso, de acuerdo a las características de cada proyecto.

3 Métodos de recolección e interpretación de datos

Para la tipificación de proyectos se consultaron los portafolios docentes de una profesora que ha coordinado cinco grupos de ASE I, de diez grupos que se han ofrecido desde el periodo de otoño de 2006 (primera ocasión en que se ofertó esta asignatura); y se consultaron también los portafolios docentes de un profesor que ha coordinado tres grupos de ASE III, de cuatro ocasiones que se ha ofrecido la asignatura desde primavera de 2009, primera vez que se ofertó para los estudiantes de ingeniería industrial. Desafortunadamente ningún profesor de ASE II proporcionó su portafolio para este trabajo.

Para la descripción de las percepciones de los estudiantes, se aplicó un cuestionario al final del semestre a 108 estudiantes, que en primavera de 2009, estaban cursando alguna asignatura de ASE: 40 estudiantes de ASE I, 55 de ASE II y 13 de ASE III. Se formularon once preguntas abiertas; se indagó el significado de las asignaturas, las diferencias y semejanzas entre éstas, los aprendizajes construidos; las fortalezas y las debilidades.

Los datos recolectados son de tipo cualitativo por lo se interpretaron a partir de la extracción de la idea principal por medio de la codificación abierta propuesta por Strauss y Corbin (2002).

4 Evidencias

Este apartado se estructura de acuerdo al objeto de estudio analizado: primero se presentan los proyectos tipificados y después, las percepciones de los estudiantes.

4.1 Tipo de proyectos

Se tipificaron por su título, 28 proyectos desarrollados en cinco grupos de ASE I de acuerdo a temas generales de ingeniería. Se encontró que 4 de ellos se relacionan con tecnologías alternativas, 8 con fuentes renovables de energía, 4 con la optimización del uso del agua, 3 con reciclaje y 9 con otras categorías. En la Tabla 1 se presenta una lista de algunos trabajos representativos.

Estos resultados corresponden a otro referente permanente en el diseño y en el desarrollo curricular de los planes de estudio de todas las carreras del Departamento de Ciencias e Ingenierías llamado desafío departamental, que es el constructo de “Sustentabilidad y calidad de vida” que implica que en “los procesos de transformación, que necesariamente involucran a la ciencia y la tecnología, se usen adecuadamente los recursos naturales para la generación de bienes y servicios que correspondan a pertinencias sociales y económicas, a fin de lograr el bienestar de la población” (Sánchez Díaz de Rivera y Salinas, 2001: p. 6)

Los proyectos desarrollados en ASE III se tipificaron por su vinculación con el sector productivo. Se encontró que 22 de 25 proyectos se realizaron en empresas privadas y solo tres se desarrollaron en otros lugares. En la Tabla 2 se presenta una lista de algunos trabajos representativos, todos relacionados con empresas privadas.

Como se puede inferir de los trabajos de los casi egresados de ingeniería industrial, los proyectos están relacionados con administración de almacenes, estudios de tiempos y movimientos, mejora continua y diseño de experimentos. Lo que significa que se está atendiendo tanto a las necesidades de mercado como a los principios que la ingeniería exige; premisa formulada en la introducción de este artículo.

Tabla 1. Títulos de algunos proyectos desarrollados por estudiantes de tercer semestre (ASE I)

	proyectos desarrollados por estudiantes de tercer semestre (ASE I)
Tecnología alternativas	Sustitución de recubrimientos tradicionales para azoteas, mediante la implementación de techos verdes en la colonia Valle Dorado en la ciudad de Puebla
	Implementación de lombricomposta en el huerto de la escuela pública Santos Degollado
Fuentes renovables de energía	Transformación de biogás en electricidad para un fraccionamiento de la ciudad de Puebla
	Construcción de un prototipo de forma de tope para la transformación de energía cinética en eléctrica para una caseta de vigilancia
	Construcción de un prototipo de cargador eólico para dispositivos con interfaz USB
	Construcción de un prototipo de partilla casera con biogás
	Construcción de un prototipo de bicicleta par transformar energía mecánica a eléctrica
Optimización de uso de agua	Prototipo de autolavado con tecnologías sustentables
	Desalación de agua por medio de la radiación solar y efecto invernadero para uso doméstico
Reciclaje	Desarrollo de un impermeabilizante a base de caucho similar a un sistema de mono capa de caucho
	Prototipo de macetas para techos verdes elaborados a base de llantas usadas

Tabla 2. Títulos de algunos proyectos desarrollados por estudiantes de octavo semestre (ASE III) Vinculados al sector privado

proyectos desarrollados por estudiantes de octavo semestre (ASE III) vinculados al sector privado
Análisis técnico de la falla de válvula FLW Ford Edge en la empresa Veritas
Aplicación de la metodología TRIZ (Teoría de resolución de problemas de inventiva) en el Centro de Pre series de la empresa Volkswagen de México
Aumento de la productividad en ruta de la empresa DHL Express México
Estandarización de la línea de producción de la empresa Sumaíz
TPM: Pilar de mejora enfocada en el área de ejes y componentes de suspensión de la empresa Volkswagen de México
Reorganización del área de almacén de la empresa “Todo de cartón, S. A. de C. V.”
Implementación de un Sistema de Gestión de Calidad ISO 9001:2008 en el proceso de nómina en la empresa Volkswagen de México
Manual 5’s para un área nueva de producción en la empresa Industrial Cogar

4.2 Percepciones de los estudiantes

Con respecto al significado de las asignaturas de síntesis y evaluación, el 39 % de las respuestas de los estudiantes se relacionaron con la aplicación de conocimientos, 29 % solamente con el desarrollo de proyectos, 16 % con la integración de conocimientos y 16 % con la evaluación de su desempeño. Estas respuestas reflejaron algunas de las características del enfoque de aprendizaje situado descritas antes por Marco (2008) y expresadas en el apartado introductorio de este trabajo. Aunque los estudiantes perciben una parte y no el todo.

En cuanto a los aprendizajes construidos a partir de esta experiencia, los estudiantes del ASE I concedieron mayor importancia a los aprendizajes metodológicos y a las habilidades comunicativas que los estudiantes de ASE II y ASE III. Mientras que los estudiantes de ASE II y ASE III reconocieron mayores aprendizajes disciplinares que metodológicos y habilidades comunicativas. Además, los estudiantes de las tres asignaturas concedieron la misma importancia al desarrollo de habilidades en equipo. Los resultados coinciden con las intenciones de cada momento, al principio se trabaja la formación básica y al final la formación profesional, sin descuidar elementos transdisciplinares como el trabajo en equipo, y la comunicación oral y escrita.

La semejanza que tuvo más presencia entre los estudiantes de ASE II y ASE III con respecto a los tres momentos fue la forma de trabajo en cuanto al acompañamiento de los profesores y en cuanto a la manera en la que se estructuran conceptualmente los proyectos. La diferencia más reconocida también por ellos fue la profundidad con las que se desarrollan los proyectos y la precisión en el uso de herramientas de ingeniería, más complejas cada vez.

La fortaleza que percibieron los estudiantes de ASE I y de ASE II es el trabajo en equipo. Todos consideraron que la mayor debilidad es el poco tiempo que tienen para el desarrollo de su proyecto. Aspecto que tiene que revisarse, aunque visto de otro modo, el ritmo de trabajo en la universidad los prepara para el ritmo de trabajo en el campo laboral.

Merecen ser reconocidas algunas alusiones como: “nos confronta con una realidad concreta”, “nos impulsa a desarrollar una manera propia de trabajar los proyectos”, “permite el diálogo con personas de otros ámbitos”, “aprendí que un proyecto no se hace de forma lineal”, “nos hace responsables y comprometidos con el entorno”, “echamos a volar la imaginación”, etc.

Por supuesto no faltaron expresiones de desagrado con respecto a recursos limitados, falta de atención de algunos profesores, falta de asesorías especializadas, poco dominio de conocimientos en ciertos campos, entre otros. Pero estas alusiones no fueron tan frecuentes como para agruparlas.

5 Conclusiones

Los tipos de proyectos desarrollados por los estudiantes de tercer semestre están fuertemente vinculados con la formación básica de un ingeniero egresado de la UIAP, lo que corresponde a las intencionalidades curriculares del primer momento de síntesis y evaluación (ASE I) y corresponde al dominio de conocimientos científico tecnológicos Por otro lado, es notable que 19 de 20 proyectos de tercer semestre aborden temas ambientales, lo que refleja compromiso con el desafío del departamento de Ciencias e Ingenierías de la UIAP: sustentabilidad y calidad de vida.

Los proyectos desarrollados por estudiantes del último semestre están relacionados con las demandas de la industria mexicana expresados por Ruiz (2004); y corresponden al área curricular que complementa y caracteriza al ingeniero industrial. Es notable que también 22 de 25 proyectos se desarrollen en empresas privadas.

Las percepciones de los estudiantes manifiestan que hay trasferencia de aprendizajes, movimiento de conocimientos, desarrollo de habilidades sociales, metodológicas y de comunicación, aprendizaje de conocimientos disciplinares, etc.

Por último, los resultados son satisfactorios y ricos cuando la aplicación de los enfoques de aprendizaje situado y de aprendizaje basado en proyectos se explicita en los planes de estudio y se hace un esfuerzo por vincular a personas de las empresas con los profesores y los estudiantes de la universidad.

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Los Retos en la Formación de Profesionales de las Telecomunicaciones en Colombia

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Abstract

In the project "Curricular, Pedagogical and Didactic Proposal for the Formation of Technicians, Technologists and Engineers in Telecommunications" several proposals for engineering education and conceptual and prospective studies in the telecommunications area has been reviewed. In addition, experts from technical, administrative and academic sectors have been consulted. As a result, several tendencies have been found, which can be order as follows: first, revalue of the engineer formation regarding from ethical, social and humanistic issues; second, development of student skills for working within groups with multiple disciplines and levels; third, postgraduate studies regarding of the professional upgrade and actualization by means of official courses and self-learning skills development which also leads to the concept of the never-ending in learning and the requirement of establish multistage between the different educative levels; fourth, the need of adequate proposal, management and development of technical and social transformation projects. From this analysis, we proposed a competency-based curriculum structured by means of four cores that are articulated with a larger project that will link research groups and industry. The first core responds to the requirement of training professionals to act in cultural, ethical and political environments. The second core addresses the scientific and technological training in the area. The third core incorporates the processes, procedures and instruments characteristic of knowledge. The fourth core deals with research and development aspects of the telecommunications area. Each core has a general training purposes as well as developing the skills that the student is expected to develop within them. Finally, the cores are structured into components and modules. This paper presents the curriculum for core formation and macro-project and cross-disciplinary skills that are developed with this proposal.

Keywords: engineering education; telecommunication engineering; project-based education.

1 Visión del sector de la Telecomunicaciones

En Latinoamérica, las telecomunicaciones presentan tendencias de crecimiento sostenido; sin embargo, desde la década de los 90 y muy especialmente durante los años transcurridos del siglo XXI, este sector presenta un desarrollo más rápido que lo registrado en décadas anteriores y, a pesar de los vaivenes de la economía mundial, continúa con un ritmo de crecimiento acelerado. Los sectores que mayor dinamismo han registrado en los años recientes son los siguientes:

- Servicios de acceso a Internet, especialmente en banda ancha
- Servicios inalámbricos y, en general, servicios móviles
- Servicios de voz sobre IP y telefonía IP
- Generación de contenido

Estos cambios en los diferentes subsectores de las telecomunicaciones indican una tendencia tecnológica hacia la convergencia de las telecomunicaciones y de la informática, la cual impone retos a todos los actores del sector. En este nuevo escenario las empresas sólo pueden ser competitivas en la medida en la cual se brinde valor agregado a los usuarios.

2 Análisis del contexto de formación para profesionales del sector de las telecomunicaciones

Según la Visión Colombia 2019[1], el país requiere transformaciones en los distintos sectores para alcanzar niveles altos de desarrollo. La Visión plantea dos principios y cuatro objetivos; para nuestro caso se resalta el siguiente principio: "afianzar un modelo socioeconómico sin exclusiones, basado en la igualdad de oportunidades y con un Estado garante de la equidad social"; y entre los objetivos se resalta: "una economía que garantice mayor nivel de bienestar social". El desarrollo de este objetivo requiere de ocho estrategias, de

las cuales se retoman dos: “fundamentar el crecimiento en el desarrollo científico y tecnológico” y “desarrollar un modelo empresarial competitivo”.
En el país se ha configurado un marco legal que evidencia el reconocimiento de que el sector educativo es de alto influjo cuando se piensa en políticas de desarrollo y, por tanto, es necesario integrarlo a las mismas, pues en él se forman los sujetos en relación con los saberes y formas de sociabilidad que hacen posibles las transformaciones que la política traza.
La reglamentación actual de la educación en el país busca promover la competencia, como factor de calidad entre las instituciones de Educación Superior [2-3]

3 Metodología

Con el fin de sondear las necesidades reales de formación de profesionales que las empresas del sector de telecomunicaciones presentan, se indagó tanto al medio empresarial como académico, mediante la realización de entrevistas expertos que se desempeñaran en diferentes áreas, es decir en el medio empresarial se seleccionaron expertos con experiencia en el área técnica, regulatoria, administrativa y de mercadeo y en el medio académico se seleccionaron expertos con experiencia docente, investigativa y administrativa. Se definió un perfil de entrevistado según el sector:

- Empresarial
  - Experiencia de al menos 5 años en el sector de las telecomunicaciones
  - Tener a cargo personal con nivel técnico, tecnológico y de ingeniería
  - Desempeñarse en el área técnica en empresas del sector
  - Desempeñarse en el área de mercadeo en empresas del sector
  - Desempeñarse en el área gerencial en empresas del sector
  - Tener título de tecnólogo o ingeniero con algún énfasis en el área
  - Tener cierto nivel de influencia en la selección de personal

- Académico (administrativo y docente)
  - Formación profesional: mínimo con maestría
  - Tres años de experiencia docente o administrativa (dirección de un programa o decanato de una escuela en relación con el área temática de las telecomunicaciones)
  - Realización de asesorías y consultorías en relación con el tema.
  - Participación en proyectos de investigación en relación con la temática.
  - Pertenencia a asociaciones, grupos o redes en los ámbitos nacional e internacional.

4 Conclusiones de la Industria

Se encontraron cuatro tendencias en la formación en ingeniería, las cuales marcan los aspectos básicos del perfil de los profesionales que requiere el sector de telecomunicaciones; estas tendencias son:

- Revaloración de la formación de la ingeniería desde los componentes éticos y sociohumanísticos.
- Desarrollo de capacidades en el estudiante para trabajar en equipos intergrupales, multidisciplinarios e interniveles.
- Actualización y especialización profesional del egresado mediante cursos de postgrado y de educación continua, así como el desarrollo de habilidades para el autoaprendizaje e investigación, lo cual supone el concepto de lo permanente en la formación y la necesidad de establecer escalonamiento entre los diferentes niveles.
- La formulación, gestión y desarrollo de proyectos técnicos y de trasformación social. La construcción de una sociedad más igualitaria y solidaria es posible a través de proyectos con impacto social y en los cuales la tecnología sea vista como un eje transversal que soporte los mismos.

5 Perfil del Ingeniero de Telecomunicaciones

Las telecomunicaciones deben ser concebidas como una herramienta que permita la transformación social y humana; a su vez la investigación como generadora de nuevos conocimientos y apropiación de las tecnologías, de cara a los requerimientos específicos del país.
El Ingeniero para el área de telecomunicaciones requiere:

- Formación para la planeación, ejecución y seguimiento de proyectos de ingeniería en el área de telecomunicaciones
- Tener sensibilidad y actitudes propicias a la responsabilidad social, la tolerancia y el respeto por la diferencia, la conciencia ambiental y el compromiso con el país.

- Reafirmarse en los valores éticos y traducirlos en acciones dentro de su desempeño cotidiano.
- Tener una sólida formación en las ciencias exactas y naturales y en ciencias básicas de la ingeniería.
- Estar en capacidad de diseñar soluciones en todas las áreas medulares de las telecomunicaciones de forma acertada, según las diferentes posibilidades tecnológicas y el desempeño requerido por las empresas de telecomunicaciones o de otras que requieren de las telecomunicaciones para su operación.
- Facilidad de comunicación e interacción con profesionales de diferentes áreas y niveles
- Actualización permanente en los avances tecnológicos.
- Contar con una formación básica en las áreas técnicas afines, con especial énfasis en el sector de la informática, de tal forma que le permitan desempeñarse con solvencia en su vida profesional y afrontar así sus responsabilidades profesionales de una manera integral.
- Tener una formación básica, técnica y humana que le permita desarrollar habilidades investigativas
- Estar dotado de creatividad, iniciativa, liderazgo y pensamiento crítico.
- Tener capacidad para autogestión y autoaprendizaje

6 Estructura macro y meso curricular - competencias

Para alcanzar el perfil del ingeniero de telecomunicaciones propuesto, se plantea la formación desde cuatro núcleos problematizadores: procesos interpretativos: construcción de la ciudadanía y la autonomía; la fundamentación científica y tecnológica; procesos tecnológicos: soluciones, procedimientos e instrumentos; e investigación y desarrollo. La especificación de cada nivel marca los énfasis y, por tanto, las diferencias formativas entre cada Eje.

6.1 Núcleo 1: Procesos Interpretativos: Construcción de la Ciudadanía y la Autonomía

El propósito de formación de este Núcleo contempla la construcción de procesos interpretativos (otorgar sentido) que derivan en:

- La convivencia asertiva con los otros: dimensión política (pluralidad, universalidad, fraternidad).
- La configuración del sí mismo: dimensión ética (autonomía, autoaprendizaje, autorregulación).
- La apreciación–valoración: dimensión estética (armonía, belleza y verdad).

Este núcleo obedece a la necesidad de que un ingeniero de telecomunicaciones comprenda, desde procesos interpretativos, cuál es la relación entre el saber que lo habilita socialmente para un desempeño y el contexto en el cual se enmarca el mismo. Esta comprensión implica entender que los saberes son posibles dentro de las condiciones sociales que los constituyen, de tal manera que hay un doble intercambio entre el saber y la sociedad.

El Núcleo funciona así: es transversal[1] dentro de la propuesta curricular. En este sentido, comporta unos cursos propios y, al tiempo, se hace visible en las problemáticas de los demás Núcleos; con ello se trata de asegurar la construcción de unas competencias específicas de acuerdo con el nivel, e igualmente un pensamiento interpretativo que permita entender la ciudadanía y la autonomía como conceptos y prácticas necesarios para el desempeño.

A continuación se indican los componentes de este Núcleo:

- Lenguajes: este componente está constituido por dos problemáticas: una de ellas referida a la lectura, la interpretación y la escritura de los códigos en los cuales está compuesto el saber propio del área de conocimiento; la otra alude a las distintas formas de apreciación estética propias de diferentes lenguajes, verbigracia: el cine, la música, la literatura.
- Política: el componente refiere a la comprensión de lo público y lo privado en términos de legalidad, legitimidad, normatividad y, en general, formas de convivencia en el marco social.
- Ética: el componente problematiza la tensión sujeto–sociedad, y en esta tensión la responsabilidad que le cabe a todo individuo y a todo profesional en el accionar social.

[1] El concepto de transversal dentro de la propuesta se refiere a la *permanencia* y a la *interdisciplinariedad* que deben acompañar los procesos formativos contemporáneos. La *permanencia* hace alusión a un elemento constante, en tanto se considera fundamental dentro de la formación; la *interdisciplinariedad*, por su parte, supone la necesaria relación entre distintos saberes para solucionar los problemas, cada vez más complejos, de conocimiento.

6.2 Núcleo 2: Pensamiento Científico – Tecnológico

Este núcleo tiene por propósito la formación sólida para el pensamiento científico tecnológico para el desempeño en Telecomunicaciones que se manifieste en:

- Capacidad para conocer, e identificar y controlar las variables de los distintos sistemas que se le presenten en su desempeño profesional teniendo como soporte la formación en la ciencia Física.
- Una formación en las ciencia básica que se manifiesta en un pensamiento lógico y analítico capaz de relacionarse con las disciplinas de la Ingeniería
- La capacidad para abstraer y modelar matemáticamente un sistema o fenómeno con el fin de estudiarlo para propiciar nuevo conocimiento o el mejoramiento del conocimiento existente.
- La capacidad para utilizar soluciones tecnológicas existentes o proponer nuevas soluciones, siempre buscando el beneficio para la humanidad.

Como su nombre lo indica, este núcleo responde a las exigencias de la formación en matemáticas, física, química y otras ciencias naturales, que con los principios básicos tecnológicos, logren ingenieros con un pensamiento lógico y analítico, articulado para la comprensión y asimilación de las competencias profesionales e investigativas.
El núcleo funciona de la siguiente manera:

- El núcleo está formado por las áreas de matemáticas/estadísticas, física y ciencias naturales buscando simultáneamente a partir de ellos, tanto los propósitos de formación, como los objetivos investigativos.
- La propuesta curricular de este núcleo debe estar articulada en sus contenidos con el perfil profesional y las competencias que se quieran lograr en la formación de los Ingenieros de Telecomunicaciones.
- El núcleo facilitará las competencias operativas y conceptuales para que en los distintos niveles de formación como áreas del conocimiento los estudiantes puedan desempeñarse de manera efectiva en las tareas investigativas y profesionales.
- El núcleo se mantendrá actualizado buscando siempre posibilitando la movilidad de los estudiantes a nivel nacional e internacional al tiempo que se facilitará la homologación con otros programas, siempre a la luz de las directrices dadas por el gobierno Nacional.

6.3 Núcleo 3: Procesos tecnológicos: soluciones, procedimientos e instrumentos

Este núcleo tiene como propósito que el estudiante articule diferentes tecnologías para diseñar e implementar soluciones según las características de un servicio o los requerimientos del usuario
Este núcleo permitirá reconocer las diferentes tecnologías de telecomunicaciones, en él se espera que el estudiante ponga en evidencia las comprensiones acerca de los sistemas de telecomunicaciones. Estas compresiones se deben ver explicitas en la realización de montajes, diseño de soluciones, manipulación de instrumentos, según el ciclo de formación en el cual se ubiquen.
Se propone la siguiente metodología de trabajo:

- Realizar laboratorios en los que se utilicen las siguientes estrategias: primero, la generación de conocimiento a través de la práctica, es decir que los estudiantes logren hacer una abstracción de un fenómeno o proceso desde su funcionamiento; segundo, la comprobación y comprensión de los conceptos expuestos en las clases, y tercero, el diseño e implementación de soluciones.
- Articulación de contenidos por semestre (si es posible) mediante proyectos que involucren competencias de diferentes núcleos pero haciendo énfasis en este.
- Durante los últimos semestres de cada ciclo, realizar pequeñas pasantías de los estudiantes en proyectos con la industria.

De este núcleo se derivan los siguientes componentes:

- Soluciones: Diseño de soluciones de telecomunicaciones que pueden incluir la articulación de diferentes tecnologías según los requerimientos del cliente y/o usuario con la mejor relación costo – beneficio. Dentro de este componente se debe responder a las siguientes preguntas: ¿Cómo ofrecer a un usuario un servicio con calidad, que sea transparente para el su utilización y al mejor costo? ¿Qué tecnologías tienen mejor desempeño según los requerimientos de los servicios o de la zona de implementación? ¿Qué normatividad debe tenerse en cuenta en el diseño de una solución?
- Procedimientos: La implantación y/o ejecución de procedimientos que permitan instalar, soportar y gestionar un sistema de telecomunicaciones de manera eficiente. Responde a las siguientes preguntas: ¿Qué procesos se deben seguir para mantener estable la red y cumplir con los requerimientos de los servicios? ¿Qué procedimientos se deben seguir para que la instalación de la red sea transparente para el usuario? ¿Qué procedimientos se deben seguir para la detección y corrección de fallas en un sistema de comunicaciones? ¿Qué registros se deben llevar en cada uno de los procedimientos que se realicen en un sistema de telecomunicaciones?

* **Instrumentos**: En esta área se enfatiza en la correcta utilización de herramientas de software y de hardware, para la instalación, mantenimiento y gestión de redes de telecomunicaciones. Este componente responde a: ¿Qué instrumentos se deben utilizar para el montaje, mantenimiento y gestión de un sistema de telecomunicaciones? ¿Qué variables se deben medir para asegurar la calidad en un sistema de telecomunicaciones?

6.4 Núcleo 4: Investigación y Desarrollo en Telecomunicaciones

Este Núcleo tiene como propósito la formación de competencias para la investigación y la intervención en el ámbito de las telecomunicaciones; estas competencias se especifican en la identificación y construcción de problemas en sus contextos de actuación y el desarrollo de proyectos de investigación o propuestas de intervención en relación con tales problemas.

Este núcleo responde a las exigencias del Ministerio de Educación Nacional en relación con la formación investigativa de los programas de pregrado y al espíritu de la Propuesta, que pretende formar ingenieros con referentes investigativos en relación con el Área.

Este Núcleo es articulador dado que: primero, posibilita la circulación de conceptos, procedimientos, teorías, valores de un Núcleo a otro; segundo, permite demostrar las competencias desarrolladas en los otros Núcleos y ampliar las mismas, en tanto las ubica en nuevos contextos de actuación; y, tercero, hace evidente la relación teoría–práctica.

Desde esta perspectiva, este Núcleo funcionará de la siguiente manera:

* Se parte de la base de que el programa cuenta con dos grupos de investigación con líneas y proyectos en el Área: GIDATI y Política y Gestión Tecnológica, así como varios semilleros de investigación asociados al área.
* El Grupo debe formular macroproyectos de investigación formativa. Se denominan macroproyectos porque contemplan, en su amplitud, problemas centrales[2] del Área (teóricos y prácticos) y deben responder a los propósitos de formación del programa, al perfil de egreso y a las capas del sistema.
* Características del macroproyecto:
    * Comprende, de manera simultánea, los objetivos de investigación y los propósitos de formación.
    * Está en interlocución con los componentes y cursos de los otros tres Núcleos, de tal manera que los problemas trabajados en éstos tengan articulación directa o indirecta con los procesos de investigación formativa que adelanten los estudiantes. Por ejemplo: si los estudiantes están en un curso de lectura y escritura (perteneciente al Núcleo de procesos interpretativos) estos procesos de lectura y escritura deben llevarse a cabo en relación con el proyecto de investigación, no con temas totalmente alejados del mismo; esto permitirá a los estudiantes establecer relaciones entre los saberes y, al tiempo, fortalecer sus comprensiones en torno a su área de formación.
    * El desarrollo del problema planteado en el macroproyecto irá de lo concreto a lo abstracto, de lo particular a lo general.
    * Debe hacer explícito el desarrollo de los tres tipos de competencias: básicas, transversales y específicas.
* El Núcleo se desarrolla desde el segundo semestre de manera progresiva, realizando cortos proyectos que articulan los conocimientos obtenidos en otros núcleos y que forman parte del proyecto macro. En el cuarto semestre todos los estudiantes deben presentar resultados del proceso: un proyecto formulado con todas las especificaciones (desde el problema, hasta el cronograma y el presupuesto). En el sexto semestre los estudiantes deben tener, además del proyecto formulado, un adelanto concreto en términos de la recolección, sistematización y escritura descriptiva de los hallazgos parciales. Para el octavo semestre los estudiantes que optan al título de ingenieros deben presentar los resultados de investigación en relación con los objetivos planteados.

A continuación se indican los componentes de este Núcleo:

* Investigación y desarrollo: este componente desarrolla la problemática y procesos referido a la producción y transferencia de conocimientos.
* Administración y Gestión: este componente desarrolla competencias relacionadas con procesos de organización que toda acción requiere para alcanzar propósito concreto. La organización exige planeación y evaluación de eficacia y eficiencia.

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[2] Se denomina problema central a aquellos referentes que constituyen la condición propia de un profesional en un área determinada; por ejemplo, en educación y pedagogía los problemas centrales están referidos a los saberes que un profesor enseña, a las maneras de enseñar y a la comprensión de los sujetos a quienes enseña y de los contextos en los que se hace; en telecomunicaciones se puede referir a las capas del sistema.

Las competencias propias de este Núcleo se expresan en la capacidad para:

- Formular proyectos de investigación o propuestas de intervención en el Área de Telecomunicaciones. Esta competencia se expresa en:
  - Detección de fallas o formulación de problemas en el Área.
  - Búsqueda de información en fuentes primarias y secundarias en relación con los problemas planteados.
  - Recolección sistemática de información pertinente (cuantitativa y cualitativa) en relación con las fallas detectadas o problemas planteados.
  - Sistematización, con el apoyo de Tecnologías de Información y Comunicación de la información recolectada.
  - Prospectiva de tiempo para la realización de actividades.
  - Proyección de gastos e inversiones en relación con un proyecto.
  - Identificación del impacto de un proyecto, en relación con la ejecución y resultados del mismo.
  - Diseño de procedimiento o metodologías para la ejecución de proyectos.
  - Reconocimiento de diversos formatos para la presentación de proyectos o propuestas de intervención.
- Ejecutar proyectos de investigación o propuestas de intervención en el Área de Telecomunicaciones. Esta competencia se expresa en:
  - Análisis de información.
  - Generación de reportes de análisis.
  - Escritura de informes de avance de proyectos.
  - Evaluación y monitoreo de proyectos en relación con procesos y resultados.
  - Seguimiento de ejecución presupuestal y de cronograma de actividades.
  - Formulación de acciones correctivas y de mejoramiento para alcanzar los propósitos del proyecto.
- Finalizar proyectos de investigación o propuestas de intervención en el Área de Telecomunicaciones. Esta competencia se expresa en:
  - Presentación de resultados de acuerdo con los objetivos trazados.
  - Evaluación de proyectos de investigación o de intervención.
  - Escritura académica de resultados de investigación.
  - Mediciones de impacto.

Este Núcleo aportará para la formación de competencias en relación con el Núcleo de procesos interpretativos: construcción de la ciudadanía y la autonomía; estas competencias se expresan en el desarrollo de la capacidad para:

- La lectura comprensiva y la producción de textos.
- La asunción de procesos de manera autónoma, disciplinada y sistemática.
- La lectura y escritura en inglés.
- El trabajo en equipo. Relación con los otros: servicios y procesos interdisciplinarios.
- El manejo de información con apoyo de TIC.
- La prevención del impacto ambiental, económico, social y cultural de su desempeño y responsabilidad.
- El ordenamiento, de manera coherente, de diferentes ideas para transmitirlas en forma oral.

7 Plan de estudios propuesto

La propuesta de plan de estudio se presenta en 9 semestres incluyendo un semestre de práctica o integración a la vida profesional como se muestra en la Figura 1. Algunos de los cursos propuestos sirven a de apoyo para la formación en varios núcleos, los cuales están demarcados de un color diferente.

Para la construcción del plan de estudios además de detallar los cursos, se definieron las intenciones en cuanto a los contenidos que se esperan de cada curso, los contenidos clasificados de forma general en conceptuales, procedimentales y axiológicos y se especificaron por sus características en la Tabla 1. Para curso entonces además de especificarse la temática requerida, se especificaron las características de los contenidos. La Figura 1 también presenta las características de los contenidos expuestos en el curso valorados en una escala de 0 a 1.

Semestre 1	Semestre 2	Semestre 3	Semestre 4	Semestre 5	Semestre 6	Semestre 7	Semestre 8	Semestre 9
Lengua y cultura FORM:0.8 TR_EQUIPO:0.1 CONTEXTO:0.1	Humanismo, cultura y valores FORM:0.8 TR_EQUIPO:0.1 CONTEXTO:0.1	Cristología FORM:0.8 TR_EQUIPO:0.1 CONTEXTO:0.1	Línea de Formación 1 FORM:0.8 TR_EQUIPO:0.1 CONTEXTO:0.1	Línea de Formación 2 FORM:0.8 TR_EQUIPO:0.1 CONTEXTO:0.1	Línea de Formación 3 FORM:0.8 TR_EQUIPO:0.1 CONTEXTO:0.1	Ética General y Profesional FORM:0.8 TR_EQUIPO:0.1 CONTEXTO:0.1	Mentalidad emprendedora FORM:0.6 TR_EQUIPO:0.1 CONTEXTO:0.1 INNOV:0.2	Integración a la vida profesional TR_EQUIPO:0.1 CONTEXTO:0.1 INNOV:0.4 INVEST:0.4
Cálculo Diferencial TEO:0.8 MODEL:0.2	Calculo integral TEO:0.8 MODEL:0.2	Matemática para Teleco. TEO:0.4 MODEL:0.6	Sistemas y Señales TEO:0.5 MODEL:0.3 LAB:0.2	Teoría de Comunicaciones TEO:0.4 MODEL:0.3 LAB:0.3	Regulación de TI REG:0.8 CONTEXTO:0.2	Innovación TR_EQUIPO:0.3 INNOV:0.7	Gestión INNOV:0.5 REG:0.2 TEO:0.2 TR_EQUIPO:0.1	
Flexible CBD TEO:1	Mecánica TEO:0.6 LAB:0.2 MODEL:0.2	Geometría Analítica y Álgebra Lineal TEO:0.8 MODEL:0.2	Probabilidad TEO:0.6 MODEL:0.4	Gestión de proyectos TEC:0.2 LAB:0.2 TR_EQUIPO:0.2 INVEST:0.4	Línea de Formación CP TEC:1	Línea de Formación CP TEC:1	Economía y mercadeo, ing social INNOV:0.5 MODEL:0.2 TEO:0.2 CONTEXTO:0.1	
Flexible CBD TEO:1	Electromagnetismo TEO:0.6 LAB:0.2 MODEL:0.2	Circuitos Eléctricos TEO:0.6 LAB:0.2 MODEL:0.2	Circuitos Electrónicos y RF TEO:0.6 LAB:0.2 MODEL:0.2	Electiva I TEC:1	Electiva II TEC:1	Optativa 1 - Postgrados TEC:1	Optativa 2 - Postgrados TEC:1	
Programación TEO:0.6 LAB:0.2 TEC:0.2	Proyectos TIC 1 TEC:0.5 LAB:0.2 TR_EQUIPO:0.1 INVEST:0.2	Programación aplicada TEC:0.6 LAB:0.4	Generalidades Sistemas Tx. TEO:0.6 LAB:0.2 MODEL:0.2	Medios Guiados TEC:0.6 LAB:0.2 MODEL:0.2	Medios NO Guiados TEC:0.6 LAB:0.2 MODEL:0.2	Comunicaciones multimedia TEC:0.4 LAB:0.4 INVEST:0.2	Proyectos sectoriales INNOV:0.3 TR_EQUIPO:0.2 CONTEXTO:0.1 REG:0.1 INVEST:0.3	
Introducción a las telecomunicaciones TEC:0.6 REG:0.2 MODEL:0.2	Redes de telecomunicaciones TEC:0.5 LAB:0.4 REG:0.1	Redes de Datos TEC:0.5 LAB:0.4 REG:0.1	Proyectos TIC 2 TEC:0.4 LAB:0.2 TR_EQUIPO:0.1 INVEST:0.3	Tecnologías de acceso TEC:0.5 LAB:0.3 REG:0.1 INVEST:0.1	Proyectos TIC 3 TEC:0.2 LAB:0.2 TR_EQUIPO:0.2 INVEST:0.4	Tecnologías de transporte TEC:0.5 LAB:0.3 REG:0.1 INVEST:0.1	Servicios de Teleco. TEC:0.5 LAB:0.3 REG:0.1 INVEST:0.1	

Procesos Interpretativos: Construcción de la Ciudadanía y la Autonomía
Pensamiento Científico – Tecnológico
Procesos tecnológicos: soluciones, procedimientos e instrumentos
Investigación y Desarrollo en Telecomunicaciones
Apoya la formación en varios núcleos

Figura 1: Plan de estudios propuesto

Una vez realizada propuesta de plan de estudio se evaluó la ponderación que se le había dado a cada característica e igualmente a cada elemento del perfil; en la Figura 2 se presenta los porcentajes asignados a cada una de las características en el plan de estudios.

Tabla 1: Características de los contenidos

FORM	Formación Humana	LAB	Laboratorio
INNOV	Innovación	TEC	Técnico
TR_EQUIPO	Trabajo en equipo	REG	Regulación
MODEL	Modelamiento	CONTEXTO	Contexto del sector y/o del país
TEO	Teórico - científico	INVEST	Investigación

El 57.46% de los contenidos tienen características técnicas, teóricas y de laboratorio como es de esperarse en un programa de ingeniería, sin embargo el 26.27% esta caracterizado por contenidos dedicados a la innovación, el trabajo en equipo, la investigación, regulación y contexto del país.

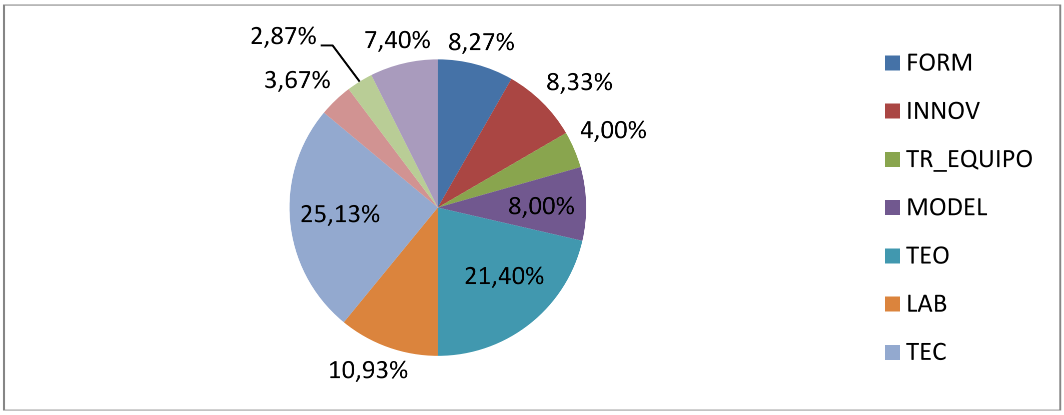

Figura 2: Porcentaje de características de los contenidos

8 Conclusiones

El estudio realizado encontró que la participación de estudiantes en proyectos a los largo de la carrera permite la articulación de competencias que dentro de la propuesta fueron agrupadas en núcleos. El núcleo de investigación y desarrollo propone que el estudiante adquiera las competencias construyendo y participando activamente en proyectos, de esta manera se convierte en un eje articulador de todo el plan de estudio. La implementación de propuestas este estilo requiere de la construcción en una comunidad académica fortalecida con actores del medio empresarial y de replantear completamente el currículo de los programas académicos actuales.

El proyecto permitió identificar las siguientes cuatro tendencias en la formación en ingeniería:

- Revaloración de la formación de la ingeniería a la luz de los componentes éticos y sociohumanísticos.
- Desarrollo de capacidades en el estudiante para trabajar en equipos intergrupales, multidisciplinarios e interniveles.
- Actualización y especialización profesional del egresado mediante cursos de postgrado de educación continua y el desarrollo de habilidades para el autoaprendizaje.
- La formulación, gestión y desarrollo de proyectos técnicos y de trasformación social.

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Aprendizaje Basado en Proyectos para el Desarrollo Regional

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Abstract

Societies of the Latin American countries require the development of more efficient engineering in the sense that seeks better conditions for life's quality. To meet those expectations, the professional practice must be based on curriculum proposals to guide students in scientific–technological knowledge, in dialogue with their peers in the world and the development of skills to offer plausible alternative and successful solutions to real problems of society. The responsibility of these proposals is of the engineering education institutions. Educational institutions must comply responsibly with the social projection component, as one of its substantive functions, inseparable from teaching and research. Thus, an important issue of work is to characterize the relationship between knowledge, the productive sector, the government and the demands of society. Under these conditions, teaching explores options consistent with the curriculum guidelines, knowledge, interests and needs of students as well as with society's real problems in an integrated and interdisciplinary management space. That involves a dynamics of teaching in line with program's vision. The research experience of the group "EDUCING", indicates that policies and academics strategies, are needed to enhance and increase achievement of institutional participation in projects. The activities within the extension or social projection of the programs provide an opportunity for communication with social expectations. It is necessary in the design and implementation consider developing a reciprocal process of situated learning and in-depth, through the formulation of projects of regional development to promote the link between the complexity of societal problems and the proposals curriculum in engineering.

Keywords: Curriculum; social context; projects learning; situated learning; engineering education

Resumen

Las Sociedades de los países de América Latina requieren el desarrollo de la ingeniería más eficientes buscando mejores condiciones para la calidad de vida. Para cumplir con esas expectativas, la práctica profesional debe basarse en las propuestas curriculares para guiar a los estudiantes en el conocimiento científico - tecnológico, en el diálogo con sus pares en el mundo y el desarrollo de habilidades para ofrecer alternativas plausibles y soluciones exitosas a problemas reales de la sociedad. La responsabilidad de estas propuestas es de las instituciones de enseñanza de ingeniería. Le corresponde a las instituciones educativas atender con responsabilidad y compromiso el componente de la proyección social como una de sus funciones sustantivas, inseparable de la docencia y la investigación. De esta manera un tema importante de trabajo es la caracterización de las relaciones entre el conocimiento, el sector productivo, el Estado y las demandas de la sociedad. En estas condiciones, le corresponde a la docencia explorar opciones metodológicas coherentes con los lineamientos curriculares, el conocimiento, los intereses y necesidades de los estudiantes, como también con las problemáticas reales de la sociedad, en un espacio de gestión integrado e interdisciplinario. Esto implica una dinámica en la docencia coherente con la visión del programa. La experiencia investigativa del grupo "EDUCING", indica que se necesitan políticas y estrategias académicas que potencien e incrementen los logros de la participación institucional en proyectos. Las actividades inscritas dentro de la extensión o proyección social de los programas constituyen una oportunidad de comunicación con las expectativas sociales. Es necesario que en su diseño e implementación se considere desarrollar un proceso recíproco de aprendizaje situado y en profundidad, a través de la formulación de proyectos de interés para el desarrollo regional que promueven el vínculo entre la complejidad de los problemas de la sociedad y las propuestas curriculares en ingeniería.

Palabras clave: Currículo; contexto social; aprendizaje por proyectos; aprendizaje situado; Educación en ingeniería.

1 Introducción

El grupo de investigación en Ingeniería EDUCING está conformado por profesores colombianos de ingeniería, con una amplia trayectoria y experiencia en el campo de la docencia y gestión universitaria, con intereses de investigación definidos en áreas relacionadas con la calidad de los procesos de formación de ingenieros, dentro de las cuales se incluye la identificación, implementación, caracterización y sistematización de experiencias pedagógicas en ingeniería, así como la valoración del compromiso de los profesores frente a sus responsabilidades de planeación y preparación, desarrollo y evaluación de actividades curriculares (Albéniz, et al, 2007).

Recientemente, el grupo abordó la reflexión sobre las brechas existentes entre la evolución en la formación de ingenieros y su efecto en el desarrollo sostenible, circunscrito en principio al caso colombiano. Avances de los resultados de sus investigaciones se presentaron recientemente en eventos como el Congreso Mundial y Exposición “Ingeniería 2010” realizado en Buenos Aires, Argentina, y en el *Global Colloquium on Engineering Education* de Singapur, en octubre de 2010.

Este artículo está inscrito dentro de las líneas de interés señaladas y enfocado en la temática central del Simposio: Aprendizaje basado en Proyectos de Ingeniería. EDUCING somete a consideración de la comunidad académica internacional sus reflexiones sobre la necesidad de promover el aprendizaje en ingeniería más allá de las aulas de las instituciones educativas, desde el marco de la complejidad, como ocurre a través de proyectos de interés para el desarrollo de las comunidades de la región.

2 El aprendizaje basado en proyectos de interés para el desarrollo

La estrategia de aprendizaje basado en proyectos constituye un modelo de formación en el que los estudiantes planean, implementan y evalúan proyectos que tienen aplicación en el mundo real, trascendiendo el espacio limitado del aula de clase (Blank, 1997) y el esquema que reduce la docencia a la transmisión de información. Con ella se promueven actividades de aprendizaje de naturaleza interdisciplinaria, con efectos formativos de largo plazo, centradas en el compromiso e interés de los estudiantes.

La incorporación de proyectos como instrumentos de aprendizaje es una alternativa para la educación, propuesta por William Herat Patrick (1918), quien la denominó como una entusiasta propuesta de acción para desarrollar en un ambiente social y que sirve para mejorar la calidad de vida de las personas. Se emplea en la formación profesional del médico desde la segunda mitad del siglo pasado como soporte para el modelo pedagógico orientado al aprendizaje activo. Ahora, la propuesta de EDUCING consiste en precisar el carácter de los proyectos seleccionados para la formación de Ingenieros. Se plantea que los propósitos del aprendizaje en los programas de ingeniería ocurran en estrecha relación con aquellos proyectos, en donde además de requerir los conocimientos científicos y tecnológicos propios de su formación ingenieril, implican habilidades tanto en la ubicación, selección y análisis de información necesaria para ejercitarse en la identificación de problemas propios de un contexto específico, como habilidades para el diseño, formulación y socialización de las alternativas de solución para enfrentar tales problemáticas (Corchuelo, 2007).

La iniciativa surge de una reflexión sobre el sentido de la praxis docente en ingeniería en estrecha relación con el sentido de la profesión. En la definición de ingeniería se incluyen tres elementos básicos: Los conocimientos científico- tecnológicos; los materiales y las fuentes energías sobre los que se actúa; y el bienestar de la humanidad como propósito de la profesión; por tanto se espera que la formación a través de proyectos geste oportunidades de aprendizaje articuladas con el desarrollo del entorno. De esta manera se fortalece la relación de mutualismo entre academia universitaria y la sociedad.

Con esta estrategia de enseñanza se tiene la oportunidad de desarrollar experiencias de *aprendizaje más allá del aula, en espacios reales, que demandan del trabajo interdisciplinario en un marco complejo, no desintegrador de la realidad. En su desarrollo pueden derivar importantes consecuencias para la formación profesional en ingeniería, mediante* el trabajo en equipo, la planeación, las habilidades comunicativas, la toma de decisiones y la solución de problemas, esto es, el saber hacer en contexto, que como lo afirma Schön (2006), en virtud de los márgenes de incertidumbre y los posibles conflictos de valores que involucran, se exige ir más allá de racionalidad técnica.

3 Aspectos Curriculares

En los contextos locales delineados por decisiones políticas, restricciones económicas, exigencias culturales y presiones sociales, (definidas entre otros factores, por el nivel general del sistema educativo, los intereses de los gobiernos, las determinaciones de los grupos de presión y las condiciones generales de vida), la ingeniería constituye el principal canal de difusión social y materialización de los avances y logros de la ciencia y la tecnología. El encuentro temprano de los estudiantes de ingeniería con las expectativas y demandas de desarrollo regional, del cual hacen parte, se convierte en un importante elemento de motivación para encontrarle sentido y pertinencia a los saberes cultivados desde las disciplinas, igualmente implican desafíos frente a los retos del contexto y simultáneamente se tienden importantes nexos con las estructuras curriculares que las integran y a la vez, les imprimen dinámicas de continua actualización.

Las propuestas de estandarización de los fundamentos curriculares para la formación de ingenieros basadas en modelos de países y sociedades con altos grados de desarrollo, deben tener en cuenta que el ejercicio de la ingeniería en regiones como Iberoamérica se enfrenta el doble compromiso de atender solventemente las exigencias de la competencia mundial y el de ofrecer soluciones a los problemas materiales básicos de las sociedades nacionales. La visión separada de estas dos líneas de responsabilidad contribuye al crecimiento y profundización de las brechas sociales, económicas, científicas y tecnológicas en detrimento de las poblaciones más vulnerables de la región.

La educación de los ingenieros debe prepararlos para promover el acercamiento de la sociedad con los métodos, estrategias, instrumentos, limitaciones y logros de la ciencia y la tecnología. La ingeniería representa un vehículo central en el proceso de alfabetización tecnológica que promueve el aprecio social por la investigación, la innovación y la integración creativa de conocimientos con propósitos de mejoramiento de la calidad de vida de la sociedad. El conocimiento oportuno por parte de los estudiantes de ingeniería de los problemas de la sociedad y el uso curricular de proyectos de influencia real en la superación de los mismos puede contribuir de manera significativa a la cualificación del ejercicio profesional.

Las estructuras curriculares están conformadas por recursos, procesos, infraestructura, actores, mecanismos de participación y evaluación, así como de estrategias de relación con la sociedad; elementos todos ellos articulados para cumplir los compromisos misionales. En el diseño de propuestas de aproximación de los estudiantes de ingeniería a los problemas reales de la sociedad es importante superar las consideraciones asistencialistas y procurar relaciones de beneficio mutuo a través de las cuales, la estructura curricular de ingeniería se apropia de casos reales de desarrollo, al tiempo que la sociedad recibe respuestas calificadas por parte de los egresados de programas de formación dentro de los cuales la realidad es un insumo cotidiano.

Las relaciones entre los desarrollos curriculares en los diferentes niveles o ciclos de formación: técnica, tecnológica y profesional, y las necesidades de la sociedad, se hacen cada vez más complejas y exigentes. Es un imperativo el diseñar y desarrollar propuestas curriculares que favorezcan el acercamiento entre las necesidades del entorno y los fines de las profesiones y disciplinas que conforman las ofertas educativas. Es deseable que las prioridades, objetivos e intereses de las instituciones responsables de la educación de ingenieros se encuentren articuladas de manera pertinente y oportuna con las demandas del entorno, y facilitar así, el cumplimiento de las responsabilidades que tiene el conocimiento con el desarrollo de la sociedad.

Es necesario que las propuestas curriculares a través de la flexibilidad, (entendida como el proceso que permite a los estudiantes transitar por los planes de estudio, consolidando su capacidad de formación autónoma, seleccionando sus áreas de interés, reconociendo los diversos ritmos, estilos de aprendizaje y la profundidad deseados), faciliten mediante los proyectos de interés para el desarrollo social, el conocimiento y atención de las problemáticas locales y regionales. Con creciente importancia y urgencia, en la región iberoamericana deben atenderse problemas relacionados con vivienda, servicios públicos, movilidad, seguridad frente a fenómenos naturales, todo ello en un marco de compromiso con el desarrollo sostenible y el progreso científico y tecnológico. Semejante escenario de acción para la ingeniería justifica el esfuerzo de consolidar propuestas curriculares consistentes –en tiempo real- con las necesidades y demandas específicas de la sociedad.

A la exigencia de rendición de cuentas por parte de las instituciones responsables de la formación de ingenieros a través de procesos de evaluación y acreditación es importante vincular una revisión crítica del resultado de los esfuerzos de inversión en relación con las necesidades básicas cuya solución sigue pendiente, al margen del crecimiento cuantitativo y el mejoramiento cualitativo de las ofertas curriculares de pregrado y posgrado en ingeniería. En el caso colombiano, es interesante contrastar el aumento, en un período de doce años, del número de programas de ingeniería en especialidades relacionadas con áreas estratégicas para el desarrollo (Figura 1), con los indicadores de calidad de vida de la sociedad en un periodo semejante (Figura 2). Se observa en la primera figura el incremento en la oferta de los programas de formación en ingeniería y simultáneamente, la segunda revela los altos índices de pobreza en el país.

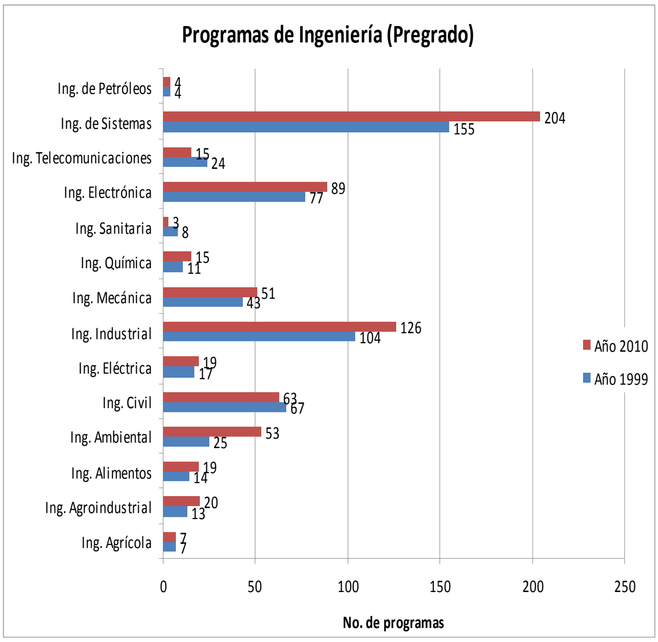

Figura 9: Programas de Ingeniería en Colombia relacionados con las áreas estratégicas de desarrollo. Fuente: ACOFI (2010)

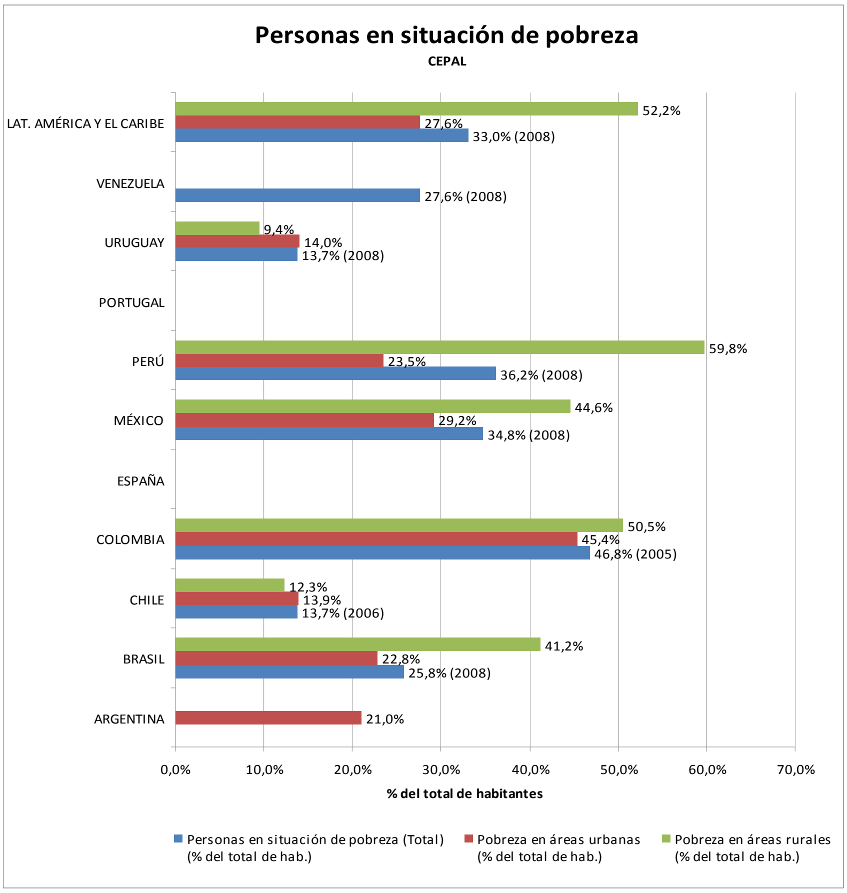

Figura 10: Colombia en el contexto de la pobreza en América Latina. Fuente: CEPAL (2010)

4 Un nuevo enfoque para la docencia en ingeniería

El centro de atención de la denominada revolución copernicana en la educación superior se localiza en el estudiante, en su compromiso de aprendizaje y en el carácter autónomo de su proceso de formación. Este enfoque tiende a soslayar el papel del profesor, confiándole un desdibujado compromiso de acompañamiento fuertemente condicionado por el uso de herramientas tecnológicas.

En oposición a las tendencias simplificadoras del papel de los profesores en el proceso formativo, es conveniente trabajar en la construcción de una nueva docencia, adecuada para acompasar la formación de nuevos ingenieros con las necesidades de desarrollo social. Desde esta perspectiva, se requieren drásticas transformaciones que desbordan las preocupaciones habituales de actualización pedagógica y entrenamiento tecnológico y plantean serios interrogantes en procesos como la selección, la formación y la evaluación de profesores para los programas de ingeniería.

La creación y consolidación de redes de docencia en ingeniería es un requisito para la apropiación de experiencias y propuestas de evaluación y mejoramiento permanente, desde el entorno local, pasando por el escenario ampliado de las regiones hasta alcanzar la visión global. Esta construcción de intereses comunes, está afectada por dificultades geopolíticas que entraban las consignas de movilidad y agravan las asimetrías y desequilibrios generados por la inequidad en la distribución de los recursos científicos y tecnológicos asignados por las sociedades para asegurar la calidad, pertinencia y competitividad de la educación en ingeniería.

El profesor de ingeniería es responsable de la inclusión en la docencia diaria de los problemas de la sociedad como objetos de estudio. Antes que profesional y docente, el profesor de ingeniería es un ciudadano en quien se encomienda una tarea de especial significado y valor estratégico para el desarrollo del conjunto social. Para cumplir las responsabilidades asignadas, es necesario que el profesor de ingeniería permanezca atento a las dinámicas sociales, políticas, científicas, tecnológicas, ambientales, académicas y económicas del entorno. Su tarea demanda una actitud rigurosa para abordar críticamente los problemas de la sociedad; sin renunciar a la tolerancia y el respeto por las opciones y las divergencias.

El profesor de ingeniería debe ser reconocido –y reconocerse él mismo- como un actor clave del desarrollo científico y tecnológico de la sociedad, en un marco que dirima los conflictos entre el poder, el conocimiento, la producción y la sociedad. Están inherentes valores como la solidaridad, la equidad, la tolerancia y la convicción de que la ingeniería debe orientarse a la promoción integral de los seres humanos. Atender este conjunto de responsabilidades justifica el esfuerzo de la profesionalización de la labor docente en ingeniería. Esta es una discusión que debe promoverse en los foros académicos nacionales, regionales e internacionales como parte de una agenda orientada a la transformación de la docencia en ingeniería como requisito para la innovación curricular.

5 Elementos básicos de una propuesta de acción

El Grupo de Investigación Educación en Ingeniería –EDUCING, basado en la reflexión sobre las discrepancias entre la expansión académica y las condiciones de vida de los sectores más deprimidos de las sociedades de la región iberoamericana, propone algunas estrategias para aproximar los objetivos y declaraciones curriculares a las necesidades no resueltas del entorno de los programas de formación de ingenieros:

- El acento de la educación de ingenieros basada en proyectos de interés para el desarrollo debe colocarse en la contextualización que se dé a la formación de los ingenieros y para ello será preciso un esfuerzo político y académico por parte de las instituciones y programas de educación superior. En el caso iberoamericano, el conocimiento de la cultura, los recursos, las expectativas y necesidades locales es deseable que se incorporen al diseño curricular, junto con las estrategias y recursos que permitan materializar el discurso de compenetración de los ingenieros en formación con la realidad. Por supuesto, el referente de desempeño de los ingenieros es global, pero el compromiso con el entorno y su desarrollo constituyen un imperativo en los planes curriculares de universidades y programas (Cañón, 2010).
- El desarrollo de la sociedad es la más significativa responsabilidad de los ingenieros y por esa razón, sin perjuicio de animar la movilidad y la internacionalización como importantes referentes de acreditación, es necesario que los programas de educación en ingeniería –en todos sus niveles y modalidades- aseguren dentro de sus compromisos misionales la revisión permanente de la vigencia y pertinencia de las relaciones entre las estructuras académicas y las necesidades, oportunidades y expectativas del entorno respectivo. Para este propósito resulta esencial el acercamiento con las autoridades locales y regionales en busca de la participación de las instituciones de educación de

ingenieros en la construcción de los planes de desarrollo. Los indicadores de calidad de vida y los proyectos de desarrollo de la sociedad constituyen un importante referente para construir o actualizar propuestas curriculares de ingeniería, ante la premisa de que los programas de ingeniería tienen un rol protagónico en la preparación de profesionales e investigadores competentes para la atención de los problemas del entorno.

- La transformación de la docencia en ingeniería resulta de interés central para la inclusión de proyectos como insumos de aprendizaje. Es esencial incluir consideraciones sobre la evolución social que ha experimentado la figura del profesor en la educación superior. Cualquier propuesta de acción debe reconocer y valorar con profundidad y detenimiento la experiencia de quienes han contribuido en la construcción del escenario actual de la docencia universitaria. El encuentro interdisciplinario e intergeneracional para el intercambio y sistematización de experiencias pedagógicas es una actividad de importante significado estratégico para reducir el fenómeno, algunas veces traumático, de relevo generacional.

- La más profunda modificación en el quehacer docente en ingeniería tiene que ver con la preparación de los profesores para ejercer su misión superando las limitaciones impuestas por la especialización de las asignaturas, es decir, para actuar como profesores con visión de Programa. La mirada exclusivamente centrada en los contenidos específicos de las asignaturas es contraria a la apertura necesaria para trabajar en las aulas con proyectos de interés para la sociedad. El abordaje curricular de tales proyectos requiere una disposición de trabajo cooperativo, transversal, interdisciplinario y dirigido a la atención de problemas reales.

- Es necesario que los profesores de ingeniería reconozcan y valoren la importancia de la reflexión y discusión en los procesos de aprendizaje, y la transfieran de manera permanente a las cuestiones curriculares, especialmente a considerar a la incorporación del aprendizaje basado en proyectos para el desarrollo regional. Advertir que la formación de ingenieros es un ejercicio que desborda las visiones aisladas y requiere un enfoque que considere las presiones y demandas externas, así como los intereses extraacadémicos ineludibles en una tarea social de esta magnitud.

- En el mediano plazo debe valorarse la conveniencia de articular el diseño curricular de los programas de ingeniería con los planes de desarrollo local y nacional, de tal forma que las actividades estén vinculadas a la atención de proyectos de interés específico, con cuyo estudio y evaluación puedan contribuir los programas. Esta modalidad de formación puede conducir a la programación de cohortes específicas cuya línea medular de trabajo académico estaría asociada a un proyecto estratégico para el desarrollo de la sociedad.

Para alcanzar esta drástica transformación de la docencia en ingeniería es necesario rediseñar los modelos de gestión de las instituciones de educación superior, renegociar los términos del reconocimiento social hacia la tarea de los profesores y, sobre todo, formular nuevos lineamientos para el tratamiento profesional de la docencia en ingeniería adecuando las políticas, estrategias e instrumentos de selección, formación, actualización y evaluación de los profesores.

Se demanda que las autoridades educativas adopten la política de promover y apoyar programas sostenidos y de trascendencia para la formación de los profesores de los programas de ingeniería, como una juiciosa inversión para el desarrollo social. No se coloca en discusión el papel estratégico de la ingeniería en los planes de mejoramiento de la calidad de vida de la sociedad y en la atención competente de sus compromisos internacionales y, por esa razón, es necesario propiciar el fortalecimiento del componente docente en los procesos de diseño y gestión curricular.

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Programas que promueven la innovación desde las asignaturas del pregrado

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Abstract

As part of the electives ''Production of Beer, wine and liquors'' and ''Production of cleaning products and cosmetics'' offered by the School of Chemical Engineering of The Universidad Pontificia Bolivariana (UPB), a high success strategy UPB Innova was implemented, in order to encourage innovation originated in the creativity and work in multidisciplinary teams from the classroom, supporting the ideas from conception to the realization of products that can be incorporated into the market. Thus, UPB Innova promoted in the second half of 2010 that the results of practical work developed by students in the course were exposed in an open fair and evaluated not only by faculty, technical experts and business owners the subject, but also by people from areas such as Graphic Design and Industrial Design to evaluate the quality of the brands and packages created. After the fair, which also was the final note of the elective, the best products of each category were selected, and those were received by the Research and Innovation Center of the University establishing a Practice Community integrated by Packing Design, Global Image, Intellectual Property and Chemical Standardization courses to further enhance the products and bring them through product testing to innovation. UPB Innova is a strategy that has been replicated for the same subjects in 2011 where students from the start not only working on technical issues, but complement their classes with talks about image packaging design and innovation and intellectual property. Their results have enabled the University to take the model to other faculties of Engineering and Architecture with results equally successful.

Keywords: Innovación, Transferencia de Conocimiento, Comunidad de Práctica, Asignaturas Electivas

1 Introducción

Los modelos curriculares y su articulación con los procesos de innovación y transferencia en las Instituciones de Educación Superior (IES) (Universidades) están evolucionando por la presión que ejerce la toma de conciencia de lograr profesionales más competentes cuyos resultados generen impactos que transformen las realidades de los contextos donde se desempeñan. La Universidad Pontificia Bolivariana (UPB) se ha dado a la tarea de tratar de comprender esta compleja situación y ha iniciado la implementación de estrategias que permitan reconocer las exigencias de la sociedad e integrarlas a los desafíos que se deben plantear a sus alumnos desde el aula de clase con el diseño de programas que promueven la innovación desde las asignaturas del pregrado.

El papel que juegan las IES, como motor de desarrollo científico, tecnológico y cultural en una región, determina su perfil que debe responder a los intereses de los estudiantes que se hacen cada vez más diversos y un mercado laboral cada vez más exigente (Seleshi, 1999). Lo anterior conlleva a que la innovación en las IES no pase solo por generar una comunicación abierta y fluida con el entorno en el que se circunscribe. Se trata también de plantearla para la propia estructura académica y el sistema formativo que incluye la docencia, la investigación y la transferencia de conocimiento, como es el énfasis de la UPB (Restrepo, 2003) (Rodríguez, 2004).

La competencia en el sector de las IES tiene mucho que ver con la producción de elementos diferenciadores (Tabak & Barr, 1999). Esto significa que la innovación juega un papel importante en el futuro de las instituciones académicas, donde la forma y estrategias para que fluya el conocimiento y se difunda, desde la generación de nuevas ideas hasta la materialización en un producto que sale al mercado o la creación de una empresa, debe permear todas las instancias de la comunidad académica (Carter, 2001). La búsqueda de nuevas metodologías y la incorporación de tecnologías más acordes con la formación que debe recibir un estudiante universitario resulta determinante en el perfil del egresado (Allgood, 2001). Es allí, donde la innovación educativa suele coincidir con la búsqueda de la mejora del docente y los alumnos, con la optimización del aula como un entorno de formación, con cambios en la pedagogía y la búsqueda de nuevas estrategias que favorezcan en la comunidad académica (que incluye docentes, investigadores, estudiantes, egresados) el flujo de conocimiento que arroje resultados con valor agregado y posibilidades de impactar significativamente a la sociedad (Kilicer, 2009)(Syh Jong, 2008).

Dentro de la comunidad académica mundial, ha existido desde el siglo XIX un relativo consenso en que las funciones sustantivas de las IES, eran la enseñanza de profesiones intelectuales y la investigación científica y preparación de futuros investigadores (Martin, B y H. Etzkowitz, 2000). No obstante, ya desde 1930, se viene discutiendo la necesidad de incorporar a estas dos funciones (enseñanza e investigación), lo que se ha denominado la "Tercera Misión de la Universidad", referida a una Universidad que propenda por la transferencia del conocimiento a la sociedad y que dé respuestas a los problemas de la misma, lo que implica un conocimiento y compromiso con su entorno (Bueno Campos, 2007).

Este contexto, y dadas las exigencias del mercado de contar con profesionales que promuevan soluciones que contribuyan significativamente al desarrollo local, regional y nacional a través de la generación, transmisión y transferencia de conocimiento útil y de alto nivel, condujo a la UPB a la pregunta que se establece como la idea central del planteamiento del problema ¿Cómo lograr capacidades sostenibles en los estudiantes para que desarrollen proyectos que generen resultados transferibles a la sociedad por su alto valor agregado y potencial de innovación? La respuesta a este cuestionamiento es la creación de la estrategia UPB Innova, desde la Coordinación de Transferencia del Centro para la Investigación y la Innovación (CIDI) como estamento orientador de las políticas de la Producción Científica y Tecnológica de la UPB.

UPB innova es una estrategia de fomento a la innovación que se ajusta a la situación actual de las asignaturas de pregrado de la UPB a través de la metodología de las Comunidades de Práctica (CoP) que utiliza actividades formales e informales motivadas desde los estudiantes donde los docentes ejercen labores de planeación y monitoreo y que confluyen en una visión compartida de generar capacidades en un proceso que ha sido complejo, pero que empieza a arrojar resultados que impone nuevos retos para mantener su vigencia.

La capacidad para generar innovaciones se incrementa con la posibilidad de trabajar de forma multidisciplinar, ya que ésta se genera en espacios transversales y esto supone elementos de hibridación (Sanz, 2005). La estrategia UPB Innova, apoya las ideas desde su concepción, con los resultados de proyectos de aula, hasta la materialización en productos que puedan ser incorporados al mercado. De esta forma, la metodología de las denominadas (CoP) entendidas por Seely y Duguid como "la célula básica de la creación de conocimiento, porque en ellas se produce el acto natural de la mejora y la innovación intrínseco a la naturaleza humana y donde si se dan condiciones, se innova, y como algo inevitable, se aprende"(Arbonies Ortiz, 2007), ha resultado especialmente útil y pertinente toda vez que facilita el flujo de conocimiento, mantiene motivados a los integrantes y hace evidente la coherencia entre el saber y la experiencia.

2 Metodología

La experiencia que se presenta utiliza una metodología que pretende la participación del estudiante en su propio proceso de aprendizaje, de forma que no sea solo un receptor de conocimientos, sino que construya sus saberes en cooperación con los demás miembros de la comunidad académica de la Universidad (que incluye docentes, investigadores, estudiantes, egresados) a través de lo que se denomina Comunidades de Práctica (CoP) (Figura 11). Se trata de un modelo caracterizado por el trabajo multidisciplinar, donde desde el inicio los estudiantes no solo trabajan en los temas técnicos referentes a cada asignatura electiva (que en este caso son: "Elaboración de Cervezas, Vinos y Licores" y "Elaboración de productos de Aseo y Cosméticos"), sino que complementan sus clases con soportes prácticos y conceptuales de otras facultades en temas como Diseño de Empaques, de Imagen Global de Marcas, Propiedad Intelectual, Planes de Negocio y Estandarización Química.

La innovación puede ser definida como la generación de nuevas ideas o algo nuevo y su implementación en un contexto dado ((Van de Ven, 1986)(Escorsa, 1997). En este sentido la metodología de las Comunidades de Práctica que utiliza UPB innova articula una serie de actividades (Figura 11 - derecha) que hacen posible la generación permanente de ideas y su implementación buscando resolver problemas o atender situaciones concretas del mundo real. Para ello, se busca favorecer ambientes de aprendizaje y acción articuladamente para estimular y llevar a cabo la innovación (Figura 11 - izquierda y arriba). Todo lo anterior fundamentado en los pilares que gobiernan las políticas de la Universidad (Figura 11 - abajo) y que formalizan sus procesos de generación, apropiación y transferencia del conocimiento.

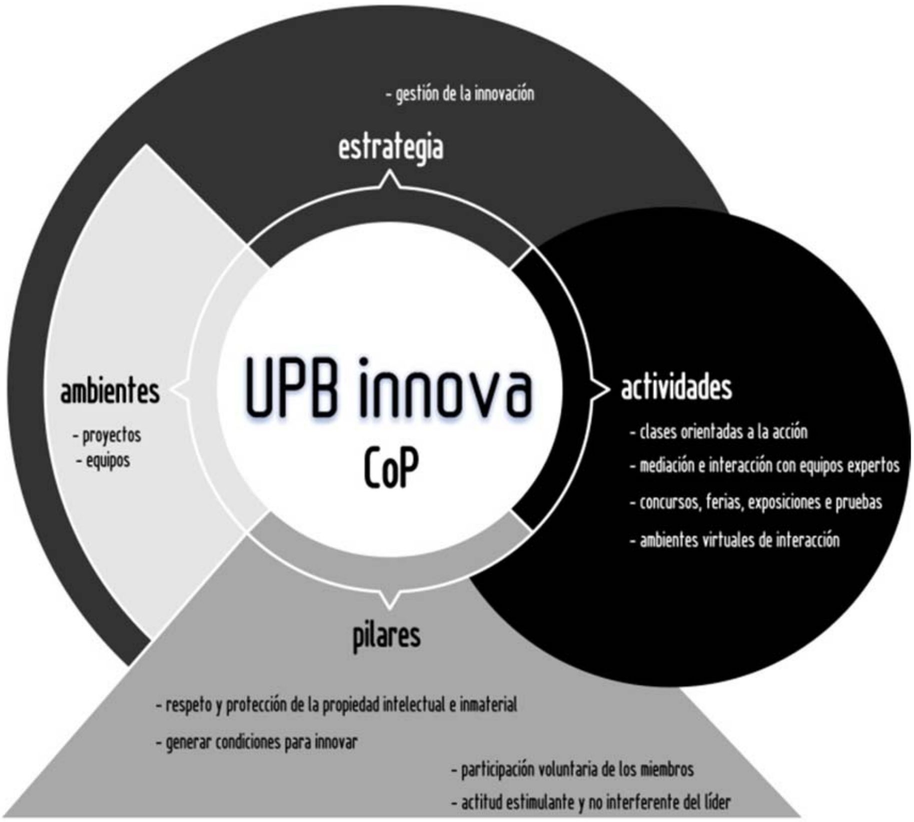

Figura 11. Metodología Implementada en la Comunidad de Práctica de Cervezas, Vinos, Licores y Cosméticos en la UPB.

2.1 Pilares y principios del espíritu de la Universidad

La concepción de la estrategia UPB Innova y su implementación en la Escuela de Ingeniería a través de Comunidades de Práctica (CoP) está fundamentada en los principios que rigen la Universidad haciendo énfasis en: i) respeto y protección de la propiedad intelectual e inmaterial que se genere, llegue o fluya como conocimiento originado desde adentro o recibido desde afuera de la CoP; ii) el deseo deliberado de generar condiciones para que los estudiantes y la comunidad académica encuentre el mejor ambiente para innovar; iii) la actitud estimulante y no interferente del líder de la CoP; y iv) participación voluntaria de los miembros con responsabilidades colectivas y compromisos personales.

UPB Innova se enmarca en un contexto de promoción y fortalecimiento de capacidades de los estudiantes para encontrar soluciones a problemas o aprovechamiento de oportunidades reales con impactos tangibles en sectores específicos. No busca distinguir entre tipos de innovación, sino fomentar y acceder a fuentes de nuevas ideas que puedan generar un impacto significativo en la sociedad.

2.2 Desarrollo de actividades prácticas y de confrontación

Se implementaron diferentes actividades como prácticas de laboratorio, juegos de roles, exposiciones de resultados, debates, etc. (ver numerales 2.2.1 a 2.2.32.2.4), que buscan estimular la creatividad, el trabajo en equipo y la disciplina que implica la gestión de la innovación. Estas actividades se han dado en forma paralela la mayoría de ellas logrando que se complementen y logren mantener en los integrantes de la CoP una actitud activa frente al proceso que se ha iniciado.

2.2.1 Clases orientadas a la acción

Las características que dieron origen a la CoP en las clases de las asignaturas electivas, enfocadas en la acción como posibilidad de aprender haciendo fueron: i) definición de programas atractivos para los estudiantes de diferentes escuelas y con adelantos progresivos que estimulan y motivan permanentemente; ii) la conformación de grupos pequeños, multidisciplinarios en lo posible, donde cada uno de los miembros tiene responsabilidades concretas para sacar adelante un proyecto de aula; y iii) contacto directo con el desarrollo experimental que permite la aplicación de los conocimientos adquiridos y la retroalimentación inmediata.

2.2.2 Concursos, ferias, exposiciones y pruebas de productos

Los resultados de los proyectos de aula, no solo fueron evaluados desde lo académico, sino que fueron sometidos a un proceso de escrutinio en el marco de una feria que se realizó al final del semestre con todos los productos obtenidos (vinos, cervezas, licores y cosméticos). Este evento abierto para la comunidad académica de la Universidad, incluyó la exposición de los productos con su correspondiente marca y envase, los cuales fueron evaluados por jurados externos a la Universidad y expertos en los temas quienes emitieron un veredicto sobre los ganadores.

Este trabajo se constituyó como la primera prueba de producto para evolucionar de una conceptualización de la idea, a una materialización de la misma. Permitió a los equipos confrontarse por primera vez con un público que les ayudó a delimitar sus alcances y expectativas en lo que se puede entender como un primer filtro del proceso de gestión de la innovación, donde se inició una selección que fue necesaria para contribuir a disminuir los riesgos e incertidumbres que se presentarán si se logra llegar al mercado.

2.2.3 Mediación e interacción con equipos expertos

La contribución de diferentes disciplinas, provenientes de otras escuelas a la Comunidad de Práctica se realizó de dos maneras: i) a través de las tutorías, diplomados y conferencias de docentes expertos en temas que complementaron el producto resultante del proyecto de aula y que siguen acompañando el proceso como jurados, asesores y colaboradores; y ii) por la intervención directa de otros cursos sobre los productos para aportarles valor y elementos diferenciadores.

Esta actividad, implicó la sincronización de cronogramas de diferentes cursos, el establecimiento de lenguajes que permitieran una comunicación fluida entre diferentes saberes para aplicar todo el talento y conocimiento sobre un interés común que son los productos que se quieren llevar hasta la innovación y, finalmente, contar con un compromiso individual y colectivo que hiciera crecer las relaciones de confianza que se van construyendo.

A las electivas “Elaboración de Cervezas, Vinos y Licores” y “Elaboración de productos de Aseo y Cosméticos” que son brindadas por la facultad de Ingeniería Química y son soportadas por el Centro de Estudios y de Investigación en Biotecnología (CIBIOT) de la Universidad, se sumaron la mediación e interacción con los docentes expertos de la Escuela de Arquitectura y Diseño de los cursos Imagen Global y Empaques, de la Escuela de Derechos y Ciencias Políticas con el curso de Propiedad Intelectual y de la Escuela de Ciencias Estratégicas con el Centro de Desarrollo Empresarial (CDE).

2.2.4 Ambientes virtuales de interacción e intercambio de información

La utilización de las tecnologías de la información y la comunicación (TICs) en la CoP se constituyó en una herramienta fundamental para el flujo de información y para mantener la motivación de los integrantes de la misma. De esta manera, se empleó una plataforma virtual con la que cuenta la Universidad, ésta funciona bajo el *software* abierto para enseñanza Moodle. Allí se establecieron foros, consultas, información permanentemente disponible, entre otros. De forma complementaria se utilizó el correo electrónico para hacer convocatorias e intercambiar datos. Finalmente, recientemente, se abrió un grupo en la red social *Facebook*, buscando una comunicación más directa y sencilla, especialmente con los estudiantes participantes.

3 Ambientes favorables para el flujo de conocimiento

La orientación contundente de la Coordinación de Transferencia del CIDI es que la misión de la Universidad debe estar orientada a generar las condiciones necesarias para que se pueda dar el flujo de conocimiento que permita egresar estudiantes con mejores competencias para la vida laboral y si es posible en ese mismo camino, obtener innovaciones que generen visibilidad y una rentabilidad que se puedan reinvertir en más investigación y mejores docentes.

Bajo esta premisa, desde la estructura académica que se da en las asignaturas electivas de las que se ha derivado la CoP, se establecen equipos multidisciplinarios pequeños y se orienta a la solución de problemas y aprovechamiento de oportunidades a través de proyectos. Estos dos elementos (equipos y proyectos), sumados a la participación de un líder asignado por el CIDI cuya función es ser motivador y no interferente, son las bases de una estrategia deliberada que busca fomentar el emprendimiento la innovación en toda la comunidad académica.

Con lo anterior se logra hacer sentir parte esencial de una comunidad, la Comunidad de Práctica a cada uno de sus miembros. Adicionalmente, otorga a cada uno responsabilidades como parte del equipo lo que favorece la autodisciplina. Y por último propicia el establecimiento de una identidad, una marca que empieza convertirse en un referente de actuación.

3.1 Estrategia, liderazgo y auto regulación

Si bien los equipos de trabajo se conforman desde el inicio de las asignaturas electivas, es necesario ayudarlos a trabajar en la creación e intercambio de conocimiento. Para ello, el CIDI como instancia que dicta las orientaciones de innovación en la Universidad, designó un líder para la CoP o lo que en otros contextos empresariales denominan un “campeón del proyecto”. Esta persona se responsabilizó de mantener articulados a los miembros de la Comunidad, no solo a partir de su aporte intelectual, sino también de la coincidencia en intereses que favorecieran a todos, situación que facilita la auto regulación debido a que se cuenta con un compromiso personal basado en la motivación.

Dado que la CoP es el instrumento a través del cual se materializa la estrategia UPB Innova, otra de las funciones que asumió el líder fue la evaluación de los aprendizajes prácticos desde el punto de vista de la gestión de la innovación. Él realiza la trazabilidad de todo el proceso desde el origen de la idea, pasando por su desarrollo (experimental y tecnológico) hasta su materialización en un resultado transferible que tenga un impacto significativo en la sociedad.

4 Resultados y discusión

La estrategia UPB Innova, implementada a través de la Comunidad de Práctica que se ha llamado CoP Cervezas, Vinos, Licores y Cosméticos, se ha estructurado a partir de cuatro elementos: i) pilares y principios del espíritu de la Universidad; ii) desarrollo de actividades prácticas y de confrontación; iii) ambientes favorables para el flujo de conocimiento; iv) estrategia, liderazgo y autoregulación. Todos ellos convergen para fomentar la innovación originada en la creatividad y el trabajo en equipo multidisciplinar desde el aula de clase, apoyando las ideas desde su concepción hasta la materialización en productos que puedan ser incorporados al mercado (Figura 11 y Figura 12).

A partir de la feria, que a su vez sirvió como nota final de las asignaturas, se seleccionaron los mejores productos por cada categoría, los cuales fueron acogidos por el Centro de Investigación e Innovación (CIDI) de la Universidad estableciendo una Comunidad de Práctica (CoP) integrada por siete estudiantes y apoyada por cursos y docentes de las asignaturas de Diseño de Empaques, Imagen Global, Propiedad Intelectual, Desarrollo Empresarial y Estandarización Química para seguir potenciando los productos y acercarlos a través de pruebas de producto hacia la innovación.

Los resultados tangibles de esta experiencia se representan en cifras como: 118 estudiantes que han sido acompañados por la estrategia UPB Innova por diferentes Escuelas; siete docentes y asesores vinculados activamente a la CoP; seis productos fabricados con potencial de mercado; una plataforma virtual activa, entre otras (Figura 12a y Figura 12c). No obstante, los logros más relevantes se han determinado a partir de valoraciones un poco menos tangibles y más contundentes y significativas para los intereses de Universidad como: creación de una cultura de la innovación en la comunidad académica, fortalecimiento de capacidades en los estudiantes para enfrentar el mercado laboral, descubrimiento de modelos de relacionamiento de diferentes saberes y públicos muy disímiles, entre otros (Figura 12b).

La CoP de Cervezas, Vinos, Licores y Cosméticos que materializa la estrategia UPB Innova realizará una nueva edición de la feria - concurso cuyos ganadores serán invitados a unirse y seguir incrementando el flujo de conocimiento (Figura 12b). Esta estrategia se ha replicado para las mismas asignaturas en 2011, donde desde el inicio los estudiantes no solo trabajan en los temas técnicos, sino que complementan sus clases con charlas de diseño de empaques e imagen y propiedad intelectual e innovación. Sus resultados han permitido a la Universidad llevar el modelo a otras facultades de las escuelas de Ingeniería y Arquitectura con resultados igualmente exitosos. Se generó en la Universidad un modelo integral que busca dar cumplimiento a la Tercera Misión de las Instituciones de Educación Superior (IES), se conformó una Comunidad de Práctica (CoP) a partir de los grupos de estudiantes en el marco de un trabajo de aula de las asignaturas electivas “Elaboración de Cervezas, Vinos y Licores” y “Elaboración de Productos de Aseo y Cosméticos” ofrecida por la Facultad de Ingeniería Química a los que se les apoyó con la estrategia UPB Innova cuyo objetivo es generar soluciones que contribuyan significativamente a los problemas del entorno a través de proyectos que arrojen productos que puedan ser transferibles al mercado por su alto valor agregado y potencial de innovación.

Para el segundo semestre de 2011, se ha pasado de dos CoP, a la conformación de 22 en las Escuelas de Ingenierías y de Arquitectura y Diseño, con la participación de más de 250 estudiantes y al menos 27 profesores. Esto ha implicado incrementar las labores de acompañamiento para garantizar la gestión de la innovación incorporando nuevas herramientas como la inclusión de un banco de ideas para sistematizar todas las iniciativas que se generan, la emisión de manuales de propiedad intelectual para la concientización de todos los públicos y el apoyo de un plan de comunicación que oriente toda la estrategia de difusión, divulgación y manejo de medios.

Las electivas en el segundo semestre de 2010 matricularon 118 estudiantes (figura a - arriba). Se han realizado dos ferias de presentación de resultados de los proyectos de aula (figura b). De allí se han seleccionado seis equipos que han empezado la conformación de la CoP. Los productos son sometidos a evaluaciones por jurados expertos en el tema y luego reciben un acompañamiento por parte de docentes de otras facultades que aportan valor y elementos diferenciadores, pasando de la idea a un desarrollo que lo acerque más al mercado en un ambiente de práctica apoyado por herramientas de las TICs (figura c) - abajo

Figura 12. Principales resultados y logros de la Comunidad de Práctica de Cervezas, Vinos, Licores y Cosméticos en la UPB.

5 Conclusiones

Las Comunidades de Práctica (CoP) se constituyen en una metodología que propicia el trabajo multidisciplinario y fomenta la innovación mientras los estudiantes aprenden. La experiencia de la Universidad Pontificia Bolivariana ha demostrado resultados contundentes que favorecen la generación y fortalecimiento de capacidades diferenciadoras de los futuros profesionales para enfrentarse al mercado laboral, así como el fomento por una cultura del emprendimiento y la innovación en toda la comunidad académica lo que redunda en el logro de impactos más significativos en la sociedad dando cumplimiento así a la filosofía de la Universidad.

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Paper Session B3

Problem/Project/Practice Based Learning and Transportation Engineering Degrees

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Abstract

The growing demand for professionals able to work with transport and mobility issues has motivated educational institutions of different countries to create engineering programs in those fields. Given the nature of the subjects involved, an intense use of active learning approaches (e.g., P3BL, or problem/project/practice based learning) would be expected in the new programs. The objective of this study was to test this assumption in some of the undergraduate programs that are now being implemented in Brazil. Knowledge tables were built to guide the analyses, which involved a thorough assessment of the learning outcomes vis-à-vis the stated goals. The new programs were also compared with the transportation courses offered in two civil engineering programs. In general, no substantial differences in terms of contents, learning outcomes, and teaching methodologies were found in the comparison. Also, active learning approaches were neither proposed nor formally detailed in any of the cases examined.

Keywords: transportation and mobility; problem based learning; project based learning; practice based learning.

1 Introduction

Many cities worldwide are still under a fast growth process, what produces a strong pressure for various public services. Safety, health, sanitation, transport and mobility are areas constantly and deeply affected by a fast and sometimes chaotic urban growth. The entire process results, among other things, in economic inefficiency and a visible degradation in the overall quality of life of urban citizens. The situation requires the development and implementation of efficient strategies or plans to deal with those problems.

Transport and quality of life in urban areas can be closely related, for example, due to the negative impacts of congestion, pollution, traffic accidents, energy consumption, and so on. Solutions for those problems, which must be viable from economic, social, and environmental standpoints, require professionals with a solid background on transportation planning. Hence, transportation engineers (or mobility engineers, to fit the concept of mobility coined in the latest years of the 20th century) may play an important role in the context of global sustainability.

In order to avoid confusions, undergraduate education here refers to a bachelor's degree program, while graduate education is related to master's or PhD degrees in graduate school. Historically, concepts and fundamentals of transportation engineering are usually taught, at the undergraduate level, only in Civil Engineering programs. Even in that case, however, the number of course credits and hours dedicated to topics related to transport and mobility are very limited, with just a few exceptions. In contrast, certain segments of the society are now advocating that specialized professionals should tackle transport and mobility problems, particularly in urban areas. As a consequence, new engineering programs directed to transportation and mobility planning have been recently proposed.

Due to the multi- and interdisciplinary nature of transport and mobility issues and their practical characteristics, an intense use of active learning methodologies, i.e., focusing on students instead of focusing on contents or even on lecturers, should be expected in the programs recently proposed. This is the hypothesis tested in this study, in which the instructional objectives and teaching-learning methodologies of a few recently proposed Transportation or Mobility Engineering programs are examined. In addition, these elements are also compared to those found in some well-known Brazilian Civil Engineering programs.

2 Background

The fast changes that took place since the latest decades of the twentieth century are demanding the creation of jobs that did not exist before. Most of them are somehow connected to information and communications technologies, but other fields are also appearing. That is the case of transportation engineering (and to a certain extent, also of mobility engineering), which was until recently independently taught all over the world only at the postgraduate level. When taught at the undergraduate level, the topics covered are usually part of the civil engineer formation. In order to contextualize the changes and issues involved in the formation of those professionals, two points are briefly reviewed in this section: *i*) the rationale for the creation of undergraduate programs focusing specifically on transportation or mobility engineering, and *ii*) active learning approaches and P3BL (i.e., problem/project/practice based learning, as in Gabb & Stojcevski, 2009).

2.1 Transportation or Mobility Engineering degrees

In recent decades, significant changes in large and medium-sized cities of many countries (e.g., Brazil) have resulted in problems in various fields of engineering. The situation created a demand for professionals specifically trained to deal with those issues, as is the case of transport and mobility. The fact has a direct impact on educational institutions, which must be prepared to form engineers able to cope with the problems arising in urban areas, many of them depending on or linked to elements of transportation and mobility systems.

In general, Civil Engineering undergraduate programs are usually the source of the largest share of the workforce hired by private companies and public agencies at different levels of government for tackling transportation and mobility problems. Many, if not most, of these programs, however, do not focus on the acquisition of skills related to teamwork, leadership, critical thinking, and analysis of socioeconomic, environmental and/or sustainability issues. Furthermore, undergraduate programs in Civil Engineering in Brazil usually concentrate on building general technical knowledge, what leaves not much time dedicated to the process of solving transportation and mobility problems in general, and even less to examine their relationships with economic, social and environmental issues.

According to Escrivão Filho & Ribeiro (2009), engineering education in Brazil still relies mostly on traditional educational approaches. As a consequence, quite often the contents of the courses have no connection with the real-world context and with the contents of other courses, what leads to a dissociation between theory and practice. Also, environmental aspects are only late integrated into the topics studied. That is the reason why Sylvester, Schünemann, Ordoñez & Vaz (2010) stated that the big challenge in this case is to implement active forms of knowledge building that are able to bring to the students the reality found in the labor market.

Thus, the recently proposed Transportation Engineering or Mobility Engineering undergraduate programs can play an important role in the current context of planning needs, which is under pressure by a growing demand, especially in urban areas. Again, given the nature of the subjects treated in their courses, these programs would clearly benefit from an intense and effective use of active learning methodologies. As a consequence, these should be highly prioritized from a pedagogical point of view.

2.2 Active learning and P3BL

The definition of educational objectives and learning outcomes is an important stage of the planning process of any instructional program, course, or even an assessment test. Among the methods that can be used to assess the consistency of educational objectives in relation to the activities and assessments proposed for a given unit is Bloom's Taxonomy. Originally published in 1956, the taxonomy had its theoretical assumptions updated in 2001 because of psycho-pedagogical and technological advances that occurred during the last decades. One of the differences between the original Bloom's taxonomy and the updated version is that the latter is organized in two dimensions: knowledge and cognitive processes, as emphasized by Ferraz & Belhot (2010).

If the educational institutions plan to form professionals with the skills needed for dealing with the comprehensive and multidisciplinary nature of current transport and mobility issues, the teaching-learning methods applied should necessarily lead students to the high levels of cognitive processes and knowledge-based dimensions of the Bloom's taxonomy (Kyte, Dixon, Abdel-Rahim, & Brown, 2010). The application of methods that enable students to be more active in building their own knowledge is then necessary, as suggested by Alvarstein & Johannesen (2001). Thus, the use of teaching-learning approaches focusing on knowledge building by students and properly conducted by instructors may be a sound strategy to the development of professional skills suited to the current real world needs. Moreover, the traditional approach, which basically involves classroom lectures complemented by numerical solving exercises and laboratory practice, and leads students to acquire only the necessary skills to succeed in exams and tests, is under pressure for change (Rodrigues da Silva, 2010).

In summary, the formation of engineers or other professionals who will work with urban mobility issues should be strongly supported by a multidisciplinary structure, and based on an active and continuous training. Also, the learning process must not be directed only by contents but also by learning outcomes that lead to the development of the required skills. PBL, or Problem Based Learning, and P3BL, or Project/Problem/Practice Based Learning, are among the active learning methodologies that can be applied in that case. The latter (i.e., P3BL) can be classified as an active learning and student-centered methodology, in which the three "Ps" stand for Problem, Project, and Practice. The approach is essentially based on solving problems and presenting those solutions in the form of projects. Also, in order to reach the solutions for the problem and to develop the projects, students need to develop a series of practical activities.

In an attempt to overcome deficiencies of traditional teaching-learning methodologies, Rodrigues da Silva (2010) adopted a P3BL approach in an Urban and Transportation Planning course. In that course, students were challenged to look for practical solutions to the problem of sustainable mobility in a given city. The study has shown promising results for the approach application, such as the positive evaluation of the course, done anonymously by the students in an online platform.

3 Methodology

The first step of this study was a search for Transportation Engineering or Mobility Engineering undergraduate programs currently offered in Brazil, as well as for pedagogic information about them. Once identified, the programs were analyzed by the pedagogical design, information available, etc. They were also compared with a couple of Civil Engineering programs of renowned Brazilian universities. The aim of the comparison was to investigate differences and similarities with respect to contents and teaching-learning methodologies.

The analysis method applied involved several procedures. A first procedure was developed to check the comprehensiveness of the knowledge covered by the courses. In that phase, the knowledge tables built by Bill, Beyerlein, Heaslip, Hurwitz, Bernhardt, Kyte, & Young (2011) served as a reference for an analysis of the contents of the courses taught in the different programs. In a specific study focusing on transportation education, those authors have applied Bloom's Taxonomy to build knowledge tables in the following areas: traffic operations, transportation planning, geometric design, transportation finance, transportation economics, traffic safety, transit and non-motorized modes. Next, customized knowledge tables were built, also based on Bloom's Taxonomy, to analyze issues related to the dimensions of knowledge (content) and the cognitive process (learning), as well as the most appropriate teaching methodology for each step of the process. These knowledge tables cover three of the main areas of transportation: transportation planning, traffic and operations, and geometric design.

The following analysis started with the organization of the relevant information about learning outcomes and teaching methods of the different programs under analysis in a single table, in such a way that comparisons between programs were made possible and straightforward. In addition to the identification of the programs, the table contains: the knowledge dimensions developed (i.e., effective/factual, conceptual, procedural, and metacognitive), the teaching methods used (i.e., traditional, integrative learning, collaborative learning, and P3BL), the dimension of the cognitive process (i.e., knowledge, competency, and skill) and a characterization on the training profile of the students (i.e., undergraduate and graduate levels).

The learning outcomes of each program were obtained by consulting the instructional objectives described in the pedagogical projects, syllabi, and general information available in the homepages. The information that would characterize the use of active learning methodologies (P3BL, PBL, etc.) was also gathered from the pedagogical projects and from the online homepages of the programs studied. However, the evidence of active learning was confirmed only if the pedagogical project had enough information or details on the methodology used.

4 Results

In the search of Transportation or Mobility Engineering undergraduate programs in Brazil, two were found: the first one offered by the Federal University of Santa Catarina at Joinville and the second one offered by the Federal University of Itajubá at Itabira, in the state of Minas Gerais. A third program, in which Transportation is a minor of a Production Engineering program, was found at the Federal University of Rio Grande do Sul. Two Civil Engineering programs were also selected, for comparison purposes. The first one offered by the School of Engineering of São Carlos of the University of São Paulo and the second one offered by the Federal University of São Carlos. A summary of the all programs selected for analysis is displayed in Table 1.

Table 9: Undergraduate programs in Transportation Engineering, Mobility Engineering, or Civil Engineering selected for analysis

UNIVERSITIES	PROGRAMS	HOME PAGES
EESC-USP	Civil Engineering	http://www.eesc.usp.br/
USFC	Mobility Engineering	http://ufsc.br/
UFRGS	Production Engineering - Transportation	http://www.ufrgs.br/ufrgs/
UFSCAR	Civil Engineering - Urban Engineering	http://www2.ufscar.br/home/index.php
UNIFEI	Mobility Engineering	http://www.unifei.edu.br/

In the first part of the analysis, the course contents of the selected Transportation or Mobility Engineering programs were compared with the contents of the knowledge tables developed by Bill, Beyerlein, Heaslip, Hurwitz, Bernhardt, Kyte, & Young (2011), as summarized in Figure 1.

The analysis of Figure 1 shows that the Mobility Engineering program at UFSC and the transportation option at UFRGS cover most of the suggested contents, except transportation finance. Conversely, the contents of the courses offered in the Mobility Engineering program at UNIFEI do not cover most of the knowledge tables used in the comparison. There are some similarities, though, in geometric design and traffic safety. This can be explained by the explicit focus on railway systems adopted in the program.

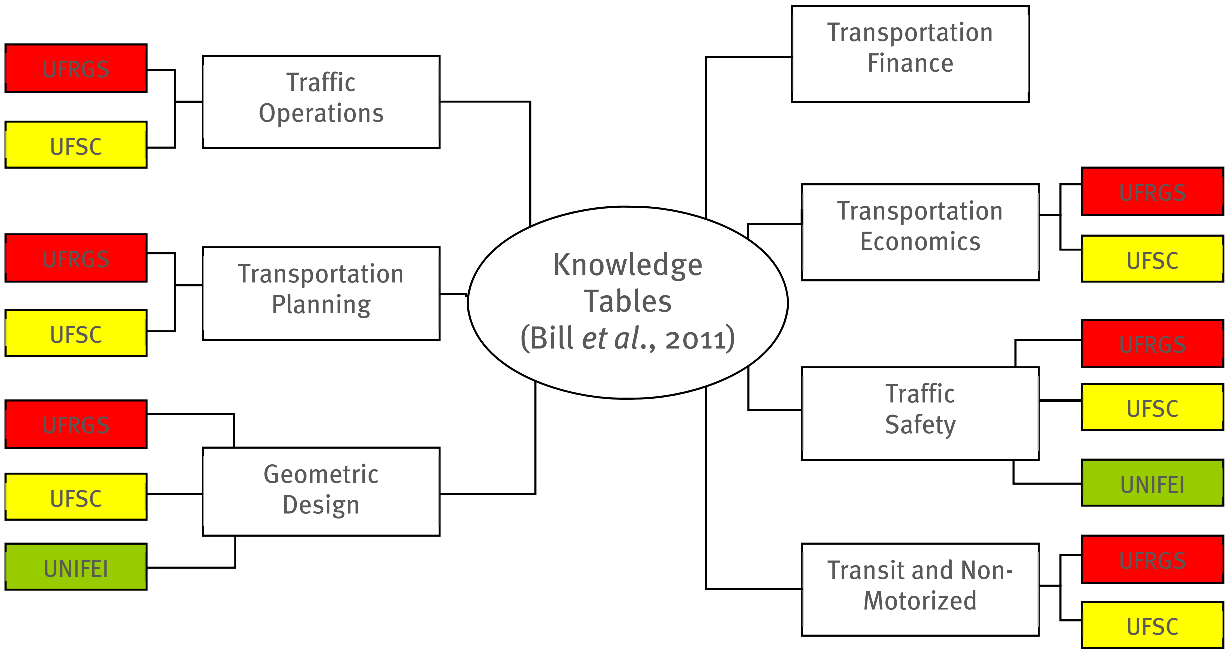

Figure 3: Comparison of the contents found in the courses of the selected Transportation or Mobility Engineering programs with the knowledge tables built by Bill *et al.* (2011)

Next, although three customized knowledge tables have been built for covering essentially the main areas of transportation (i.e., transportation planning, traffic and operations, and geometric design), only the one related to transportation planning is presented here (Table 2). These tables made possible to analyze the proposed learning outcomes for all programs. As they were built following the concepts and classifications found in the updated version of Bloom's Taxonomy, they can be used to explore the format of the contents offered, the processes of knowledge acquisition, and the methodologies applied in the programs under analysis. Furthermore, the tables can be used to examine the relationships between the educational levels (i.e., undergraduate vs. graduate programs) and the dimensions of the cognitive process currently found in the field of transportation in Brazil. Knowledge tables can highlight, as in the example of Table 2, that the instructional objectives of the recently proposed undergraduate programs are directed to competences directly associated to practical aspects of transportation and mobility engineering. In addition, if the students aim at knowledge construction or skills-oriented research activities, they must necessarily proceed to studies at the graduate level.

Table 2: Customized knowledge table referring to transportation planning

Knowledge Table - Transportation Planning						
Knowledge Dimensions	Cognitive Process Dimensions					
	Contents/Information		Competency	Skill		
	Remember…	Understand…	Apply…	Analyze…	Evaluate…	Create…
Effective/Factual	… issues related to social, economic, political and environmental aspects of transport, recognizing these situations in different contexts.					
Conceptual		… the operation of the planning instruments, implying their use and application. … transport planning in the definition of criteria for design of urban road systems, playing practical situations.				
Procedural			… systems analysis in transportation: transport demand and supply and transport pricing methods, executing standard procedures.	… transportation costs, differentiating their classification (fixed, variable, average, marginal).	… transportation projects, checking planning and operation issues.	
Metacognitive				… environmental impacts of transport, providing control and reduction measures.	… the balance between demand and supply, checking the operating conditions.	… models of transport demand and supply, generalizing applications.
	Undergraduate Level or Technological Education *Practice*			Graduate Level - *Stricto Sensu* *Research*		

In general, no evident differences in teaching methodologies were detected when comparing the Transportation or Mobility Engineering programs with the selected Civil Engineering programs. That happens essentially because all considered programs make use of traditional teaching-learning methodologies. Visible differences were found only in the comprehensiveness of the course contents and workload. A comparative analysis of the studied programs based on the knowledge tables is summarized in Figure 2. The results show that, in general, the programs analyzed were exactly the same in terms of the knowledge dimensions and quite similar in terms of the cognitive process dimensions.

The traditional teaching-learning methods used involve essentially the dimensions of the cognitive process related to specific learning outcomes, in this case those associated to the knowledge of technical contents for use in professional activities, particularly those conducted on a regular basis. Another point that must be highlighted in Figure 2 is the association between the dimensions of the cognitive process and the educational levels. While undergraduate studies are essentially connected to knowledge and expertise, graduate studies are associated to skills. Therefore, the undergraduate level training forms professionals for field practice, while the graduate level training focuses on the processes of teaching and research.

Regarding active learning approaches, especially P3BL, there is clearly a lack of these methodologies in the programs analyzed, as shown in Figure 2. The use of traditional methodologies supported by audiovisual resources is evident and emphasized in the pedagogical projects. Even though the use of integrative learning and collaborative learning was mentioned in the pedagogical projects of some programs (Figure 2), no details that might indeed characterize these activities as active learning were provided in the available information.

5 Conclusions

This study examined the instructional objectives and teaching-learning methodologies of a few recently proposed Transportation or Mobility Engineering undergraduate programs, in order to look for evidences of an intense use of active learning methodologies, and particularly P3BL. Those were expected due to the overall characteristics of transport and mobility issues.

The study has initially shown the viability of using knowledge tables based on Bloom's Taxonomy to analyze the learning outcomes and the application of active learning methods in Transportation or Mobility Engineering programs. The analyses have also shown that no differences in terms of contents, learning outcomes, and teaching methodologies were found from the comparison of Transportation or Mobility Engineering programs with the selected Civil Engineering programs. Similar procedures were found in nearly all programs in terms of transferring contents and learning dynamics of the students in the knowledge dimensions and in the cognitive process dimensions.

In addition, the analysis of the learning outcomes has shown a clear focus on the knowledge of the course contents by the students, reached through individual guidance. The goal is to provide the students with a technical knowledge that can be professionally used after graduation. This assumption is confirmed when the stated learning outcomes of the courses are examined under the framework of Figure 2. They clearly match the dimensions of knowledge and competency in the cognitive process, which in turn are linked to the following verbs: remember, understand, and apply. Further analyses of the programs have shown that these elements may be associated with activities carried out in undergraduate programs, while those associated with the skills (or to the verbs analyze, evaluate, and create) are usually linked to graduate studies. This relationship between the dimension of the cognitive process of Bloom's Taxonomy with higher education levels and graduate programs currently found in Brazil seems to be not very different from what is observed in most developed and also emerging countries.

Finally, the use of active learning methodologies was neither proposed nor formally detailed in any of the programs analyzed, according to the information sources researched. However, activities associated to integrative and collaborative learning, which can be part of active learning, were observed in the programs offered by UFSC and UFRGS, respectively.

It is worth mentioning that although limited and restricted to undergraduate programs in transportation, this study can be extended to analyze civil engineering in Brazil.

Assessment Reference Table											
Universities/ Programs	Knowledge Dimensions				Teaching Methods	Cognitive Process Dimensions					
						Knowledge		Competency	Skill		
	Effective/Fact	Conceptual	Procedural	Metacognitive		Remember	Understand	Apply	Analyze	Evaluate	Create
EESC-USP/ Civil Engineering	x	x	x		Traditional	x	x	x			
					Integrative Learning: Interdisciplinary						
					Collaborative Learning: Team-based						
					P3BL						
UFRGS/ Industrial Engineering - Transportation	x	x	x		Traditional	x	x				
					Integrative Learning: Interdisciplinary						
					Collaborative Learning: Team-based			x			
					P3BL						
UFSC/ Mobility Engineering	x	x	x		Traditional	x					
					Integrative Learning: Interdisciplinary		x				
					Collaborative Learning: Team-based			x			
					P3BL						
UFSCAR/ Civil Engineering - Urban Engineering	x	x	x		Traditional	x					
					Integrative Learning: Interdisciplinary		x				
					Collaborative Learning: Team-based			x			
					P3BL						
UNIFEI/ Mobility Engineering	x	x	x		Traditional	x	x				
					Integrative Learning: Interdisciplinary						
					Collaborative Learning: Team-based						
					P3BL						
						Undergraduate Level or Technological Education - *Practice*			Graduate Level - *Stricto Sensu* - *Research*		

Figure 2: Comparative analysis of Transportation or Mobility programs and selected Civil Engineering programs based on customized knowledge tables (as in Table 2)

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Collaborative Work in Projects for Laboratory Teaching in Chemical and Environmental Engineering

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Abstract

Teaching in science and engineering courses include a major bearing on laboratory practice. These practices are an important part of the training of students since they combine theoretical principles in solving practical problems. Traditionally, laboratory practice sessions consisted of a series of predefined tasks included in a script that the professor provides to students in the beginning of the class. Students were expected to strictly follow the script to reach the expected results in the class-time. This model can be useful in the early years of education of students, when teaching is focused on learning basic concepts and techniques. However, this kind of practices limit creativity, self-criticism, thoughtful analysis and independent learning. This paper presents a new option of what we call "creative laboratory practices". In this model, students are encouraged to solve a problem in a free and independent way. There is not script students can follow. Students are not expected to reach the final result in only one practice session. The result of each proposed problem to the students is not predefined, so there may be as many solutions as students. The professor must provide students with a basic data about the problem, and some advices to be able to reach a satisfactory solution. Professor will only act as a supervisor, following the students work. Professor must encourage students to think of different options, advantages and disadvantages of each option, and ultimately, helping them to reach a satisfactory solution. This model has been followed in an environmental engineering course in the degree of Industrial Engineering at the University of Vigo (Spain). Professor designed a set of laboratory practices covering the most important concepts of the course. Students were given basic information about equipment, materials and techniques available in the laboratory. Each laboratory practice was related to an environmental problem associated with industrial activity. In each laboratory practice, students should use one of the environmental technologies or processes studied in the theoretical classes. Students should test different operating conditions, different materials or different processes to find the proper solution to each laboratory practice. Finally, students must design a treatment process for the chemical waste generated in all laboratory practices, so that the final residue was minimized. This approach to the laboratory teaching makes students to use all the theoretical concepts in a creative way. This allows students to achieve a comprehensive knowledge of the course using the following learning techniques: self-criticism, discussion, and working in groups.

Keywords: Laboratory teaching, environmental engineering, chemical engineering.

1 Introduction

Teaching in science and engineering courses includes a major bearing on laboratory practice. These practices are an important part of the training of students since they combine theoretical principles in solving practical problems.

Traditionally, laboratory practice sessions consisted of a series of predefined tasks in a script that the professor provides to students. Students were expected to strictly follow the script to reach the expected results in one practice session. This model can be useful in the early years of education of students, when teaching is focused on learning basic concepts and techniques. However, this model of practices shows limited creativity, self-criticism, thoughtful analysis and independent learning.

Compared with the classical model, this paper presents an alternative model for laboratory teaching that we call "creative laboratory practices". In this model, students are encouraged to solve a problem in a free and independent way. There is not script students can follow. Students are not expected to reach the final result in only one practice session. The result of each proposed problem to the students is not predefined, so there may be as many solutions as students. The professor must provide students with a basic data about the problem, and some advices to be able to reach a satisfactory solution. Professor will only act as a supervisor, following the students work. Professor must encourage students to think of different options, advantages and disadvantages of each option, and ultimately, helping them to reach a satisfactory solution.

This model has been followed in the course "Degradation and Recycling of Industrial Products" in the degree of "Industrial Engineering" at the University of Vigo (Spain). We designed a set of practices covering the most important concepts of each theory topic. Students received basic information on equipment usage, materials and techniques available in the laboratory. Each practice was related to a problem of environmental pollution associated with industrial activity. Each practice was designed to allow the students to use one of the technologies or processes studied in the theoretical classes. Students can test different operating conditions, different materials or different processes to find out a solution to each problem. Students can decide what solution is the most appropriate, with the supervision of the Professor. Finally, as a fundamental part of the course "Degradation and Recycling of Industrial Products", students must design a set of processes for the treatment of the chemical waste generated in the laboratory. So, the final residue is minimized. It makes that the students use the environmental technology for waste treatment studied in theoretical classes, but in the laboratory, they can do it in a creative way. It allows students to achieve a better knowledge on the subject using the following learning techniques: logical reasoning, seeking information, self-criticism, discussion and working in groups (Cameselle, 2010).

2 Laboratory practice. Classical model.

The classical model of laboratory practices is based on a script that sets out clearly the materials and methods to be used, and describes clearly the steps to be follow in order to get the final result. The script also includes the results expected in any intermediate step. Practices are conducted with a predefined experimental setup. Thee experimental setup is usually prepared before the practice session by the Professor. The availability of material and equipment really fits the necessities of the students, there is not spare material or its availability is very limited. The material to be used in each practice is described in the script and the Professor supplies that material to the students. If additional information is necessary, that information is usually attached to the script or the Professor provides the students with the required reference books or articles, usually as hand-outs. Thus, it is not necessary the students prepare or study the practice before going to the laboratory. The practice sessions are usually short (about 2 or 3 h) and that time is enough to achieve the desired result. Student work is limited to the steps in the script, and supervision of the professor is also pre-defined. In this model it is possible that the professor supervises large groups of students.

3 Creative practices.

The model of creative practices presented in this paper has completely different characteristics from traditional laboratory practices. The first difference is that there is not a script to define what the experimental procedure is. Of course, this model gives the student the starting point, the goal to be achieved, and a few ideas about the direction to take in order to solve the problem. There is not a pre-defined experimental setup. Student can design their own method, and their own experimental set-up. Therefore, it is necessary to have plenty of material and laboratory equipment and analytical methods. Students must study the problem proposed in each practice before going to the laboratory. Students must plan their work in the laboratory and elaborate their proposals and design their own solution to the problem in every practice. The proposals and methods to be used must be revised by the professor and discussed with the students before the beginning of the practice session. Students require access to several information sources (books, databases, Internet, etc.) for the preparation of the practice. Each student may require different information depending on their proposal. Considering what has been commented before, laboratory sessions should be long enough (at least 3 or 4 hours per session) to be able to design the practice, organize the experimental setup, and obtain the results. However, the resolution of the problem cannot be assured in a single laboratory session. This model of creative laboratory practices, results in more work for students, and closer supervision and control by the professor. This is only feasible is the practice sessions are organized for small groups of students.

4 Laboratory practices proposed.

The subject "Degradation and Recycling of Industrial Products" is intended to give students a background in management and treatment of industrial waste. The laboratory practices are designed as a complement to theoretical issues, so that students can apply in the laboratory the theoretical principles of physics, chemistry, biology and engineering. Students use in the laboratory environmental processes and technologies to solve environmental problems related to pollution and waste management and treatment. The laboratory practices proposed are as follows:

4.1 Operation of a biological reactor for water purification. Activated sludge reactor.

The first practice session starts with the use of an activated sludge reactor to treat industrial wastewater contaminated with biodegradable organic matter. Students should understand the operation of reaction system and identify a number of parameters in the inlet and outlet effluents to know the reactor performance and efficiency. The selected parameters are: COD, solid content, biomass concentration, oxygen consumption, sludge volumetric index, sludge settling rate, nitrogen content, phosphorus content, chloride content, glucose content and protein concentration. Based on the results, students may propose changes in operating conditions to improve the effectiveness of the biological reactor.

4.2 Electrochemical oxidation of organic pollutants.

Complex organic compounds are difficult to biodegrade, so it is necessary to develop new advanced oxidation processes to treat the industrial effluents that contain such compounds. In this laboratory practice, students can test the electrochemical oxidation of organics. The process variables are: electric current intensity and voltage drop, electrode materials, concentration of organic contaminants and the use of chemicals to improve the process. Students should test different operating conditions to propose an effective solution considering not only the environmental criteria but also economic criteria: the cost of materials and energy cost.

4.3 Photochemical treatment of effluents.

It has been demonstrated that ultraviolet (UV) radiation can degrade complex organics that cannot be degraded in biological process. However, the effectiveness of the UV radiation in a photochemical degrading process is limited. Photochemical treatment can be improved if it is combined with chemical oxidants in order to achieve a synergistic effect. The objective of this laboratory practice is the study of the combination of photochemical and chemical degrading processes. An industrial effluent with organic compounds with complex chemical structures is used. Different combinations of chemical oxidants (hydrogen peroxide, Fenton's reagent, persulfate, ...) and ultraviolet radiation are tested to determine the contribution of each process and oxidant in the degrading process. The best operating conditions must be determined considering the efficiency of the process, the treatment time, and the amount and characteristics of the produced wastes.

4.4 Electrokinetic remediation of contaminated soils.

One of the biggest environmental problems is the remediation of contaminated soils. In this laboratory practice the variables affecting the recovery of a model soil are studied. The model soil is prepared in the laboratory mixing clay with a solution of copper sulfate. Students will study the variables affecting the electrokinetic treatment and how these variables (electric current, pH, copper complexing agents,...) can affect the removal of copper from soil. The practice also includes the treatment of a model clay soil contaminated with Cr and Fe. This test permits to evaluate the interaction among pollutants and how that interaction affects the electrokinetic treatment.

4.5 Contaminants in the subsurface. Permeable reactive barriers.

Permeable reactive barriers is a technology designed to treat contaminated groundwater, so that the barrier acts as a filter of pollutants when installed in the course of groundwater. Students learn in this practice the strategic use of chemistry to create an adequate barrier for the type of contaminants being treated. The practice also examines the effect of the permeability barrier to retain and degrade contaminants.

4.6 Improving the quality of raw materials. Removal of contaminants.

Mineral raw materials are contaminated with compounds that significantly reduce their quality and applicability in industrial processes. In this laboratory practice, students must design a treatment for clay contaminated with an iron ore, selecting a specific chemical extractant, its concentration, pH, temperature and treatment time.

4.7 Adsorption of contaminants.

The absorption of water pollutants to obtain purified water is a common practice in industry and it can also be applied at home. In this laboratory practice, the absorption of metal ions on activated carbon is studied and modeled using Langmuir and Freundlinch isotherms.

4.8 Waste management and laboratory.

The waste generated in the laboratory is collected and stored along the semester. In the last practice session, students must design a process or a set of processes to transform, degrade and/or immobilized the chemical waste generated in the laboratory practice sessions. Processes such as neutralization, precipitation, ion exchange, photochemical or electrochemical degradation of organic compounds, and biological treatment, can be used. The objective of this laboratory practice is to minimize the amount of waste and its possible negative effects on the environment.

5 Results and discussion

This model of laboratory practices was used during the course 2010-2011 in the degree of Industrial Engineering in the University of Vigo. The use of this model can be considered very successful considering the actual knowledge of the students in the beginning of the semester and the results of the exam at the end. All the students had a course of chemistry in the first year. Since them, students only have contact with a chemistry or environmental laboratory in the 4^{th} year. One year ago, since this lab practices corresponds to the 2^{nd} semester of the 5^{th} year. The limited background in chemistry and environment of the student resulted in at least two problems that are described below. Solutions to these problems are also proposed.

In the laboratory teaching model described in this document, students are provided with basic information of the laboratory practices in the first laboratory session. Thus, students know the objective of each practice and have a general idea about the procedures and techniques to achieve such objective. However, students of the degree in Industrial Engineering have a limited background in chemistry laboratory techniques, and they require a close supervision and guidance. They do not know exactly how to prepare dissolutions, how to use a pH-meter or how to use a spectrophotometer. Furthermore, they do not know analytical techniques and their knowledge about the most frequent chemical compounds and their use is very limited. So, they need to be guided throughout the first session. The positive point is they can learn very quickly. All the basic procedures in a chemistry laboratory learned in the first session, students can use them in the following sessions. Despite the relatively good progress of the students during the practices, it is considered for the next semester to start the laboratory practices with a session specifically designed to learn about the material, procedures and analytical techniques available in the laboratory.

The set of laboratory practices includes very different environmental techniques. During the laboratory sessions it was observed that students find difficult to design the experimental set-up and make the control of the process and optimize the procedures making changes in variables such as temperature, chemical composition,... Again, students require a close guidance helping them towards a satisfactory solution for each practice. It was considered more appropriated to supply the students with a dossier with more detailed information about each practice. The document must contain the definition of the environmental problem, the objective to be reached, but it is recommended the dossier includes also a basic experimental set-up, the chemicals and conditions to be used and, a brief discussion of the chemical changes involved in the process. It will make that the students gain a basic knowledge of the process to be tested and they can make changes in the key variables of the process in order to improve the results. It makes the students work more autonomous, more creative and innovative.

6 Conclusions

The model of creative lab practices help the students develop their skills in laboratory work focused on solving practical problems. Students can combine their knowledge and skills to seek for specific information in the literature to provide a solution to a specific problem. So, students develop their critical thinking, reasoning abilities, and skills for working in groups.

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Project-based Learning in Industrial Environment from the Perspective of Students, Teachers and Company

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Abstract

Project-based learning is an effective learning methodology in which students are confronted with complex problems with multiple solutions in a real working environment and where they should acquire and implement new knowledge. This methodology allows students to have a closer contact with real problems and help them developing both technical and soft skills. This article is based on a project-based learning experience, developed by University of Minho students in partnership with a subsidiary of an international industrial company that produces automotive components. The work aims to analyze the impact of this type of project, which follows the PLE (Project Led Education) methodology, on all the involved stakeholders identifying the main advantages and disadvantages, the importance of these projects and the relevance of their replication and existence. With this purpose, a survey and interviews were carried out to company employees, production chiefs, students and teachers. Results showed that this project was considered very successful by all the stakeholders. Almost all participants of this experience demonstrated interest in taking part on it and evaluated this type of project as relevant for all. Unquestionably, these projects should keep on existing.

Keywords: Project based learning, project management methodology, stakeholders, survey, interviews

1 Introduction

Over the years, learning through projects has become increasingly important for the proper and sustainable development of University students. Several authors have published their experiences and points of view on such projects, where students were able to acquire various skills through close contact with professional reality. This type of learning can be implemented by performing internships during the first years of University education (Katajavuori et al, 2006) or during projects on the University course (Harrison et al, 2007; Okudan and Rzasa, 2006). Helle et al (2006) expressed that there are three models of project work in education. The first model refers to the project exercise, with a particular subject and with the purpose of enforcing knowledge and techniques obtained in a known context. The project-component is the second model that works in conjunction with various subjects and is more interdisciplinary. This kind of project is more related to real world concerns. Finally, the third model refers to an approach to the course as a whole, instead of considering the traditional subjects.

The University of Minho has been playing a key role in developing projects that integrate contents from various curricular units over one semester, according to the methodology PLE (Project Led Education) as described in Powell and Weenk (2003). The first experience at the University of Minho with this kind of projects dates back to 2002 and, since then, the teaching methodology associated with it has been continuously developing and evolving (Lima et al, 2007). These team works, which follow the principles of an education based on projects – Project Led Education – give a new meaning to the learning process, as this is done trough the resolution of complex problems by teams of students in a real industrial environment (Lima et al, 2005). According to Lima et al (2005), this type of project "is focused on the students and on their performance in order to achieve the competencies defined", fostering the development of several types of skills. Drummond et al (1998) claims that students are able to develop skills more efficiently if they are in contact with the work reality, than if they are subjected to the traditional way of learning. Students have the opportunity of acquiring the skills required for each one of the curricular units involved in this project and at the same time developing soft skills such as communication skills, time management or projects management (Helle et al, 2006; Powell and Weenk, 2003). Gibb (2002) refers that students should also acquire entrepreneurship skills, such as creativity, leadership and capacity for initiative. Martinez et al (2007) also emphasize these entrepreneurship skills, paying particular attention to autonomy, decision-making ability and ability to solve problems. As proposed by Johnson and Johnson (1991), another important part of this type of projects is also the development of one particular skill, the conflict management. Students can assimilate all the contents and issues related to the various curricular units associated with the project and apply the acquired skills on the resolution of real problems. Students have an integrated vision of problems as they appear in real life situations in an industrial context anticipating their experience in the labor market.

This article is based on a project that took place at the University of Minho, in the framework of the Integrated Master in Industrial Engineering and Management, 4th year. That project was developed, for four month – from October 2010 to January 2011 – together with a Portuguese company, located in the northern city of Trofa (in Douro region, Oporto district), which manufactures components for automobiles. In this company, especially due to its large dimension, it was only studied the functioning of one productive section, where are produced radio and air conditioning modules for cars. Thus, this project was based on the educational methodology PLE (Project Led Education) and consisted of applying the knowledge, lectured during classes, from the five Curricular Units that students have during a semester. There were thirty seven students, divided in five groups of six students and one group of seven. The students had to analyze the productive system and then suggest some improvement proposals using the contents of the Curricular Units involved in the project.

In order to assess the impact of the implementation of the developed project and of the methodology followed in the process, they were described and analysed the opinions and the perceptions of the various stakeholders involved in this project (from the University: students, professors involved and professors not involved in the project; from the Company: production chiefs and employees), trying to identify problems and potential areas for improvement. It is also intended to assess the perception of the company, finding out their degree of acceptance of the ideas suggested by students and if they plan to implement their proposals, understanding the usefulness and the efficiency of this kind of projects. The study of this University-Industry partnership was developed using survey and interviews that were conducted by the authors of this article. In this context, the survey was made to the company employees and to the company members. Professors and students were interviewed, as well.

2 Methodology

In order to analyse and understand the opinion of the various stakeholders involved in this project, an experimental research work was carried out based on the information collected through survey and interviews. The survey and the interviews were conducted three months after the end of the project and were made in Portuguese and then translated to English.

The questionnaire survey was delivered to the company employees and later collected. The questionnaire survey was composed of twenty two questions formulated with five-point Likert scaling (1 is “never” and 5 “always”). Four different issues/aspects that are important to analyse were considered in the design of the questionnaire survey: i) the project ii) the employees’ expectations iii) the company acceptance and iv) the students’ role. This anonymous survey was distributed to the employees during the working hours and answered during their lunchtime break. It is important to refer that the population considered for this study is consisted only by women with an average age of 37 (from 21 to 57), who are machine operators and have, in average, 16 years of work in the company. To analyse more efficiently the information collected from the survey, the data was treated using the statistic software SPSS – Statistical Package for the Social Sciences (IMB).

Regarding the interviews it was important to distinguish four different groups of persons because of their different involvement and role in the project: i) the company members ii) the professors involved in the project iii) the professors not involved in the project and iv) the students. Relatively to the company members, they were interviewed two chiefs of production and the head of the Logistics Department. The interview was conducted simultaneously to all three and was recorded so as not to lose any information. The interview consisted of twenty three questions, some directly related to the project, others related to the students’ behaviour and others concerning the University-Company relationship. In what concerns the group of professors involved in the project, five professors were selected for the interviews. The selection criterion was the professors’ awareness and knowledge about the work carried out by the students. The selected professors are also the ones with whom the students had a more close contact and easy access. These interviews were also recorded and consisted of seventeen questions that can also be dived into three aspects: i) the project itself ii) the students’ learning process and iii) the Curricular Unit lectured by the respective professor. In relation to the group of professors non-participating in the project, the selection criterion was their expertise in relation to the project topics. In such way, it was decided that one professor of each area would be interviewed, namely: Industrial Management, Numerical Methods and Statistic, Optimization and Operational Research, Human Engineering and Economic Engineering. These interviews were also recorded and consisted of eleven questions about the project, the students and the Curricular Units. Finally, concerning the students, two students were randomly selected from each project group. These recorded interviews were conducted simultaneously to the two members of each group and had twenty six questions regarding i) the project, ii) the students behaviour, iii) the Curricular Units involved and iv) the company. The students' opinion is one of the most relevant to take into consideration in this study since the project was carried out by them being extremely important to their learning and education process.

3 Survey and Interviews Analysis

In order to analyse the survey and the interviews more efficiently, the population was divided in two groups – the University group and the Company group. In the University group it was scrutinized the students and professors' perceptions (those directly involved and those not involved in the project) and in the Company group it was explored the company members' perception, both the employees and the production chiefs.

3.1 University

The students and professors' opinions show that this type of project has a lot of advantages for both the University and the Company. It is important to refer that the professors' perception is based on their professional experience along several years, while the students' perception is only based on this project in particular (due to the fact that this was their first contact with this kind of projects).

The students have the opportunity of establishing their first contact with a real company, dealing with real problems of day to day business. It is no longer an academic exercise and the students are able to apply the knowledge acquired at the University to solve real problems and they can suggest various improvements that can be implemented in the company where the study was carried out. Another benefit brought by this project is that students learn to solve real problems working in teams and may achieve good communication skills.

> "The students begin to see the practice, the reality, how companies work (...)"
>
> Professor involved in the project (Activity Area: Industrial and Systems Management)

> "I think the greatest advantage is for us. (…) It was our chance of seeing how things work out there. (…) what is taught here at the University is not always as linear out there and things do not always work so well."
>
> Student (Group 3)

This project brings advantages for the University itself too, since the University and Course's name and reputation are spread and divulged. If the students manage to do a good job and if there are no problems attached, the University can maintain a good relationship with the Company in order to establish future new projects.

> "This interaction is most beneficial to students and to the University than to the company (...). The projects that exist in the course are very tight on time, a semester is too short. Yet, in my opinion the company has, in the end, a perfect notion of what a group of students is capable of, what the course is capable of, what the University itself is capable of."
>
> Professor involved in the project (Activity Area: Optimization and Operation Research)

According to several stakeholders' opinion a project of this kind can be very interesting, for the Company, as students bring new ideas, different approaches and updated information on technologies and methodologies. The University is always updated and can freely give the knowledge the Company needs to succeed. Students can have a fresh new look over the problems and propose different ways of solving them.

> "I think that it brings tremendous advantages to the company for one simple reason: the company is concerned about the operational management (satisfy orders, customers and deadlines) and forget that sometimes it's necessary to take someone who thinks about the way they operate and how they can improve their business. And I think that students, some students, are even a stone in a pond to these companies because they benefit enormously from the work they have there."
>
> Professor not involved in the project (Activity Area: Industrial and Systems Management)

Concerning problems that may arise from this kind of project, professors and students showed different opinions. In the professors' opinion, the problem that can induce more the good project development is the coordination of the professor's team (the ones involved in the project). Another problem is that some students give more importance to the project than to the information transmitted in the Curricular Units (CU), not acquiring the entire knowledge taught throughout each one of the CU's along the semester. Finally, the professors involved in the project also told that some of the students didn't do their "homework", i.e., they do not prepare the questions for the visits to the Company so they cannot get all the information needed.

> "When students go to the company trying to understand the productive system, they can't get there and just ask how to make the Production Planning and Control. It is a question so difficult to answer that no one responds to. So they have to do a previous homework in order they will be able to ask more direct and precise questions."

Professor involved in the project (Activity Area: Industrial and Systems Management)

> "A potential disadvantage of this project, (...) may be the fact that this project is something different from other Curricular Units, where basically you come to classes (...) have to study (...). And this project does not usually have these things you dislike. You basically have to work, have a space to work (...) And then the tendency that is sometimes observed is that this project is almost everything for you, in a semester you dedicate 90% of the work to this project but it's only worth 30% of the grade (...) there is something that is unbalanced."
>
> Professor not involved in the project (Activity Area: Human Engineering)

On the other hand, students point out the conflicts among the group as the worst problem. To this project it is needed a strong team work that sometimes lacks in the groups. To the students, the coordination of the work schedules and the maturity of some members of the groups were mentioned as problems as well. At last, they considered that the role of the tutor is very important too and sometimes he/she did not correspond to the students' expectations and needs.

> "The main problems are the lack of team work (...) sometimes one of the group members do not work and some other times, there are conflicts within the group (...). The relationship with the company may also be a problem because sometimes there is not enough openness to consider the students recommendations. Then there's the side of students. Sometimes they are not enough responsible, they are not mature enough to have this relationship with the company (...). Another problem that may occur is the role of the tutor, who may not always be present."
>
> Student (Group 2)

In spite of these different opinions, there are a few problems in which both of them agreed on. The difficulty to access to the information and the lack of availability by the company members were the most commonly pointed out problems. Other problems are the short time to do the project, the long time needed for the visits to the Company and the travelling costs to the company, due to its distance (approximately 30Km). Another problem very mentioned, mainly by the students, was the lack of communication between the University and the Company.

In what concerns the students learning process, with this kind of projects, students are able to acquire two types of skills – the technical skills and the soft skills. Concerning the technical skills, they can comprehend the Curricular Units' concepts better by applying them in the project context. Relatively to the soft skills, there are many important ones to consider, such as team spirit, time management, communication skills, critical power, projects management, organization, discipline, conflicts management and resolution in the work team.

> "I think it's the team work, to have the power of initiative, critical thinking (...) a good relationship with people, to have a position of humility, being an entrepreneur but also know how to listen to what people have to say (...), be diplomatic."
>
> Professor involved in the project (Activity Area: Industrial and Systems Management)

Comparing the students' learning process when they do this kind of project with the traditional learning process (classes, tests and academic works), it is possible to understand that the majority of the interviewed considered that this project is a capital gain, especially for students. Even though most of the people agreed, there were some professors who said that students cannot neglect the learning basis and the scientific knowledge.

> "The students are more motivated. And then we have the fact that they see how companies apply the knowledge we teach here (that students sometimes think it is very vague and not applicable). (...) This motivates students to be more attentive in class, trying to figure things out, so of course they learn more."
>
> Professor involved in the project (Activity Area: Industrial and Systems Management)

> "I think that in some issues the students can keep a registration, can remember more. But they learn a practical case and they may not learn a general theoretical situation which could then be applied to different variations in many scenarios. They are there just to study a scenario, which is reductive (...). We should learn the gravity law and not only observe how the rock falls."
>
> Professor not involved in the project (Activity Area: Optimization and Operation Research)

When confronted with the question about the existence of more of such projects throughout the course, the interviewed showed different opinions. The professors involved in the project demonstrated interest in having a similar project also in other previous course years and even one in every course year, but with a smaller dimension. The professors not involved in the project said that this project should be kept in the 4th year or, possibly, there could be one project of this kind in the 3rd year. In the remaining previous years there could be visits to companies for students to have more close contact with business reality. The majority of these non participating professors would like to see their Curricular Units involved in this type of projects too. The students all agreed that there should be at least another project of this kind in the previous year but not one in every year because the Curricular Units of the first years are not the most adequate to this kind of projects.

3.2 Company

The company involved in this project had never participated in a project of this kind. However, the company believe that students could bring new ideas, new technology, more updated tools and, at the same time, it could bring a capital gain. They also assumed that they would have time to receive students and to support them in their activities, being available to answer to all students' questions.

> "Typically, the visits were scheduled, the students settled a time to be here and I knew that in that time I had to be available (...). I never lacked the will to receive students."
>
> Company's Production Chief

Once the company had access to the students' improvement proposition/suggestion, they could understand the potential of their application. Some suggestions were already implemented (the lighting improvement in the workplace), others seemed to be more difficult to implement (the layout adjustment) and others are into consideration (the improvement of the replenishment of materials to production lines).

> "There are proposals that could be implemented but not easily. There are solutions that involve drastic changes in the layout (...) changing the layout is not an easy thing to do."
>
> Company's Production Chief

Nevertheless the good reception from the company to students' ideas it was not always possible to answer to students' doubts and questions. It was the case when students asked for some information that was considered confidential and the production chiefs could not give them a direct answer. Another situation was when the required data was not confidential however the company members to make public that kind of information need their superiors' permission.

The analysis of the obtained results was made taking into account three different categories answers: i) positive answer, the higher the score the more positive is the answer ii) negative answer, the lower the score the more positive is the answer and iii) informative answer. In this way, for each the 22 questions of the questionnaire survey, the average of the scores for the individual questions were computed, see Figure 4, where the green colour represents the type i) questions, the orange colour represents the type ii) questions and the grey colour represents the type iii) questions. For the positive answers (type i) questions) an average evaluation higher than 3 (solid horizontal line) has a positive meaning and corresponds to the expected score value for these questions. An opposite behaviour is expected for the questions type ii), where an average score value less than 3 represents a positive perspective (orange bars).

Analyzing Figure 4 it is possible to recognize that the answers given to the questions corresponding to the orange bars (type ii) questions) are considered positive. For example, in questions 19 (P19: "Have you felt any discomfort due to the presence of students in your workspace?") and in 21 (P21: "Have you ever had to interrupt your work to answer questions raised by students?"), the average score values are lower than 2 (or "not much") meaning that the employees support that the presence of students on their workplaces was not incommodious.

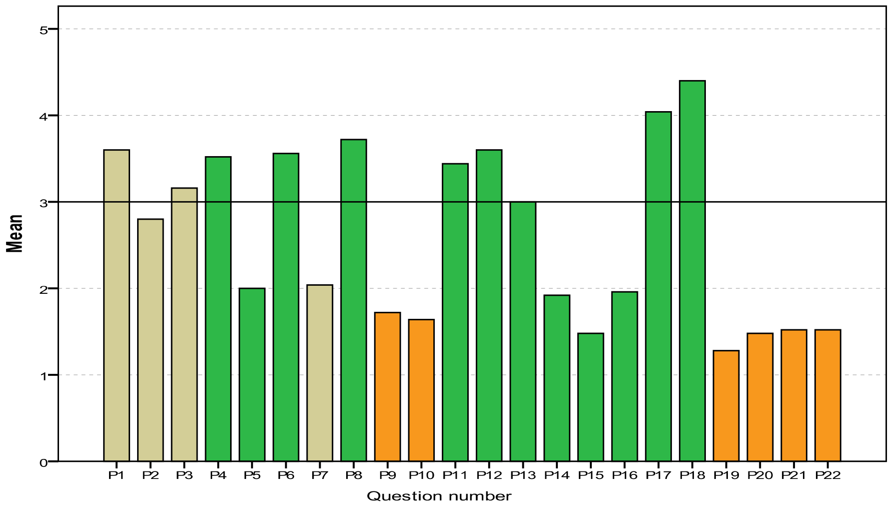

Figure 4: Mean values for each question of the survey

Regarding the green bars, questions with a positive answer, it is possible to observe that 8 on 12 answers given by the employees are positive (average score value higher than 3). The question with the highest positive average score corresponds to question 18 (P18: "Did you felt well treated by the students?") this might mean that students had a correct attitude and posture when approached the employees. Nevertheless, for four questions, the average score obtained is below 3. After analysing the possible causes of these low values, it was possible to conclude that they were normal, since the questions were related to the improvement and changes of the employees' workplace. As this study was conducted three months after the end of the project, it is possibly that this time was not enough so that the changes proposed by the students have been implemented and their results properly analyzed. Regarding the grey bars, informative answers, the average scores obtained were as expected, except for the question 7 (P7: "Your superiors always notify you in advance when students visited the company's facilities?"). In average, the employees demonstrated that they were "not always" informed regarding to the students' visits.

Comparing the production chiefs' and the employees' perception, both agreed that their relationship with students during the project was extremely good. The questions 18 (P18: "Did you felt well treated by the students?") and 20 (P20: "Would you like to have had less contact with the students?") could demonstrate that the employees felt comfortable with the presence of the students, and confirmed by the production chiefs answer in the interviews:

> "I think that our relationship with the students was great, it couldn't have been better!"
>
> Company's Production Chief

Concerning the employees' attitude while the students were in the shop floor, again both the employees and the production chiefs agreed. In general, the employees considered that, even though there were outsiders analyzing their performance, they did not feel pressured and had the same behaviour while doing their job (P10: "Do you think you worked/behaved differently when students were in your workspace?"), with an average lower than 2 ("not always"). The production chiefs believe that employees' attitude has not changed, however they felt more useful by answering the students' questions and motivated by the students' interests regarding their work.

In general, it is possible to conclude that there weren't negative aspects that affected the correct running of the project. It is also important to refer that the majority of the company members showed some interest in having this type of project in their company again and shortly. However, with some exceptions, since not all the employees looked very enthusiastic with this project. The average score value obtained for the question 4 (P4: "Do you think that it would be interesting to repeat this type of project in this company?"), despite of being positive, was only of 3.5 (Figure 4) meaning an answer between the "may be" and "without an opinion". This opinion is not influenced by the employees' working years at the company, meaning that, regardless the years of service at the company, the opinion concerning the interested in repeating this project is similar ($p > 0.05$).

3.3 Comparison between University's perception and Company's perception

After analyzing the two separate perceptions, both of the University's and the Company's, it is important to relate them to understand completely this duality. The students' posture and attitude during the project was considered, by the involved professors, as good. In spite of their big motivation, some students had a punctuality problem, arriving late to meetings and to the company visits. The professors also said that a few students showed assiduity problems and even a little lack of responsibility, but, the majority of the students were very interested, enthusiastic and motivated to do a good job.

> "In general, students were punctual within tolerance (10min) (...). Most groups were committed, although there were some students or groups who didn't showed much responsibility.
>
> Professor involved in the project (Activity Area: Human Engineering)

> "What I felt over the years can be resumed in two distinct phases: an initial phase of concern by the students, they do not quite know what will happen to them; the information is often slow to arrive because they don't control it (...). In the second phase, I notice a great willingness of students to work and the company's visits become very motivating."
>
> Professor involved in the project (Activity Area: Optimization and Operation Research)

The production chiefs also referred the punctuality as a small problem. However, they said that students were very interested in analyzing the productive section and considered it as a very stimulating experience.

> "The punctuality was very bad, even though, by the end of the project it started to be better. I think that they were very interested, that sometimes it became a little annoying (...). Questions repeated twenty times it´s a little exhausting but, in general, I think it was a great experience (...). Some students faced the project in a very positive way, transforming it in a good challenge."
>
> Company's Production Chief

The students themselves considered they were interested and committed, but sometimes some conflicts arose among the group. They also mentioned the punctuality as a problem of some group members. Overall, they stated they had the right posture and attitude to accomplish this project.

Regarding the communication between students and company members (production chiefs and employees), it is relevant to indicate that everybody have the perception that there might be a little problem. This communication problem occurs due to a language/ vocabulary barrier which affects the good understanding between both parts. This language barrier takes place because of the use of different terminologies, used to describe some activities in the production system, that are different at University and Company.

Students consider that the relationship between them and the company members was very good. They believe they were well received and that the company members were very collaborative and helpful all the time, so they felt comfortable in the company.

> "In terms of personal relationship it was good, the production chief was an impeccable person and the employees were very nice (...). The relationship was very informal."
>
> Student (Group 3)
>
> "We were received very well and they were very helpful, we had no reasons to complain."
>
> Student (Group 4)
>
> "I think it was good. In the beginning, it caused an impact to the company employees because they didn´t know the students, but after some contact with them we had always a good relationship and we could even exchange a lot of information."
>
> Student (Group 6)

4 Conclusion

As part of the PLE method proposed by Powell (2003), the project that was the basis of this article was intended to allow students to examine a section of a production system in a real industrial unit and propose suggestions for improvement. This article aimed at analyzing the perceptions of various stakeholders involved in this process, which could be grasped through survey and interviews conducted three months after completion of the project. In order to more carefully and deeply analyze the results, the two main entities involved in this project - University and Company - were considered separately. With regard to University, they were interviewed students, teachers involved in the project and teachers not involved in the project. In the company they were interviewed two production chiefs and the head of the logistics department and was performed a survey to the employees of the section under study.

After analyzing the survey and the interviews it was possible to conclude that, in general, this project was beneficial for all parts involved. Students had, in an early phase, their first contact with professional reality and had the opportunity of developing their creativity and applying their ideas and knowledge acquired in class. This project was also important for students to achieve certain soft skills important for their future careers, such as project management, time management, teamwork, leadership and communication skills. The companies had the opportunity of receiving some interesting and feasible suggestions, based on a different view on the problems and using updated techniques and knowledge.

These projects can also serve as a marketing strategy, as the University can promote itself as well as its courses and projects. A great added value pointed out by all stakeholders was the good relationship between students and teachers and all the company members. However, although this project has brought undoubtedly many benefits, there were also some problems, such as the communication between students and the company members, since the terminology used is different, the restricted access to information because of the confidentiality of some of it, the conflicts within the group members and also the distance that the students had to travel to reach the company. Another problem often mentioned in interviews, both by teachers and heads of production, was the lack of punctuality of some students.

In conclusion, this project was very fruitful and beneficial for all parts involved. The vast majority of participants expressed its interest in participating and in repeating this experience and considered that these projects are crucial for a good students' learning process and should undoubtedly continue to exist.

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Paper Session C1

Hands-on simulation in the classroom to teach new concepts and to prepare future industrial engineers as operator´s instructors

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Abstract

This paper presents a hands-on simulation approach developed in a Curricular Unit of the 5th year of the Industrial Management and Engineering (IME) Integrated Master degree of University of Minho. The students, working in teams, were invited to prepare a potential training session to instruct operators in a work environment about cell operating modes (specific thematic in the Curricular Unit contents, defined by the teacher). The teams had freedom to prepare this session as they desired and to use all kind of concepts, tools, techniques they already know or acquire. All teams decided to use a torches kit, available by the teacher, with a product to assembly (the torch), in a different cell operating mode. With the hands-on simulation, the students learn how to prepare a training session, learn new concepts, and apply concepts and tools learned in previous classes. Student's opinions and results of this hands-on simulation are presented.

Keywords: student-centred learning methodologies; hands-on simulation approaches.

1 Introduction

The Bologna process (Eurydice, 2010) puts some challenges to the academic community. Some of these challenges come from the need to change teaching methodologies. Traditional lecture based teaching methodologies are being replaced by active learning methodologies, that involve the student in his own learning. Either based on technology, like the Technology Enabled Active Learning (TEAL) project in MIT (Dori, 2008) or on projects/problem, the objective is the same, engage students deeply in their learning process. At the School of Engineering of University of Minho, some projects based on *Project Led Education* (PLE) (Powell & Weenk, 2003; Powell, 2004; Lima et al., 2007) have been developed for students of the 1st and 4th year of the Industrial Management and Engineering (IME) Integrated Master degree (Lima et al., 2009a; Lima et al., 2009b). The 5th and last year implies for the students an individual project, normally, in a company (Alves et al., 2009b) so, these students do not have any PLE project. In spite of that, each Curricular Unit (CU) gives teamwork assignments that involve active learning methodologies. This paper presents and explains an experience developed in CU of the 5th year in an active learning context. The students were invited to prepare a potential training session to instruct operators in a work environment about operating modes (specific thematic in the CU contents, defined by the teacher). All students in different teams were supposed to simulate a different operating mode, using the same product – a torches kit, to assembly in a hands-on simulation. Additionally, the students learn new concepts and compare the different operating modes. Hands-on simulations have been explored to promote understanding of complex subjects in a deep and intuitive way (McManus et al., 2007).

2 Student-centred learning methodologies

The Bologna Declaration is said to promote a shift from traditional, teacher-centred approach to a student-centred approach to learning, taking the learning outcomes as a starting point, instead of content-driven. Using methods that are centred on the students, instead of on the teachers, implies three fundamental shifts in thinking about learning (Jonassen & Land, 2000). The first shift is from knowledge transmission to a process of making meaning. Learners try to resolve the dissonance between what they know for sure and what they perceive or believe that others know. Secondly, the social nature of the construction of meaning increases the focus of learning as a process of social interaction, rather than an individual process. The third shift in assumptions relates to the communities in which the process of making meaning is taking place. The locus of meaning making is not only in the head of the learner, but also in the discourse among individuals, the social relationships that bind them and the physical artefacts, models, theories and methods they are involved in (Jonassen & Land, 2000). In a student-centred approach to learning, students need social interaction to construct meaning. This means a learning environment in which students are engaged in activities that provide opportunities to interact with other and with the world around them. Shifting responsibilities from teachers to students makes students more active in the learning process and increases interaction between students and the teacher and between the students and their peers. Weimer (2002) identifies five key elements of change towards a learner-centred practice, starting with the balance of power that is, traditionally, with the teacher. Student-centred learning means a shift of power from the teacher to the student and confidence in the ability of the student to make decisions about his learning. It does not imply a complete transfer of power, but rather a share of power. The function of content is the second key element of student-centred learning. Weimer (2002) argues that a too strong orientation on content can hinder learning. On the other hand, learning about learning and learning content simultaneously is a different way of looking at content in learning. The role of the teacher is a third key element in student-centred learning. The focus of faculty needs to be on learning to become aware of how teaching influences learning. Faculty facilitates learning and is no longer the centre of attention. The responsibility for learning needs to be accepted by students, as a fourth key element of student-centred learning. Teachers can create conditions and help students to be willing to learn, but, in the end, the students have to do the learning. Weimer (2002) argues that discipline is not the key to student learning, but that logical consequences are necessary to change unfavourable behaviour. There must be consistency in word and deed with regard to students. The purpose and process of evaluation is the last key element identified by Weimer (2002).

In this study, students are involved in a specific activity that aimed to construct as many torches as possible with a specific operating mode. Students have to work in teams and carry out an open-ended assignment. T

3 The teamwork assignment

The teamwork assignment was carried out by teams of 3 students and consisted in developing a plan to operationalise a session to train operators in working operating modes (Alves et al., 2003; Alves & Carmo-Silva, 2006) adopted for cells (Hyer & Wemmerlöv, 2002). A cell is a production system layout that could be projected as a *"…small organizational units which complete all the set (or family) of products or components which they make, through one or a few major processing stages, such as metal founding, machining and assembly, and are equipped with all the machines and other processing equipment they need to do so."* (Burbidge, 1989). An extended definition points to a production system that groups and organizes the manufacturing resources (e.g., people, machines, tools, buffers, and handling devices) necessary to manufacture a family of parts and/or assemble a family of products, with identical or similar manufacturing requirements.

Seven teams were formed (21 students), each team approaching a different operation mode: Baton Touch; Bucket Brigades in line and in cell; Rabbit Chase; Working Balance, Toyota Sewing System and Assembly Line (Figure 1).

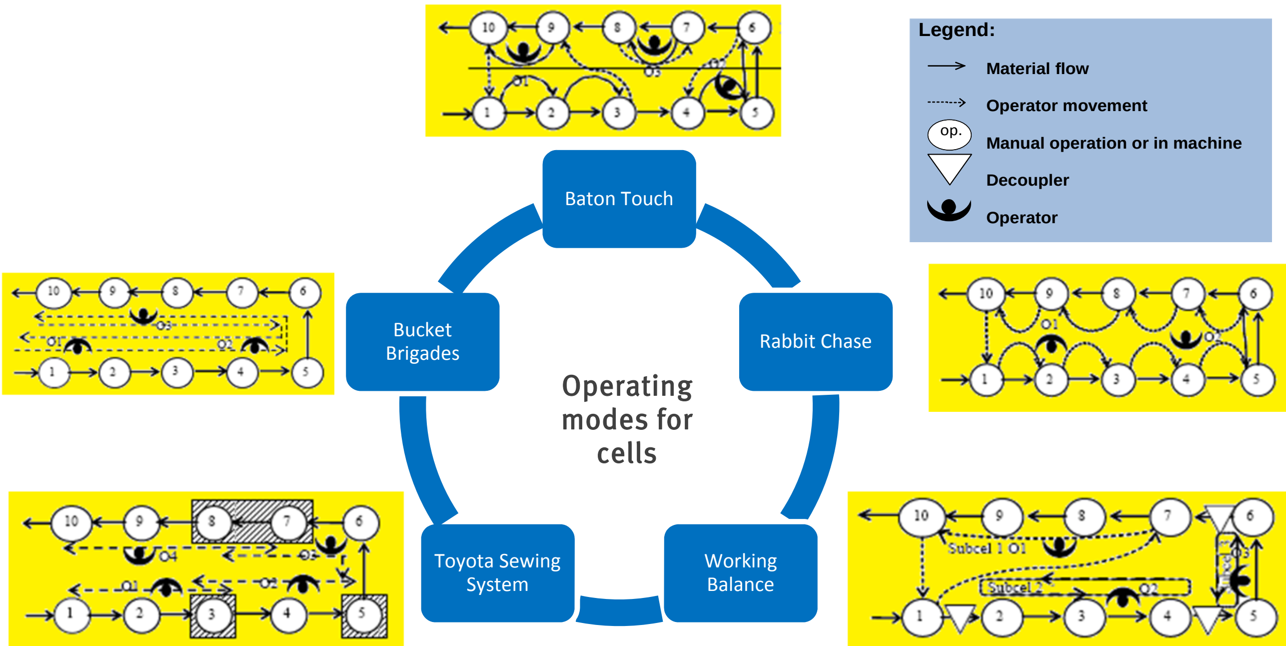

Figure 1: Schematic representation of operating modes for cells (Alves, 2007)

In simple terms, working operating modes mean the internal organisation and distribution of the operators by the workstations related with how people work and flow within a cell (Oliveira & Alves, 2009). Each operating mode has some characteristics distinguishable and each team had to study these characteristics in order to present to the teacher and colleagues how works the mode allocated to the team. All teams receive a document with a basic description about the operating modes with the Figure 1. They also had access to operating modes literature and a review already done in Alves (2007).

The teams had totally free choice to do the plan how they wanted and used tools available or others they found out. They had available a torch kit (Figure 2) for the hands-on simulation with a very simple manual (Lean Games, 2006) which describe the operations to assembly a torch.

Figure 2: Torches kit (Lean Games, 2006)

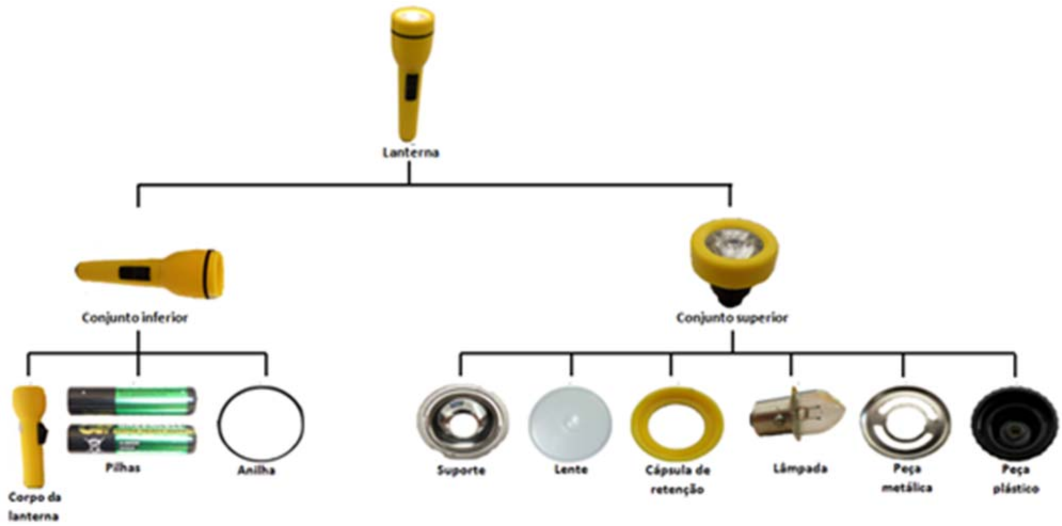

Figure 3: The torch and torch components (Bills of materials)

All teams decided to use this kit to do the hands-on simulation. The product to assembly in the cells was torches with different colours. Each team has to prepare the layout for the cell, attending to the operating mode allocated and all material (documents, presentations, ...) that they consider for the operating mode formation plan.

This work assignment was one of the assessment components (25%). Other components were the written test (40%) and an individual project in a company (35%), resulting in a technical report. This individual project is what Peter (2010) calls a hands-on case study, a teaching methodology that helped students to assimilate the CU contents and engage them in a work industrial environment. The opinions students on that experience were collected by email in the end of the semester.

4 The sessions preparation

The first task was to standardize the operation times for all assemblies operations, defined by the teacher and students before the simulation sessions. Having these common operations times, each team made some experiences, and then sent the results to the teacher that found out an average that all teams could use in order to compare results. The common material to be used by all teams was the torch kit, the torch kit manual, the operation and operation times. In class, a simulation time of 5 minutes was defined to demonstrate the operating mode. Knowing this time and the longest operation time, the demand and the theoretical operators' number were defined.

So, the initial data for simulation was 5 minutes for simulation, chronometric time, longest operation time was 5,7 seconds, expected demand was 53 torches and the initial number of operators was 5. This number puts some challenges to the teams since they had 3 members and need more people than this number. When the first session took place, the team needed 5 operators and even with the volunteers called by the teacher the students did not offer help other teams. The teacher had to interfere to make students help each other out to run the simulation.

These simulations took place in three sessions with a total time per group of 10 minutes. Each team simulation had three parts: the preparation (introduction by the team of the operating mode), the hands-on simulation (involving team members and others colleagues) and the conclusion (the findings). All sessions were video-taped and became available to the teams in the end of the sessions. There were not restrictions to the tools, documents or figures they could use. Each part demanded different approaches and they could use whatever they want.

5 The results

The outputs from each team were diverse since they used different approaches to "train the operators"; the Table 1 resumes these approaches. Some introduce the theme with a presentation, others with posters. One team used a simulation model using the software ARENA to show the layout and the operating mode (Figure 4).

Table 1. Approaches used by the teams to present (conclude) the operating modes

Teams	G1	G2	G3	G4	G5	G6	G7
Operating modes	BT (5 op)	RC (4 op.)	WB (5 op.)	TSS (5 op.)	BBline (4 op.)	BBcell (4 op.)	LP "L" (5 op.)
Reports			X				X
Presentations	X	X		X	X	X	X
Posters			X				
Video					X		
ARENA simulation							X
Hands-on simulation	X	X	X	X	X	X	X

It is important notice that the manual provided to the students was simple, without pictures, except for the torch picture, so all the pictures, including the pictures components in figure 3, were photographed by the teams. In order to demonstrate how the operating mode worked, the teams created many documents, tools used in the hands-on simulation, applied concepts learned in others previous CU (bills of materials – BOM-, balancing methods, process flow diagrams, Activity On Node – AON - Networks to represent operations sequence,...).

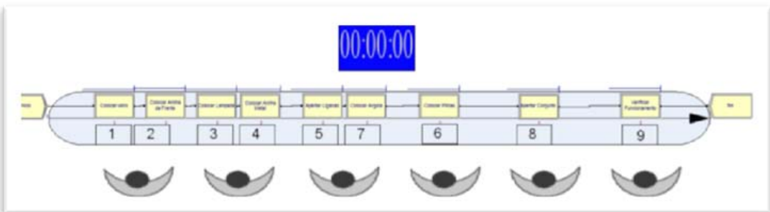

Figure 4: ARENA simulation of the Torches Assembly Line by G7

The Table 2 summarizes these technical documents; in brackets it is the operators number simulated in each operating mode.

Table 2. Tools, documents and mechanisms developed by the teams

Teams	G1	G2	G3	G4	G5	G6	G7
Operating modes	BT (5 op)	RC (4 op.)	WB (5 op.)	TSS (5 op.)	BBline (4 op.)	BBcell (4 op.)	LP "L" (5 op.)
Standards work sheets	X					X	
Work instructions written		X	X		X		X
Work instructions oral		X		X			
Balancing sheets			X			X	X
Process flow diagrams			X				
Work combination chart			X				
Mechanisms Poka-yoke	X						
Box to serve as contentors			X				
Kanban cards						X	
Activity on Node diagrams			X				

Figure 5 and Figure 6 shows examples of one work combination chart and work instruction written to put in the workstations.

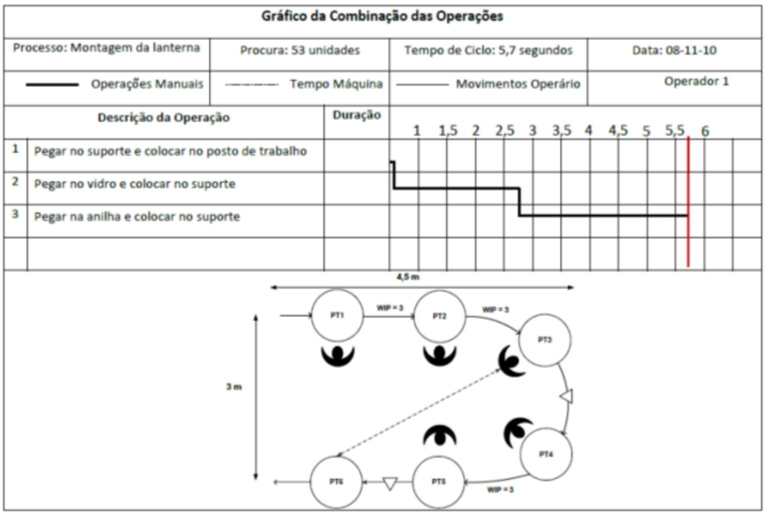

Figure 5: Example of work combination chart by G3

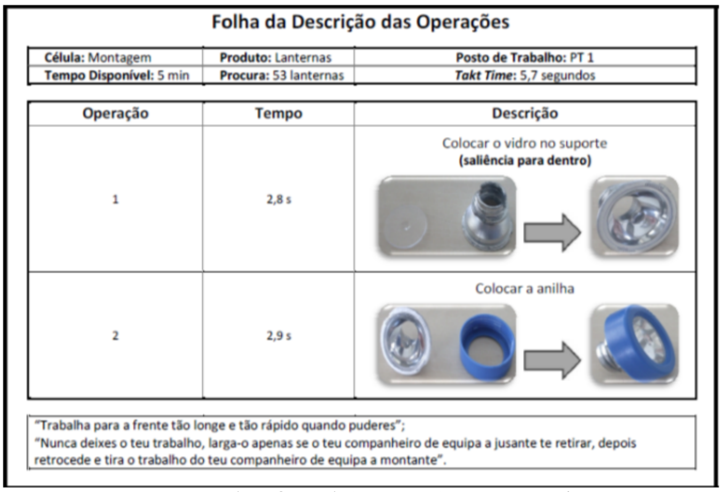

Figure 6: Example of work instruction written by G5

6 Students perceptions and opinions

In the final experience the students were asked, as a team or as an individually, to share their perceptions and give their opinions about this hands-on simulation. The opinions and feedback were very positive and encouraging. One team opinion was: *"Our team enjoys the experience because it was something more practical and motivator comparing with the typical research work. We think it was positive because when we train we debate some ideas with other colleagues and this help us knowing better other operating modes."* This opinion was shared by others members: "*very interesting*"; "*more practical*"; "*more reality approach*";

"*more easy to retain the knowledge*". One student say *"In my opinion you should maintain this assessment form and incentive the team students to participate in others operating modes."*

Other team point out the positive aspects and aspects to improve. The positives aspects were *"This experience helps us to understand and assimilate concepts from different operating modes and the functioning mode on the industrial practice. The fact of the teams help each other contribute to our knowledge of the other operating modes. Additionally we have to think in details about to train operators and force us to review all CU contents. This assignment contributes to a deep learning of all members of the team. This hands-on simulation could teach us that, in practice, some operating modes are adapting, not following strict the author definition."* This team considered as aspects to improve the criteria used in simulation evaluation. They referred the clarification of these criteria because they were not sufficiently enlightened about these.

And another team perception was: *"These activities are always more interesting than an expositive work. The team feels more motivated and think this could be extended to other subjects because promote more understandable. Being a formation type it is very important since we have to do something like this when we have to present something new in companies. We hope that others colleagues from the next years have these kind of opportunities."*

7 Final remarks

This paper described a hands-on simulation in a final year course of the IME Master´s degree programme. The different outputs of teams work, resulting from their motivation and dedication exceeded the expectations. Their free choice promotes their creativity and problem solving in a way not expected. This experience revealed that students when properly stimulated are capable of amazing things. The students learn how to prepare a training session, learn new concepts, and apply concepts and tools learned in previous classes. Of course, this experience had some pitfalls as pointed out by the students, for example, the evaluation process was not very well clarified in the beginning. This was one first experience and not knowing what to expect from the students, makes it difficult to plan the assessment process in detail. Furthermore, two technical objectives were focused on at the beginning and this becomes difficult to control. These objectives were the cell operating modes compare and the training session learning. Future editions must detail better the evaluation process and focus only one objective, in this case the training session preparation it reveals to be the most important.

Acknowledgment

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Competence oriented technical education in Austrian upper secondary technical and vocational colleges (HTL)

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Abstract

Until now the curricula of the upper secondary technical and vocational education was topic oriented. The new generation of these curricula has the technical, vocational but also the social competences in mind. These competences are: professionalism (knowledge about facts and theories), method competence and social, personal, communicative as well as emotional competence. To teach these competences new educational methods are required. Until now the project based learning was a central method, now the problem based learning aspects will be focused more and more. The paper covers the idea behind the new curricula and the planned conversion into the real educational situation. The new challenges in education and the labour market were the reasons for the development of new competence oriented curricula for the Austrian upper secondary technical and vocational colleges (HTL). This paper covers the results of the working group for the new curricula which worked the last 2 years.

Keywords: competence oriented education; problem based learning; technical and vocational college

1 Introduction

Competence are the connection of knowledge and skills, they enable for the coping with problems, duties and situations, and include the willingness to use these skills flexibly. This somewhat simplified definition of the competence concept after Weinert constitutes a major challenge for us teachers, our lessons to change from that point of view. Now a new learning culture will, supported by new curricula with suitable accompanying measures, change our schools and become the new leading teaching culture. This can succeed only in connection with a new exam culture by new exam forms.

The new curriculum generation intends a paradigm change. The curricula are output and competence oriented. This leads to new educational attempts above all in the area of the specialised theoretical lessons.

1.1 Motivation

Competence plays a big role in the professional education, because with them the "occupational ability" walks along. They describe more than pure knowledge contents. The individual competence contains a network of coherent aspects like knowledge, skills, understanding, experience and motivation. It shows therefore the condition to master a specific problem situation. Today competence is seen as an essential graduation for the success by learning processes.

By lessons oriented to competences students should learn how they "transfer" on the one hand (sluggish) knowledge in competent action, and on the other hand, as they use available knowledge in actions.

The competence orientation should become an essential component of the teaching planning, teaching realisation and the result assessment.

2 Competence orientation

The competence orientation is an important part of the teaching world – from the teaching planning about the realisation up to the result assessment– and is therefore the essential basic element for the competence-based, part-standardised school leaving exam valid from the school year 2014/15.

The reaching of the competences requires a changed role understanding of all affected persons in the education system. The teaching-learning relations must be defined new because the focus is directed now upon the learning process as well as upon the competences to be reached. More activity, self control and own responsibility is asked from the learners in the learning process. Learning is to be seen as an active process. The job of the teachers is aimed also new: They become "bearers" of knowledge and „catalysts“of learning processes – it is assigned to them supporting functions within the learning process. Teaching situations oriented to competence require a role change of the teaching person from the knowledge mediators to the learning companion, to the presenter or to the coach who has a support function for the self steered learning processes and is responsible for the creation of the learning sphere. The job of teachers is to plan learning surroundings and to create in which the students handle with knowledge and reach exactly defined competences. It is an aim that the students discover the learning situation or problem formulation as a job relevant for themselves. Competence-oriented lessons support therefore among other things also the development of that competence which allows self steered learning. With it the foundation-stone is laid for a lifelong participation in the educational process.

3 Lesson planning

3.1 Principles of lesson planning

3.1.1 Teaching objects within the educational goal

An important portion comes up to every teaching object with the acquisition of the totality of the competences necessary for the planned career. Teaching planning orientates itself basically by the duties which close to the teaching object area within the specific education way.

Good teaching planning assumes to recognise the own teaching object as a part of the whole education draught and to accept. Besides, the clearly defined exam shares of the final check, but the educational order which closes to own object with the achievement of the educational aim specific for education are not meant. Therefore this basic adjustment is valid in the same manner for all teaching objects, even if they are not immediately a direct part of the final exam.

The teaching planning orientates itself by the intermediately competence and has the curriculum and if necessary defined educational standards as bases. Developments in the field and in the occupational field require a regular, co-ordinated adaptation of this teaching planning. Equally the orientation towards the competence state of the single students at the beginning of the common lessons is an essential base to be able to straighten the other learning targets generally. For this different instruments to the learning state elevation (e.g., diagnosis checks) are available.

3.1.2 Sustainability

Responsible teaching planning puts the aspect of the sustainability in the centre of competence oriented teaching.

The achievement of a possibly high degree of sustainability is the most important job of every lesson. Pure fact knowledge, often in a few points compiled, is more and more short-lived than acquired, on fact knowledge and understanding based, complex competences. A once acquired competence gets lost only in big periods again. This makes clear that competence oriented lessons and sustainability are to be seen in a narrow context.

A responsible teaching planning particularly follows the lasting backup to the respective object or education way to forming the basic standards as a central core.

3.1.3 Individualization

Contemporary lessons mean a maximum in promoting the individual talents and interests. The schoolgirls and schoolboys should be taught to remain curious. This means that teaching planning is tuned not only to the totality of a class, but orientates itself for the purposes of the heterogeneity of a class in – at the beginning to be analysed – part groups. The uniform teaching aim of the whole class gives way to different, gradated learning targets with clear, differentiated judgement. At the same time the teacher should consider the different learning types of the students.

The averting of the uniform teaching aim for the totality of a class means absolutely for many teachers a paradigm change. However, under it is not to be understood that different students within the class association receive the same evaluation for different achievements! Supposed is that suitable individual learning targets according to their learning speed are defined with the students to her individual potentials which lead, in the end, also to a differentiated evaluation. Besides, the fulfilment of the basic competence demanded in each case to the acquisition of a positive end of the year stands except doubt. For example, it is absolutely conceivable to agree on learning targets merely in view of "enough" or with the weaker students for most different reasons "adequate" and to straighten the individual demands on it.

Such an individuation of the teaching events after part groups – and in special cases even covered to single students – needs not only a careful teaching planning, but also the application of diagnosis instruments as well as a running observation of the individual learning progress.

3.1.4 From steered to the self steered learning-individual of learning progress

Competence oriented lessons cause for the teachers a movement away from the steering talk to the learning company. Besides, for the students the self responsible learning steps more and more in the centre. Self acting learning requires a high degree of motivation which cannot be generated from the teaching person, but can be promoted. A teaching creation which walks on this contemporary way needs a long-term, careful and extensive planning.

Competence, in contrast to the acquisition of pure fact knowledge, may only be acquired and developed by independent action. To the teaching person comes up, besides, the responsible role of a coach which makes spontaneous demands for the teaching person in the teaching events and calls a high flexibility. The real teaching events never foresee in detail such situations. Only a careful preliminary planning and running post planning (rolling planning) can make sure with the demanded flexibility that the teaching goal is not lost out of sight. The teachers need for that suitable method knowledge which contains the educational bases, but also the methods of the field.

Examples of widely self steered teaching forms:

a) Problem Based Learning, case studies and virtual companies: With case studies the treatment of practical cases from the economy is central by the students. Under the coordination of students themselves the class develops in several teams' ideas and possible problem solutions. The learning platform serves for the project planning, the documentation and the exchange of views. Besides, discussion forums and Wikis are used. More experienced students can also administer independently the whole platform as "a peer knowledge manager".

b) Learning by teaching (LbT): Learning by teaching is a method where students process new teaching contents didactically and present other students. The learners become active and, besides, acquire competence in the area of presentation group work (Social competence). LbT is no eLearning specific teaching form, indeed, preparation and coaching of the planned teaching of the students can be well supported with a learning platform.

3.1.5 Adjustment in the actual developments of the aimed occupational field

Contemporary teaching planning at a vocational school considers constantly the actual developments of own department as well as the aimed occupational field.

Bringing in of actual developments in the own teaching planning is an educational basic principle. It encloses the educational, methodical-didactic fields like the technical areas of the respective teaching object in the same manner. However, for informing at vocational schools it is essential, in view of the whole education goal, to observe also the developments in the occupational fields aimed by the learner and to let it flow in into teaching planning and lessons. Only so it is possible to hold own lessons constantly actual.

3.2 Organisation of the lessons

Contemporary, competence-oriented lessons are marked by a variety of teaching forms. Good teaching planning already tries to select in the approach to prepare the most efficient organisation form of the lessons considering the respective learning target, the learning contents and the organizational basic conditions. Besides, a special role in particular also plays the respective class profile as well as the personality of the teacher. Besides, basic meaning comes up to the class profile adjusted and with the total concept of the education way co-ordinated choice of teaching documents and teaching aids.

Teaching documents (school books, reference books ...) and teaching aids (electronic aids, application of mediation media ...) have central influence on taking up the provided teaching contents by the learners as well as on the efficiency of the self learning parts. Therefore, quite a particular importance has a responsible choice them and a choice never may be isolated in an object or object area.

3.2.1 Choice of the teaching method

The teaching methods elective for learning units must be likely to develop the desired competence and to build up the knowledge necessary in addition with lasting effects. If the development of competence is central, collaborative teaching methods basically oriented to actions are better suitable than purely instructive ones.

Co-operative and collaborative learning and working forms cause high activity of the learners as a high learning motivation factor. These both criteria serve substantially to avoid sluggish knowledge and to protect acquired knowledge and competence with lasting effects. In addition, problem-based and project-based teaching methods are used in the vocational area very well to promote general and linked up competences with lasting effects.

3.2.2 Integration of media

Good teaching planning means long-term, careful and responsible planning and preparation of an efficient, educational-didactic application of contemporary technologies and media, in particular under integration of the possibilities of the internet.

3.2.3 Problem-Based Learning

Problem-Based Learning (PBL) enables the learners to apply knowledge and skills in concrete situations or in practically oriented settings of tasks and show therefore an essential element of the competence development.

PBL is suited very well to the construction of competences. Beside the enlargement of the technical, social and communicative competence acquire the students learning solution competences by work on concrete, practical cases. Besides, they learn to analyse problems building up on their prebuilt knowledge and to solve these problems by appropriation of new knowledge. By the work in the team the social-communicative competence and the team ability in particular also increases.

Besides, the teaching persons act as a coach. Their consultation is aimed at the development of new perceptions and at the enlargement of the personal potentials. Beside this function oriented to duty the coach also has a function oriented to the group but the responsibility for the learning process lies extensively with the learners. This is particularly to be considered by the teaching planning.

3.3 Co-operative open learning (COOL)

COOL is a teaching method which considers on the increasing heterogeneity in the classes but also takes care on the demands of economy and professional life after more independent acting graduates.

The concept is based on the basic principles of the Dalton plan (USA) and was developed by cooperation with vocational schools in the Netherlands and Denmark. These principles are:

– **Freedom**: Freedom of choice with regard to sequence of the problems, learning place and social form to strengthen the own responsibility of the learners for their learning progress.

– **Cooperation**: Cooperation of teachers and team ability of learners, as well as cooperation of teachers with learners.

– **Budgeting time**: independent planning and organising of learning work by the learners.

4 Conditions for the conversion of lessons to competence orientation

Critical elements of a standard-based teaching realisation are – on the part of the teachers – the following factors:

- Well-grounded knowledge of the actual state of the educational standards in the vocational training – knowledge about competence models, descriptors and available teaching examples
- Skills for the adaptation and reorganisation of teaching examples of own lessons
- Diagnostic competence concerning the abilities of the learners
- Method competence for the realisation of lessons oriented to competence
- Knowledge about competence models and teaching examples in neighbouring fields and about comprehensive competence areas

Not only on the part of the teachers, but also concerning the learners, some base qualifications and conditions are necessary, so that a successful competence-oriented learning can take place. Some of these aspects stage themselves as follows:

- The necessary cognitive base competence on which the lessons are based
- Acceptance of the lessons oriented to competence from perspective of motivation
- Skills of self steered learning, in particular of the reflection of own level of knowledge
- Social competence
- Self learning competence

- Possibility and readiness to the transfer of the learned topics from the teaching situation in the professional context

5 Criteria for the conversion of lessons to competence orientation

- Give to the lessons structure and produce clarity about learning targets
- Vary methods in learning and working forms
  - *Admit self steered learning and support*
  - *Allow common seed learning in groups*
  - *Promote special working forms in the vocational training (e.g., workshops, labs, practise companies)*
- Integrate learning into sense-donating contexts: Students are most attentive if they deal with the learning duties which are personally knowingly for them.
- Apply (systematically) learned in life-practical and professional situations: Systematic learning and learning in "real situations" always belong together because only thus the relevance of the contents is made clear for the learners
- Variation of practicing and training
- Lessons linked up vertically
- Allow the experience of competence increase: the students must very often have the opportunity to show their skills and experiences
- Distinguish learning situations and achievement situations
- Discuss solution ways together
- Evaluate learning actions and give plausible feedback
- Give time for learning
- Stimulate criticism ability
- Provide a learning-conducive climate: to learn motivated, students need the feeling that the teachers seriously have interest in their getting on and have trust in her abilities

6 Instruments for the observation and description of competences in the lessons

The teacher logbook was developed for a systematic observation and documentation of the lessons. This instrument serves as a basis and assistance for teaching observations and teaching recordings in view of acquired competences. The teachers are able to measure and observe with it not only the professionalism of the learners, but also the performance level of the concerning methods, socially, staff, communication and the emotional competences. The basic structure was developed by the chair of economic educational theory at the University of Paderborn in cooperation with the Karl Schiller occupational college in Dortmund.

7 Performance appraisal and evaluation

Essential characteristic features of the competence-based teaching are the work after a two-dimensional competence model in which the action dimension has the same relevance like the contents dimension. The competence increase of the students is in the centre. This also causes more responsibility of the students in the learning process, more co-determination of the learners about teaching contents and the kind of the mediation to organise slow, but lasting learning progress with many "learning spirals". Covered to the lesson, if one could say that less content is more because he is lighted up by different sides. Not serial processing of teaching material is central, but the construction of interlinking and connections which become conscious from several sides.

7.1 Conversion steps to competence oriented "examining"

Competence-oriented examining is a process which must mediate between the personal competence acquisition of the students and the norms of the final results. This can be organised best of all by the use of methods like the portfolio, individual learning contracts and instruments like learning state elevations in a very free teaching company so that these elevations have purely diagnostic character and must be separated from the personal achievement evaluation of the students.

Within the scope of the competence oriented teaching and examining it is essential to differentiate between the achievement assessment as an instrument of the information of the personal learning progress of the students as well as the consultation and the classical achievement evaluation which awards a qualification report.

7.1.1 Three essential principles for evaluation in competence oriented surroundings

Principle 1: Decoupling of the teaching time in learning situations and exam situations

Principle 2: Decoupling of the role of the teaching person as a coach, teacher and examiner

Principle 3: Possible instruments and methods

Learning contract: Definition and documentation of the learning targets. An arrangement between teacher and learners guarantees the content clarity about learning targets, dependably kept rules to prove the responsibility takeover on the part of the learners.

Learning diary: Responsibility takeover for own learning processes, self evaluation of the learning progress. Learning observation and learning control occur through the students themselves by which achievements, working behaviour and social behaviour can be perceived and then be evaluated. In the long term positive changes are reached by evaluations and self evaluations and students find out repeatedly their weaknesses, however, also strengths. Own abilities and behaviour patterns are reflected and also steered.

Learning target-oriented evaluation / individual learning plans: Learning runs only successfully if the learning target is defined clearly, is well communicated and is recognised. In addition it is necessary that learning steps are expelled clearly, partial successes are made visible and also are paid. This decreases the achievement pressure and makes repeating of missed learning targets possibly.

Individual diagnostics: Diagnosis means the appraisal of individual learning states of the students which deliver an image of the momentary competence development outgoing from competence models. Learning states are determined by means of the settings of tasks which refer to certain competences of the students.

Competence grids are tabular attached achievement expectations which document the learning progress in level steps. They are, primarily, an instrument of the self evaluation, however, are suited also for a foreign evaluation.

Portfolio method as a possibility of subject-oriented achievement assessment: the portfolio serves the individuation of the learning and the examining. Besides, the learning portfolio indicates the landmarks on the way of the individual development.

Peer-Evaluation: in the teaching practise the assessment is fixed by student on the role the teachers. Feedback about a student takes place mostly only between the teacher and the learner, the peer group is included too seldom in this process. The self-assessment of the students as an important moment in the lessons also promotes the process of the ability to give feedback to the group and to take feedback from the group. However, for this peer evaluation good structures and behaviour patterns are to be installed in the learning group, like sandwich feedback, feedback as a present („is determined for my advancement“).

8 Conclusion

The new challenges in education and the labour market were the reasons for the development of new competence oriented curricula for the Austrian upper secondary technical and vocational colleges (HTL). This paper covers the results of the working group for the new curricula which worked the last 2 years.

These results flowed into the work of the working groups for the individual curricula of the various disciplines. These working groups develop the new competence oriented curricula and educational standards in the close future. With these new curricula the Austrian federal ministry of education, culture and art provides a new basis for the future education at Austrian HTLs. In the next 2 or 3 years all HTLs will start with these new curricula.

Therefore this paper is no scientific paper of the author at all but the result of the work of the whole working group. The presentation covers the new future way of the Austrian secondary technical education.

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New teaching activities for learning Robot Mechanics

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Abstract

The adaptation of university studies to the new European Higher Education Area (EHEA) established in the Bologna Declaration is showing the necessity of design and introduce new activities in the teaching process. Within this framework, a serie of teaching activities are proposed in this paper with the aim of *improve the learning of the techniques used in the mechanical analysis of industrial robots* and increase the students´ interest in the contents included in the subject "*Robot Mechanics*". The aim is to overcome the difficulties that students find in learning the "*Robot Mechanics*" contents. In essence, these difficulties can be summarized in two: (i) the correct interpretation and understanding of the results of mechanical analysis of a robot manipulator (3D mechanism) and, (ii) the laborious mathematical procedures used in these mechanical analysis, enhancing the students' understanding of the concepts and calculation methods studied on the position, kinematic and dynamic analysis of manipulators.

Keywords: teaching activities; active learning; robots mechanics; skills adquisition.

1 Introduction

The adaptation of university studies to the new European Higher Education Area (EHEA) established in the Bologna Declaration is showing the necessity of design and introduce new activities in the teaching process. The aim of these activities is to make the process of change to the new role easier for *both* students and university teachers. First ones must assume a more active attitude, beyond mere receptors of knowledge, and the second ones must change from transmitters of knowledge in lectures to developers (covering design, plan and coordination) of diverse teaching activities that ensure the students' skills acquisition (Zoller et al, 2003). These changes are particularly useful in technical studies where the students face multiple and diverse difficulties due to the complex problems covered by engineering studies. Within this framework, a serie of teaching activities are proposed in this paper with the aim of *improve the learning of the techniques needed for the mechanical analysis of industrial robots* and increase the students´ interest in the contents included in the subject "*Robot Mechanics*".

The activities were planned considering the available equipments in the "*Escuela Técnica Superior de Ingeniería Industrial*" (ETSII) of the University of Salamanca (industrial robot ABB IRB140, Fig 1a, which can be controlled on-line with the flexpendent unit or off-line with a computer, and an electrical gripper SCHUNK EZ64, Fig 1b) with the objective of overcome the difficulties that the students find in learning the "*Robot Mechanics*" contents. In essence, according to previous studies (Cabezas & Lorenzo, 2006) these difficulties can be summarized in two: (i) on one hand, the correct interpretation and understanding of the results of mechanical analysis of a robot manipulator (3D mechanism), and (ii) on the other hand, the laborious mathematical procedures used in this mechanical analysis. Proposed activities are designed to apply in a real industrial robot the solutions obtained in the mechanical analysis (including both direct and inverse position and kinematic analysis), and simulating diverse industrial processes where mechanical analysis is needed, such as object manipulation, welding, cutting and so on. The aim of this work is to overcome these difficulties, enhancing the students' understanding of the concepts and calculation methods studied on the *position, kinematic* and *dynamic* analysis of manipulators, by combining the available technical equipments with the advantages that the design and dynamic simulation software, widely used in mechanic engineering industries, offer nowadays for mutibody systems analysis of mechanical elements such as manipulators. According to previous works (Vergara, Lorenzo & Rubio, 2007; Vergara, Rubio & Lorenzo, 2008) the application of active teaching methodologies, based on skills acquisition with a direct and active role of students will provide an improvement of the learning process.

(a) (b)

Figure 5: (a) Robot ABB IRB140 with flexpendant unit and (b) electric grip SCHUNK.

Some of the proposed activities are based on previous works of the authors, where an application developed in Mathematica® (the well known general porpoise mathematical commercial software) for the analysis of mechanisms was adapted to manipulators. It follows a pure teaching approach (step by step analysis), and includes a 3D visualization and simulation of obtained results (Cabezas, Martínez, Hernández, Moreno & Pérez-Cerdán, 2002). In spite of being a powerful tool for teaching Robot Mechanics, it was revealed that a student's previous knowledge of the Mathematica® environment was required. To avoid this shortcoming, the authors developed the same step by step analysis in another more flexible environment (Mathcad®) where the user requirements are less strict because it uses intuitive, more visual and easy commands (Lorenzo & Cabezas, 2006; Vergara, Lorenzo & Rubio, 2007; Vergara, Rubio & Lorenzo, 2008). On the opposite side, the "black box" approach where only the final result is shown (widely used in the software developed by the most important robots manufactures, namely ABB, KUKA, etc... (ABB, KUKA) or in dynamic simulation software, such as Autodesk Inventor®) is also interesting for the teaching of Robot Mechanics in certain circumstances (Cabezas & Lorenzo, 2008). Both approaches could be very useful because they complement each other in the teaching process, as was shown in Cabezas & Lorenzo (2008), where a comparison of both approaches for the teaching of robots mechanics was developed. The use of both applications by the students would enhance the *self-learning* and could be very useful for checking the analytic results obtained by themselves.

2 Subject description

"*Robot Mechanics*" is an optional subject included in the Degree of Mechanical Engineering in the second semester of the fourth course. Nowadays, the ETSII of the University of Salamanca started the teaching of the first course of such degree and it is expected that the teaching of the subject Robot Mechanics begins in the academic course 2012/2013. According to the degree planning, the subject covers 6 ECTS (i.e., 150 hours of student dedication), 2.7 ECTS (67.5 hours) of those are presential and 3.3 ECTS (82.5 hours) are devoted to the student's autonomous work. The different types of allowed activities are classified according to the number of students that forms the class groups:

- Master classes in big groups (without limits of number of students).
- Middle groups activities (with a maximum of 30 students).
- Reduced group activities, i.e., laboratory practice (with a maximum of 15 students).
- Seminars (with a maximum numbers of 25 students).
- Tutoring which can be individual or collective.
- Exams or evaluation tests.
- Non presential activities.

The students will pass the subject if they demonstrate the acquisition of the following skills during the development of the diverse activities: (i) Capacity of analysis and synthesis, (ii) Capacity of resolution of problems and (iii) Knowledge of position, kinematic and dynamic analyses of manipulators. The subject is divided into the following units:

- **Unit 1: Introduction.** Robots historic evolution, concept of a robot, components of an industrial robot, mechanical structure of a manipulator, applications of robots to the industry.
- **Unit 2: Position analysis:** Introduction, study of manipulators (Denavit-Hartenberg formalism, direct and inverse position problems, application to robot ABB IRB140), working space.
- **Unit 3: Kinematic analysis:** Introduction, definition of Jacobian, direct and Inverse Kinematic problem, application to ABB IRB 140, singular configurations, recurrent calculus of velocities and accelerations.
- **Unit 4: Dynamic analysis:** Introduction, Newton-Euler formulation, back recurrent equations, inverse dynamic problem, applications to 3R plane manipulator.

The development of the diverse presential activities must be carried out during 4 hours per week distributed in two blocks of 2 hours during the semester. From the previous years statistics, the expected number of students is approximately 30, so the groups distribution according to the established limits is the following: a big group for master lessons and problems (medium group), and two groups for the practice laboratory classes (small group) and seminars. Taking into account that the subject is optional, and it is placed in the last course of the degree, it is considered that the enrolled students are strongly interested in the subject.

3 Description of proposed activities

During the previous years, the authors of this work developed and applied diverse new techniques based on the development of new software application tools (as mentioned at the end of the introduction of this paper). From the conclusions obtained during these experiences the authors considered the convenience of develop a new teaching approach including diverse activities in which students participate actively with a direct contact with the available robot. Taking into account the conclusions of such experiences, the diverse proposed activities were developed according to the previously established formats: master classes, problems classes, laboratory practices, seminars, individual/collective tutoring and a final evaluation exam, or alternatively the defence of a work developed during the last part of the semester, where the students show individually the acquisition of the subject skills. Each one of the proposed activities allows an adaptation of the contents to the student academic formation and complements each other with the end of improvement the learning process, solving the common difficulties that were observed during the years of academic experience of the authors. Next, a brief discussion about each activity is shown with a more detailed description of the new activities that are specially focused on the active participation of the students (laboratory practices and seminars).

Master classes are planned as the start point of the students´ basic formation of the subject contents from the theoretical background in a unique group class. These classes are mainly focused on the essential aspects and orientations about how to go further in the unit contents. At the beginning of the course the students have the subject´s notes for the monitoring of the classes.

Problem classes are considered as a direct application of the concepts developed in the master classes and allow students to have a first contact with the mechanical analysis of the manipulators covered there. During these classes the professor solves step by step some of the problems included in the problems collection available for the students from the beginning of the course. At the end of each class, a similar problem is proposed to be solved as homework. The potential doubts of the students are solved in tutoring hours. Some of the proposed problems must be solved analytically and those which require the repetitions of the mathematical work can be solved with the help of computing applications developed by the authors. The basic use of such applications is included in seminars as is latterly stated. By this way, students can analyze more complex problems whose analytical solution would require a long, repetitive and, consequently, tedious mathematical work.

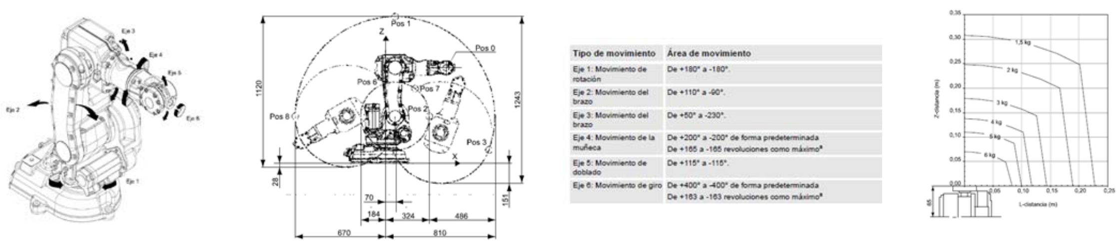
Two different types of *seminars classes* are considered: first one is dedicated to the resolution by the student of certain relevant exercises of the problems collection with the professor assistance. During this activity, students face directly with the problem resolution revealing the potential misunderstood concepts. From this information, the professor can establish alternative activities that enhance the understanding of such concepts. Second ones are those activities, developed during the teaching period, that provide a complementary formation of the subject contents, for instance, the use of diverse software applications such as Mathcad® or dynamic simulation software (Autodesk Inventor® for the analysis of any robot, or Robostudio® for the analysis of ABB robots). The use of such software applications enhances the students´

self-learning. In addition, these activities let to introduce basic issues of robot programming in Rapid (ABB programming language), very useful for the development of the practice with the robot ABB IRB 140. These seminars are planned under a purely practical point of view with a direct and active role of the students during the seminar. For these reasons, these classes should be carried out in the computing classroom. Next a description of each one is detailed:

- **Seminar 1: Mathcad® application:** The aim of this activity is to carry out with the Mathcad® application the mechanical analysis of the ABB IRB140 robot, previously developed theoretically step by step in the problem classes. This way, students discover how the analysis can be developed automatically and generalized to more complex problems involving more variables.
- **Seminar 2: Inventor®:** This activity provides students the basic knowledge for the movement simulation with Inventor® dynamic simulation module and later analysis of the results for any manipulator system. The robot components can be downloaded from the diverse manufacturer web pages and, once the axle restrictions were imposed, the movement simulation can be performed.
- **Seminar 3: Robostudio®/Rapid:** This software allows particularizing the robots analysis to the ones manufactured by ABB. Besides, this seminar let to introduce basic knowledge of the flexpendant component (cf. Fig. 1a) which allows the direct control of the robot and the programming environment. In addition, it is possible to simulate the movement of the robot in a manufacturing process using the element included in the component library. It is important to carry out this seminar previously to the development of the practice 2 to make student familiarize with the robot ABB interface.

Laboratory practices represents the student's first contact with an industrial robot, and allows a direct visualization and check of the obtained results from both points of view: theoretically throughout the analytic resolution of the problem (problem classes) and throughout the use of the diverse computer tools. These activities are performed in small groups of 15 students that are subdivided in 5 groups of 3 students during the practice class. Next, a description of the proposed practices is detailed:

Practice 1: Technical specifications of robot ABB: The main objective of this practice is to have students become familiar with the robot ABB IRB140 throughout the development of simple activities. These activities consist in searching information in the technical specifications of the robot and, when possible, compare it with the real ABB IRB140 robot: identify the different components of the industrial robot, the manipulator axes and types of movement applying the movement (Fig. 2a) axle by axle with the flexpendant unit (on-line working). Therefore, a basic knowledge of the use of the flexpendant unit for the direct control of the robot is required. Next, they must decide if a series of positions of the extreme element of the robot are accessible or not according to the robot working space that they must find out inside the technical specifications book (Fig. 2b). Then, they must decide if a series of combinations of axels angles are possible to be applied and in that case apply them to the robot (Fig. 2c). Another task is to define the maximum load allowable at a certain distance from the extreme element applying the load diagram given by the manufacturer (Fig. 2d). Finally, a commentary about relevant technical information such as repeatability is given and information about safety use of the robot. This practice is developed at the end of the first unit of the subject when the students have general knowledge of the components of the industrial robot, types of control, applications, etc.



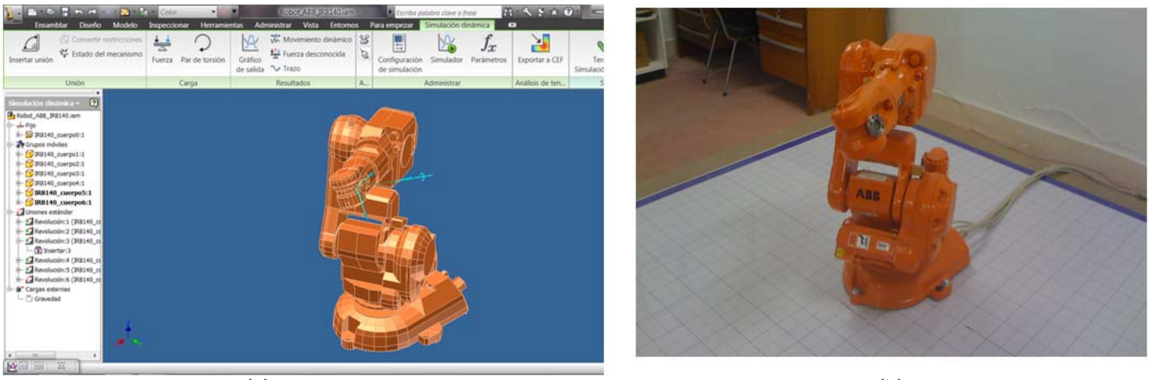
Tipo de movimiento	Área de movimiento
Eje 1: Movimiento de rotación	De +180° a -180°.
Eje 2: Movimiento del brazo	De +110° a -90°.
Eje 3: Movimiento del brazo	De +50° a -230°.
Eje 4: Movimiento de la muñeca	De +200° a -200° de forma predeterminada De +165 a -165 revoluciones como máximo*
Eje 5: Movimiento de doblado	De +115° a -115°.
Eje 6: Movimiento de giro	De +400° a -400° de forma predeterminada De +163 a -163 revoluciones como máximo*

(a) (b) (c) (d)

Figure 2: Information provided by the ABB manufacturer used by the students to perform the first practice and apply it to the robot ABB: (a) Manipulator axes, (b) working space, (c) ranges of movement and (d) load diagram.

- **Practice 2: Analysis of position applied to the robot ABB IRB:** In this practice two different position problems (direct and inverse) are covered. Each one is developed in two phases: firstly simulation and secondly the application to the robot ABB IRB140. The direct position problem consists in obtaining the final position of the robot´s extreme for a given set of axle angles. The simulation stage is done with the computer simulation (student must have the knowledge of movement simulation with Inventor® and

Robostudio® so the corresponding seminars must be done previously), obtaining the three cartesian coordinates of the interest point of the terminal element. Also the simulation provides an image of the robot at that position. Then, students move the robot axle by axle until the desired axle angles are reached, and take a photo of the final configuration of the robot. Next, a student checks the position of the extreme element with a laser measurement device. These coordinates are read by other student; laser device gives the z coordinate and laser spot gives the x and y coordinates. In the practice report, students compare the two solutions, virtual with simulation software and real with the ABB robot.



(a) (b)

Figure 3: One solution of the inverse position problem using (a) simulation with Inventor® and (b) ABB IRB140 robot.

The second problem, the inverse position problem, consists in obtaining the values of the set of angles which applied to each axle set the robot in a given position. According to the theory, 8 different ways of raise a certain position are mathematically possible (Fu, Gonzalez & Lee, 1988). First, the students use the computer application in Mathcad® for obtaining the 8 possible solutions of the manipulator and check if one is mechanically possible according to the technical data of the robot (studied in practice 1). Then, students simulate the movement in Inventor® to all the positions observing the possible collision between robot elements for the non accessible mechanic solutions, and keeping an image of each possible solution. Then, the students apply to the robot all the mechanical solutions, checking the final position with the laser device. As in the previous case, the students take photos of the robot at each position and comparing real and simulation in the final report. For this practice previous knowledge of the use of the Mathcad® and the Inventor® applications is needed, so this activity should be performed after the seminars 1 and 2.

- **Practice 3: Process simulation with the robot ABB IRB:** The aim of this practice is to show students how a industrial process can be programmed and executed by the robot. Three different simple processes are considered. The first one refers to the manipulation of objects with diverse geometries from a certain point inside a box to another point in other box. The objective is to make student realize the relevance of determining not only the position but the orientation of the final element. The boxes were placed in different orientations and positions over the robot gird and the students must firstly move the robot to the point A (where the object is placed with the right position and orientation), catch the object closing the jaws gripper and then move it to the point B where the empty box is placed with the right position and orientation. Then, the students calculate with the Mathcad® application the solution of the inverse position problem, simulate the eight solutions with Inventor® and decide which one of the eight is the most appropriate according to angles ranges. Finally, students program the movement in the robot and simulate it in Robostudio®. The second process is to perform a certain trajectory point by point with the robot in a given plane. This trajectory could represent a welding beam or a cutting process. The steps are the following: students design a trajectory defined by points, then they program the coordinates in the Robostudio® software and simulate the movement. Finally, they apply it to the robot ABB, where a pencil is subjected by the jaw. When the robot describes such trajectory leave on a piece of sheet a drawing that represents the trajectory of the final element of the robot (Fig. 4).

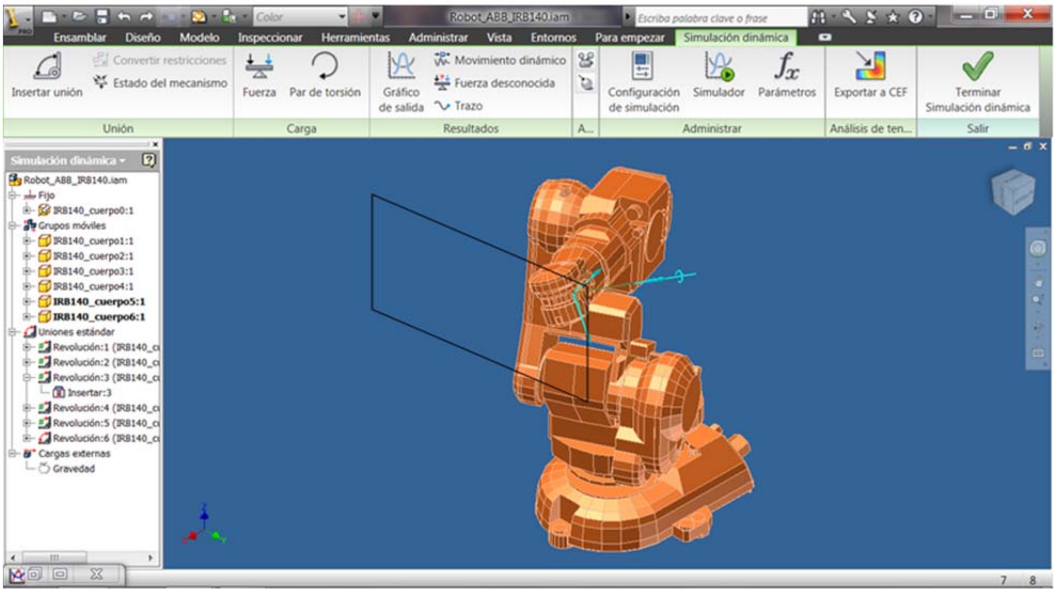


Figure 4: Inventor® simulation of the trajectory on the plane YZ.

- **Practice 4: Kinematic analysis:** The last practice consists in the analysis of the two types of simple movements: the simplest circular movement of an axle and the more complex movement along a linear trajectory with a certain velocity. The first one consists in moving a certain angle and measure the time with a chronometer and to obtain the linear and angular velocity of the extreme element. These results are compared with the one obtained from both Mathcad® and Inventor® applications. The second one is to solve the inverse kinematic problem. So, firstly, students must use the Mathcad® application to obtain the numerical solution and then apply the values of the axle velocities to the simulation in Inventor®, and finally apply it to the robot. This final practice must be carried out after the theoretical analysis of the kinematics of manipulators was performed.

4 Evaluation and expected results

Changes in teaching methodology must include evaluation task as well. With this in mind, the evaluation components, which provide information about the work and achievements of the student in relation with the activities programmed (within a system of continuous evaluation), were thought to increment the motivation and incentivize the student active participation. In this sense, the knowledge of the real working hours dedicated by the student for the elaboration of such activities is a key issue with the final aim of correctly fitting the ECTS value.

Activities evaluation to guarantee the skills acquisition established are planned from the following statement: apply a system of continuous evaluation that enhance and incentive the progressive study of the student during the subject development. They include non-presential ones, such as delivery of proposed works, and presential ones, such as seminars where students solve more complex problems with the professor orientation and with the help of computer applications or lab practices. These activities allow professor to know the degree of learning of the students in master and problems classes. In addition, they let to detect the possible difficult points in which is necessary to reinforce teaching, or detect particular problems that individually some of the students present. Appropriate corrective actions let to recover those students in the learning process increasing their motivation and avoiding their frustration. Two types of corrective actions are considered depending on whether the problem is widespread or only is detected in punctual cases. First one considers the performance of collective tutoring in small groups where adapted teaching activities would be applied. Second one considers the possibility of perform individual tutoring with the aim of orient and plan the learning process of the student according to the problems that exhibit. To make this planning effective, the activities must be developed in a progressive way during the semester, insisting that the most essential part of the subject is covered during half semester approximately. Taking into account such statement, the evaluation system is considered as follows:

- **Practices:** To pass the subject is mandatory to perform all the practices and deliver a report of them during the semester. Thus, an effective continuous evaluation process of the students learning can be carried out. The weight of this part in the final evaluation is 15%.

- **Proposed homeworks:** As in the case of the practice, these activities are distributed along the academic year, giving a reasonable time for the study of the subject. They allow professor to know if the learning process is effective or not. The weight of this works is 15% of the final mark.
- **Seminars:** Only seminars where students solve problems individually are evaluated for knowing if students acquire the required established skills established. In addition, the results validate the autonomous learning of the students. Taking into account the importance of this activity, its weight in the final evaluation is 20%.
- **Final evaluation:** It is constituted by two options that student could choose before the first third of the semester as was described before. First is a conventional writing exam where student must demonstrate the skills acquisitions (solving new problems) trough the analysis of position and kinematic analysis of an industrial robot with a similar difficulty to the ones studied in class. Second one, the students must perform a work, where an analysis of the position, kinematic and dynamic of an industrial manipulator is included, considering the programming and execution of a manufacturing process with the ABB robot, with the help of the diverse computer applications under continuous supervision of the professor. The evaluation is performed on the memory that they must present and on brief (10 min) exposition and defense of the work. Both options let to know the final degree of learning of the subject and, therefore, they have the higher weight (50%). The performance of any one of the two options is mandatory and student must raise a minimum punctuation of 4 over 10 points in such test to pass the subject.

The expected results of the application of the proposed activities included in this paper are: improve the spatial visualization and the interpretation of theoretical results of the mechanical analysis of the manipulator, apply the knowledge acquired in the theoretical and problem classes to a real industrial robot, enhance the student learning process and promote the student self-learning through the performing the diverse proposed activities, promote the new role of the student in the process of teaching/learning within the EHEA framework, enhance the skills acquisition both specific and transversal included in the subject “Robot Mechanics”, fit a better distribution of the ECTS credits by quantifying the personal working hours dedicated by the students to the new tasks, establish new procedures of continuous evaluation, try to estimate the degree of satisfaction, accepting and valuation of the activities and other parameters, enhance the comprehension of the theoretical concepts and the analysis procedures by the visualization in situ of the real manipulator, put into practice the previous knowledge acquired in the master classes or seminars, put in direct contact students with a real robot in all the stages of an automation robots process: design, programming, simulation and execution of the process.

In order to obtain information of the impact of proposed activities in students learning, a collective interview was performed after final marks publishing. During this interview students expressed their opinion about the learning process carried out by applying the diverse activities answering some questions. In general terms, the comments revealed that the proposed activities were useful for their learning process. They assessed those activities (seminars and problem homeworks) as very important tasks because they forced to face directly with the subject problems. According to their opinion, solving those problems was for them a challenge which increased their motivation and interest for the subject contents. In addition, they remarked the usefulness of the developed software applications for the understanding and visualization of the obtained results revealing that the autonomous use of these applications enhanced their self-learning.

5 Conclusions

Within the new EHEA framework established in the Bologna treatment, in this paper a proposal of teaching activities applied to the subject “Robot Mechanics” was exposed in order to overcome the traditional problems associated with the students learning. The real results of these activities will be revealed until the instauration of the fourth course of the mechanical engineering degree in the academic year 2012/2013. However, these activities were tested this year in volunteer students showing promising results, increasing student motivation, active participation, interest for the subject contents and, consequently, an improvement of the learning process. The continuous evaluation leads to the skills acquisition with an expected increment of the success rate of the subject.

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Enhancing Student Engagement – A CDIO Approach in an Engineering Physics Master Program

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Abstract

This paper describes a project for first year students at the Master program in Engineering Physics at Linköping University (LiU) in Sweden. The project follows the approach of CDIO (Conceive, Design, Implement and Operate), and introduces a project model that has been developed at Linköping University. During the course, the students apply the project model to a CDIO project. The idea to use this approach is to enhance student engagement, one of the key aspects for achieving a deep-level approach to learning. According to the course and project evaluation, the students are become very engaged in the projects, finding it stimulating, interesting and relevant, which highly contributes to student engagement and a deep-level approach to learning. It is also noted that the students appear to learn more effectively and with an improved conceptual understanding than students attending a course with similar content but with a classical course approach.

Keywords: CDIO, student engagement, active learning, engineering project, LIPS, project model.

1 Introduction

CDIO, Conceive, Design, Implement and Operate, was developed as an international initiative for engineering education, characterized by a formalized platform for projects in an engineering education context (Young, et al., 2005). This approach is used in several courses at the Master program in Engineering Physics at Linköping University (LiU) in Sweden. The particular project presented here "Heat loss from the human body" is designed for the first course, in which the students are introduced to among others a project model invented for engineering education projects at LiU, project management, group dynamics and written and oral communication.

One of the basic ideas of the CDIO concept is to get the students involved and engaged in their work – an active learning, which has been shown to significantly improve student learning (Bonwell and Eison, 1991; Johnson, Johnson & Smith, 1991). The idea is to get the students involved in their learning, and has been described as "When using active learning students are engaged in more activities than just listening. They are involved in dialog, debate, writing, and problem solving, as well as higher-order thinking, e.g., analysis, synthesis and evaluation." (Bonwell and Eison, 1991).

The aim of the project is to determine (i.e. estimate) how much heat the human body loses to the surroundings under various circumstances. The project is designed to be quite "wide" in order to facilitate the student's creative thinking, and to let them learn project work/management and the CDIO concept without distinctive boundaries that limit their activities. The project includes several engineering aspects – from own manufacturing, evaluation and use of temperature sensors to experimental design, applying simplifying assumptions in order to carry out the necessary calculations. According to the course and project evaluation, the students are become very engaged in the projects, finding it stimulating, interesting and relevant, which highly contributes to student engagement and a deep-level approach to learning (Tebbe, 2007).

2 Context of the Study

The students of interest in this study had just started a 5 year Master's program in Engineering physics and electronics at Linköping University, Sweden. About 160 students start the program each year. The program is considered to be quite theoretical, with the majority of courses in mathematics, engineering physics and electronics.

In parallel with the course "Enginereing project using a CDIO approach" of interest in this study, the students took courses in Mathematics (calculus and linear algebra) and digital technology.

Education in the programme are mainly carried out as lectures, lessons and laboratory sessions (when appropriate), although in some courses some of the lectures and/or lessons are replaced by seminars. In a typical engineering course, 40-50 % of the education is carried out as lectures, 40-50 % as lessons and 5-10 % as laboratory experiments. The traditional seminar at Linköping University can be seen as a mix of lecture and lesson.

The lectures are normally dominated by one-way communication from teacher to students as the students are supposed to listen and take notes. Asking questions is not at all prohibited, but not very common, thus this educational design makes the students' relatively passive. During a typical lesson, 25% of the time is taken up by a summary during which the teacher briefly discusses theory and solves a few standard problems. The students then work with problems on their own, discussing problems with each other and with the teacher.

The laboratory sessions can be based upon "hardware" or be "computer labs". Labs normally last 2-4 hours and consist of assignments solved in groups of 3-5 students. There are often some preparatory tasks for the students to work with before the lab, and they often write a report describing how they solved the tasks assigned and answer the preparatory questions etc. following the lab.

3 The Course "Engineering project using a CDIO approach"

3.1 Overview of the Course

The course starts at the beginning of the first semester, and runs during the first two semesters. The course makes up about 20% of the workload for the students during this period.

The course is intended to give the students an introduction of working in "real" engineering projects using the CDIO approach which is described below (CDIO: Conceive, Design, Implement, Operate). The objective of CDIO is to teach the basic concepts and disciplines of engineering in the context of hands-on exercises where students have the opportunity to manipulate concrete objects and ground abstract thought in experience, see e.g. Miller et al. (2002). For more information about the CDIO™ please see (CDIO, 2011).

Theory and practice of leading and working in projects are presented at a few lectures at the beginning of the course, which for example cover topics as project work, project management models, written and oral communication, seeking and evaluation of information and group dynamics. The students work in groups with engineering projects that are introduced at the beginning of the course. The project follows the LIPS project model (Svensson, T. & Krysander, C., 2003) described below (LIPS: "Easy Interavtive Project Model" (translated from Swedish)). A road map of the course is found in Figure 1.

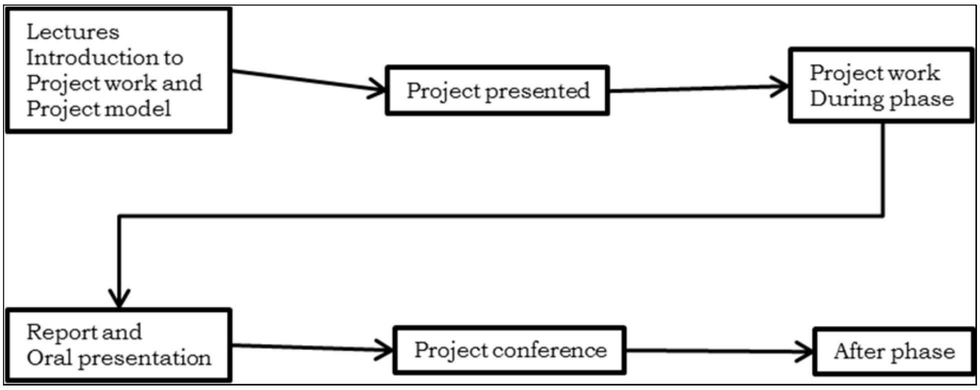

Figure 6: Overview of the moments in the course. The course starts with lectures describing projects as a way of organizing work, and work and management of projects including project management models. This is followed by a presentation of the projects, forming of the project teams and project plans. The groups then work under supervision for about 10 weeks before the results are presented in a written report as well as orally. Before the project is ended, the project is evaluated.

To manage the projects in an industrial-like way, but also follow the educational demands, the roles customer, supervisor and project group are used. Different teachers are assigned the roles as customer and supervisor, in this case the authors of this work. Each project group consists of 5-6 students who carry out the project work.

The customer is responsible for the demands on the project and its deliverables, and is also examiner of the students. The students work on the project following the LIPS model described above. The supervisor is a discussion partner for the students, but also serves as a spokesman for the communication of information between the customer and students. The supervisor guides the students through the writing of project documents, helps in interpreting the demands stipulated by the customer, and supervises the various parts of the project work and finally serves as "control station" of the final product before delivery to the customer. The supervisor meeting time is generally short about 30 minutes per week for each project group and each group is responsible to book these meetings when needed.

Twelve different projects with very different focus run in parallel during the course. Each project is carried out by 2-3 student groups that do not cooperate between the groups. The project of interest in this study is named "Heat loss during breathing", and is described below. Other projects regard for example the development of a weather station, communication over the internet, a system for simulating the dose for radiation treatment for cancer patients, and development of an optical system for measurement of gas contents in industrial processes.

3.2 The LIPS Project Model

LIPS, "Easy Interactive Project Model" (translated from Swedish) is a project template developed at Linköping University. The aim of the template is to mimic an industrial way of working and managing projects, but at the same time be adapted to the learning environment at a university.

LIPS was created in order to formulate and describe how to pursue a project. It can be scaled to fit projects on different complexity levels:

- Level 1: Short straight-forward projects, suitable for learning a project model.
- Level 2: Design projects with about 5-6 group members with clear roles, project and time plans, and milestones.
- Level 3: Large projects including e.g. quality assessment and formulated evaluation.

The project model has three distinguished phases, before, during and after, which all are included in the present course/projects (see also Figure 2).

1. The Before phase. Initiated by the customer in form of a project demand document, the requirement specification, where the aims, demands and deliverables are described and split up in smaller measurable units together with a priority setting. The requirement specification is the main input to the project group and this is used by the group to prepare a project plan including a time plan. During this phase, the students also formulate and sign a group contract, which can be described as a set of rules for the project work.
2. The During Phase. The main work of the project is carried out in this phase. The work aims at fulfilling the project requirements in the stipulated time with the resources at hand. It also includes deliverables (reports and/or a product). Milestones that represents a significant and measurable occurrence in the project are used for quality assurance. A positive side-effect is that the students get a feeling for the progress of the project. The milestones also serve as gates/decision points where the customer decides whether the requirements are met or not. At the time of each decision point, there is a communication between the customer and the project group to secure a correct valuation of the milestones.
3. The After phase. This phase closes the project. The project is evaluated, and students give and take feedback on the project.

The LIPS project model includes a more or less complete set of template documents for the project and its management, for example requirement specification, project plan, time plan, status reports and final report. Depending on the complexity level of the project, some of the project documents can be omitted.

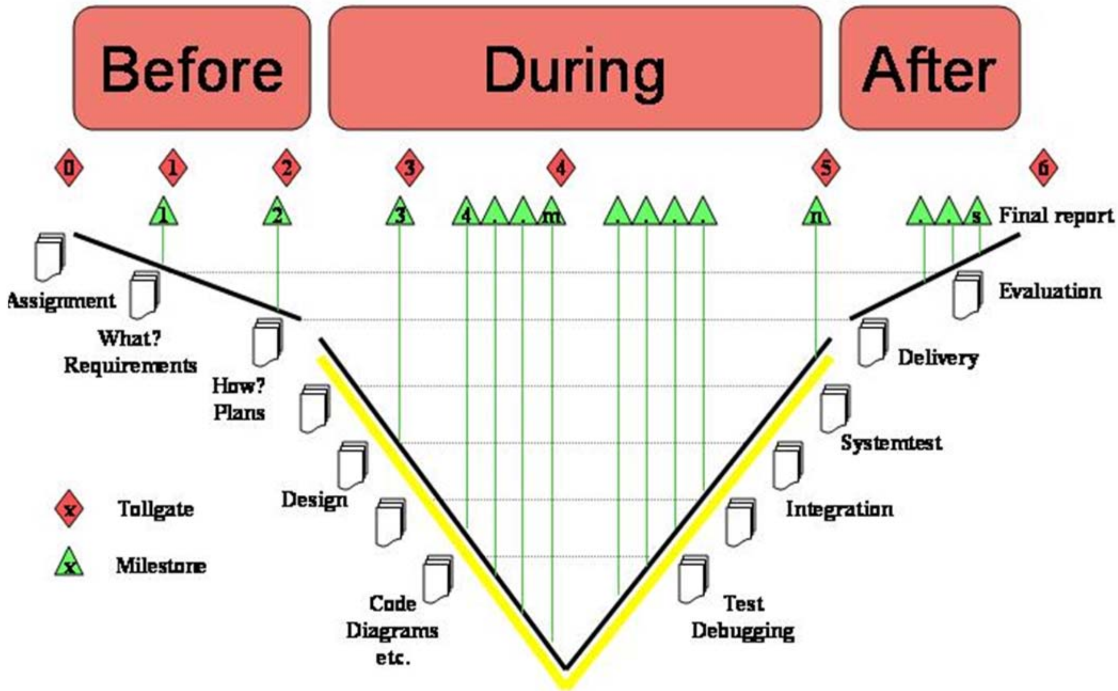

Figure 2: The LIPS project model and its phases *Before*, *During* and *After*. See further description in the text.

3.3 The Project – Heat loss during breathing

The project aims at an analysis and estimation of the heat loss of the human body, particularly due to respiration. To achieve this, the students should also design, build and evaluate a simple system for measurement of breathing temperature and volume. The project is divided into work packages and milestones as described by the requirement specification.

The project starts with the before phase by an introduction of the project and the requirement specification by the customer for 2 student groups with 6 students in each group. The background and aims of the project is presented, and the content of the project is discussed. Each group decides which student that should be responsible for the various roles in the project; project leader, responsible for customer contacts, documentation, system testing and heat loss estimation. The time spent on these roles is maximized to 25% of the total working time for each student. The group must also prepare and sign a group contract, which can be described as a set of rules for the project work. The next step is to prepare a project plan including a time plan. All major parts of the work should be included, and it should also be specified how much time each student is planned to spend on different tasks. The group continuously reports the time spent on various activities, and updates the previously created time plan if necessary.

When the project plan, time plan and group contract is finished, the During phase starts. Due to the multidisciplinary nature of the project in combination with the students' sparse knowledge about its areas, the students should first gain knowledge about the areas of the project, e.g. basic heat transfer, heat transfer interaction between the human body and the surroundings, and temperature measurement systems and their evaluation. Since the course is focused on projects and not heat transfer or medical aspects, the students are provided with literature and other support, and a relatively large amount of supervision during the initial part of the During phase of the project.

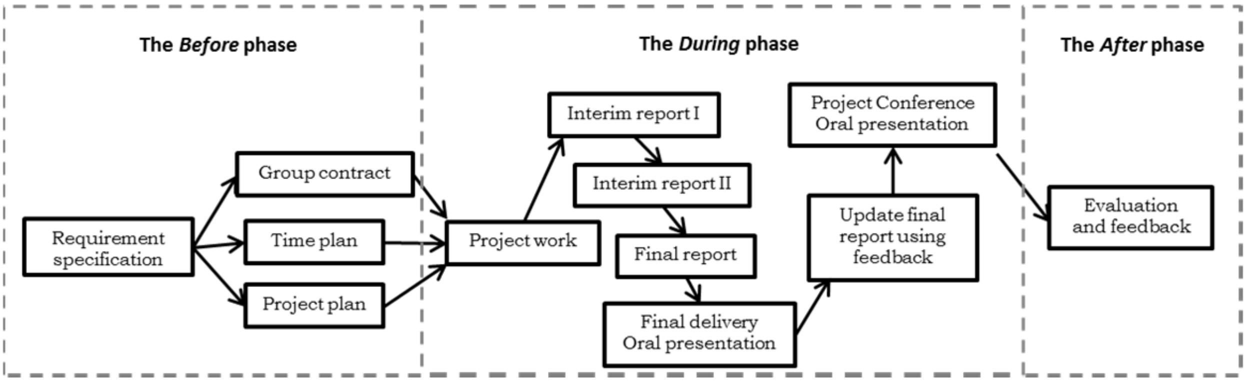

Figure 3: The LIPS project model and its phases *Before*, *During* and *After* and their respective content applied to the present project. Please see further description in the text.

The students then start to build, test and evaluate temperature sensors that later should be used in the system for respiration heat loss analysis. In the requirements is stated that focus should be on stability, response time and accuracy. The sensors are then to be combined with a simple device for measurement of respiration volume. This device is developed and manufactured by the students. One group for example fitted a pipe to a deflated plastic bag, and then let the respiration fill the bag while the temperature of the inspired, expired and bag air was measured and subsequently used for the heat loss estimations. Three reports should be prepared under the During phase:

1. Interim report 1. This includes a description of the heat transfer, breathing and temperature measurement aspects of the projects. A plan for testing of the temperature sensors should also be included.
2. Interim report 2. Include the result of the testing and evaluation of the sensors, and a plan for the design of the simple measurement system including an analysis of the aspects that affects the heat loss estimation.
3. Final report. The final report contains the most important parts of the 2 part deliveries, and also a description of the measurement system and its use. Calculation of the heat loss due to respiration should be included, together with an analysis of the validity of the results.

The supervisor meets the groups each week for supervision, and helps solving both theoretical and practical matters. Supervision covers both work strategies and contents of the project. The customer, supervisor and other teachers can be consulted as "experts" during the project. The main role of the customer is to give feedback on the reports, and make sure the groups follow the requirements of the project. The supervisor and customer also discuss the work of the groups along the project, so that the supervision etcetera can be adapted to the specific needs of each group.

The During phase is finished by 2 oral presentations (see Figure 2). The first is at the delivery to the customer. At this occasion, the customer is present together with a teacher specialized in communication. The students get feed-back on both the oral presentation and the written final report, and should update the report based on the feed-back. The other oral presentation is held at the project conference. At this conference, all students in the course present their project to other students in the course (students that have carried out other projects). All students must present their project, and listen to a few other projects.

In the After phase, the projects are evaluated. The students carry out a self-evaluation considering their work, plans documents etcetera in retrospect. The students also evaluate the project and the project teachers (customer and supervisor) as well as the course as a whole.

4 Evaluation

An important part of the evaluation process is the project evaluation carried at the end of the course. This document is available as one of the project templates, and consists of about 15 open questions that the students answer on a group basis by writing a short evaluation report. The questions are divided into 4 groups:

1. Time and Project plan
2. Analysis of work and task
3. Target achievement
4. Summary

Analysis of work and task together with target achievements are the two groups that are evaluated most thoroughly, and are made up of about 10 questions, for example “What happened during the project phases (good/bad/reason)?”, “How was the project model used?”, “How was the relation between project group and supervisor, and project group and customer?” and “What was the major learning outcomes?”

The project evaluation template is quite focused on the project, project work and management, project model etc. To also investigate the project from a learning perspective, both the supervisor and the customer discussed this issue with the students at several occasions during the project, both with the individual students and with the respective groups.

Finally, the teachers (customer and supervisor) evaluated the project work from a teacher perspective. This evaluation focused both on the process (project as a form of work) and the knowledge and skills in e.g. heat transfer that the students got during the project. The outcome of the latter is carried out with reference to the results of courses regarding heat transfer and measurement technology with more traditional design.

5 Results

From a student perspective, the main opinion of the course is positive. The project together with e.g. lectures and project conference give a thorough introduction to projects as a work form, project models and documents as well as project management.

One of the first things the students carry out in the project is the time plan. They think this is tricky, in part since this is the first time they encounter a ptoject time plan, and in part since they have only limited knowledge of the specific subjects included in the project. It is found that most groups overestimate the time required for specific tasks in the project by about 10-20%, but at the same time they under-estimate the time for “unspecified activities” e.g. “slack” and in-productive time.

Another aspect that the students highlight as a key to success is the communication, both within the group, and between the group and supervisor and customer. The students express the importance of focused and well documented meetings in order to be overall efficient in the project work.

All groups stress the importance of real hands-on projects to learn about how to work in projects using project models etc in an efficient way. The project should be sufficiently complex and stimulating to “force” the groups into using a project model, project documents etc. as well as teamwork. It is also believed that the use of different roles in the project makes the work more focused and efficient.

The students also express their increased knowledge regarding heat transfer and measurement technology, and analysis and evaluation of measurement methods and results. The general opinion was that the group had reached the goals of the project, both regarding project work in a general sense and the aims of the specific project. The following quotation from one of the groups illustrates the learning situation:

“In the project, we were responsible for how the project aims were met. This was demanding, but also stimulating. Since we worked in a group with different responsibilities, we constantly needed to communicate and discuss what we had learnt and what we needed to learn more about, both within the group and with the supervisor. “

From a teacher perspective, it is clear that the students appear to learn heat transfer, thermodynamics and measurement technology more effectively than students attending a course with similar content but with a classical course approach. It also appears to be an improved conceptual understanding using the project approach.

6 Discussion and Conclusion

The learning during a CDIO project during a first year Master program in engineering physics has been studied. The main objective of the course was to introduce project work and management using a project model, together with providing supporting skills such as project management, group dynamics and written and oral communication. To achieve this, the students worked in groups with industrial-like projects – the project of interest in this study was about development and evaluation of a system for estimation of heat loss due to breathing.

There are several reasons to use projects in engineering education. One reason is that the future engineers need training in an environment that mirrors that of a future working place. One reason is that most engineering subjects are either closely related to other subjects (e.g. Solid mechanics to Engineering materials), and/or multi-facetted in themselves (e.g. Machine design); in such cases, complex tasks are needed to be realistic. Regardless of the reason for using projects, it is important to recognize the strengths and weaknesses of this form of education. One benefit with projects in engineering education is that a deep-level approach to learning is facilitated. According to Karlsson (1991) , the deep-level approach to learning is all about gaining understanding, seeing the phenomenon in a holistic manner and relating things to each others, whereas a surface approach might be described by an atomistic view of learning focused on, for instance, reproducing facts seen as separate parts. A deep-level approach to learning is stimulated if the student for example experiences clear goals regarding the aims of the course and what is expected of the student, and time for individual studies and exchange with other students (Karlsson, 1991).

These are examples of learning situations present in the investigated project. It is interesting to note that the students seem to agree on this in the discussions with the teachers. Even if the project requirements are predefined by the customer, the student groups need to interpret the demands gives a high degree of ownership of the problem which enhances motivation for solving problems (Silén, 2000). This is in line with the teachers' experience that the students learn more effectively and with an improved conceptual understanding than students attending a course with similar content but with a classical course approach. One reason to this can be related to the frequent presenting and discussion of the project on a relatively advanced level, activities known to facilitate an active and deep-level approach to learning. It would have been interesting to investigate these aspects in detail, but this is beyond the scope of the present study.

The project evaluation using the evaluation template is the same for all groups in the course. The evaluation template has a clear project perspective, as most important aspects of the project work and management in the present situation is evaluated. Since the project evaluation using the template was carried out on a group by group basis, the answer of each groups tend to show the main consensus of the group. If there is a large diversity between the individual opinions in the group, this is not catch by the evaluation. The teachers' opinion based on many discussions with the groups, however, is that the diversity of the opinions is small in most cases.

In conclusion, it has been found that the students become very engaged in the projects, finding it stimulating, interesting and relevant, which highly contributes to student engagement and a deep-level approach to learning (Tebbe, 2007). It is also noted that the students appear to learn more effectively and with an improved conceptual understanding than students attending a course with similar content but with a classical course approach.

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Applicability of Serious Games in Statistics Education

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Abstract

Approaches based on Serious Games can engage and involve students, workers, teachers, managers, trainers and others, with the purpose of developing new knowledge and skills. It is well known that Statistics topics, in a general way, are not popular among students. However, they provide important methods for decision-making processes. Thus, trying to follow the technological and the new teaching-learning methodologies developments, a group of Statistics teachers/investigators, wanted to: (1) identify the areas where the SG have been used, (2) perceive how students understand the use of SG and (3) understand how they can be used as a didactic tool in universities for Statistics topics. This paper describes the development of a serious game, to explore Statistics topics of a post graduate course, as a support for pedagogical activities. The story in the game is about a kidnapping where the most of clues are provide as statistical information. Several suspects are listed and should be eliminated using probability calculations, confidence intervals and hypothesis testing. Students must use some concepts acquired in classroom to solve that crime. As additional incentive, the student must hold the real guilty in a pre-defined period of time.

Keywords: Learning, Serious Games, Statistics Education

1 Introduction

"You can learn more about a man in an hour of play than in a year of conversation" Plato

Sentence even though quite ancient, describes in a way, the main theme of this paper: learning by playing. Nowadays, and subscribing Ulicsak' definition, "Serious games are the accepted term for games with an educational intent. They need to be engaging, although not necessarily fun, while the learning can be implicit or explicit" (Ulicsak & Wright, 2010).

Throughout the years, Serious Games (SG) has been developed as a special category of games devoted to increase a fun activity with specific content. Nowadays, the areas of applicability of SG has been expanded and applications can already be found in several and distinct areas, such as Education, Health, Advertising, Politics among others (Machado *et al.*, 2009; Zyda, 2005) Figure 1.

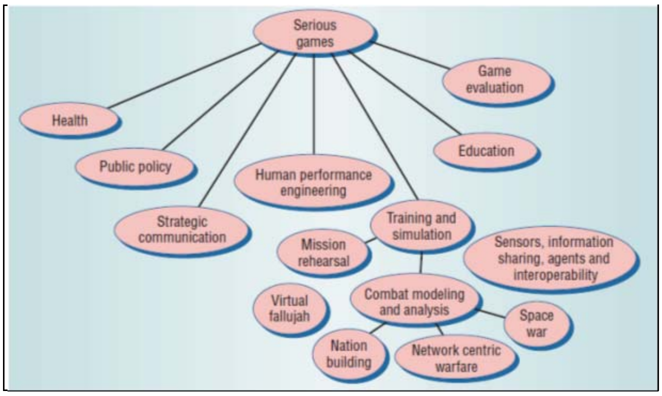

Figure 7: SG methodology different areas of application (from Zyda, 2005)

These games have a pedagogical purpose. In large part, since they promote the active learning and that they can analyze alternative answers through observations and experiences in virtual real applications. Thus, and according to Thompson "*these games are examples of mediators capable of providing the player immersion, attention, working knowledge, goal setting, self-control, decision making, self-efficacy , internal motivation and feelings of competence and autonomy*", Morais et al., 2008.

The use of computers for games started on the 50's and, 30 years later, the SG firstly, developed as war simulators, namely as flight simulator, extended to the military vehicles' operation, were created. Nowadays, one field of application that had beneficiated of the SG as an important tool of training is the Health field (Machado *et al.*, 2009). As stated by Zyda (Zyda, 2005), the need for "*better computer characters and story increases with the complexity of visual displays and with the release of each new, more complex-than-ever game*". The author also mentioned that the game innovations are becoming a competitive necessity.
Following this idea and the technology developments, a group of Statistics teachers/investigators decided to develop a SG in Statistics Education in higher education level. The SG is still in development and, when finished, students will be encouraged to use and improve their knowledge of Statistics, as well as know applications of Statistics, just playing the game.

2 SG in Statistic Education: developments

The SG development could be a hard or even complex task, time consuming and costly (Nadoslsky et al., 2007). To help on the SG design, it is necessary that the pedagogical purpose and applicability of the SG be very well defined. In that way, the SG' several components and their relationships, the SG' based scenario and design complexity could be reduced. All of this specifications and methodologies are collected in a document named as "design bible". The "design bible" can be used as a guide of all the game development process. This document contains the guidelines of the SG, their artistic conceptualization, game details and instructions and interface definitions.

The Statistic SG will be a mystery game. The main idea is to engage the student to solve a kidnapping where most of the leads have statistical information, i.e., based on statistical knowledge, the student better understand and follow a specific lead, in the right direction. The game script is: a baby is kidnapping at his house and several suspects are identified and eliminated through probabilistic estimations, confidence intervals and hypothesis tests (first level on a Statistic subjects for engineering courses).

3 Conclusion

This paper tries to show the developments of a multidisciplinary team linking teaching, statisticians, informatics and students with the same main interest in the application of Serious Games in Statistics Education. This work is still under development, being only the stage (1), areas identification where the SG have been used, completed. The following two stages are in progress. They will allow understanding the students' perceptions in using SG as learning tool in universities for Statistics topics.

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Active learning strategy and conceptual change in an undergraduate electrical circuit course

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Abstract

This paper begins with a brief historical and conceptual presentation of Inquiry Based Science Education (IBSE) as well as some evaluation results obtained with this strategy. Next, the paper presents a brief abstract of the challenges concerning the typical conceptual misconceptions that students have concerning electrical circuits at undergraduate level. Following, the electrical circuit course based on IBSE is presented. IBSE approach can be viewed as a well-constructed sequence of small research projects. This document ends presenting some of the obtained results in relation with the evolution of student's learning.

Keywords: Inquiry based education; Active learning; performance assessment.

1 Introduction

During the last two decades the interest in exploring new strategies in teaching and learning has grown, trying to deal with new challenges in engineering education. In fact, engineers need to face more complex problems that in the past. An examination of the requirement evolution present in ABET criteria or the findings of the European Tuning project serve as illustration of this process. The main conclusion: more complex transversal competencies and deep understanding of the engineering foundations.

In parallel, engineering schools face a demanding increase of accountability from the society. Examples of this tendency are the tests named GSA in Australia, CLA in the USA, AHELO of OECD or the new high education test in Colombia called SABER PRO. All those tests are based in new approaches that try to assess high-level transversal competencies. Memory and procedural learning is not enough.

But, the need to modify teaching strategies is not only due to new requirements but also related with the lack to fulfill old requirements. Recent results and findings show that "classical" teaching approach doesn´t come to modify big misconceptions that avoids a deep disciplinary understanding. When students learn specific subjects, such as electrical circuits, they have misconceptions and in many cases those misconceptions are not modified during the subject specific course development.

This paper presents a course designed to try to deal with both problems: increase deep understanding promoting conceptual change, and high level transversal competencies promoting an inquiry learning approach based on small research projects. In order to evaluate the effectiveness of this design, the paper presents some preliminary learning assessment results based on performance assessment and assessment based on evidences.

Two questions are explored in this paper:

- Introduction of conceptual change strategies could improve IBSE?
- Could learning more complex topics change basic Misconceptions?

2 Inquiry based science education

2.1 Some history

Inquiry as teaching strategy was proposed by Dewey early in the twenty century (Dewey, 1910). He presented inquiry as the sublime art of teaching and learning. Some scientists, including Einstein, in their reflexion about the epistemology of science and in particular about how science constructs knowledge, approached the actual vision of Scientific Inquiry (Holton, 1982). Those visions were far away from the idea of the "Scientific method", understanding in particular that the scientific activity is messy and in some ways a chaotic process that differs in function from the research question. However, most of science textbooks present the "scientific method" as a true and almost unique path for doing science. Indeed, Teaching science for the most part of the twentieth century were teaching of facts as truths and perform some "scientific" activities following "cookbook recipes" based on the idea of a "scientific method".

When the Sputnik was launched in 1957, EEUU realized that their science and technological education was at risk. As consequence, important resources were assigned for developing modern science curriculums. Those curriculums were used until the 80s. Student assessments showed that this kind of curriculums didn't have an impact and the science education seemed to be in big problems. An evaluation of those curriculums elaborated by disciplinary experts, without teachers' intervention, seemed to be the main problem: the scientific methods continued to be used. Those curricula were known as cookbook science. Two main problems continued: big misconceptions concerning science and science foundations remain in the students; and the interest for science dropped.

Starting the 90s a new family of curriculums were born. Those curriculums were based on a transposition of Inquiry to the classroom (National Research Council, 1996):

> Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world.

A fast growing in science education programs concerning Inquiry Based Science Education (IBSE) is happening. At the end of the twentieth century less than 10 countries were using IBSE. However, 10 years before, at least 40 countries worked with curricula based on IBSE in K-12 education. In recent years, this approach was articulated with technology and maths based on country competitiveness needs (National Research Council, 2002; National Research Council & National Academy of Engineering, 2002).

However, IBSE is used manly in K-12 education with few experiences in higher education where some documents recommended its introduction (Albert et al., 2000).

2.2 Some results: is IBSE effectiveness?

IBSE can't be interpreted as a method or a methodology but as an approach, a philosophy based on the scientific paradigm: built knowledge trying to reach a scientific answer to a scientific question framed in small research projects worked in groups. However, different class practices could be proposed based on this paradigm. As related in section 2.1, there are different approaches concerning IBSE. The main question concerns the effectively of this approach: could students learn efficiently and deeply if they use inquiry as a learning strategy?

Multiple studies have approached these questions. The results are contradictory: while some studies show positive results, other studies didn't come to find differences in relation with "traditional" approaches (Pine & Aschbacher, 2006; Pine et al., 2006). Two recent meta-studies present a general survey concerning results of IBSE (Minner, Levy, & Century, 2010; Ruiz-Primo, Briggs, Iverson, Talbot, & Shepard, 2011). The last one shows that in general different studies seem to evidence a positive effect of the IBSE approach.

One of the explanations in relation with the contradictory results of IBSE approach is the "Fidelity of the Implementation". In fact, some studies have shown that a bad implementation of any educational strategy, particularly when this strategy is not understood, produce poor results (Ruiz-Primo, 2006, 2008a; Stigler & Hiebert, 1999).

In general, the "fidelity of the implementation" requires a conceptual framework of the intended innovations. For any evaluation activity this framework is fundamental and required in order to obtain a valid evaluation.

A good fidelity of IBSE approach requires well-designed curriculums. The construction of those curriculums are not an easy task and require a strong research in science didactic and professional development (Butler Songer, 2006; Pajares, 1992). A general view of one possible design process is shown in (Worth, Saltier, & Duque, 2009). In particular Fidelity of the implementation seems to be strongly correlated with an appropriated professional development strategy that includes PCK (pedagogical content knowledge) and IBSE approach (Abell, Rogers, Deborah, & Gagnon, 2009; Sanchez, Manrique, & Duque, 2009). Some previous studies concerning IBSE in electrical circuit have been proposed (Getty, 2009). Next section presents the framework used in this work.

2.3 Conceptual Framework

IBSE is based on didactical transposition of the scientific inquiry activity in the classroom. Different approaches have evolved over the last two decades. Different types of IBSE can be identified (Banchi & Bell, 2008): Confirmation inquiry, structured inquiry, guided inquiry and open inquiry. There is not "the best approach" in IBSE. In fact, each approach has advantages and disadvantages. For example, open inquiry, gives students a complete freedom to act like scientists, proposing their own questions, designing and carrying out investigations, and communicating their results. However, this approach implies that the student has a capacity to conduct autonomous research, the alignment to a science curriculum could be weak and this approach takes time.

On the other hand, in structured inquiry, the teacher provides the question and procedure; and students generate an explanation supported by the evidence they have collected. This approach is focused on knowledge construction around big science ideas. Guided inquiry is in the middle of these approaches: teacher guides students to construct their own questions and to conceive the research process. In this way, students can understand better the science procedures, and eventually the nature of science knowledge. This last aspect, in opinion of some researchers, has to be taught explicitly (Borda, Duque, & Carulla, 2008; Duschl, 2000).

The framework retained for the IBSE in the Colombian program is shown in the next table (Ruiz-Primo, 2008b):

Table 10: Strands of IBSE

Facet	Description
Conceptual Schemes	Know, use, and interpret scientific explanations of the natural world. This strand stresses acquiring facts, building organized and meaningful conceptual structures that incorporates these facts, and employing these conceptual structures during the interpretation, construction, an refinement of explanations, arguments, or models.
Process Strategies	Generate and evaluate evidence and explanations. This strand encompasses the knowledge and skills needed to build and refine models based on evidence. This includes designing and analyzing empirical investigations and using empirical evidence to construct and defend arguments.
Epistemic Frameworks	Understand the nature and development of scientific knowledge. This strand focuses on students' understanding of science as a way of knowing. Scientific knowledge is a particular kind of knowledge with its own sources, justifications, and uncertainties. Students who understand scientific knowledge recognize that predictions or explanations can be revised on the basis of seeing new evidence or developing a new model.
Social Processes	Participate productively in scientific practices and discourse. This strand includes students' understanding of the norms of participating in science as well as their motivation and attitudes toward science.

Concerning the process, the following figure illustrate the messy workflow (Worth, et al., 2009):

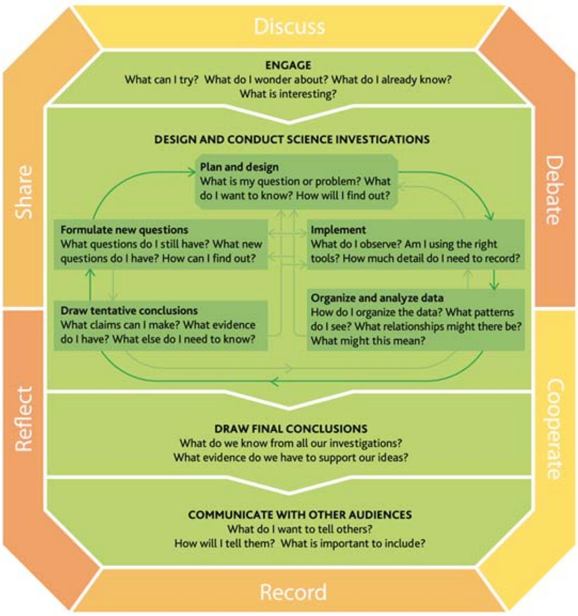

Figure 8: IBSE process

This approach could be related with the proposed approach by Kolb (Kolb, 1984). The following figure illustrate this relationship (Borda, et al., 2008):

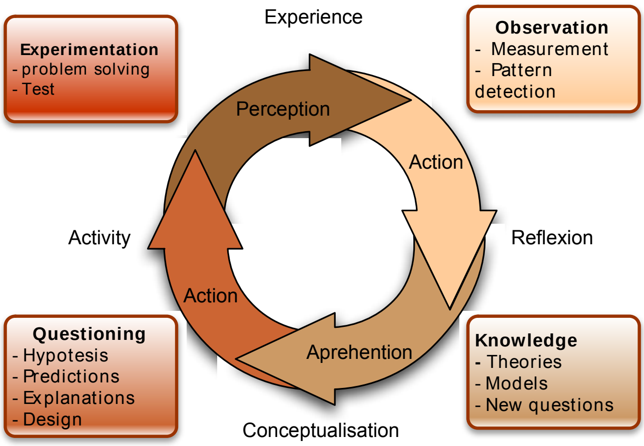

Figure 9: IBSE vs. Experimental learning by Kolb

The last aspect that has been included in the conceptual framework of the circuit course design was "conceptual Change". Next section presents some very common and durable misconceptions related with electrical circuits. A big number of studies show that those misconceptions remain even after "good instruction" is given (Duit & Treagust, 2003; Duschl, 1991). These misconceptions are common in undergraduate students and often survive to physic and circuit courses:

1) existing ideas must be found to be unsatisfactory,
2) the new idea must be intelligible, coherent and internally consistent,
3) the new idea must be plausible,
4) the new idea must be preferable to the old view point of view on the grounds of perceived elegance, parsimony, and/or usefulness

The electrical circuit course that is presented in this paper is based on IBSE and conceptual change strategies.

In order to set the goals, this work uses the following knowledge categories: declarative knowledge, procedural knowledge, schematic knowledge and strategic knowledge as proposed in (Solaz-Portolés & López, 2008).

3 Electrical circuits misconceptions and learning path

Some of the researches concerning the way in which students acquire knowledge show that in the learning-teaching process the students come to the classroom with practical and intuitive knowledge concerning laws and physical phenomenon and with which they explain how things work in the real world.

During the last decades, several studies have shown that there is an ample range of these previous ideas and the form in which students reason concerning these ideas (Closset, 1983; Furió & Guisasola, 1999; Gonzalez, 2006; Hierrezuelo & Montero, 1988 ; Picciarelli, Di Gennaro, Stella, & Conte, 1991; Pontes & De Pro, 2001; Shipstone, 1984 ; Varela, Manrique, & Favigres, 1988).

According to these previous idea studies and in which they agree, are:

1. Difficulties to distinguish between, and to the use of, terms like: potential difference, voltage, current, etc.
2. The current is thought of as a fluid material.
3. They do not see the necessity for the circuit to be closed to be an electrical current.
4. They tend to use sequential reasoning and, for example, they think that the current becomes weakened or exhausted as it passes through a circuit or think there can only be charges after the circuit element changes.
5. Tend to interpret the voltage as a property of the current, instead of considering the current to be a consequence of the difference in potential between two points of a conductor.

6. The students have difficulties in interpreting the graphical representations of the circuits. They are not able of associating the real circuit with their graphical representations, though it is a question of simple assemblies.
7. Students use local reasoning to understand circuits. A change in the circuit is thought as only affecting the current and / or voltage in the circuit where the changes are made. (Bernhard & Cartestensen, 2002)

The ideas on which the emphasis was made in this study are 2, 3, 4, and 7.

Next figure resume typical moments in the electrical circuit understanding:

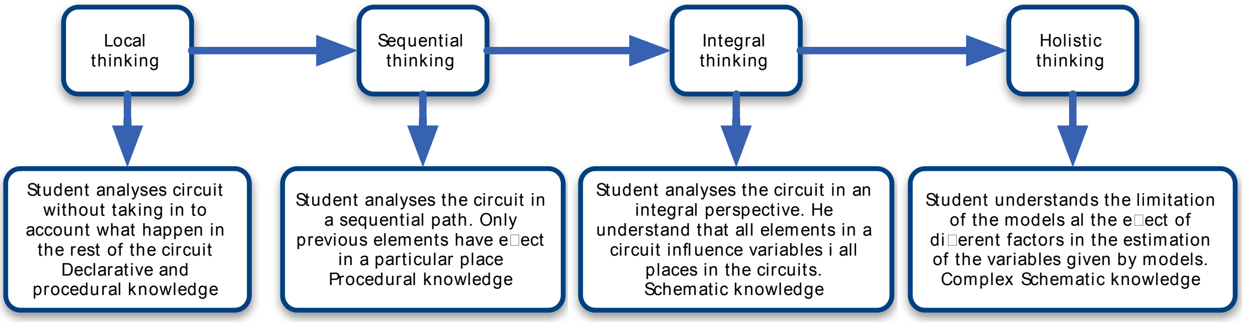

Figure 10: Electrical circuit evolution of the students' thinking

4 Course structure and context

The course was run over 3 semesters (2010-1, 2010-2, 2011-1). During the first semester the main aspects of the course were tested (learning path, main activities and assessment tools). The second semester implemented a "classical" ISBE approach with no explicit "conceptual change" activities. The last semester a reduce IBSE approach with explicit conceptual change activities was proposed.

The course was structured in three main modules: static circuits, dynamic circuits and frequency response in circuits. This experiment was focus only in static circuits. However the second and third modules use the same approach. The following figure presents the structure of the first module that is composed by 7 units.

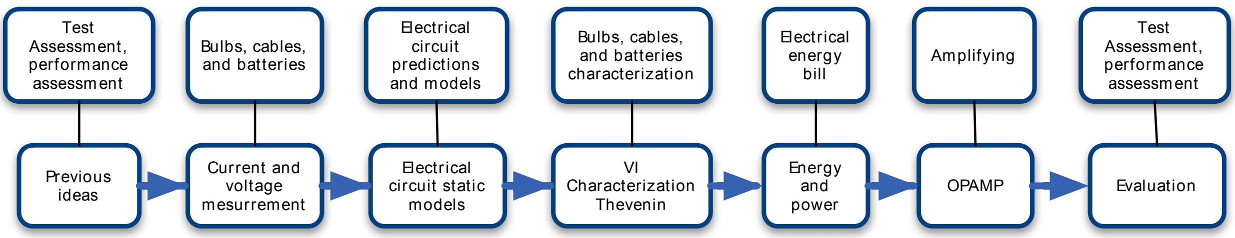

Figure 11: Electrical circuit course structure of module 1 In the IBSE approach each unit includes hands-on activities. Each unit is composed with several sessions.

5 Results

Concerning the first question (Introduction of conceptual change strategies could improve IBSE?) figure 5-a shows the obtained result:

- Introduction of conceptual change strategies, when hands-on activities are reduced has a bad impact in expected learning in this specific case.
- A non-expected result concerning evidence 6.4.2 is obtained. However, a close examination of the items used to evaluate this evidence shows that the items in the pretest and posttest are not as equivalent as supposed.

Concerning the second question (Could changes basic misconceptions through learning more complex topics?) figure 5-b seems to show:

- In general, during the second part of the semester there is an evolution of the understanding in relation with basic electric circuits aspects.
- The results concerning evidence 6.2.4 explore a misconception that wasn´t treated directly in the course and that requires knowledge transfer. Clearly students have big problems with this question.

Summarizing, the answer to the second question, in the context of this electrical circuit, suggests a positive answer. However, the introduction of Conceptual change strategies instead of some hands-on activities seems to reduce the impact of the IBSE strategy. Nevertheless, these conclusions have to be taking into account as a hypothesis for future studies, because different groups could obtain different results.

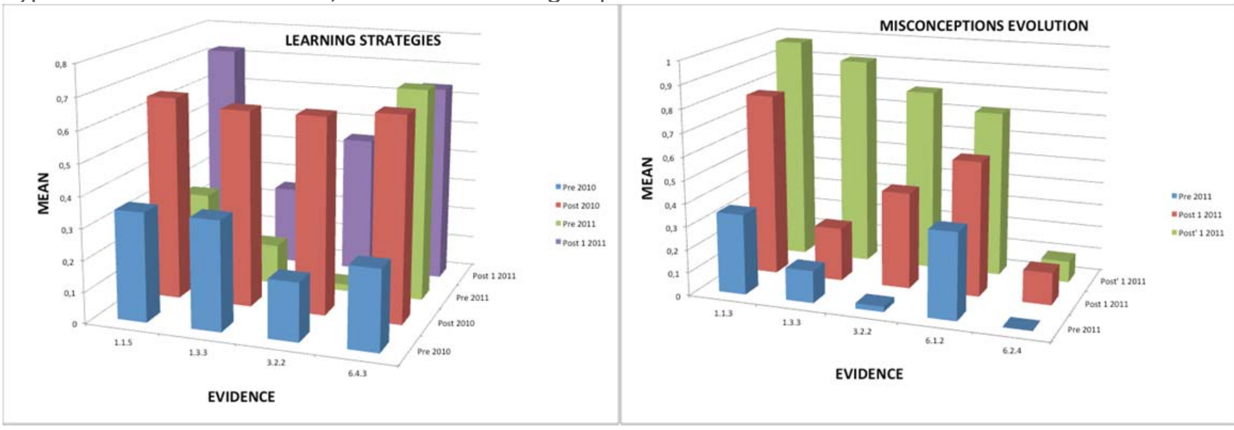

Figure 12: General results (a) Introduction of conceptual change strategies could improve IBSE? (b) Could changes basic misconceptions through learning more complex topics?

6 Conclusions

In general, students are pleased when a different teaching strategy that includes more hands-on activities and less teacher lectures, is proposed. This situation could improve motivation and possibly learning, however, this improvement is not completely trustworthy and, well-designed assessments are needed in order to confirm this learning increase. Frequently, course reforms ends up with poorer learning (Stigler & Hiebert, 1999)

The use of an inquiry based science education approach based on a sequence of small research projects complemented with conceptual change activities, as a teaching strategy in the undergraduate electrical circuit course, seems to have interesting results (Duque & Guayacundo, 2011), but in this study the substitution of hands-on activities for more conceptual change strategies seems to be inadequate.

This study seems to show that Active learning approaches need strong reflexion activities (as proposed in Kolb cycle) based on structured approach like conceptual change strategies to deal with current misconceptions.

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Paper Session C2

Experiência Inovadora em Projetos de Sistemas de Produção do Curso de Engenharia de Produção da Universidade de Brasília

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Resumo

O mercado passou a exigir do profissional de engenharia, além das competências técnicas, competências transversais tais como habilidades de comunicação, trabalho em equipe, gestão de projetos, identificação e resolução de problemas etc. Para possibilitar uma aprendizagem consoante a essa demanda do mercado, o curso de Engenharia de Produção da Universidade de Brasília - UnB, fundamentado na metodologia de aprendizagem baseada em projetos (PBL), propõe a implantação gradual de sete Projetos de Sistemas de Produção (PSP1 a PSP7). Em março de 2011 entrou em vigor o primeiro PSP. Este artigo tem como objetivo fornecer uma visão geral dos 7 PSPs, do PSP1, e das expectativas dos alunos com relação a essa nova forma de aprendizagem. A partir de um questionário formulado com base na Metodologia de Multicritério de Apoio à Decisão (MCDA), dentre outras constatações, verificou-se que apenas um aluno obteve pontuação abaixo de 50 e aproximadamente 86% dos alunos estão otimistas quanto à nova abordagem de ensino aprendizagem.

Palavras-chave: aprendizagem baseada em projetos (PBL); método de aprendizagem; abordagem de projetos; educação em Engenharia de Produção.

Abstract

Besides technical skills, the market demands engineers that also have soft skills, such as communication, teamwork, project management, problem identification and solution. Taking this into account, the University of Brasilia (UnB) Production Engineering Undergraduate Program has introduced a project-based learning (PBL) methodology, with the gradual implementation of seven Production Systems Projects (PSP1 to PSP7). In March 2011 the first PSP was implemented. This article aims to provide an overview of the seven PSPs, emphasizing the first one (PSP1), and the expectations of the students with respect to this new form of learning. From a questionnaire based on the Multicriteria Decision Aid (MCDA) methodology, it was found, among other findings, that only one student scored below 50 and about 86% of the students are optimistic about the new approach.

Keywords: project-based learning (PBL); method learning; project approaches; education in Production Engineering.

1 Introdução

No ensino tradicional, a maioria dos estudantes envolve-se passivamente na aprendizagem, apenas ouvindo o professor. Eventualmente olham para um *slide* e, quando cobrados, lêem o livro texto. Algumas pesquisas apontam que esse envolvimento passivo conduz a uma baixa retenção do conhecimento exposto. Singhal, Bellamy, McNeill, (1997) e Surgenor, Firth (2006) citam a "Pirâmide da Aprendizagem", em que a taxa de retenção do conteúdo abordado é função dos diferentes métodos de ensino/aprendizagem utilizados. O topo da pirâmide é ocupado pela aula tradicional, com retenção média de apenas 5%, enquanto que na base da pirâmide as atividades praticar fazendo e *"ensinar outros"* permite uma retenção média de respectivamente 75% e 90% do conhecimento apresentado.

Através de estudos realizados por Kjersdam, Enemark (1994); Kanet, Barut (2003) e Rau,Chu, Lin (2004) as universidades têm adotado a metodologia de aprendizagem baseada em projetos (PBL) no ensino de engenharia, formando engenheiros com elevada autoconfiança profissional, onde analisar uma questão, estruturar informações, trabalhar em equipe, conduzir e presidir discussões e apresentar idéias, tornam-se tarefas realizadas sem maior dificuldade.

O curso de Engenharia de Produção da Universidade de Brasília (UnB) tomou como referência para os Projetos de Gradução 1 e 2 o Projeto de Graduação (*Graduation Project*) do Curso de Graduação em *Industrial*

Engineering da *University of Illinois at Urbana-Champaign*. A diferença entre as propostas pedagógicas é que, na UnB, o conjunto de Projetos PSP1 a PSP7 constitui uma interligação do núcleo conceitual com o Projeto de Graduação, sempre buscando soluções para problemas reais em temas da atualidade.

A referência sobre aprendizagem baseada em projeto na UnB tem sido os cursos de graduação do Departamento de Produção e Sistemas da Universidade do Minho. Os PSPs foram fundamentados com base em sessões de trabalho que ocorreram como parte de dois seminários, realizados em Brasília no segundo semestre de 2010, conduzidos por professores e pesquisadores da Universidade do Minho, sobre aprendizagem baseada em projeto.

O curso de graduação em Engenharia de Produção da Universidade de Brasília é noturno, com fluxo normal de doze semestres, perfazendo um total de 3.600 horas de atividades. Desde agosto de 2009, mês de início do programa, 50 novos alunos são admitidos a cada semestre, o que resultará em um corpo discente de 600 alunos quando em regime. Este artigo demonstra uma inovação na grade curricular do referido curso a qual está pautada na abordagem Project-Based Learning (PBL).

2 Visão Geral dos Projetos de Sistemas de Produção (PSPs) do Curso de Engenharia de Produção da Universidade de Brasília (UnB)

A construção do currículo para um curso de graduação pode ser entendida com um processo de produção de serviços em educação. Dentre todos os *stakeholders* que participam deste processo: alunos, mercado de trabalho, instituição de ensino, sociedade. A instituição de ensino deve direcionar seus esforços no sentido de atender às demandas solicitadas pelo mercado de trabalho. A abordagem PBL incentiva os alunos a "aprender fazendo na prática", conduzindo-os a problematizar, investigar, questionar, descobrir e propor algo novo. Estas novas habilidades adquiridas pelos alunos são conceituadas como competências transversais e são fundamentais para assegurar a empregabilidade, uma vez que se tornou uma exigência do mercado de trabalho. A fim de atender às novas exigências solicitadas pelo mercado e com o intuito de desenvolver as competências transversais dos alunos buscou-se uma abordagem inovadora baseada em sete disciplinas de Projeto de Sistemas de Produção que serão detalhados a seguir.

A proposta curricular do curso segue as diretrizes curriculares nacionais estabelecidas pelo Conselho Nacional de Educação – CNE (2002) e foi estruturada de modo a capacitar o seu egresso a lidar com os problemas dentro de um enfoque sistêmico, no qual a atividade de engenharia é vista como uma interação do profissional com os vários ambientes nos quais a sua atuação interfere e, ao mesmo, tempo é afetada. A proposta pedagógica procura garantir uma visão articulada entre as características da atuação profissional e as diferentes áreas de conhecimento, permitindo compreender a multiplicidade de aspectos determinantes envolvidos na solução de problemas.

Todo semestre, a partir do quarto, os estudantes desenvolverão projetos buscando-se a consolidação dos aspectos metodológicos dos PSPs com assuntos abordados em disciplinas de conteúdo técnico, tendo sempre como foco a realidade trazida por agentes externos vinculados a cada tema de projeto.

Os temas dos projetos associados às disciplinas PSP1 a PSP7 serão definidos a cada semestre. A disciplina PSP4 consolidará todos os aspectos de engenharia de produção estudados até o semestre, incluindo estudos preliminares para a implantação de empreendimentos sustentáveis. As disciplinas PSP5 a PSP7, que, respectivamente, têm Engenharia Econômica e Pesquisa Operacional em Engenharia 1 como pré-requisitos, ampliarão o escopo dos projetos, incluindo estudos de viabilidade técnica, econômica e ambiental, visando à implantação sustentável de empreendimentos associados aos resultados dos projetos.

O perfil esperado do egresso pode ser descrito como: (i) com capacidade para criar valor em distintos espaços, (ii) que consiga desempenhar diferentes papéis em projetos (iii) focado na solução de problemas reais, (iv) com ênfase na produção de serviços em geral, serviços públicos em particular, e produção fabril, (v) entendendo os diferentes poderes e níveis de estado, inclusive entidades internacionais, que proporcione uma visão geral de mundo, com destaque para posicionamentos em cenários regionais e globais, (vi) tudo isso dentro da perspectiva do papel da UnB tanto como universidade de destaque nacional quanto por sua localização no centro-oeste.

Conforme ilustra a Figura 1, os projetos estão baseados em quatro âncoras principais: disciplinas de metodologia de projetos sustentáveis; disciplinas de conteúdo técnico; agentes externos vinculados a problemas reais; e outras disciplinas com interesses em tópicos específicos do projeto.

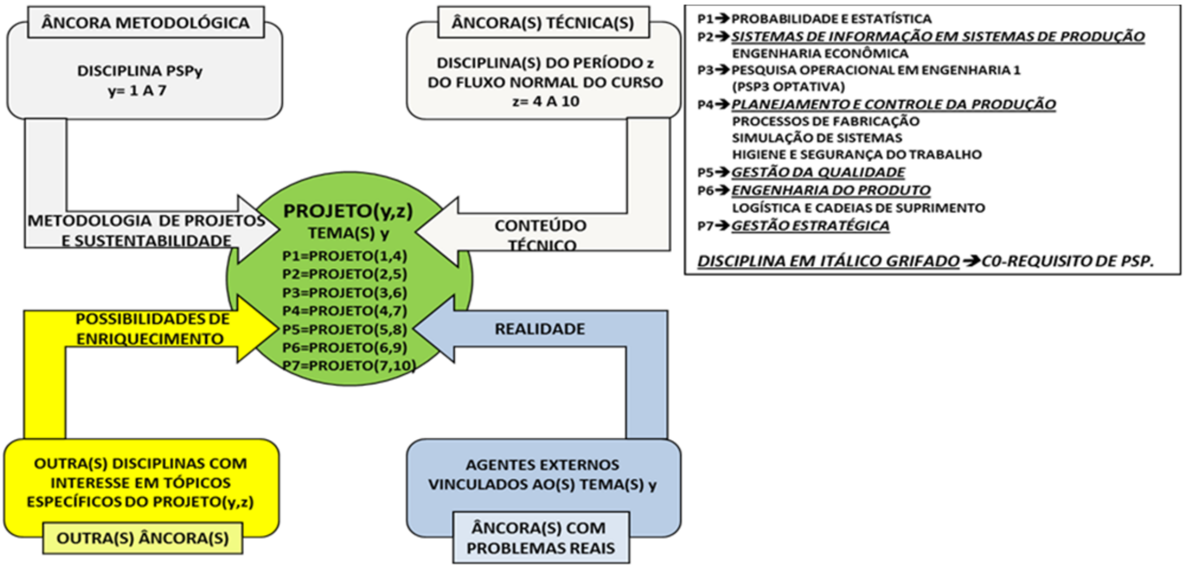

Figura 1: Esquema Geral de Âncoras para Projetos (y,z) de Sistema de Produção

A partir do quarto semestre do fluxo normal, haverá o Projeto(y,z), com um único ou vários temas y, no qual y representa o correspondente PSP (y=1 a 7) e z identifica o semestre do fluxo normal do curso (z=4 a 10). Problemas pertinentes a temas do Projeto(y,z) serão designados a “equipes de projeto”, cada qual com a tarefa de explorar as questões pertinentes e elaborar respostas e soluções ao longo do semestre letivo. A solução do problema exigirá a busca de fontes e a integração de conhecimentos multidisciplinares, bem como habilidades de trabalho em equipe. O Projeto(1,4), ponto inicial da série de sete projetos, teve sua primeira oferta iniciadaem março de 2011.

Os trabalhos no âmbito dos Projetos(y,z) terão como características gerais:

a) Trabalho em grupo sem a presença do professor supervisor na maior parte do tempo;
b) Tarefas propostas realísticas, envolvendo a aplicação dos conceitos da Engenharia de Produção a problemas concretos oriundos da interação do curso com o mundo real;
c) Tarefas envolverão aspectos do currículo e crescerão em complexidade à medida que o aluno avançar no curso;
d) Aulas/palestras/apresentações sobre aspectos específicos das tarefas organizadas pelo professor supervisor do grupo, à medida que se tornem necessárias;
e) Trabalho de grupo orientado à consolidação de conhecimentos e habilidades;
f) Divisão de tarefas dentro do grupo orientada na direção da otimização dos resultados;
g) Cada aluno, em diferentes projetos, desempenhará diferentes papéis no grupo;
h) Alunos terão sua atuação centrada mais em atividade de projeto do que em atividades de classe;
i) Desenvolvimento de senso de responsabilidade no trabalho de projeto;
j) Atividades de acompanhamento e supervisão terão lugar em sala especialmente desenhada para trabalho em grupo;
k) Avaliação tanto do trabalho conjunto quanto dos resultados do trabalho conjunto, incluindo a autoavaliação e avaliação dos pares.

Quando em regime, a cada semestre haverá um total de 350 alunos, a serem alocados em sete tarefas tipo “Projeto(y,z)”. Com base no modelo de âncoras, para o referido curso considerou-se as seguintes configurações de Projeto(y,z):

- Projeto(1,4)→A1-Metodologia: PSP1; A2-Conteúdo Técnico: Probabilidade e Estatística; A3-Agentes Externos (Grandes Provedores de Bases de Dados): Públicos, Privados, ONGs; A4-Outras Disciplinas: A definir.
- Projeto(2,5)→A1-Metodologia: PSP2; A2-Conteúdo Técnico: Engenharia Econômica e Sistemas de Informação em Sistemas de Produção; A3-Agentes Externos: Públicos; Privados; ONGs; A4-Outras Disciplinas: A definir.
- Projeto(3,6)→A1-Metodologia: PSP3; A2-Conteúdo Técnico: Pesquisa Operacional em Engenharia 1; A3-Agentes Externos: Públicos; Privados; ONGs; A4-Outras Disciplinas: A definir.
- Projeto(4,7)→A1-Metodologia: PSP4; A2-Conteúdo Técnico: Processos de Fabricação, Planejamento e Controle da Produção, Simulação de Sistemas e Higiene e Segurança do Trabalho; A3-Agentes Externos: Públicos; Privados; ONGs; A4-Outras Disciplinas: A definir.

- Projeto(5,8)➔A1-Metodologia: PSP5; A2-Conteúdo Técnico: Gestão da Qualidade; A3-Agentes Externos: Públicos; Privados; ONGs; A4-Outras Disciplinas: A definir.
- Projeto(6,9)➔A1-Metodologia: PSP6; A2-Conteúdo Técnico: Engenharia do Produto e Logística e Cadeia de Suprimento; A3-Agentes Externos: Públicos; Privados; ONGs; A4-Outras Disciplinas: A definir.
- Projeto(7,10)➔A1-Metodologia: PSP7; A2-Conteúdo Técnico: Gestão Estratégica; A3-Agentes Externos: Públicos; Privados; ONGs; A4-Outras Disciplinas: A definir.

Esta estratégia vai além de um simples método educacional. Uma forma de estudar e aprender baseada na troca de informações no interior da "equipe de projeto". A análise dos desafios colocados pela tarefa proposta, a partir da base de conhecimento e da experiência de cada membro do grupo, indicará a direção a ser tomada na procura de soluções. O trabalho e as discussões dentro do grupo ensejarão uma compreensão da teoria e a aprendizagem de como aplicá-la na prática. Adicionalmente, os alunos exercitarão habilidades como defender efetivamente um ponto de vista, debater e se comunicar nas linguagens escrita, visual e oral.

3 Estruturação da Disciplina de Projeto de Sistema de Produção1 (PSP1)

A disciplina PSP1 é a base para implementação dos PSPs, sendo o único dos sete PSPs previsto no fluxo do curso que além da âncora metodológica, apresenta conteúdo de metodologia de projeto e sustentabilidade para suprir as necessidades do trabalho em equipe. Em PSP1 são abordados tópicos de sistemas e modelos, interação humana e convivência, gestão do conhecimento, busca em base de informações, normas técnicas ABNT, comportamento em equipe e metodologia de projetos sustentáveis, necessários à contextualização de ambos no Projeto Político Pedagógico – PPP do curso como um todo e, particularmente, como componente de um dos blocos da espinha dorsal do curso, que trata da síntese, integração e empreendedorismo. Esses tópicos fazem parte do conteúdo das disciplinas Formação de Valor em Sistemas de Produção, Ergonomia e Comportamento Humano no Trabalho e Metodologia de Projeto de Sistemas de Produção, pré-requisitos para PSP1.

A disciplina Probabilidade e Estatística – PE é a âncora de conteúdo técnico que forneceu a fundamentação teórica para o desenvolvimento do projeto. Além da teoria de probabilidade e estatística, esta turma de PE foi criada com o objetivo de utilizar intensamente a Plataforma SAS em seus exercícios, preferencialmente utilizando bases de dados reais.

Segundo Zeichner (1983), as Instituições de Ensino Superior devem assegurar condições e recursos de aprendizagem no ambiente em que desenvolvam as competências técnicas e transversais, mas não é responsabilidade apenas das Instituições de Ensino Superior, conforme propõe Nóvoa (1988), que aponta os agentes externos como fonte de fomento para estimular o aprendizado.

A visão de realidade do agente externo foi obtida via acesso a bases de dados de entidades públicas e privadas, com prioridade à utilização da Plataforma SAS. O tema selecionado para esse período diz respeito à geração de empregos verdes no Brasil, problematizada pelo agente externo OIT (Organização Internacional do Trabalho). Os grupos não deviam apresentar uma solução única para o projeto proposto, a geração de empregos verdes no Brasil é um tema atual e desafiador. Os projetos deviam atender a três premissas básicas: manipulação de bancos de dados, tratamento estatístico dos dados e o escopo voltado para o tema proposto pela OIT (empregos verdes no Brasil).

3.1 Requisitos para a Divisão dos Grupos

Os alunos matriculados em PSP1 foram divididos em seis Grupos de cinco, cabendo a cada um o desenvolvimento de um Trabalho em Equipe – TE específico sobre um Tema. Os requisitos utilizados na divisão dos grupos foram: gênero e se cursou ou está cursando a disciplina de PE. A distribuição foi aleatória e necessariamente contemplou grupos heterogêneos e pelo menos três alunos que estão cursando a disciplina de PE.

3.2 Estruturação dos Tutores

A equipe de coordenação do Projeto de Sistema de Produção 1 (PSP1) é composta pelo docente que realiza o suporte técnico à disciplina âncora (Probabilidade e Estatística), coordenador do Projeto de Sistema de Produção 1 (PSP1) e pelos 4 docentes tutores. Tal equipe tem a finalidade de dar apoio pedagógico (aplicar metodologias ativas de ensino/aprendizagem) e auxiliar na condução dos grupos e no desenvolvimento das competências contempladas no projeto.

Cada grupo tem um tutor orientador que acompanha o desenvolvimento do projeto e estabelece diretrizes básicas ao grupo. O monitoramento do processo é realizado pelo tutor orientador através de pontos de controle e permite aos alunos obter *feedback* quanto ao trabalho desenvolvido. Este tutor orientador é o elemento de ligação entre o grupo e a equipe de coordenação do projeto e é responsável pela aderência ao objeto do projeto. Além disso, todos os grupos recebem tutoria de estatística, de projetos e de comportamento. Os tutores de estatística e de projetos são responsáveis por validar e direcionar o escopo do projeto sob o ponto de vista técnico. Cabe ao tutor de estatística verificar a aderência às análises estatísticas pertinentes ao projeto e ao tutor de projeto, verificar a aderência quanto à metodologia de projeto. O tutor de comportamento tem o papel de observar o funcionamento do grupo, identificar suas dificuldades no desenvolvimento do projeto, principalmente no que diz respeito ao relacionamento interpessoal e verificar a aderência do aluno ao trabalho em equipe.

3.3 Detalhamento dos Componentes das Entregas

As entregas foram estruturadas em três fases respectivas ao desenvolvimento do projeto: Projeto Preliminar; Projeto Intermediário e Projeto Final. Em cada uma das Entregas foi verificada a aprendizagem em três linguagens: Escrita➔Súmula Escrita; Visual➔Arquivo da Apresentação e Oral➔Apresentação Pública. Houve um inter-relacionamento entre as entregas, onde a Súmula Escrita foi a base para a Apresentação Pública.

3.4 Detalhamento da Súmula Escrita

A avaliação da linguagem escrita na Súmula Escrita levará em consideração: adequação do trabalho aos objetivos; estrutura da súmula; fundamentação e rigor conceitual; capacidade de síntese e análise crítica; formatação e apresentação gráfica; respeito às regras de produção acadêmica e respeito às normas da língua portuguesa.

3.5 Arquivo da Apresentação

A linguagem visual será avaliada por meio do Arquivo da Apresentação, de acordo com a capacidade de síntese do conteúdo; ênfase gráfica (Figuras ao invés de textos); estrutura da apresentação (Tópicos, agenda, sumário da apresentação); objetivo, introdução, fechamento/conclusão; formatação da apresentação (Visualização do conteúdo e das figuras) e ordenação das idéias no desenvolvimento do tema (Piramidal).

3.6 Apresentação Pública

A linguagem oral será avaliada por meio da Apresentação Pública do TE, na qual serão levados em conta a capacidade de expressar os conteúdos apresentados; cumprimento do tempo de apresentação; preparação (prévia) da equipe para apresentação; integração e equilíbrio da equipe (evitar simples divisão de tópicos) e o companheirismo.

4 Metodologia da Pesquisa

Devido à necessidade dos decisores (docentes tutores) saberem a opinião dos alunos sobre a nova abordagem de ensino, buscou-se identificar as expectativas dos alunos na disciplina PSP1 utilizando-se da modelagem baseada na análise multicritério, denominada de *Multicriteria Decision Aid* (Metodologia de Multicritério de Apoio à Decisão – MCDA), por ser a mais adequada para este tipo de pesquisa. Os métodos de pesquisa utilizados foram o indutivo e o dedutivo. O indutivo no sentido de que os pesquisadores passaram a identificar as variáveis utilizadas para avaliar a expectativa dos alunos com relação à disciplina PSP1 e o dedutivo na fase de avaliação do modelo, pois o pesquisador tem uma resposta para a questão de pesquisa e pretende confirmá-la, por isso, decidiu-se utilizar o MCDA como ferramenta para tal finalidade (ENSSLIN; MONTIBELLER & NORONHA, 2001).

4.1 Procedimentos para Construção do Modelo de Avaliação

A metodologia se divide em três fases: (i) fase da estruturação, identificação dos critérios avaliativos; (ii) fase da avaliação: (a) mensuração dos critérios (peso ou taxa de substituição); (b) avaliação das alternativas (expectativas dos alunos do PSP1), feita com o uso do *software Macbeth-scores* (Bana e Costa & Vasnick, 1997) e a (iii) fase de elaboração de recomendações, que consiste em elaborar estratégias para identificar se os alunos são otimistas ou pessimistas com relação à nova forma de aprendizagem PBL implementada no PSP1.

5 Análise Preliminar das Expectativas dos Alunos Quanto à Nova Forma de Aprendizagem (PBL) na disciplina PSP1

Nesta seção são apresentados os resultados da pesquisa realizada na disciplina PSP1 do curso de Engenharia de Produção da UnB.

5.1 Fase de Estruturação

Na fase de estruturação foram identificados cinco critérios de avaliação e seis subcritérios. Os critérios/subcritérios têm estrutura hierárquica e são denominados, na metodologia MCDA, de Árvore de Pontos de Vista (Bana e Costa & Silva, 1994), ou Estrutura Hierárquica de Valores (Keeney, 1992). A Figura 2 apresenta a Estrutura Hierárquica de Valor, identificada pelos decisores, portanto, legitimada.

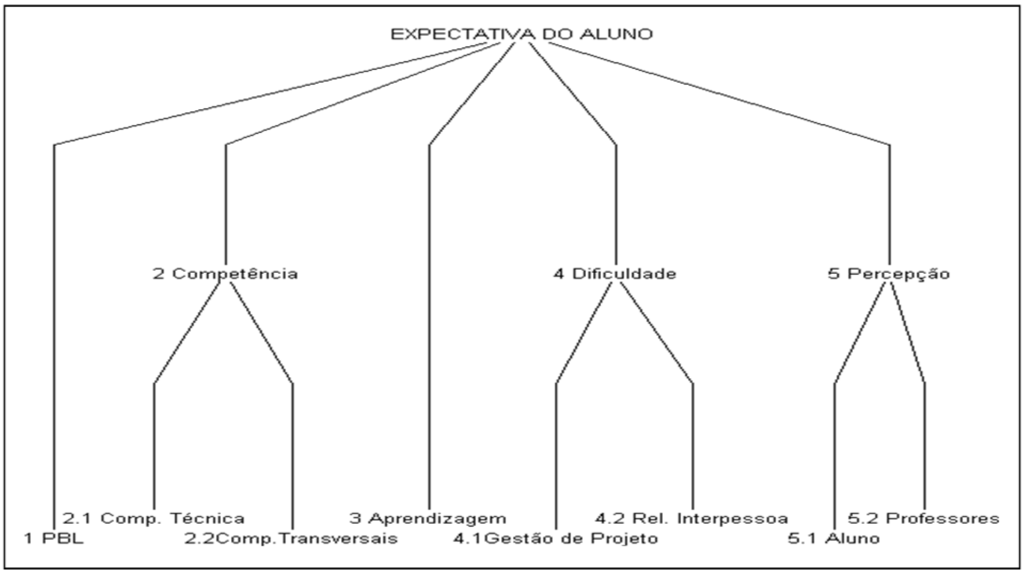

Figura 2: Árvore de Pontos de Vista

O Quadro 1 descreve os critérios com seus respectivos subcritérios adotados para avaliar as expectativas dos alunos matriculados em PSP1.

Quadro 1: Descrição dos critérios e subcritérios

CRITÉRIOS	DESCRIÇÃO	SUBCRITÉRIOS	DESCRIÇÃO
1. Abordagem PBL	Ênfase do trabalho em equipe, da resolução de problemas e da articulação teoria e prática	-	-
2. Competência	Conhecimento teórico e habilidade de cumprir metas	2.1 Competência Técnica	Conhecimento de estatística básica
		2.1 Competência Transversal	Respeito às diferenças culturais e sociais de cada membro do grupo
3. Aprendizagem	Aprendizagem centrada no aluno	-	-
4. Dificuldade	Dificuldades encontradas com relação à gestão de projeto e relacionamento interpessoal	4.1 Gestão de Projeto	Cumprimento das metas estabelecidas pela equipe
		4.2 Relacionamento Interpessoal	Aprendizado da gestão de conflitos
5. Percepção	Percepção do aluno com relação ao seu desenvolvimento na disciplina e percepção dos professores quanto ao desenvolvimento do aluno	5.1 Percepção do Aluno	Capacidade de comunicação e pensamento crítico
		5.2 Percepções dos Professores	Atuação do aluno na gestão de projetos

5.2 Fase de Avaliação

De acordo com o juízo de valor dos decisores, por meio da utilização do software MACBETH (Bana e Costa; Stewart & Vansnick, 1995), os critérios obtiveram os seguintes pesos, por ordem decrescente: Aprendizagem = 23%; Percepção = 21%; Dificuldade = 20%; PBL = 19% e Competência = 17%. Foram entrevistados 22 alunos que responderam ao questionário. O resultado da avaliação é ilustrado no Quadro 2.

Quadro 2: Avaliação global da expectativa de cada aluno com relação a disciplina PSP1

EXPECTATIVA DO ALUNO	Weight	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	A21	A22
1 PBL*	19	67	67	100	0	67	0	100	67	33	67	100	67	100	67	67	67	67	100	67	67	67	100
2 Competência	17	67	84	84	50	84	84	84	67	67	84	84	84	84	67	84	84	67	84	17	67	67	67
3 Aprendizagem*	23	33	33	100	33	100	100	100	100	67	67	100	67	100	67	100	100	67	67	100	67	67	100
4 Dificuldade	20	37	37	84	67	67	67	67	67	84	34	50	67	34	67	34	17	34	67	34	67	84	34
5 Percepção	21	67	84	84	50	67	84	84	34	50	84	84	67	84	67	67	67	67	84	100	84	67	67
TOTAL	100	53	59	90	40	77	68	87	68	60	67	84	70	80	67	71	67	60	80	66	70	70	74

De acordo com o Quadro 2, a primeira coluna representa o peso dos critérios, a segunda coluna e as demais representam a pontuação de cada aluno (A1 - aluno 1) em cada critério e a última linha representa a avaliação global de cada aluno.

Somente um aluno obteve uma pontuação abaixo de 50 pontos, dois obtiveram pontuação 53 e 59 e o restante dos alunos obteve pontuação superior ou igual a 60 pontos, portanto, aproximadamente 86% dos alunos estão otimistas quanto à nova abordagem de aprendizagem utilizada em PSP1.

6 Principais Dificuldades Encontradas

A definição dos problemas com os quais os alunos iriam trabalhar deveria partir de demandas de um agente externo, por isso, esta etapa deveria ter sido planejada com antecedência para que, já no início da disciplina, fosse possível transcrever o objetivo do projeto aos alunos para que os mesmos definissem o escopo de seu projeto, no entanto, o agente externo só foi definido na terceira semana após o início das aulas. Essa dificuldade se tornou uma lição aprendida e essa etapa vem sendo planejada com antecedência para o próximo semestre. É fundamental que os professores tenham claro o tema e o objetivo do projeto antes do início das aulas e no primeiro dia de aula seja apresentado aos alunos da próxima turma de PSP1.

A não previsão de um critério de avaliação individual associado à avaliação de grupo foi outro ponto de dificuldade, pois, passados 2/3 das aulas, um grupo alegou problemas porque um de seus componentes não vinha participando do desenvolvimento do projeto. Devido à falta de um critério individual de avaliação, a coordenação se viu em dificuldade de solucionar o problema. A coordenadora geral do PSP1, juntamente com a Tutora responsável por assuntos de comportamento, se reuniu com o grupo tendo chegado a um resultado bastante positivo de participação do “aluno-problema”, conforme evidenciado na apresentação oral e final do referido grupo.

7 Considerações Finais

A abordagem PBL propicia condições para uma aprendizagem mais ativa, pois, os alunos têm autonomia para gerir a sua própria aprendizagem, seu desenvolvimento pessoal e profissional, tornando-os diferenciados dos demais engenheiros.

Entende-se que o objetivo foi atendido, o modelo Multicritério de Apoio a Decisão (MCDA) foi construído conforme a identificação dos critérios de avaliação pelos docentes, possibilitando uma avaliação global da expectativa dos alunos, os quais acreditam que terão um ganho de conhecimento ao apontar soluções para problemas propostos por agentes externos.

A partir da aplicação de outro questionário, no término da condução da disciplina, foi avaliado se as expectativas dos alunos foram plenamente atendidas, no entanto, o estudo comparativo está em fase de conclusão. Pesquisas futuras relatarão os resultados obtidos entre a expectativa do aluno no início e no término do semestre, resultado esse que poderá servir de *feedback* para redirecionar o planejamento da disciplina no próximo semestre.

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Aprendizado Baseado em Projetos na Disciplina de Humanidades e Cidadania para Engenheiros da Universidade de Brasília - UnB

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Abstract

This paper presents the experience of teaching the major Humanities and Citizenship for engineers of the Gama Campus, a school of engineering of University of Brasília. The results of the teaching experience with this major were 73 technology projects for society, mostly multidisciplinary projects involving the four engineering areas: energy, electronic, software and automotive, presented by 520 students during four semesters of 2009 and 2010. The major has a main methodological axe the application of PBL in the construction of the didactic experience. There is a historical problem in integrating sociology and engineering and usually students have to go outside the faculty to study majors such as introduction to sociology, without integration with the engineering world. In order to compensate this problem, we have created a new project-based approach major about society and technology, based on the research of students about local or regional problems and the proposal of a project to minimize them. Students group are formed and a project plan is specified and written under methodological constraints. PBL has shown to be a successful approach to this major, due to the former high lack of interest of engineering students when learning humanities.

Keywords: humanities; social sciences; project-based learning; citizenship.

1 Introdução

O ensino de engenharia no Brasil foi readaptado para adequar-se a exigências de acomodação de disciplinas específicas na área de sociologia para contribuir na formação humanística de engenheiros. Esta acomodação foi fruto de avaliações de curriculum de diversos cursos de engenharia no Brasil e no Mundo, além de estudos realizados sobre educação em engenharia tendo como enfoque a formação do engenheiro socialmente atuante. A resolução do Ministério da Educação do Brasil informa que os "*currículos dos Cursos de Engenharia deverão dar condições a seus egressos para adquirir um perfil profissional compreendendo uma sólida formação técnico-científica e profissional geral que o capacite 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*". Com destaque para a visão ética e humanística, socialmente justificadas, é que foi criada a disciplina de Humanidades e Cidadania, cujos objetivos são: i) introduzir conceitos das humanidades, ciências sociais e políticas no contexto das engenharias; ii) oferecer ao aluno bases conceituais e pragmáticas, visões de autores e legislação brasileira que rege sobre a atividade do engenheiro no contexto de produção, com enfoque no atendimento às demandas da sociedade e principalmente da humanização do processo produtivo e finalmente iii) orientar sobre as entidades de classe e normas existentes que regem a atividade do engenheiro.

A disciplina apresenta o papel social do engenheiro, o qual representa um elo entre a tecnologia e sociedade. Para tanto, ele precisa ter a sua formação bases sólidas da sociologia com enfoque nos grupos humanos que serão beneficiados pelas suas técnicas, processos e produtos, oriundos de seu trabalho. O alvo é formação da identidade do engenheiro humanista, a despeito da "fama"que o engenheiro tem na sociedade em geral de ser um profissional extremante voltado para cálculos exatos e precisos, com enfoque excessivo no processo e produto da engenharia, com pouca ou nenhuma formação sociológica, sem envolvimento com os problemas sociais. A experiência adquirida com a regência desta disciplina em 2009 e 2010 é o objeto de apresentação deste artigo que teve como enfoque o procedimento metodológico de basear o ensino e o aprendizado humanístico de humanidades e cidadania no método PBL para atingir os objetivos pedagógicos propostos.

1.1 Motivação

A motivação para a adaptação metodológica para a criação da disciplina de Humanidades e Cidadania partiu do desafio complexo de se propor um novo conteúdo, oriundo de outras áreas de conhecimento das ciências humanas (ciências sociais), para estudantes que por opção escolheram a área de exatas. Desafio representado pela necessidade de unir técnicas e objetivos da engenharia com as necessidades sociais, de modo que a formação e visão humanística do papel do engenheiro na sociedade pudesse ser adaptado a um modelo de trabalho diferente.

Em virtude de exigência dos órgãos nacionais que regulam o ensino de engenharia, como o Ministério da Educação e o sistema Confea/CREA, a nova disciplina de humanidades dentro do curso de engenharia é motivada pela necessidade do curriculum dos cursos de engenharia da Faculdade UnB Gama estejam em conformidade com as Diretrizes Curriculares dos Cursos de Engenharia (MEC, 2002). Ademais, visa atender à demanda de reformulação curricular oriunda dos exames nacionais do ensino superior (Araújo, 2011) que orientam a formação humanística do engenheiro. Outro aspecto relevante é atender a demanda de habilitação profissional de engenharia junto à entidade de classe CREA.

Em especial, vale destacar a motivação principal de se adaptar o atual curriculum de humanidades. Na prática, em cursos de engenharia no Brasil, em especial na UnB, o estudante de engenharia cursa a disciplina de Introdução a Sociologia em uma outra faculdade, em um contexto diferente do de tecnologia, em que o aproveitamento da disciplina se restringe à esfera teórica das ciências sociais. Destarte, o desafio deste curso de Humanidades e Cidadania é o de adaptar a prática pedagógica ao ensino da sociologia e suas vertentes para engenharia, tendo como base uma linguagem adaptada ao ambiente tecnológico, a objetivos pedagógicos que resultem na formação humanística de engenheiros, e sobretudo que tenha como resultados projetos de tecnologia voltados às comunidades locais e à sociedade em geral. Por esses motivos é que se propôs o planejamento e a realização da docência da disciplinada de Humanidades e Cidadania com base no método PBL de modo a tornar o aprendizado contextualizado e resultando em projeto de tecnologia socialmente justificada e também de tecnologias sociais.

2 O planejamento da disciplina baseada em projetos

Nesta seção apresentamos o planejamento da disciplina baseada em projetos que foi utilizado. A disciplina de Humanidades e Cidadania é composta de um programa de ensino oriundo das ciências sociais com abordagem voltada para as engenharias. Contém os seguintes assuntos principais: sociologia dos grupos, tecnologia e sociedade, legislação e ética. Nas universidades brasileiras esses tópicos são correntemente ministrados por departamentos de sociologia, direito e ciência política. Nesse campus da FGA, ela foi criada pelas comissões curriculares formadas para esta expansão do REUNI, atendendo às exigências curriculares do MEC e do Conselho Federal de Engenharia (CONFEA), mas certamente ainda precisará de alguns anos de maturação e de adequação da prática curricular em função de uma série de aspectos de conteúdo, de integração com as 4 engenharias e suas tecnologias, a partir da troca de experiências acadêmicas e principalmente da vivência social com a comunidade local.

2.1 Ementa e conteúdos

A metodologia utilizada para ensino foi dividida em três módulos: palestras, planejamento de projeto humanista, e apresentações de projetos. No primeiro módulo, são realizadas palestras acerca de excertos das obras bibliográficas indicadas no curso. As palestras em sala de aula são dedicadas à obtenção de conceitos gerais e específicos do universo em estudo, de modo a fomentar tanto a aquisição do conhecimento quanto a criação de visão crítica do papel do engenheiro na sociedade. O método expositivo utilizado em sala de aula leva à reflexão, que poderá ser expressa por meio de pequenos debates em sala de aula e principalmente de resumos críticos sobre os assuntos tratados em sala de aula. As palestras foram realizadas para atrair a atenção dos alunos para a disciplina de humanidades, situando-a como elemento de grande importância para o exercício da profissão de engenheiro. Neste módulo foram trabalhados assuntos como sistemas políticos e tecnologia e sociedade, os quais foram extraídos de obras de Freyre (1987),Berger (1986), Fromm (1969), Ferkiss (1972), Kawamura (1972). O método de palestra com interação foi também aplicado no intuito de trabalhar a audiência e silêncio dos alunos em sala de aula, para amenizar os problemas citados, como grande número de alunos em sala de aula (100 alunos) assim como uma tendência à conversa, falta de atenção e excitação, características da idade dos alunos. As palestras são seguidas de discussão em sala e atividades extras como resumo de textos, redação crítica e contextualização das idéias com exemplos reais da sociedade em que está inserido o aluno. No final do primeiro módulo, os alunos passaram a elaborar os projetos de engenharia com enfoque social, voltados para a comunidade do Gama e Distrito Federal, e que tratassem de tecnologias de engenharia das áreas de energia, eletrônica, automotiva e software. No Segundo módulo da disciplina, são realizadas aulas com interação dos alunos mais participativos, com enfoque em aspectos de cidadania, responsabilidade social e ambiental, voltados para os projetos de seminário que estavam elaborando, de modo a identificar aspectos de ética e cidadania que deveriam ser atendidos pelos projetos, considerando-se as responsabilidades sociais do engenheiro na condução dos mesmos. O trabalho de aulas foi realizado com atendimento semanal do professor aos grupos de trabalho em busca de aspectos a serem abordados nos trabalhos, melhorias e orientação em geral. Foi elaborado pelo professor um modelo de avaliação de projeto com 18 aspectos a serem abordados (tabela 1), como objetivos e métodos do projeto, descrição da sociedade beneficiada pelo projeto, planejamento de fases e etapas, resultados esperados, revisão de literatura sobre o assunto escolhido, oportunidades de publicação e financiamento, etc. Os projetos são socialmente embasados a partir da coleta de informações sócio-econômicas da comunidade do Gama e DF, assim como por meio de entrevistas com a comunidade, em média de 250 pessoas entrevistadas por semestre, buscando-se assim trabalhar a noção de demanda e impacto de tecnologias na comunidade alvo dos trabalhos. No terceiro módulo da disciplina, os alunos tiveram contato direto com as entidades de classe, sistema CONFEA/CREA/MÚTUA, legislação da área, considerando-se as leis que regem a atuação profissional do engenheiro, o código de ética dos engenheiros, o código civil, estatuto do idoso, estatuto da criança e do adolescente, dentre outros (Oliveira, 2009)

2.2 Dinâmica de sala de aula para preparação dos projetos

Dinâmica de sala de aula foi proposta com base num modelo metodológico proposto por meio de um documento-mestre do projeto. É distribuído um *template* de um documento de planejamento do projeto que contém os itens necessários para o seu planejamento e construção. Os alunos formam grupos de trabalho, por meio dos quais são planejados os projetos. Os grupos se formam livremente por áreas de interesse comuns, afinidade interpessoal, interesse temático por problemas ou soluções, ou por envolvimento prévio em outras disciplinas ou projetos já realizados em outras disciplinas dos cursos de engenharia. Os itens que são entregues aos alunos, no primeiro encontro de projeto, que se realiza no final do primeiro mês de aula, são os seguintes:

Tabela 1: Itens de especificação de projetos de humanidades

Item metodológico	*Descrição*
Título do seminário	Identificar se o título reflete plenamente o conteúdo e objetivos do projeto. Deve ser interessante, atraente e sucinto
Nome dos componentes de grupo – Ficha técnica	Identificar se todos os membros foram devidamente listados no trabalho, desde o início da organização
Tema do projeto	Avaliar se o tema é pertinente, está escrito de maneira correta, reflete o problema e a solução propostos.
Descrição do problema	Avaliar se de fato a problemática está bem abordada, de maneira específica e também geral, mas que esteja de tal forma associada aos objetivos do projeto, ou seja, que o trabalho possa de fato resolver todo ou parte do problema apresentado.
Sociedade que será beneficiada pelo projeto	Identificar e descrever quais grupos sociais serão diretamente beneficiados pelo projeto. Avaliar se os alunos caracterizaram a comunidade específica que será alvo do projeto. Identificou o local e características? Identificou o tamanho da população? Identificou a formação da população em termos de gênero, atividade profissional e demais aspectos estatísticos que possam identificar as necessidades da população beneficiada?
Objetivos do projeto	Especificou o objetivo geral de maneira abrangente?Especificou os objetivos específicos, no mínimo 3. Todos os objetivos específicos devem estar contidos no objetivo geral. Apresentou objetivos factíveis, que podem ser viabilizados por meio da metodologia proposta?O alcance dos objetivos de fato poderá resolver o problema descrito?Os objetivos estão escrito com o verbo no infinitivo? Os objetivos estão redigidos de maneira clara e sucinta?
Metodologia do projeto	Escrever aqui como o trabalho será elaborado. Exemplos: pesquisa de campo, leitura de obras de referência, pesquisa de tecnologias, reuniões de grupo, discussões, elaboração de proposta, etc. Descreveu os passos necessários para a realização do trabalho? Identificou os métodos que serão utilizados, tanto qualitativos quanto quantitativos? Identificou mecanismos, instrumentos, produtos ou soluções que serão utilizados para executar o projeto?
Cronograma - descrição de fases e atividades do projeto	Identificou cada uma das fases, suas características? Identificou as atividades que serão realizadas em cada uma das fases? Identificou as atividades a partir da descrição da metodologia do trabalho? Apresentou de maneira objetiva, bem estruturada e organizada? A seqüência de fases e atividades dá a entender que o projeto é viável? Identificou o esforço de tempo necessário para cada uma das atividades do projeto? A distribuição de esforço está compatível com o bom senso para sua execução?
Formato do seminário	Escrever aqui a idéia de apresentação do seminário, seja em forma de palestra, dinâmica de grupo, filme, debate, artigo, pôster, visita técnica, etc. Apresentou e descreveu em detalhes como o trabalho será apresentado? Descreveu a técnica de apresentação oral e visual do trabalho para a turma?
Custo estimado do projeto	Listar por atividades e tipos de trabalho estimativas de custo para o projeto. 1. Custo de pessoal 2. Custo de aquisição de tecnologia 3. Custo de implantação 4. Custo de manutenção etc. Descreveu os custos específicos de cada atividade proposta no trabalho?
Bibliografia	Listar bibliografia com base na norma ABNT NBR 6023de referências bibliográficas. Listar todos os livros consultados par ao projeto Listar os websites utilizados para consulta de referências e tecnologias Etc. Apresentou bibliografia referente ao problema abordado? Apresentou bibliografia referente à solução proposta? Apresentou bibliografia sobre as metodologias propostas? Apresentou bibliografia sobre projetos semelhantes em elaboração ou prontos no Brasil e no mundo? Citou exemplos que agregam valor ao trabalho, apóiam o entendimento? Apresentou referências bibliográficas que situam o trabalho como um todo, dentro da engenharia
Fontes de financiamento do projeto	Identificar potencias fontes de financiamento de pesquisa científica. Órgãos de fomento público ou privado, no Brasil e no mundo.
Eventos para publicação do projeto	Pesquisar e citar eventos para os quais o trabalho poderá ser enviado para publicação científica
Ficha técnica do projeto	Descreveu detalhadamente todas as atividades executadas pelos indivíduos que compõem o grupo? As atividades resultantes do trabalho estão de acordo com o resultado apresentado?

2.3 Pontos de controle de produtividade dos alunos

O curso de Humanidades e Cidadania, de 60 horas por semestre, contém 4 encontros de 4horas/aula, de 4 créditos, e turmas de 240 alunos. Os pontos de controle são voltados para a reunião de grupos e atendimento individual a cada um deles. As reuniões duram 20 minutos com cada grupo para que sejam apresentados os progressos do trabalho e as pendências a serem resolvidas. No primeiro encontro, que ocorre no final do primeiro mês de aula, Os líderes do grupo apresentam um cronograma com o planejamento das atividades do trabalho, conforme apresentado na tabela 2 abaixo.

Tarefa / Mês	*1º mês*	*2º mês*	*3º mês*	*4º mês*
Pontos de Controle: 2 encontros de 4 horas, atendimento por grupo, dinâmicas de exposição de tarefas, prática de liderança e comunicação, relatórios e motivação dos grupos	Apresentação do cronograma plano de projeto: problema, objetivos, metodologia.	Revisão de progresso de projeto e apresentação de produtos parciais: resultados esperados e população entrevistada e cronograma	Ajustes finais de produtos e apresentação parcial de resultados: finalização de parte teórica, protótipo e ensaio de apresentação.	Apresentação final de projetos e menções finais. Encaminhamento para publicação de trabalhos.

Nos pontos de controle acima apresentados, os alunos são avaliados quanto ao grau de comprometimento que possuem com o projeto: discussão de idéias, colaboração no brainstorming, sugestão de potenciais soluções, disposição para finalidades logísticas de atendimento às atividades. As lideranças podem ser mudadas em função de melhor afinidade ou admiração de alguns membros do grupo por outros, ou pela adesão do grupo a ideias propostas por determinados membros. Desta forma, há um processo inerente de seleção natural de lideranças. Não optamos por lideranças fixas em função dessa dinâmica natural de escolha do grupo por conta do desempenho de alunos com característica líderes.

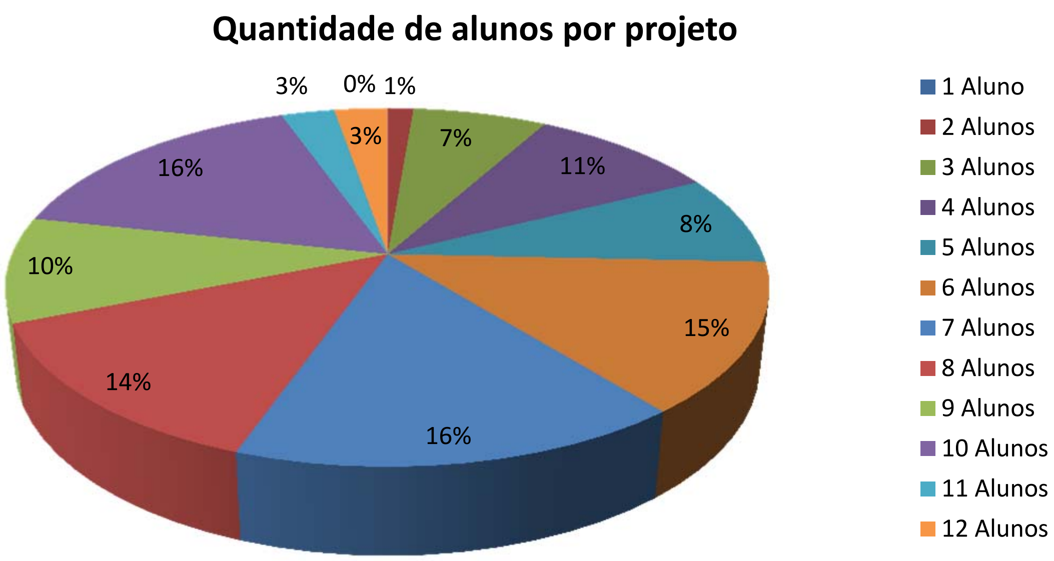
3 Resultados da disciplina de Humanidades e Cidadania

Nesta seção apresentaremos os principais resultados de produtividade oriundos da prática de dois anos de regência da nova disciplina de Humanidades e Cidadania, proposta para os cursos de engenharia do Campus do Gama da Universidade de Brasília. A PBL permitiu que o processo de ensino-aprendizagem de sociologia no contexto da tecnologia pudesse ser feito de maneira mais contextualizada, pragmática e sobretudo de maneira instigante e interessante para os alunos. De uma maneira investigativa e curiosa, os alunos buscam identificar na realidade da sociedade pesquisada os aspectos teóricos de sociologia apresentados na introdução do curso, apresentados acima. O método guiado por meio de checklist de atividades e de itens de projeto ajuda os alunos a se orientarem quanto aos passos tomados pelo grupo. O curso foi aplicado 4 vezes em 4 semestres para um total de 520 estudantes universitários, conforme apresentado a seguir.

3.1 Distribuição de projetos por área de engenharia

Nesta seção apresentamos resultados alcançados na preparação de alunos para a dinâmica de planejamento e execução de projetos em grupo. O curso de Humanidades e Cidadania totalizou, nos anos de 2009 e 2010, a formação de 520 estudantes de engenharia, divididos por semestre em duas turmas de 120 estudantes, aproximadamente, em uma carga horária de 60h por semestre.

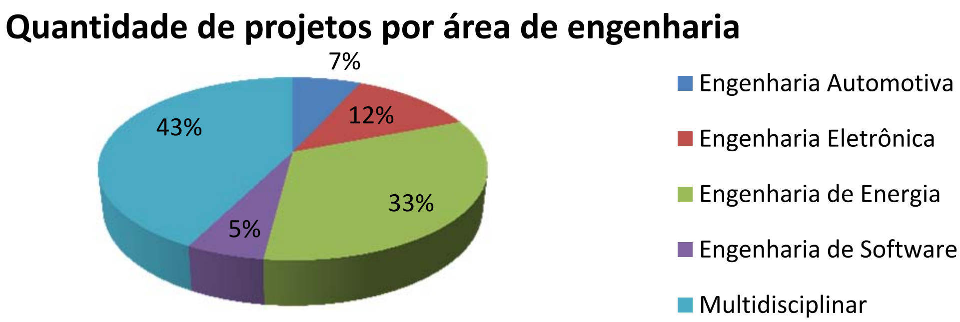
Pela característica de permitir que os alunos se agrupassem em função de suas afinidades, interesses e áreas de engenharia que pretendiam atuar, o gráfico abaixo revela a proporção de projetos por alunos. A grande maioria de projetos foi feita por grupos formados por 10 a 6 alunos (71% dos projetos). Os demais foram realizados por grupos menores (29% os projetos). Tais dados revelam que os alunos, apesar de reconhecerem a dificuldade de se formarem grupos muito grandes, da importância em se distribuírem tarefas com maior equanimidade e de se aumentarem também as chances de se ter um projeto mais avançado em que possuam objetivos mais desafiadores. O processo avaliativo também leva em conta a proporção de alunos por grupo, vislumbrando, por meio da contagem de horas de trabalho, o esforço de todo o grupo em comparação aos resultados objetivos.



3.2 Distribuição de projetos por área de engenharia

Por meio da tabela ao lado, é possível identificar a tendência de que os projetos apresentados (73 no total em 2 anos) sejam em sua maioria (42%) de projeto multidisciplinares, ou seja, são projetos que integram duas ou mais áreas de engenharia ofertadas no campus da Faculdade UnB Gama. Isso representa um grande potencial dos alunos de poderem integrar as áreas, seus talentos e visões acerca de suas preferências de atuação científica, além de se proporem a projetos cujos produtos são de alguma forma acoplada, integrada ou embarcada, por meio de técnicas respectivas e oriundas das áreas em questão.

Área	Qtd.	%
Engenharia Automotiva	5	6,8
Engenharia Eletrônica	9	12,3
Engenharia de Energia	24	32,9
Engenharia de Software	4	5,5
Multidisciplinar	31	42,5
Total de Projetos	73	100



Podemos observar no gráfico a quantidade de projetos multidisciplinares em 43% do total de 73 projetos elaborados pelos alunos. Isso revela a tendência de se trabalhar diversas oportunidades temáticas, formando grupos híbridos compostos por alunos com interesses em mais de uma das áreas de engenharia oferecida pela Faculdade UnB Gama. Isso representa um aspecto muito positivo de se buscar soluções que integrem as 4 áreas citadas.

3.3 Temas dos Projetos Apresentados em 2009 e 2010

Nesta seção apresentaremos os principais temas dos projetos apresentados pelos alunos da disciplina de Humanidades e Cidadania da Faculdade UnB Gama, da Universidade de Brasília. É interessante essa apresentação de resultados contextualizar tematicamente a produção discente. O resultado final desses projetos foram apresentados em sala de aula para todos os alunos do curso, em média uma audiência de 120 alunos, professores orientadores e demais convidados, membros das comunidades para as quais os projetos são destinados. Vale ressaltar a prática dos estudantes em fazerem apresentações científicas para grupos grandes de audiências. Os documentos que são entregues pelos alunos,contendo o projeto, são listados na tabela 4, ao lado. Abaixo exemplos de alguns os temas de projetos apresentados.

Tabela 4: produtos finais de projetos

Produtos Finais apresentados pelos alunos
Documento de aproximadamente 60 páginas de descrição dos projetos, com todos os seus itens metodológicos descritos
Pôster científico do projeto para submissão a congressos na área
Apresentação em formato PowerPoint do trabalho, para 40 min de projeção
Protótipo ou modelo desenhado em software CATIA da solução proposta
Modelo conceitual da solução em desenho livre

Abaixo exemplos de alguns os temas de projetos apresentados:

Usar um biodigestor para processar o lixo orgânico produzido no restaurante universtiário, gerando uma energia limpa.

Trocar o sistema de ar condicionado por um de climatização evaporativa

Criar mecanismo para produzir espaçadores de nebulímetros a partir de garrafas PET

Produzir energia elétrica de forma alternativa e limpa

Semana das Atitudes Sustentáveis - Conscientizar estudantes a respeito dos benefícios do uso sustentável dos recursos naturais

Aulas de reforços ministradas por graduandos em Engenharia na FGA

Kibutz Energético no Gama - Um movimento comunitário para produção de energia

Plataforma de ensino a distância e virtual visando a preparação e orientação do aluno para o vestibular

Estacionamentos verticais, em modelos de edifício-garagem

Implantação de aparelho eletrônico, para informar ao condutor possíveis problemas que possam acontecer

Fazer um jornal para a UnB campus Gama

Diminuir a taxa de energia que o futuro campus necessitará, reutilizando os recursos hídricos

Implantação de infraestrutura como: pavimentação, arborização e drenagem pluvial no estacionamento da FGA

Adaptações nos prédios e nas ruas para melhoria na acessibilidade do campus FGA

Usina de Geração de Energia com Sistema Inteligente de Piezoelétricos - Transformar energia mecânica para alimentação energética de uma cidade

Monitoramento por meio de aeronaves não tripuladas, a fim de encontrar áreas com focos de incêndio no Cerrado

Comunicação facilitada entre motoristas de carros por meio de ondas de rádio (via Bluetooth)

Recolhimento de materiais a serem reciclados por meio de Coleta Seletiva Voluntária

Museu das Engenharias do Gama - Criar um lugar para expor essas tecnologias

Garrafas pet auxiliando a infiltração das águas pluviais

Monitorar os veículos, permitindo a sua localização exata e também a quantidade de passageiros nele

Adotar a tecnologia de caixa preta em automóveis, para diagnosticar possíveis causas de acidentes

Desenvolver um carro híbrido (elétrico e solar)

Criação de uma rádio integradora entre os 4 campi da UnB para comunicaçao comunitária

Projetar um mecanismo aclopado a cadeira de rodas, que auxilia a locomoção do deficiente

Implantação de um sistema de sincronismo dos semáforos através do fluxo de carros

Utilização de tecnologias sustentáveis para modelos habitacionais de baixa renda

Educar a população sobre o descarte correto de pilhas e baterias

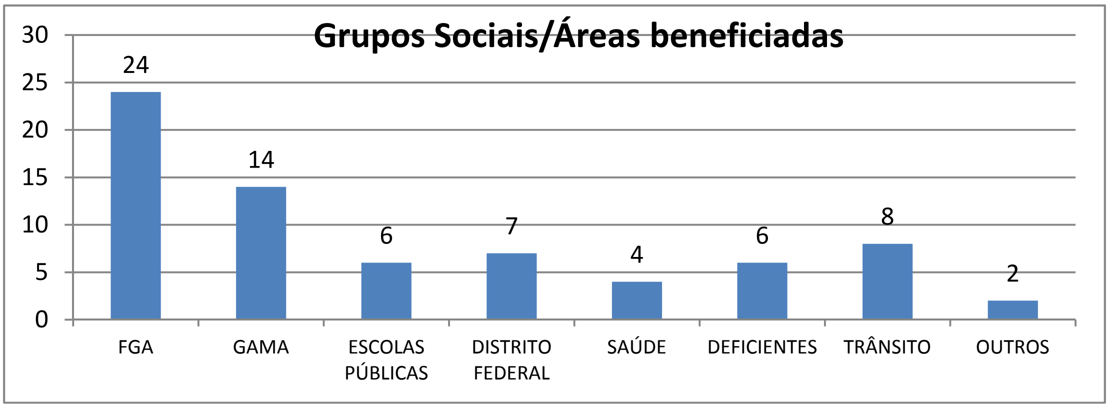
Implantar tecnologia após o processo da queima do óleo diesel fazendo com que menos poluentes fossem jogados no meio ambiente

Proporcionar maior liberdade aos deficientes visuais maior liberdade, criando um aparelho similar ao GPS

Aumento da segurança local e reforma na infra-estrutura de um parque urbano no Gama

3.4 Entidades beneficiadas pelos projetos

Como futuros engenheiros que irão criar e planejar projetos cotidianamente, os alunos de Humanidade e Cidadania têm uma primeira experiência de como identificar um problema e pensar em uma maneira de solucioná-lo ou apenas amenizá-lo, trazendo contribuições para a sociedade. Além de estimular a criatividade e a inovação, requisitos que importantes para o atual mercado de trabalho, o método PBL pode ser aplicado na realidade e não ficar apenas no papel, assim os estudantes veem o seu pequeno projeto tornando-se realidade e ajudando as pessoas ao seu redor. Na maioria dos projetos, os alunos procuram solucionar problemas que fazem parte do seu cotidiano, como a família, a própria UnB, a sua cidade, e, os mais audaciosos, o Brasil. No gráfico a baixo temos a relação de quantidade de projetos e as sociedades beneficiadas pelos mesmos. Pelo gráfico abaixo, percebe-se que a UnB, no campus Gama, é a mais recorrente, mas pode ser justificado pelo fato que o campus ainda não está pronto e está aberto a pequenos projetos para melhorá-lo, já que quem irá estudar nele serão os próprios alunos. Por termos cursos de engenharia, alguns tópicos recorrentes são bastante incomuns, como a saúde que esteve em aproximadamente 5% dos projetos, e a educação com cerca de 8%, mesmo que os cursos de automotiva, energia, software e eletrônica não pareçam ter uma relação com a saúde, os alunos foram capazes de aplicar o que aprenderam em novas áreas, utilizando a criatividade para inovar em áreas tão deficientes



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Quando os alunos podem atuar para modificar o seu próprio contexto, ocorre uma estimulação para continuar no curso, pois sabem que são agentes de mudança no seu contexto. Quando os alunos passam de passivos, ou seja, aprendendo na teoria, e se tornam ativos, são sujeitos a ter melhores chances no mercado de trabalho e melhoram o seu desempenho, já que obtiveram chances de errar em um projeto e com o aprendizado dos seus erros, estão mais preparados para gerenciar um grande projeto com êxito.

4 Conclusões

A análise dos resultados da regência da disciplina de Humanidades revelou que o método PBL é muito útil para ser utilizado na dinâmica de ensino de projetos de humanidades e cidadania, utilizando-se de procedimentos, técnicas e produtos das engenharias de energia, eletrônica, software e automotiva. A variedade de temas propostos pelos alunos revela um real conhecimento e sensibilidade dos mesmos com relação às necessidades específicas de seu campus universitário e da comunidade do Gama, na qual o campus está inserido. Um projeto de pesquisa em que os próprios alunos e suas comunidades são o alvo de solução de problemas demonstra ser um elemento motivador de grande importância, dado o grau de comprometimento e envolvimento com a comunidade que eles apresentam. Esse é um dos principais aspectos motivadores que os estudantes levam em conta, por serem ao mesmo tempo não só propositores de soluções, mas também são os beneficiados por essas soluções.

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Avaliação do Emprego do PBL: a concepção de Professores e Alunos

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Abstract

The Problem Based-Learning (PBL) method intends to make the student capable of building the learning conceptual, procedural and attitudinal learning through proposed problems that expose them for situations to motivate and prepare to the market considering simulations closer to the real challenges. The method applied in the discipline of finance in the course of Business Administration led us to perform the research from two guiding questions: 1) Can it be stated that it is in accordance with the theoretical assumptions of the method?; 2) What are the challenges for the improvement of PBL at the discipline of finance? This study aims to evaluate these issues from the conceptions of teachers and students. It is expected that the evaluation of the method can serve as a source of information and improve the use of the method PBL in the course of Business Administration.

Keywords: valuation; high school; PBL.

1 Introdução

Muito se discute sobre os propósitos do Ensino Superior e sobre a eficiência dos métodos de ensino e aprendizagem dentro da universidade, considerando em especial, a complexidade das exigências provenientes de um mercado cada vez mais globalizado e competitivo. (Flint, 2007).

Atualmente, é exigida uma formação que alie teoria à prática e que promova ao aluno uma série de características que o permita desenvolver um trabalho sem comprometer os seus estudos. A informação passou a ser disseminada de forma indiscriminada e o sistema universitário passa então por uma transformação, cuja adaptação se faz necessária em detrimento das constantes exigências da sociedade, da cultura e da ciência.

Nesse contexto, surge a possibilidade da aplicação do método Problem-Based Learning (PBL), com o propósito de tornar o aluno capaz de construir o aprendizado cognitivo por meio de problemas propostos que o expõe a situações motivadoras e o prepare para o mercado com simulações próximas à realidade que enfrentará, inserindo-o como foco central da aprendizagem. (Delisle, 1997; Duch, 2001).

O PBL surgiu na década de 60 na escola de medicina da Universidade MacMaster, Canadá em resposta à insatisfação dos alunos em relação ao exacerbado número de irrelevantes informações da prática médica. O método, também implantado em universidades de outros países como Maastricht, na Holanda, Newcastle, na Austrália, Harvard, nos Estados Unidos, chegou ao Brasil em 1993, com a Escola de Saúde Pública do Ceará. (Ribeiro, 2008).

O presente artigo objetiva retratar análise introdutória de uma pesquisa em desenvolvimento. Trata-se de um estudo sobre o processo de desenvolvimento do método PBL que foi implantado em 2008 por uma universidade particular no Brasil, no curso de Administração de Empresas. Em 2009 o método foi aplicado pela primeira vez na disciplina de finanças. As orientações gerais propostas são de desenvolver conhecimento, habilidade e atitude dentro desta metodologia de ensino-aprendizagem colaborativa.

A partir do acompanhamento deste trabalho ora apresentado, duas questões norteadoras foram formuladas: 1) Ao se avaliar o trabalho desenvolvido a partir do método PBL aplicado na disciplina de finanças do curso de Administração de Empresas, pode-se afirmar que o mesmo está de acordo com os pressupostos teóricos do referido método?; 2) Quais os desafios para o aprimoramento do PBL na disciplina de finanças?

Decorrentes destas questões temos ainda dúvidas que podem ser assim representadas: Qual a infraestrutura ideal para a aplicação do método?; Quais devem ser as obrigações dos professores?; Como eles se comunicam e interagem?; É possível maximizar o tempo de resposta dos trabalhos aos alunos?; Como devem ser formados os grupos de trabalho? Qual o número ideal de participantes em cada grupo?; Qual deve ser o papel dos participantes? Devem ser alterados? Com que frequência?; Quais os instrumentos de acompanhamento são necessários para desenvolvimento do método?; Quais os procedimentos avaliativos e de *feedback* que demonstram a real aprendizagem dos conteúdos trabalhados?

Para responder estas questões, o presente trabalho tem por objetivo geral avaliar a aplicação do método Problem-Based Learning (PBL) na disciplina de finanças do curso de Administração de Empresas e por objetivos específicos: a) Avaliar a coerência entre os pressupostos teóricos e a aplicação do método Problem Based-Learning (PBL) na disciplina de finanças; b) Analisar os materiais atualmente empregados para o desenvolvimento do método, com a finalidade de verificar sua eficiência no que tange ao cumprimento dos objetivos traçados pelo método PBL; c) Identificar possíveis mudanças visando o aprimoramento da aplicação do método a partir das concepções de docentes e discentes.

Antes de descrevermos o trabalho apresentamos o marco teórico no qual fundamentamos a pesquisa.

2 Referencial Teórico

Ao se avaliar os espaços de aprendizagem na universidade, busca-se a ampliação de conhecimentos do processo de ensino e aprendizagem.

O PBL é essencialmente um método de ensino-aprendizagem colaborativo e participativo, onde o aluno, integrante de uma equipe, é estimulado a desenvolver habilidades e atitudes por meio da solução de problemas propostos e a adquirir conceitos teóricos relevantes a partir da pesquisa bibliográfica (Boud, Feletti, 1999).

Mudanças e desafios, palavras-chave para o início da discussão do método PBL. Questões organizacionais e de cunho pessoal podem auxiliar ou dificultar a implantação de uma perspectiva diferenciada de ensino e aprendizagem na universidade. Para Moesby (2009) a resistência às mudanças é um desafio a ser vencido, sendo a omissão, o abandono ou o retrocesso às práticas anteriores fatores demonstrativos desta resistência. "Para uma implementação bem-sucedida dessa transformação, é fundamental explicar as intenções, o processo, as expectativas, o comprometimento que se espera dos professores e os benefícios que eles terão, e estabelecer prazos". (p. 43)

As aulas, interativas, iniciam-se com o professor propondo para os alunos em grupo uma situação problema, cuja elaboração prevê o conteúdo apresentado no plano da disciplina, bem como o consenso auferido por uma comissão de professores da área do saber, buscando inclusive a padronização da aplicação e da avaliação dos resultados.

Schmidt (1983 apud Araújo; Sastre, 2009) descreve uma estratégia de etapas chamada de "sete passos" com o objetivo de auxiliar os estudantes na resolução de um determinado problema, a partir do levantamento de causas, buscando analisar os processos ou princípios subjacentes dos fenômenos descritos. 1. Esclarecer frases e conceitos confusos na formulação do problema; 2. Definir o problema: descrever exatamente que fenômenos devem ser explicados e entendidos; 3. Chuva de ideias (B*rainstorming*): usar conhecimentos prévios e senso comum próprios. Tentar formular o máximo possível de explicações; 4. Detalhar as explicações propostas: tentar construir uma "teoria"pessoal, coerente e detalhada dos processos subjacentes aos fenômenos; 5. Propor temas para a aprendizagem autodirigida; 6. Procura preencher as lacunas do próprio conhecimento por meio do estudo individual; 7. Compartilhar as próprias conclusões com o grupo e procurar integrar os conhecimentos adquiridos em uma explicação adequada dos fenômenos. Comprovar se sabe o suficiente. Avaliar o processo de aquisição de conhecimentos. (Araújo; Sastre, 2009, p. 84).

O levantamento bibliográfico inicial demonstra uma maior incidência nas pesquisas sobre o método PBL na área da saúde. (Moraes, Manzini, 2006; Cyrino, Toralles-Pereira, 2004). Diante de tais aspectos apontados, faz-se necessário um estudo sobre a aplicação e do método PBL em outras áreas de conhecimento. "Sob vários aspectos, a aprendizagem humana parece ocorrer quase continuamente, como se todas as coisas que os indivíduos fazem hoje geram conhecimento ou capacidades que afetam o modo como eles farão outras coisas amanhã e depois". (Schmidt; Wrisberg, 2006, p.190).

Como resposta à consulta realizada na Biblioteca Digital Brasileira de Teses e Dissertações (BDTD), foram encontrados cento e noventa e cinco trabalhos relacionados ao tema e no banco de teses da Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), foram encontrados cento e dezessete trabalhos. Destes, apenas dois trabalhos apresentavam em seu título informações sobre curso ou disciplina ligados aos cursos de Administração de Empresas, Economia ou Ciências Contábeis, cuja disciplina de finanças se faz presente.

O primeiro trabalho, apresentado em 2008 pela autora Mara Alves Soares traz como título "Aplicação do método de ensino Problem Based Learning (PBL) no curso de Ciências Contábeis: um estudo empírico" e o segundo, da autora Evaneide Barbosa de Oliveira apresentado em 2010, "Aprendizado baseado em problemas (problem based learning): a sua importância no ensino da contabilidade.".

A pesquisa de Soares (2008) verificou a efetividade da utilização do PBL no curso de Ciências Contábeis da FEA-RP/USP por meio do método descritivo e exploratório. O trabalho trouxe uma abordagem quantitativa com o uso de questionário e análise de confiabilidade, validade e regressão e qualitativa se utilizando de instrumentos de coletas de dados como observação, entrevista e análise documental e bibliográfica. Como resultado principal, concluiu que com o uso do PBL é possível alinhar o conhecimento com o desenvolvimento de habilidades de comunicação, trabalho em equipe e confiança com o aumento da responsabilidade do educando o estimulando a investigar e resolver problemas próprios do mercado em que atuará.

O trabalho de Oliveira (2010) analisou a metodologia do PBL para identificar suas possíveis contribuições para o processo ensino-aprendizagem da contabilidade através do método exploratório baseada na abordagem qualitativa explorando as técnicas da observação e entrevista e abordagem quantitativa com o uso de questionário fechado. Como resultado, concluiu que o PBL promove o desenvolvimento do raciocínio lógico, do pensamento crítico, da habilidade de trabalhar em grupo, da administração de conflitos, do aprimoramento do autoaprendizado, do envolvimento com a pesquisa e o amadurecimento da competência para a resolução de problemas atrelados ao contexto de situações reais.

3 Metodologia

Visando o cumprimento dos objetivos deste estudo, inicialmente estamos realizando um levantamento bibliográfico sobre o método PBL em obras nacionais e internacionais. Após este levantamento, o estudo conta com três momentos específicos:

1. Pesquisa documental coletando informações que permitam demonstrar a evolução do emprego do método PBL para a disciplina de finanças do curso de Administração de Empresas de uma universidade particular no Brasil, como os relatórios atualmente empregados, os resultados finais dos alunos e as avaliações realizadas pelo corpo discente. Estão sendo coletadas informações referentes ao 2º semestre de 2009 e anos de 2010 e 2011 que permitam demonstrar a evolução do emprego do método PBL para a disciplina de finanças do curso de Administração de Empresas. Dentre os materiais coletados, estão os relatórios atualmente empregados, tais como o Relatório Parcial, usado para a identificação da situação problema, possíveis causas, argumentos e estratégia de pesquisa e estudo, Relatório do Líder, tratando da autoavaliação do líder sobre a condução dos trabalhos e uma avaliação de seus pares, considerando presença, preparação, participação, organização, contribuição e ética e Relatório Final, momento em que são informadas as questões de pesquisa, conceitos relevantes e conclusão. Os resultados finais dos alunos e as avaliações do corpo discente realizadas no período também serão objeto de análise.

2. Questionários e Entrevistas. a) Questionário com 50 discentes que já tenham concluído a disciplina de finanças do curso de administração de empresas, visando identificar características importantes do trabalho desenvolvido; b) Entrevista semiestruturada com 5 docentes identificando pontos frágeis e relevantes apresentados ao longo do curso; c) Entrevista conjunta semiestruturada com o ex-diretor de Centro e o ex-diretor da faculdade de Administração de Empresas, que acompanharam todo o processo de estruturação e implantação do método.

3. Observação natural direta de um módulo com o objetivo de analisar o contexto real, observando os espaços de aprendizagem (sala de aula e biblioteca), os relacionamentos interpessoais e a realização dos relatórios desenvolvidos pelos discentes.

A presença do investigador pode mudar o comportamento do objeto investigado, motivo pelo qual é aconselhável que o investigador busque interagir com os seus sujeitos da forma mais natural possível, não intrusiva e não ameaçadora. Como o interesse está no modo como as pessoas se comportam e pensam em seu ambiente natural, deve buscar agir de forma que sua presença não afete significativamente as ações dos sujeitos investigados. (Bogdan e Biklen, 1994).

Os instrumentos ora apresentados pretendem mapear os itens: material atualmente utilizado; percepção de professores e alunos sob o aspecto de eficácia de aprendizagem quanto à aplicação do método; necessidade de reunião periódica dos professores envolvidos em busca de melhoria constante no processo de ensino e aprendizagem; prazos para a confecção, avaliação e devolução dos trabalhos desenvolvidos, permitindo que o aluno possa refletir sobre os seus erros e acertos, pontos fortes e fracos; definição clara de regras de aplicação e avaliação; infraestrutura disponível, e forma como os trabalhos devem ser apresentados.

4 Resultados parciais e esperados

A aplicação do método PBL para a disciplina de finanças ainda é muito recente, e com este trabalho é esperado que surjam diferentes pontos de vista em cada uma das atividades desenvolvidas. Após a pesquisa, é desejável a identificação dos pontos importantes que demandam aperfeiçoamento e que surjam propostas para suprir as necessidades identificadas.

É importante que a avaliação possa diagnosticar qualitativamente a eficiência do processo pedagógico e que possibilite o desenvolvimento de uma sistemática que objetive o aperfeiçoamento da qualidade da educação, sendo "... a avaliação é ferramenta de gestão, é exercício para execução de qualquer tarefa com qualidade e serve de base para a comparação entre a realidade de um objeto e seu estado desejável". (Bartnik; Silva, 2009, p.465).

Como resultados parciais, apresentamos a organização de documentos utilizados para o acompanhamento do trabalho. Destacamos a seguir os pontos que se articulam com os princípios do PBL.

RELATÓRIO PARCIAL

Disciplina:	Problema nº	Grupo:	Data:
Defina o problema:			
Com relação ao problema		Com relação ao trabalho do grupo	
Possíveis causas	Pontos-chave (fatos)	Tópicos a pesquisar	Plano de estudo
Com base nas informações que a equipe dispõe, aponte, sem censura, tudo aquilo que possa estar contribuindo para que o problema ocorra.	*Informações extraídas do texto que estejam relacionadas com o problema definido, e/ou informações que não estejam no texto mas se referem ao problema.*	*Assuntos, temas, conceitos relevantes a serem pesquisados, analisados, discutidos e propostos para a solução do problema.*	*Informe como a equipe irá pesquisar os tópicos: O quê? (assuntos) Quem? (responsável) Quando? (data) Onde? (livro, periódico, internet, empresa, etc.)*

Coordenador:	Redator:	Porta-Voz:	Membro:	Membro:	Membro:
RA:	RA:	RA:	RA:	RA:	RA:

AUTO-AVALIAÇÃO DO LÍDER E AVALIAÇÃO DOS PARES

Disciplina:	**Professor (a):**
Grupo:	**Situação-problema:**
Use a seguinte escala para avaliar a si mesmo(a) e os outros membros do seu grupo: **(E)** excelente; **(B)** bom; **(R)** regular; **(I)** insuficiente; **(S)** sem avaliação	
CONSIDERE: a presença do grupo em todos os encontros; a preparação para os encontros; observe os prazos estabelecidos pelo grupo; a participação nas discussões dentro e fora da sala de aula; o respeito pelas opiniões dos membros do grupo; a contribuição para organização do trabalho; a contribuição para construção de consenso e realização das tarefas, etc.	
1. Líder:	
2. Redator:	
3. Membro:	
4. Membro:	
5. Membro:	
6. Membro:	
7. Membro:	
8. Membro:	
Use este espaço para fazer comentários sobre a sua auto-avaliação acima, indicando como esta pode ser melhorada.	
Use este espaço para colocar as dificuldades encontradas pelo grupo bem como as estratégias de superação implantadas ou passíveis de serem implementadas em trabalhos futuros.	
Comente sobre a postura ética do grupo na realização dos trabalhos.	

A análise destes documentos indica que os registros a serem realizados pelos discentes e posteriormente analisados pelos docentes estão de acordo com os princípios descritos para o desenvolvimento do PBL. Destaca-se que ao preencher os relatórios, os discentes necessariamente precisam prever as etapas denominadas de "sete passos" apresentados por Schmidt (1983) na busca dos fenômenos descritos. (Schmidt, 1983 apud Araújo; Sastre, 2009).

Quanto ao processo avaliativo realizado por docentes temos os seguintes documentos:

Critérios de Avaliação do Relatório Parcial

	INSUFICIENTE	RAZOÁVEL	BOM	EXCELENTE
REGISTRO DO BRAINSTORMING	Brainstorming pobre, inadequado e não relacionado à situação-problema.	Brainstorming pobre, parcialmente relacionado à situação-problema.	Brainstorming rico, parcialmente relacionado com a situação-problema.	Brainstorming rico, bem articulado com a situação-problema.
PONTOS-CHAVE	Não identificou pontos fundamentais apresentados na situação-problema	Identificou alguns pontos fundamentais apresentados na situação-problema	Identificou a maioria dos pontos fundamentais apresentados na situação-problema	Pontos-chave bem identificados e articulados com o brainstorming
DEFINIÇÃO DO PROBLEMA	Problema confuso e desarticulado com o brainstorming e com os pontos-chave	Problema formulado de forma insuficiente e relativamente articulado com o brainstorming e com os pontos-chave	Problema claramente formulado e relativamente articulado com o brainstorming e com os pontos-chave	Problema claramente formulado e articulado com o brainstorming e com os pontos-chave
QUESTÕES DE PESQUISA	Conceitos e assuntos não formulados ou inadequados	Conceitos ou assuntos insuficientes para desenvolver o problema	Conceitos ou assuntos suficientes para desenvolver o problema	Conceitos ou assuntos que esclarecem o problema e permitem aprofundamento da pesquisa
PLANEJAMENTO DA PESQUISA	Não definiu atividades e responsabilidades	Definição apenas geral de atividades e responsabilidades	Definição clara de atividades e responsabilidades	Definição clara de atividades e responsabilidades

Critérios de Avaliação do Relatório Final

	INSUFICIENTE	RAZOÁVEL	BOM	EXCELENTE
FUNDAMENTAÇÃO TEÓRICA	Não se pauta em conceitos ou teorias	Fundamentação insuficiente, pesquisa de poucas obras ou superficial	Relaciona teorias e conceitos com o problema	Fundamentação teórica completa, incluindo comparações entre abordagens alternativas.
SOLUÇÃO PROPOSTA	Não apresenta encaminhamento baseado nos fatos e conceitos discutidos	Apresenta encaminhamento parcialmente articulado com os conceitos	Apresenta encaminhamento articulado com os conceitos	Apresenta vários encaminhamentos viáveis, fazendo comparações, referências e articulações com os conceitos
FORMATO	Escrito à mão ou formato inaceitável para uma comunicação empresarial. Não segue normas da ABNT (referências e citações)	Documento aparentemente bem feito, mas ainda fora dos padrões de comunicação em uma empresa. Segue parcialmente as normas da ABNT	Documento de acordo com as diretrizes de comunicação empresarial. Segue as normas da ABNT	Documento de acordo com as diretrizes de comunicação empresarial. Segue as normas da ABNT
USO DA LINGUA	Documento com erros gramaticais graves e com linguagem imprópria	Documento com alguns erros gramaticais e impróprio	Poucas incorreções gramaticais e de uso da língua, podendo ser usado em ambiente profissional	Correto gramaticalmente e com linguagem adequada, podendo ser usado em ambiente profissional

Critérios de Avaliação da Apresentação

	INSUFICIENTE	RAZOÁVEL	BOM	EXCELENTE
CONTEÚDO	Conceitos insuficientes ou expostos de modo superficial. Não mostra relações entre problema, conceitos e solução	Conceitos adequados mas expostos de modo superficial. Mostra poucas relações entre problema, conceitos e solução	Apresenta conceitos de modo preciso e suscinto, indicando as relações entre problema, conceitos e solução	Apresenta conceitos e relações de modo preciso, comparando diferentes soluções e suas implicações , explorando aspectos originais
FORMATO	Slides com muito texto, letras pequenas e descuido com a gramática	Slides pouco elaborados, sem tabelas e sem atrativos	Slides elaborados, porém sem tabelas ou pouco atrativos	Slides bem elaborados, com tabelas, figuras, gráficos, ilustrações visualmente atrativos
ORATÓRIA	Lê os slides, fala de costas, voz baixa e sem entonação	Fala sem ler, mas com insegurança, olha para a platéia	Fala com segurança, mas não vai muito além das informações nos slides, tom audível	Desenvolve bem as informações dos slides, fala em tom audível para todos na sala e usa anotações sem perder a espontaneidade

Critérios de Avaliação do Debate

	INSUFICIENTE	RAZOÁVEL	BOM	EXCELENTE
PERTINÊNCIA	Não faz referências à apresentação que está sendo debatida	Faz referências à apresentação em debate mas não especifica conceitos e soluções	Faz referências específicas a conceitos e soluções expostas na apresentação que está sendo debatida	Faz referências específicas a conceitos e soluções apresentadas, criticando, comparando e expandindo as idéias
POSICIONAMENTO	Não define a posição do grupo sobre as questões abordadas	Define de modo incompleto as posições sobre as questões abordadas	Define a posição do grupo sobre a maioria das questões abordadas	Define a posição do grupo sobre todas as questões abordadas
FUNDAMENTAÇÃO	Não apresenta fundamentação teórica nem factuais para seus comentários	A fundamentação teórica baseia-se em conceitos já apresentados, abordados de forma incompleta ou equivocada	A fundamentação teórica baseia-se em conceitos já apresentados, abordados corretamente	Apresenta fundamentação teórica e fatos distintos dos apresentados anteriormente, que revelam novos aspectos do problema
ARGUMENTAÇÃO	Não convincente aos demais participantes	Pouco convincente aos demais participantes	Convincente aos demais participantes	Muito convincente aos demais participantes

Nota-se pela documentação que a avaliação resgata todo o processo desenvolvido, e assim como os demais documentos já analisados preveem princípios e organização do PBL. No entanto ao se pensar na configuração de um semestre ou de um módulo de aprendizagem, algumas questões nos parecem pertinentes. O docente possui tempo hábil para avaliação e correção dos relatórios considerando a devolutiva aos discentes, promovendo o resultado esperado dentro do processo de aprendizagem? Quais as dificuldades do docente encontradas no processo avaliativo? Para responder a estas questões, daremos continuidade a esta pesquisa com os instrumentos destacados no item metodologia.

É esperado que sejam publicados artigos sobre o emprego do método PBL na disciplina de finanças, e como resultado final que a avaliação seja uma ferramenta de reflexão sobre a qualidade de ensino universitário e profissionalizante que está sendo oferecida ao exigente mercado de trabalho. Espera-se, também que a presente pesquisa possa subsidiar o aprimoramento do uso do método em busca da melhor qualidade de ensino oferecida dentro das universidades.

5 Conclusão

Apesar do método PBL ter sido utilizado nos cursos da área de saúde desde a década de sessenta, e no Brasil desde 1993, as pesquisas apontam que o uso do método na disciplina de finanças é muito recente e para tanto, carece de uma avaliação de seu emprego.

O início da pesquisa demonstra que o PBL promove a autonomia intelectual do corpo discente uma vez que os alunos são incentivados a discutir os problemas propostos em equipe, pesquisar e exteriorizar o aprendizado. Durante o processo de aplicação do método, os alunos discutem o problema proposto pelo professor dentro de uma equipe, onde as experiências individuais são socializadas. As pesquisas são realizadas em biblioteca e as respostas surgem sem influência direta do professor que tem por principal função fazer o discente pensar e buscar por si só resultados que atendam adequadamente a solução do problema. Durante a fase de apresentação do resultado encontrado, o professor promove um debate intergrupo com o objetivo de levantar diferentes possibilidades de solução de um mesmo problema. Para complementar o aprendizado, a cada problema levantado, o professor sugere um fechamento analisando todos os aspectos levantados pelo corpo discente, aproveitando a oportunidade para exteriorizar as suas experiências pessoais, complementando a boa formação profissionalizante do seu educando.

Cabe agora dar prosseguimento na pesquisa em busca de respostas aos objetivos propostos para que o trabalho possa servir como referência às universidades espalhadas pelo mundo, que tenham a pretensão de utilizar o PBL como metodologia de ensino, especialmente dentro do curso de Administração de Empresas.

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Ambiente Virtual de Aprendizagem Aplicado ao Ensino de Disciplinas da Engenharia

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Abstract

It has been believed that the insertion of computer technology could provide to the teachers and students a new way to teaching and learning certain subjects. This way this work aims to present the preliminary actions to develop a Virtual Learning Environment (VLE), which will be a supporting tool for the improvement of the learning process in engineering courses at campus Gama – University of Brasilia. To illustrate the use of this tool in such a way, the paper shows a prototype of the environment applied to a specific course in the engineering field, i.e., Mechanics of Solids.

Keywords: Virtual Learning Environment; Mechanics of Solids; e*ngineering courses*; didactic tools.

1 Introdução

Por mais de 20 anos, algumas pesquisas em educação constataram a forte influência das crenças do professor em suas práticas pedagógicas (Niederhauser & Stoddart, 2001), ou seja, seu comportamento e a didática aplicada em sala de aula são direcionados por suas convicções quanto à metodologia ideal.

Desde as últimas décadas, o número de pessoas com acesso a recursos de informática tem sido cada vez maior. De fato as novas tecnologias de informação e comunicação têm revolucionado diversos aspectos da vida moderna, dentre eles a educação. Assim para muitos profissionais da área, a inserção de ferramentas computacionais no processo de ensino e aprendizagem passou a fazer parte de suas práticas docentes.

Neste sentido, percebe-se que os avanços da informática, aliados à tentativa de levar conhecimento àqueles que não podem estar em um ambiente de sala de aula, deram início ao sistema de Educação à Distância *online* (EaD). Ao longo da história, vários fatos demonstram que a busca pelo aprendizado, fora do ambiente da sala de aula, foram decisivos para a criação de uma cultura de ensino à distância. Cita-se o curso de taquigrafia domiciliar através do envio semanal de lições se ainda no séc. XVIII como uma primeira experiência de EaD. Cursos de línguas por correspondência em 1891 e propostas de Thomas J. Foster que dá início ao *International Correspondence Institute*. Como estes, outros acontecimentos reafirmam a EaD como uma prática já difundida, conforme citado em Lobo Neto (1998).

Todas essas situações se configuram como tentativas de ensinar conteúdos desvinculados da presença física de professor e estudante. A escrita, em convergência com a técnica de impressão dada por Gutenberg, é apontada como uma tecnologia capaz de ampliar temporalmente a presença do autor. Configura-se assim condição ideal para que a escrita e a informática sejam reconhecidas como tecnologias da inteligência (Pierre Lévy, 1993).

Durante a segunda metade da década de 90, o ambiente virtual de aprendizagem (AVA) passou a representar uma ferramenta capaz de viabilizar o EaD. Este ambiente pode ser entendido como um conjunto de recursos digitais de comunicação e computação, utilizados para mediar a aprendizagem (Filatro, 2003). Amplia- se assim as possibilidades dadas pela escrita e pela impressão pelo uso de ferramentas multimídias na difusão e criação de conteúdos didáticos.

Em agosto de 2008, inaugura-se a Faculdade UnB Gama (FGA) - Universidade de Brasília com vocação exclusiva para formação de engenheiros; que, segundo a Resolução CNE/CES 11/2002 do Brasil devem cursar obrigatoriamente disciplinas fundamentais do núcleo de conteúdos básicos. Em 2009, um grupo de professores e estudantes começa a se dedicar ao desenvolvimento de um ambiente virtual de aprendizagem aplicado ao ensino de álgebra linear (Shzu, Silva & al, 2009).

Em 2010, o grupo passa a se chamar i-GPDAM - Grupo de Pesquisa e Desenvolvimento de Ambientes Interativos e sofre mudanças. Dentre elas citam-se a formação multidisciplinar dos professores e estudantes de graduação e pós-graduação que o compõem, abrangendo profissionais das áreas de Programação Orientada a Objetos, Mecânica dos Materiais e Artes voltada ao conhecimento do *design* instrucional.

Do *design* instrucional, herda-se a mediação tecnológica como parceira do conhecimento e as interações e simulações capazes de complementar, e não substituir, a presença do professor em sala de aula. Ressalta-se que a natureza multimídia do ambiente e o emprego de estratégias diferenciadas de intervenção do trabalho pedagógico proporcionam a transmediação que garante que nenhuma ação, no processo de aprendizagem, seja excludente. Emprega-se o termo transmediação para referenciar um tipo de conteúdo complementar que utiliza de diversas mídias na sua recepção e criação (Jenkins, 2006). A Figura 1 destaca os meios utilizados para promover o aprendizado do estudante dentro deste conceito.

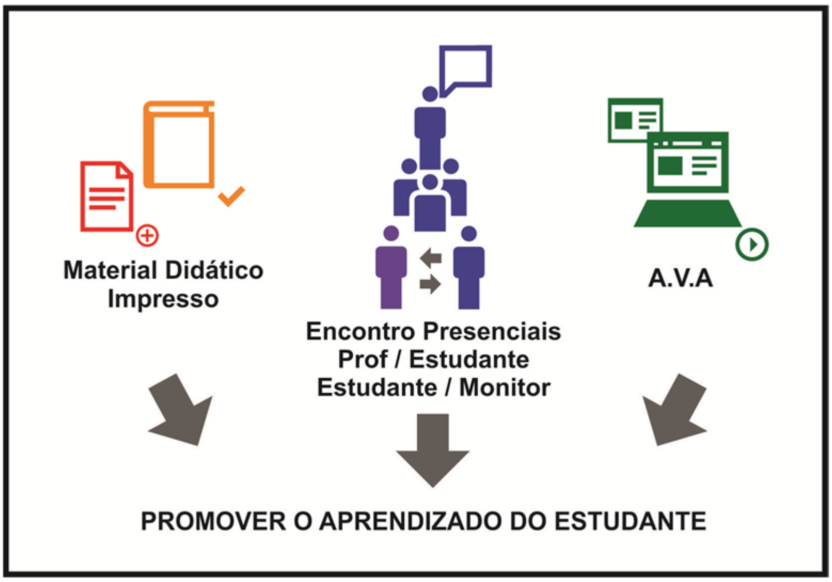

Figura 13: Esquema de aquisição de conhecimento sugerido no processo de aprendizagem

Assim, de forma geral, a proposta do grupo passa a ser a criação de um AVA capaz de auxiliar no ensino e na aprendizagem de disciplinas dos cursos de engenharias da FGA; este será denominado Projeto Piloto. Dessa forma, o presente trabalho traz ainda, a proposta preliminar de construção do AVA aplicado à disciplina de Mecânica dos Sólidos (MecSol). Para tanto, será discutida a importância da disciplina na formação do engenheiro; estratégias de desenvolvimento do ambiente, adequação ao conteúdo da referida disciplina e principais características do ambiente em desenvolvimento; métodos de aplicação e controle quando de sua colocação em uso e as principais conclusões.

1.1 Motivação da escolha do projeto piloto: disciplina Mecânica dos Sólidos

Tendo em vista que o Projeto Piloto do AVA, nesta fase se baseia no desenvolvimento de um ambiente aplicado à disciplina Mecânica dos Sólidos, julga-se importante fornecer alguns conceitos básicos e, esclarecer o leitor a respeito dos assuntos que tal área trata, dentro do contexto da Mecânica Aplicada.

Os sólidos representam conjuntos de pontos materiais que possuem forma definida, ou seja , indeformáveis quando não submetidos a solicitações externas. Conceitualmente, na Mecânica dos Meios Contínuos, os sólidos são considerados um conjunto contínuo de pontos que podem ser identificados pela posição, relativamente a um sistema de referência, que ocupam no espaço físico 3-D. Estes sólidos podem ser ditos rígidos se não há alteração na distância relativa entre quaisquer de seus pontos materiais no decurso do tempo. Caso contrário, serão ditos deformáveis (Pimenta, 2006).

Assim, a Mecânica dos Sólidos pode ser entendida como a ciência que descreve as condições de movimento e repouso de corpos rígidos ou não, sob a ação de forças. No campo da Mecânica dos corpos rígidos há a seguinte subdivisão Estática, Cinemática e Dinâmica; enquanto que para os corpos deformáveis inclui-se a Resistência dos Materiais. Temas esses que exigem a visualização de situações próprias da engenharia modeladas tridimensionalmente para criação de ambientes interativos de simulação. Trata-se de transpor os conteúdos estáticos dos livros e apostilas para meios mulitimídia e interativos.

Conforme citado na seção 1, MecSol faz parte do núcleo de conteúdos básicos sendo, portanto, uma disciplina considerada importante na formação de um engenheiro. Na matriz curricular aprovada para os cursos da instituição, esta disciplina constitui o primeiro contato do estudante de engenharia com o estudo do comportamento de estruturas. Os conteúdos abordados no curso tratam tanto dos corpos rígidos, no tocante à Estática, como de conceitos básicos relativos à Resistência dos Materiais, quais sejam estados de tensão-deformação e suas relações.

Conforme destacado na Figura 1, a motivação para o estabelecimento do ciclo de aprendizagem proposto nasce da necessidade de se reforçar conceitos básicos a serem dominados por jovens engenheiros, mas também pela dificuldade apresentada na disciplina pelos estudantes. O índice de reprovação nesta desde a primeira oferta no campus (2º semestre de 2009) oscila entre 30% e 45%, sendo que em outras instituições este índice se encontra na mesma ordem de grandeza.

O conteúdo abordado em aula é extenso e traz para a sala de aula, aspectos nunca antes tratados pelos estudantes, integrando conhecimentos de Física e de Álgebra Linear. De fato a disciplina aborda conteúdos diretamente aplicáveis à vida profissional para estudantes do 3º semestre de engenharia, logo estes são, ainda, um pouco imaturos para compreender conteúdos que envolvem certa complexidade.

Neste sentido, as integrações entre os encontros presenciais professor/estudante, monitor/estudante e AVA/Material didático escrito (Figura 1) parecem bastante propícios para promover o conhecimento do estudante no tocante à disciplina. Estes são contemplados com suporte de ensino adaptados à disciplina e inovadores através do AVA.

2 Aprendizagem automatizada

O ambiente AVA em desenvolvimento têm três partes bem definidas: a modelagem gráfica, a interação do aprendiz/instrutor via ambiente e a modelagem do conhecimento/raciocínio necessários a esta interação. As suas primeiras parte já estão implementadas e são apresentadas na seção 3. A última, também denominada "aprendizagem automatizada", está em fase de implementação e é descrita nesta seção.

O ambiente AVA definido permite a criação automatizada de perfis de interação diferenciados para cada aprendiz ou instrutor. Os perfis definidos são: aprendiz (básico, médio e avançado) e instrutor (professor e tutor). Cada perfil é identificado: (1) a partir da representação individualizada do caminho de aprendizagem de cada aprendiz a partir de descrição prévia (Bossois 2010), (2) da representação conceitual dos conteúdos através de exercícios e (3) da ontologia de conceitos que relacionam os conhecimentos intra e inter disciplinares (Pereira, Seibel, Freitas 2009). O raciocínio referente ao processo de enquadramento de um dado estudante, com um dado perfil, num dado ponto da ontologia é feito através de inferência abdutiva (Brewka, Diz, Konoliga 1997) sobre as interações feitas, os exercícios respondidos e o conhecimento prévio sobre o contexto aprendriz/conteúdo/tutor.

Algumas das inferências utilizadas são:

(1) Dado o conjunto de conceitos expressos num ou mais exercícios, quando um aprendiz responde acertadamente este conjunto implica que ele conhece o conteúdo expresso.
(2) Um exercício futuro que reafirme um conteúdo previamente aprendido, quando respondido erroneamente pelo aprendiz, induz uma falha no seu conhecimento prévio, o qual é representado de maneira não monotônica (Seibel, Freitas 2007). Neste caso o conceito prévio contido no exercício é retirado da base de conhecimento do aprendiz.
(3) Mais de um exercício sobre um mesmo conteúdo deve ser realizado para reinserir conceitos reavaliados (item 2).

O conjunto de conceitos a serem aprendidos por um aprendiz numa dada disciplina caracterizam o chamado aprendiz modelo. É a diferença entre este aprendiz modelo e o conhecimento do aprendiz em aprendizagem, que identificar, através de regras heurísticas, a categoria em que o aprendiz se enquadra.

A partir do modelo ideal criado e das regras de categorização definidas, o ambiente AVA identifica um aprendiz num dado contexto de aprendizagem. Dependendo do desempenho deste neste contexto, é feita uma categorização onde pode acontecer que este seja levado a refazer alguns percursos anteriores, ou, caso demonstre conhecimento avançado sobre o assunto, encurte percursos futuros.

3 Aplicação do Ambiente Virtual de Aprendizagem

No AVA, o mapa de abordagem dos conteúdos referentes à Estática de corpos rígidos segue a estruturação mostrada na (Figura 2).

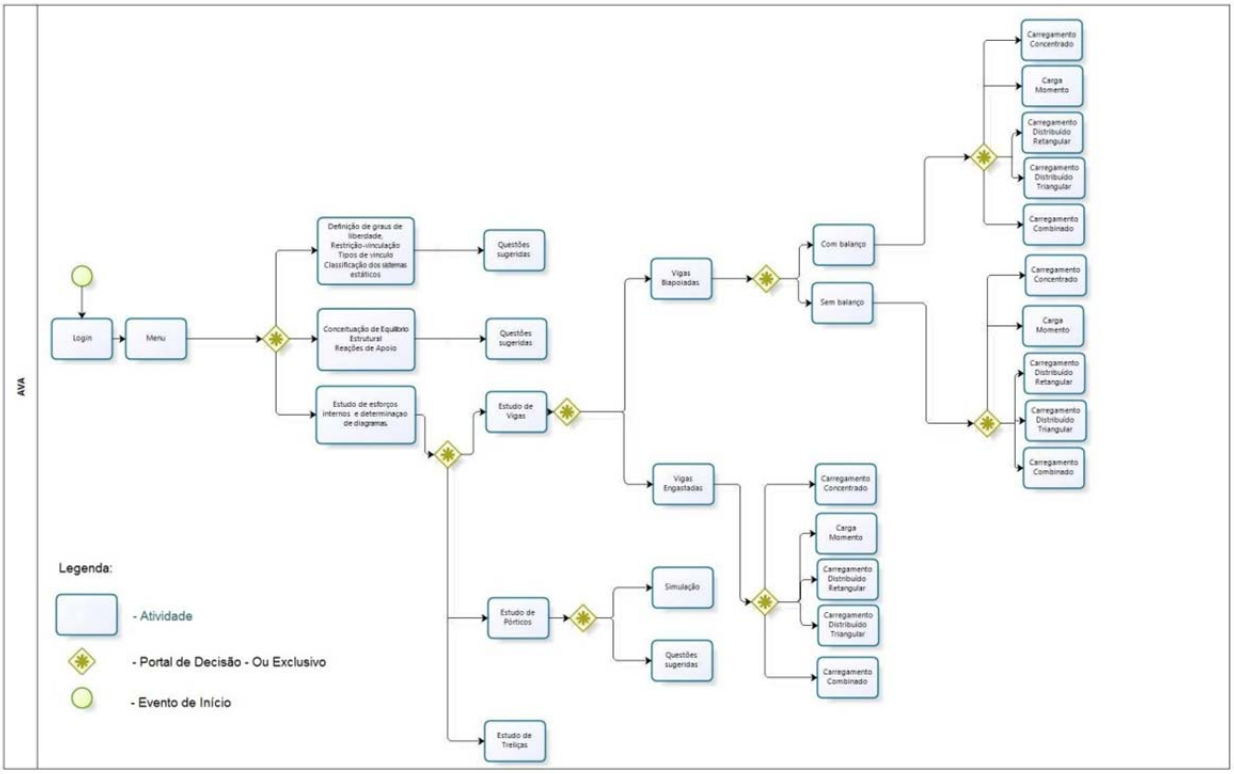

Figura 2: Mapa de abordagem do conteúdo Estática no AVA (fase preliminar)

A inserção do AVA no processo de aprendizagem se dá através do Guia do Estudante, que segundo a Figura 1 classifica-se como mídia Material Didático Escrito[3]. Seu propósito é apresentar uma abordagem teórica sobre os conteúdos da Estática (fase preliminar) de forma condensada e contextualizada. Neste Guia, nos conteúdos ilustrados na Figura 2, o estudante é convidado a entrar no AVA a partir de ícones alusivos que o remetem a alguns conceitos, nos quais ele pode se exercitar ou encontrar maiores esclarecimentos. De fato o *link* Guia do Estudante → AVA é estruturado de forma a estabelecer o diálogo entre o conteúdo hipertextual e o AVA.

Segundo a Figura 2, nessa primeira etapa de desenvolvimento o estudante terá como objetivo final determinar os Diagramas de Momento Fletor e Esforços Cortante de estruturas, no caso, vigas e pórticos planos (2D). Estas duas classes de estruturas são ditas reticuladas e se diferem pelo tipo de elementos estruturais que as formam. No caso, os pórticos são estruturas formadas por elementos de viga e elementos de coluna conectados de forma a permitir a interação de força e momentos.

Neste sentido, a estruturação do ambiente o leva primeiramente ao estudo e, portanto, à definição de graus de liberdade, restrição através da vinculação da estrutura, tipos de vínculos e classificação de sistemas estáticos (estruturas isostáticas, hiperestáticas e hipostáticas). Ao final desta etapa, ele deverá ser capaz de determinar os graus de liberdade, tipos e número de restrições das estruturas, além de classificá-las.

O próximo tópico apresenta ao estudante a conceituação de equilíbrio estrutural, que abordará, exclusivamente, estruturas isostáticas (número de graus de liberdade = número de restrições). O estudo deste tópico permitirá que o estudante encontre através do equilíbrio da estrutura, as reações nos apoios aplicando no desenvolvimento deste trabalho a 1ª e a 3ª Leis de Newton, além dos conceitos de equilíbrio vetorial. Para tanto terá que ser capaz de identificar o sistema de forças aplicado (carregamentos distribuídos, concentrados, binários) e características geométricas (vão livre, existência ou não de balanços, altura). A Figura 3 ilustra os objetos de aprendizagem com os conceitos envolvidos na sua compreensão.

[3] O Guia do Estudante é editado em *Microsoft Office Word* com ilustrações feitas em *CorelDraw*.

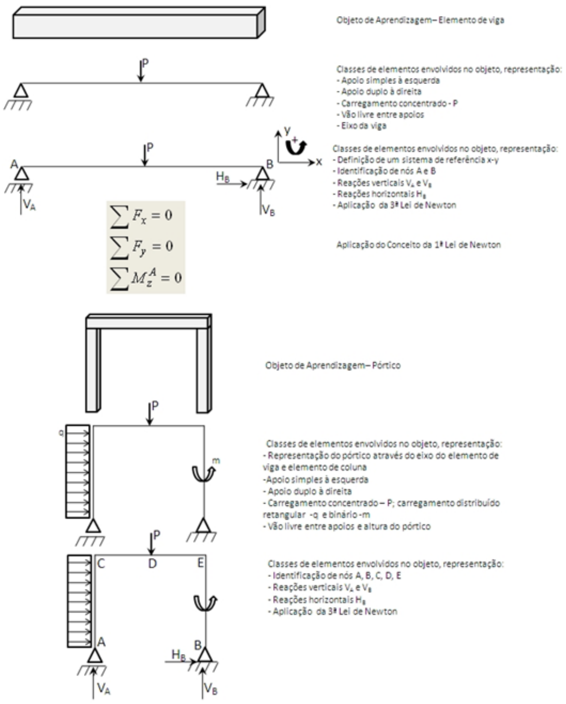

Figura 3: Especificação do objeto de aprendizagem de uma viga e de um pórtico – equilíbrio de estruturas

Em seguida, o traçado dos diagramas de esforços internos é proposto ao estudante segundo a ordem apontada na Figura 2. Cabe ressaltar que esta ordem respeita a evolução no nível de dificuldade na resolução da estrutura proposta. Ressalta-se também que cada um dos tópicos mostrados sugere sempre ao final uma bateria de questões interativos ou não para que o estudante teste seus conhecimentos, o nível de dificuldade varia em fácil, médio e difícil.

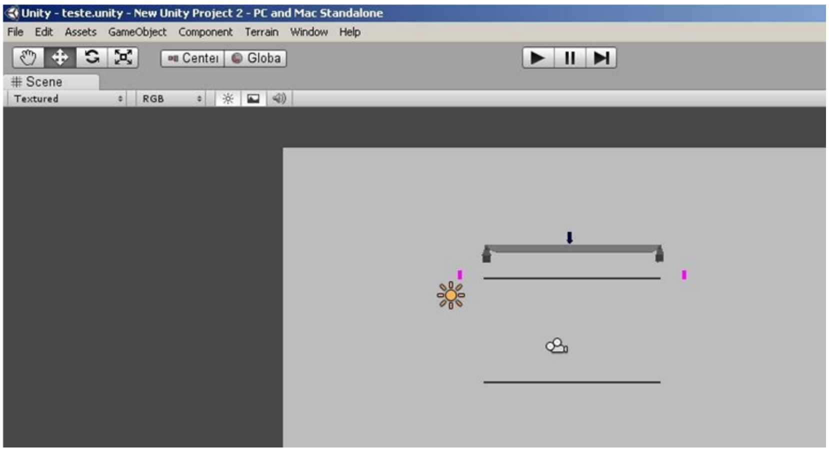

Figura 4: Modelagem da viga dentro o UNITY

A Figura 4 mostra como as vigas, apoios e cargas são modelados dentro do ambiente Unity. O Unity permite a modelagem de objetos 3D, bem como a criação de interações de todos os objetos. Através do Unity é possível criar animações interativas. Esta interação foi utilizada para a modelagem das vigas e na criação dos elementos de interação onde o aprendiz testa os objetos de aprendizagem (Figura 3). O Unity gera arquivos executáveis para diversas plataformas: Windows, Mac entre outros.

Logo após os testes de conceitos realizados pelo aprendiz, lhe é apresentada uma nova fase na qual ele testará seus conhecimentos. Esta nova fase é composta, essencialmente, de exercícios de múltipla escolha. Um exemplo é apresentado na Figura 5.

Figura 5: Exemplo de exercício de fixação (adaptado de Beer Johnston, 1989)

A aprendizagem automatizada atua antes e a após a apresentação de um dado exercício ao aprendiz (Figura 5). O exercício não será apresentado caso os conceitos presentes no exercício já estejam consolidados no conhecimento do aprendiz. Caso contrário, o exercício é apresentado e deve ser respondido. Se a resposta dada for correta, então o conceito é considerado aprendido pelo aprendiz em questão. Senão é então considerada a distância entre o conceito pretendido na resposta correta e o da resposta dada. Esta distância definirá o tipo de plano a ser seguido: repetição do mesmo exercício, apresentação de um novo exercício com conteúdo semelhante ou não apresentação de outro exercício.

4 Avaliação do Ambiente Virtual de Aprendizagem

Para validação do ambiente, está sendo formado um Grupo de Avaliação composto por estudantes de graduação da FGA que já cursaram ou estão cursando a disciplina. Aqueles que já cursaram podem ser repetentes ou não. O perfil deste usuário abrange a faixa etária de 19 a 21 anos, do sexo feminino ou masculino. A dinâmica de avaliação passa por quatro etapas até ter seu uso difundido a todos os estudantes. A primeira Etapa considera um grupo de 20 estudantes o que representa uma porcentagem de 10% do total de estudantes; a segunda 36 estudantes, ou seja, 18% do total; a terceira 30% o que abrange 60 estudantes. Na quarta Etapa seu uso abrange toda a população de estudantes.

Para avaliação será aplicado um questionário abrangendo o máximo de objetos de aprendizagem. Este questionário está em fase de elaboração.

5 Conclusão

A necessidade de criação de um AVA específico para os conteúdos da engenharia foi percebida pelos educadores e professores da FGA, para funcionar como um suporte midiático complementar à apresentação de conteúdos. Percebe-se também que quando integrado ao ambiente multimídia, contribui-se para que os conteúdos da disciplina Mecânica dos Sólidos atinjam este novo perfil de estudante, ou seja, aquele integrado ao mundo informatizado. Isto porque, conteúdos que apresentam simulações ganham em produtividade quando estão diluídos em ferramentas e suportes que permitem a manipulação direta pelo estudante. O ato de interagir com o ambiente garante ao estudante uma postura autônoma na busca e aquisição do conhecimento em suas operações, trata-se de uma série de qualidades que já foi apontada por Johnson (2005) quando o autor fala dos benefícios cognitivos do jogo e de outras mídias interativas na formação de um pensamento associativo, de tomada de decisão, de priorizar e de julgar ações com base na observação do ambiente. Acredita-se que essas habilidades são requeridas ao estudante quando esse lida com o AVA.

O ambiente desenvolvido, em sua segunda versão[4], está em fase de avaliação dentro da comunidade bem como de ampliação dada à utilização de perfis de aprendizagem. Também está sendo remodelada a arquitetura interna do sistema computacional de modo a permitir um ambiente acessível via web.

Ressalta-se que a eficácia do ambiente proposto exige uma conduta ativa por parte do estudante, diferentemente do que se encontra disponível na Web por meio de vídeos[5].

6 Agradecimentos

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[4] A primeira versão utilizou o Blender como ferramenta de modelagem.

[5] O Youtube, por exemplo, fornece diversos vídeos com animações que tangenciam o conteúdo de MecSol e mais uma vez esbarra-se em vídeos, prioritariamente, em língua inglesa, seja com legendas ou narração em voz *off*.

A Construção de Atitudes na Aprendizagem Cooperativa: Benefícios da Relação Tutorial

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Abstract

This is a theoretical study on issues related to the role of mentoring in building attitudes, cooperation and attitudinal content essential for the conduct of cooperative learning. In a specific way, this article aims to examine what attitudes students can build and need to be made effective in the classroom, the cooperation and the work of peer tutoring. The theoretical framework brings the discussion of authors who approach the ethics and morality, and articulate this knowledge with the didactic procedures that allow building some attitudes related to interpersonal responsibilities. This, specifically, the contribution of formative assessment to monitor the processes of teaching and learning in the field of attitudinal content, based on data developed by teachers, tutors and students from a collaborative work. Describes, in theory, about the performance of the authority and the role of the tutor in a constructively perspective, demonstrating the benefits of intellectual, emotional and moral mentoring brings to the participants of the educational process. It is based on the view that the formation of citizenship allows to overcome the problems of violence and other conflicts at school daily depending in fact, the reorganize of a cooperative atmosphere in which everyone involved can feel pertaining and acting.

Keywords: cooperative learning; moral; formative assessment; cooperation; violence at school.

Resumo

Trata-se de um estudo teórico sobre aspectos relacionados ao papel da tutoria na construção de atitudes, na cooperação e nos conteúdos atitudinais essenciais para a condução de uma aprendizagem cooperativa. De maneira específica, o presente artigo tem por objetivo analisar quais atitudes os alunos e alunas podem e precisam construir para que se efetive, em sala de aula, a cooperação entre pares e o trabalho da tutoria. O referencial teórico traz a discussão de autores que abordam a ética e a moral, e articula estes conhecimentos com os procedimentos didáticos que possibilitam a construção de determinadas atitudes relacionadas com as responsabilidades interpessoais. Trata, de forma específica da contribuição da avaliação formativa para o acompanhamento dos processos de ensino e aprendizagem no campo dos conteúdos atitudinais, avaliação esta desenvolvida por docentes, tutores e discentes a partir de um trabalho colaborativo. Descreve, teoricamente, a atuação da autoridade e destaca o papel do tutor em uma perspectiva construtiva, demonstrando os benefícios intelectuais, afetivos e morais que a tutoria traz para os participantes do processo educacional, pautando-se na perspectiva de que um trabalho de formação da cidadania que possibilite vencer os problemas de violência ou outros conflitos cotidianos na escola depende de fato da reorganização de um ambiente cooperativo em que todos os envolvidos possam de sentir pertencentes e atuantes.

Palavras-chave: aprendizagem cooperativa; moral; avaliação formativa; cooperação; violência na escola

1 Introdução

A tese central deste artigo é que, se necessitamos mais solidariedade e formas de resolução de conflitos menos violentas entre as pessoas chamadas de cidadãs na convivência social, há que se romper com a perpetuação do individualismo e autoritarismo que vêm triunfando nas sociedades pós-industriais e que se reproduzem nas instituições escolares. Sem menosprezar outras iniciativas em outros âmbitos sociais, será preciso rever o tipo de educação e o próprio papel formador de tal cidadania pela escola e colocar em pauta os princípios da cooperação e da participação democrática. É preciso ainda superar a ideia de que cooperação é uma simples atitude de trabalho entre crianças e jovens para fins estritamente acadêmicos ou que sua tradução para a práxis pedagógica seja apenas uma forma de “ajuda” entre as pessoas. Se nos voltarmos ao conceito já apontado por Piaget em 1932 tomando sua dimensão psicológica e sociológica teremos que cooperar mais do que colaborar e sim, estabelecer uma coordenação de ações em plano mental conjuntamente. Como assinala Lacroix (1996), o contexto atual exige uma moral planetária, que estabeleça um contrato de cooperação com a Natureza e com a Humanidade em seu conjunto, visando uma perspectiva de futuro, estendendo este contrato de cooperação às gerações vindouras. Necessariamente, portanto, em termos de cooperação na escola, experimentar diferentes perspectivas quando na relação entre pares e com a autoridade, poderá fortalecer alunos a ver o outro e qualquer outro, como também alguém de direito.

Tal trabalho de educação para a cooperação na escola supõe alguns princípios de educação moral. Vale dizer, que as atitudes e valores não mudam pela ação docente somente, mas sim, pela forma de produzir as relações e a organização da aula e do projeto pedagógico escolar. Piaget (1974) dizia com razão que se educa mais pelo que se faz do que pelo que se ensina. Isso nos indica que temos que ter a consciência da importância do contexto organizativo e das relações sociais nas aulas, as quais, em grande parte, são responsáveis pelos processos de socialização dos alunos, pois é nelas que a construção de valores acontece e as atitudes são tomadas pela participação efetiva dos alunos na estrutura da regulação das relações na escola. Educar visando o desenvolvimento pleno de crianças e jovens coloca portanto, a cooperação e a participação solidária como centrais nos currículos escolares, como apontou Dewey (1967).

Por certo, um trabalho em favor da cooperação, fomenta a necessidade que temos dos outros, já que a descentração é um movimento para se tomar outra perspectiva para a possível superação das diferenças como entraves na convivência. Diferentes pesquisas (Tognetta, 2003; Tognetta & Vinha, 2009) têm mostrado que como diria Piaget, a qualidade do ambiente e das relações interpessoais que nele acontecem, baseadas no respeito mútuo, na confiança que a criança pode ter com a autoridade, na participação efetiva dos alunos é o primeiro passo para a superação dos problemas de ordem moral e para a formação de pessoas que se respeitem e respeitem o outro.

Nos objetivos dos projetos pedagógicos de diferentes escolas analisados em nossas pesquisas (Braga, 2008; Tardeli, 2003; Tognetta et al, 2010) não encontramos, de maneira explícita, a formação de pessoas obedientes, acríticas, submissas ou heterônomas. Nenhum educador pretende formar pessoas que sejam reguladas por mecanismos exteriores, seguindo ou não determinado princípio moral ou regra dependendo do contexto. Contudo, se os valores morais não estiverem alicerçados numa convicção pessoal, os alunos não estarão prontos para seguirem as regras e os princípios, especialmente na ausência de uma autoridade. Porém, o que ocorre frequentemente é que, no cotidiano da escola, os adultos utilizam procedimentos que levam os alunos a se submeterem a essas normas porque uma autoridade (diretor, professores etc.) assim o quer ou "sabe o que é melhor para eles e para a instituição" (grifo das autoras). Na prática, valorizam a obediência às normas e regras definidas previamente e nem sempre se preocupam em explicar aos alunos as razões delas nem consultá-los acerca do assunto, atuando, por conseguinte, por caminhos que promovem mais a obediência do que a autonomia (Tognetta & Vinha, 2009). Da mesma forma, o trabalho com o conhecimento nas escolas que temos pesquisado, tem se mostrado cada vez mais distante das características que compõem o movimento pós-moderno em que a escola está inserida. Educadores, ainda pautados na concepção de que a escola deva se ancorar na informação, parecem pouco compreender a necessidade de que para se construir um conhecimento de qualquer natureza, é preciso que o sujeito seja agente. Nesse sentido, informar não é nem parece ter sido, nunca, a tarefa da escola (ainda que em tempos atrás a transmissão de conhecimentos fosse suficiente): sua tarefa é maior, é possibilitar que os alunos possam tomar consciência de qualquer que seja o conhecimento pela própria ação – correlacionando temas, comparando possibilidades de resolver os problemas, pensando em soluções para os próprios conflitos que tenham.

A escolha de um projeto educativo que promova a formação de cidadãos conscientes, portanto, pode se aproveitar das investigações de outras ciências como a psicologia, a filosofia, a sociologia que têm encontrado hoje um elo comum para o entendimento das questões sobre a moralidade humana ou a formação ética que nos propomos. Tem-se demonstrado em diferentes pesquisas o quanto o respeito ao outro depende necessariamente da construção de uma espécie de autorrespeito. (Taylor,1998; Comte-Sponville, 1999; La Taille, 2009; Savater, 2002; Tognetta & La Taille,2008).

Isso posto, é possível pensar que tal autorrespeito é construído a partir de uma prática em que se vislumbre procedimentos bastante diferentes dos que temos assistido atualmente e que se distanciam dessa construção quando alunos não se sentem acolhidos na escola, não participam diretamente das decisões sobre a convivência, não fazem escolhas, não avaliam suas ações e tão poucos têm a possibilidade de descobertas próprias. Por tal realidade e, por termos ensaiado evidenciar até aqui a necessidade de que a escola se volte às diferentes pesquisas que insistem na mudança do tipo de relações que são constrúidas na escola – com a autoridade, com os pares e com o conhecimento - passamos a apresentar, então, uma proposta que poderia tornar possível a formação moral de crianças e adolescentes fundamentada em pressupostos construtivistas que insistem que o autorrespeito é caminho para que se consiga de fato, a atribuição de valor ao outro.

Temos por objetivo neste artigo, apresentar uma possibilidade de superação dos problemas que a escola vem enfrentando, enquanto instituição educativa, quanto à convivência entre iguais e entre alunos e professores e quanto à organização do conhecimento. De que maneira o faremos? Trata-se de uma proposta sustentada teoricamente que aponta para o fato de que buscar a superação dos problemas exige de nós o entendimento de formas adequadas de ação. Nesse sentido, a primeira das nossas reflexões busca salientar a necessidade de um ambiente cooperativo em que o alunos realmente possam conviver democraticamente e isto leva-nos a pensar na estrutura e organização das aulas. Como veremos, as relações tutoriais, a possibilidade da troca entre pares pautada na necessidade de descentração cognitiva e afetiva para que se possa prover formas mais equilibradas de resolver seus conflitos e o papel da avaliação formativa são fundamentais para a construção de atitudes cooperativas. Passemos então a discorrer sobre tal estrutura de uma sala de aula.

2 A organização do trabalho de sala de aula numa visão construtivista

A organização de um dia de trabalho na sala de aula está fundamentada nos pressupostos construtivistas e deve ajustar-se às características específicas de cada turma. Organizar a sala de aula de maneira a garantir a participação efetiva e democrática de todos os envolvidos é tarefa que perpassa pela Educação Infantil ao Ensino Superior e não encontra, apenas em um desses níveis sua eficácia. É necessária a compreensão do desenvolvimento do trabalho diário, considerando a necessidade de os educadores estarem sempre atentos aos aspectos específicos de cada situação. O princípio de toda a organização diária está na construção de uma cultura cooperativa e democrática, fundamentada no respeito mútuo e nos princípios da diversidade e da equidade. Para a organização das aulas devem ser priorizados os seguintes procedimentos didáticos que contribuem para uma aprendizagem cooperativa: planejamento das aulas, atividades coletivas, atividade individual, atividade independente e atividade em pequenos grupos. Além das atividades desenvolvidas no horário de aula, os alunos podem participar das atividades extracurriculares. A utilização desses procedimentos didáticos pode, inicialmente, constituir-se em um trabalho com um certo grau de dificuldade para os educadores e educandos, mas a experiência tem comprovado que após algumas semanas de trabalho estas dificuldades podem ser vencidas adquirindo um grau de eficácia, desde que ambos se organizem e o professor acredite que esta organização possibilita a aprendizagem efetiva.

Podemos nos indagar: quais seriam as etapas para esse processo de reorganização da estrutura de um dia de aula? Uma etapa importante é o **planejamento do professor**. O docente pode organizar seu planejamento em períodos que considerar mais adequado levando em conta o conteúdo a ser desenvolvido. As atividades que ocorrerão durante esse período só poderão ser bem sucedidas a partir da elaboração cuidadosa de um planejamento que tem por finalidade estabelecer os objetivos específicos e os procedimentos que deverão ser utilizados para que estes propostos no Plano de Ensino sejam atingidos.

Para a seleção dos procedimentos didáticos mais eficazes é necessário que o educador busque informações em fontes diversas, tais como: o próprio currículo, livros de diferentes autores, artigos científicos, internet, revistas, Diretrizes Curriculares Nacionais para a Formação de Professores da Educação Básica (2002), materiais estudados nos cursos de Formação Continuada oferecidos pelo Núcleo de Formação das Universidades, entre outros. As atividades selecionadas devem se constituir em boas situações de aprendizagem, desafiadoras e possíveis de serem realizadas pelos alunos, seguindo os princípios estabelecidos por Weisz (2003, p.66): Os alunos precisam pôr em jogo tudo o que sabem e pensam sobre o conteúdo que se quer ensinar; os alunos têm problemas a resolver e decisões a tomar em função do que se propõem produzir; a organização da tarefa pelo professor garante a máxima circulação de informação possível; o conteúdo trabalhado mantém suas características de objeto sociocultural real, sem se transformar em objeto escolar vazio de significado social.

O professor tem um importante papel no desenvolvimento de seus alunos. Cabe a ele, portanto, a tarefa de selecionar e organizar situações que deverão ser propiciadas aos alunos, a fim de que estejam garantidas as condições básicas para que eles se desenvolvam de acordo com suas possibilidades. A sua intervenção é absolutamente necessária tendo em vista que suas incitações podem fazer o aluno refletir sobre suas próprias ações, explicar os fatos que observa e, por conseguinte, caminhar em direção da ampliação do conhecimento.

A seguir, apresentamos explicações sobre alguns procedimentos, destacando os objetivos principais de cada uma deles.

2.1 Planejamento das atividades

Trata-se de um momento coletivo, no qual os alunos juntamente com o professor, decidem sobre o trabalho que será realizado e a sequência em que as diferentes atividades acontecerão. Normalmente, no primeiro momento se discute o plano e a organização das atividades que ocorrerão durante o trabalho a ser desenvolvido, o que denominamos de trabalho em pequenos grupos. O professor explica aos alunos todas as atividades e seus objetivos sendo que todos podem opinar sobre a condução do trabalho. Após esse momento, o professor conduz a organização da pauta de trabalho que deve ser organizada de acordo com a realidade da sala, garantindo que todos os alunos tenham clareza dos objetivos.

Para Mantovani de Assis (2002) o planejamento do dia constitui-se um momento importante, pois neste desenvolvimento os alunos podem: refletir antes de agir e autorregular-se em relação ao tempo e organização das atividades; estabelecer relações entre o pensar, o agir e as consequências de suas escolhas; aprender a organizar-se; tomar decisões e assumi-las com responsabilidade; estabelecer normas, regras e valores; decidir os recursos a serem utilizados para registro das atividades planejadas; desenvolver o respeito mútuo e interação; desenvolver a capacidade de comunicar-se, ouvir, defender e expor ideias.

2.2 Atividades Coletivas

As atividades coletivas se constituem em momentos em que todos os alunos da classe participam conjuntamente de uma tarefa. As atividades coletivas têm por principais finalidades: a troca de diferentes pontos de vista e de opiniões; oportunidade de vivenciar a democracia; apresentação de ideias e de argumentos; e aprendizagem de normas de convivência social. (Mantovani de Assis, 2002)

Geralmente, os alunos iniciam a atividade compondo uma rede de ideias com o objetivo principal de discutir novos conteúdos, revendo alguns aspectos do tema trabalhado e que necessitam da orientação do professor, e acrescentando ainda, novas informações. Esse momento também é oportuno para a discussão de regras e normas de convivência e organização do trabalho, denominada por alguns professores de "contrato didático". Ao final dos trabalhos, os alunos realizam novamente a rede de ideias que comporá a sistematização de conteúdos possibilitando a troca efetiva dos participantes de todos os grupos, momento em que expõem o que aprenderam durante as atividades realizadas.

Algumas atividades também consideradas como coletivas podem ser realizadas em duplas. O professor propõe uma mesma atividade para todos da sala, com dificuldades diferenciadas e os alunos, em duplas, resolvem a tarefa trocando suas opiniões. Geralmente, ao final, o professor propõe a socialização das aprendizagens.

Além do momento de rede de ideias e da atividade em duplas, outros momentos também são considerados como atividades coletivas, tais como: socialização das tarefas, produções diversas, leitura compartilhada, exploração de algum tema da atualidade, dinâmicas de interação social entre os grupos, avaliação dos resultados. A avaliação pode ser realizada também a partir da rede de ideias na qual se discutem as atividades realizadas, como foi a participação de todos, qual o produto final do trabalho, a cooperação entre os participantes, o cumprimento às regras, a iniciativa, a responsabilidade, entre outros.

Nesse momento, alunos e professor poderão reconstituir os acontecimentos vivenciados, evocar e refletir sobre o que sentiram, o que realizaram, como realizaram, o que construíram. É um momento para autoavaliação e permite que os participantes tomem consciência das próprias ações, para que progressivamente se tornem mais responsáveis por elas. Para o professor a autoavaliação é a oportunidade para refletir sobre suas atitudes e práticas pedagógicas. Ao fazer comentários sobre si, o professor demonstra ser capaz de considerar o aluno como igual, dentro de um relacionamento baseado no respeito mútuo. Enfim, a avaliação deverá ter como resultado a transformação de algo considerado pelo grupo como inadequado, sanar falhas, servir de elemento para um replanejamento dos alunos e professor tendo como resultado final a tomada de consciência de suas próprias ações e possibilidades.

2.3 Atendimento Individual

No momento dessa atividade o professor trabalha individualmente com pequenos grupos. Permite ao professor uma interação direta com os alunos tendo a finalidade de acompanhar seus raciocínios e perceber a compreensão que os mesmos possuem sobre o que está sendo trabalhado e, portanto, conhecê-los melhor. Assim, o atendimento individual é proposto pelo professor na tentativa de intervir na defasagem e na dificuldade de aprendizagem dos alunos, com o objetivo principal de ampliar o conhecimento deles. Essa atividade pode ser realizada em qualquer momento no decorrer do semestre e cada professor deve procurar o horário mais adequado para realizá-la. No que diz respeito aos alunos que necessitam de um atendimento mais especializado, o atendimento individual pode ocorrer logo após a sistematização de um conteúdo, após a correção dos trabalhos considerando as dificuldades apresentadas, com auxílio de tutores ou de órgãos especializados oferecidos na Universidade.

2.4 Atividade Independente

A atividade independente tem por objetivo principal desenvolver a responsabilidade, a iniciativa e a autonomia. Oportuniza aos alunos um momento específico em que podem desenvolver qualquer atividade sem a orientação direta do docente. Pode ocorrer em qualquer momento do semestre, sendo que o aluno tem a possibilidade de escolher uma proposta que quer desenvolver dentro de um leque de opções podendo ser realizada individualmente ou em grupo. O professor deve previamente organizar temas relacionados com o objeto de estudo, visando o estabelecimento da relação entre os conhecimentos e a realidade.

2.5 Atividades em pequenos grupos

O trabalho em pequenos grupos contempla atividades diversificadas e o seu desenvolvimento possibilita chegar aos objetivos estabelecidos. Várias são as razões que justificam esse procedimento didático que propicia o desenvolvimento dos aspectos cognitivo, sociomoral e afetivo. Com esse trabalho é possível propiciar aos alunos maiores possibilidades de interação social, de cooperação, de oportunidade de trocas de experiências entre os pares, de aprendizagem da dosagem de tempo, de escolhas e de progressão da autonomia, constituindo-se como uma forma propícia e contínua de construção de conhecimentos. O professor ao planejar as atividades em pequenos grupos, deve estar atento ao conteúdo a ser desenvolvido no semestre e também ao número de aulas semanais. A experiência tem comprovado que essa organização de trabalho realmente é produtiva quando dois aspectos são associados: o primeiro, o professor deve dominar o conteúdo de sua disciplina e a articulação com outras contidas na grade; e o segundo, refere-se à permanência dessa atividade; os alunos só aprenderão a trabalhar em pequenos grupos se todos os dias puderem exercitar os procedimentos necessários para o seu desenvolvimento.

É importante ressaltar que as atividades desenvolvidas durante o trabalho em pequenos grupos apresentam como objetivo principal a construção de novos conhecimentos e não devem ser vistas como exercícios de fixação. Assim, o professor deve realizar o levantamento dos conhecimentos prévios dos alunos para garantir o planejamento de atividades significativas. Para a organização das atividades o professor precisa prever alguns itens importantes:

Planejamento: A escolha das atividades é extremamente importante para o sucesso do trabalho em pequenos grupos. Parte-se primeiramente dos conhecimentos prévios e interesses dos alunos e, a seguir, organiza-se a elaboração do plano da semana considerando a grade curricular e o plano de ensino, como já foi dito. No planejamento das atividades é preciso garantir a sequência da aprendizagem dos conteúdos (levantamento de conhecimentos prévios, desenvolvimento e sistematização dos conhecimentos). Os estilos de atividades são escolhidos de acordo com as características de cada unidade de trabalho: a) orais e escritos – a comanda poderá indicar que os alunos devam trocar opiniões e registrar os temas discutidos; b) resolução de problemas – a comanda indicará um problema para que os alunos entrem em contato com determinados conteúdos contemplados no plano de ensino.

Comandas ou consignas: Após a elaboração do plano, o professor organiza uma comanda para cada proposta de atividade. A comanda deverá explicar de forma clara e objetiva o que os alunos precisam fazer para concluir a atividade.

Fichas de controle: O professor organiza uma ficha de controle em que o líder do grupo anota as atividades já desenvolvidas pelo grupo.

Composição dos grupos: a) quantidade de integrantes: a quantidade de participantes vai depender dos objetivos estabelecidos e do tipo de atividade. Geralmente utiliza-se o de quatro componentes, sendo que o professor pode solicitar trabalho em duplas e posteriores trocas entre os participantes. Esse é um número adequado para a realização de várias atividades, tais como resolução de situações-problema, produção, revisão de textos ou resumos; b) heterogeneidade: é necessário que o professor garanta, diante dos objetivos estabelecidos, a heterogeneidade dos grupos considerando-se os diferentes níveis de aprendizagem de conceitos, de procedimentos ou de atitudes, por exemplo, níveis e ritmos de alunos, alunos mais necessitados, alunos mais comunicativos, alunos que apresentam condutas prossociais. Orienta-se que o professor considere, ao realizar os agrupamentos, que as diferenças entre níveis de conhecimento sejam próximas para que possam ser mais produtivas. Além da organização dos grupos escolhidos por critérios estabelecidos pelo professor, os alunos podem agrupar-se por escolha própria. O professor pode considerar também a heterogeneidade favorecendo grupos mistos considerando o gênero ou idade. É importante garantir a inclusão de todos os alunos valorizando suas habilidades; c) mobilidade: os alunos trabalham em grupos fixos durante a atividade ou após o encerramento de algum conteúdo. Essa não é uma regra fixa, sendo que o professor deve observar a produtividade e as dificuldades de funcionamento de cada grupo, intervindo quando necessário ou organizando novos grupos que garantam uma melhor integração entre os participantes. A oportunidade de contato entre todos os alunos deve ser prevista na organização dos grupos durante o semestre.

Desenvolvimento: Inicialmente, as atividades e/ou conteúdos são apresentados como um todo pelo professor e, durante um determinado período, os alunos desenvolvem as atividades em grupos seguindo orientações da pauta de trabalho. Os alunos trabalham em grupos fixos, sendo que um dos componentes é o líder (escolhido diretamente pelo professor ou pelo próprio grupo ou por meio de um sorteio). É de responsabilidade do líder buscar, guardar e registrar as atividades realizadas na ficha de controle. Existem duas formas de organização do trabalho em pequenos grupos: a primeira que mescla a aprendizagem individual e a aprendizagem cooperativa, sendo que os integrantes do grupo conversam entre si sobre a tarefa a ser desenvolvida, mas cada um realiza sua própria atividade anotando os registros pessoais a partir das trocas estabelecidas; a segunda prioriza o trabalho em grupos operativos que segundo Bonals (2003) define-se como um grupo que realmente compartilha um objetivo comum exercitando-se para operar como uma equipe. Dessa definição infere-se que os integrantes ao participarem dessa dinâmica de trabalho aprendem, além dos conteúdos curriculares, a trabalhar em grupo. Em ambas as organizações é preciso que o professor ao planejar as atividades estabeleça na comanda a necessidade de troca de opiniões para a realização da tarefa e durante o trabalho sensibilize os alunos para a importância da cooperação.

Socialização e sistematização dos conhecimentos: A sistematização dos conhecimentos é uma etapa importante do processo de aprendizagem. Ao final do trabalho, o professor organiza uma rede de ideias para concluir o tema estudado. Nesse momento é importante que o professor resgate todos os procedimentos de registro utilizados pelos alunos. Os alunos devem expor oralmente o que aprenderam e o professor deve estar preparado para coordenar os diferentes pontos de vista e organizar oralmente ou por escrito uma síntese final que agregue os dados e informações. No momento de sistematização também é realizada a avaliação, momento em que o grupo socializa as aprendizagens com os demais grupos e avalia o seu trabalho quanto ao produto, às atividades realizadas, à participação do grupo referentes à organização do trabalho. A avaliação pode ser oral ou escrita, sendo que nesta última o grupo ou o líder registra o processo considerando o início, o desenvolvimento e o final do trabalho. Mas, por que avaliar? Cabe-nos discutir um pouco mais esse aspecto presente na relação ensino-aprendizagem que na verdade, não corresponde a um fechamento de ciclo, mas a uma exigência de repensar a própria prática educativa do professor e não só dele, mas de todos os envolvidos nesse processo.

3 Não existe planejamento e execução sem avaliação: uma prática de cooperação se permite pensar, reconstituir, antecipar....participar

Um aspecto importante a ser considerado no processo de ensino e aprendizagem é a avaliação. Por um lado, a finalidade básica da avaliação é a de servir como instrumento para a intervenção considerando a tomada de decisões educativas e a observação da evolução do processo de desenvolvimento da criança, para garantir a todos os alunos a possibilidade de vivenciarem experiências de sucesso. Por outro, é oportunidade de quem é de direito, o próprio aprendiz, da tomada de consciência do que já sabe e do que ainda não sabe – sejam conteúdos de conhecimento ou sejam nas relações interpessoais. Enquanto processo, se sistematizada, podemos destacar três tipos de avaliação - inicial ou diagnóstica, formativa e somativa (Luckesi, 2005) - devem permear o processo de ensino e aprendizagem. A avaliação inicial ou diagnóstica informa sobre o conhecimento e as capacidades dos alunos em relação aos novos conteúdos de aprendizagem, denominado de conhecimentos prévios.

A avaliação diagnóstica tem por objetivo principal ajustar, modificar ou programar melhoras nas atividades que haviam sido preparadas. A avaliação diagnóstica é realizada no início do ano, denominado de período de sondagem ou ao iniciar um novo conteúdo para identificar o que os alunos já sabem e o que ainda precisam aprender. É importante ressaltar que o período de sondagem acontece conjuntamente com o desenvolvimento de atividades da rotina diária. Durante o desenvolvimento das atividades é realizada a avaliação formativa, ou seja, o professor observa e acompanha as estratégias utilizadas pelos alunos, os erros e dificuldades bem como o avanço em suas aprendizagens. Damos ênfase a esse tipo de avaliação por entendermos que ela é promotora de novas aprendizagens, tanto conceituais como procedimentais e atitudinais. Tal forma possibilita, durante sua interlocução, o verdadeiro diálogo entre docente e discente, no qual ambos podem se posicionar a respeito das aprendizagens, das suas conquistas e de suas dificuldades, como agentes do próprio conhecimento. Fernandes (2006) considera a avaliação formativa como um processo pedagógico interativo, e associado à didática com a função de conseguir que os alunos aprendam melhor a partir de uma redefinição de papeis dos decentes e discentes.

O terceiro tipo de avaliação, chamada de somativa, é realizada ao final de um processo de ensino e aprendizagem com a finalidade de registrar as informações sobre o que os alunos aprenderam em relação aos conteúdos. Assim como as outras formas de avaliação, tem por função indicar em que ponto o professor precisa replanejar o processo de ensino (Bassedas, Huguet, & Solé, 1999), quais os objetivos educacionais que foram traçados para as aprendizagens, do ponto de vista dos alunos, e se foram atingidos ou não.

Assim, estabelecer critérios precisos a partir dos conteúdos de todos os campos do conhecimento - conceituais, procedimentais e atitudinais – pode ajudar o professor a identificar o que é preciso observar nos procedimentos executados pelos alunos. Dessa forma, a partir dos dados coletados, podem-se estabelecer metas, ações e intervenções pedagógicas pensando em quais demandas de ensino (introduzir, trabalhar ou avançar para novos conteúdos/atividades) serão necessárias para ajudar o aluno a avançar em seus conhecimentos. Obviamente, a documentação para justificar as observações e a avaliação realizadas pelo professor são necessárias.

Todos os encaminhamentos de um dia de trabalho apresentados até aqui nos permitem pensar os pressupostos de um ambiente cooperativo que permitam contribuir para a formação de sujeitos atuantes em sua própria educação. São aspectos que se referem não somente ao trabalho com o conhecimento, mas também às formas pelas quais os sujeitos se relacionam. Contudo, parece-nos relevante acentuar ainda, nesse contexto dois pontos básicos para pensar a aprendizagem cooperativa: o papel do professor e os benefícios da tutoria, uma forma de relação entre pares.

4 A convivência num espaço participativo: a relação com o professor e a relação entre pares na perspectiva construtivista – quem são os tutores?

Todos sabemos da exigência da presença de um professor que conheça mais, que saiba dos princípios que sustentam as regras pelas quais vale lutar, que entenda de desenvolvimento humano a ponto de saber intervir de forma a garantir a construção do conhecimento. Contudo, diferentes pesquisas têm demonstrado a necessidade de que a relação entre pares também esteja presente todo o tempo já que é pela possibilidade de se descentrar e trocar pontos de vista que um conhecimento pode ser construído. Por exemplo, ao tratar da dinâmica de trabalho em pequenos grupos, é papel do professor criar boas condições de aprendizagem e acompanhar os grupos, sendo que ele "poderá propor a utilização de uma série de procedimentos para serem praticados nos grupos, principalmente naqueles em que seja necessário re-orientar, ou cujo procedimento de trabalho se deva aperfeiçoar" (Bonals, 2003, p. 39). Isso significa dizer, que não se tira o trabalho do professor quando se quer de fato a cooperação, mas ele age como um coordenador, aquele que observa e intervém para explorar o que os alunos estão fazendo, propondo-lhes novos desafios, fazendo-os refletir, pesquisar, trocar opiniões e perceber que é preciso comprovar as descobertas ao término da atividade. O professor, na verdade, não é um igual no sentido de permitir que o conhecimento do aluno perpetue da mesma forma. Ele é um interventor, tanto no sentido do conhecimento como no sentido das relações interpessoais. Da mesma forma, o papel do professor, enquanto autoridade, nas relações interpessoais não é o de resolver os conflitos, mas o de mediar e permitir que crianças e adolescentes possam resolver seus problemas de forma a tomar consciência da necessidade do outro, de suas angústias assim como transformar em formas mais equilibradas as angústias ou outros sentimentos que o levam a agir mal. Mas ele não é o único a educar. Muito se aprende com os iguais, o que nos parece relevante destacar.

Dessa forma, a relação tutorial que se propõe enquanto um trabalho em que os próprios alunos possam se autorregular, tem se apresentado no cenário educacional como algo a ser incentivado, e que tem respaldo em teorias psicológicas que trazem como princípio a aprendizagem entre pares ou aprendizagem entre pessoas com níveis de conhecimentos diferenciados. Esse procedimento já era destacado desde o século XIX, a partir de diversas necessidades: política – escolaridade obrigatória e gratuita -, econômica ou precariedade de recursos pessoais. A falta de adultos preparados para atender uma população maior de estudantes, favoreceu a prática de alunos com maior nível de conhecimento em determinado conteúdo em ensinar outros, ou ainda, a se organizar grupos de alunos que pudessem desenvolver atividades escolares com certa autonomia. (Enesco, 1991)

Contudo, não é pela falta de autoridades que temos a necessidade de uma relação tutorial e sim pelos ganhos que se pode ter quando um igual passa a ensinar ou a desequilibrar o outro para que um conhecimento seja construído. Numa relação tutorial, um aluno com maior nível de conhecimento auxilia outros alunos com um nível de conhecimento inferior em determinada área. A relação tutorial pode se dar espontaneamente, quando um aluno auxilia o outro em sala de aula, ou ser planejada, sendo que os tutores são previamente selecionados e orientados sobre o que e como ensinar. Embora com conhecimentos diferenciados, a relação entre tutor e tutorado pode ser considerada mais simétrica quando comparada com a relação professor-aluno, podendo favorecer um ambiente com maior diálogo e trocas efetivas.

Entretanto, algumas condições precisam ser preservadas na relação tutorial: 1) o tutor deve organizar as instruções de como o tutorado deve proceder a atividade a ser desenvolvida, ou seja, deve ser um bom comunicador; 2) organização de sequências didáticas com níveis de complexidades diferenciados; 3) a relação entre tutor e tutorado é muito importante; a aceitação de ambos pode ser fator decisivo para a aprendizagem; 4) as situações de conflito cognitivos podem favorecer a aprendizagem. Isso significa dizer que na verdade, não se transfere o poder da autoridade do professor para o tutor visto que ele ainda será um par. Alertamos para tal discussão, pois muitas escolas tendem a adotar a tutoria como uma forma de "supervisão" ou de "controle" de uns sobre os outros, o que pouco favorecerá ao desenvolvimento moral de crianças e adolescentes.

Quem recebe os benefícios dessa relação, tutor ou tutorado? Iniciemos pelo papel do tutor. Se entendermos que ao ensinar, o tutor precisa reorganizar seus conhecimentos e que a própria situação de ensino pode promover conflitos cognitivos e favorecer o processo de tomada de consciência, entende-se que há muitos benefícios ao se dispor a ser um tutor. Com certeza, a relação de aprendizagem é muito diferente quando estuda-se para aprender ou quando estuda-se para ensinar determinado conteúdo. Segundo Enesco (1991, p.69) "muitos estudos mostram precisamente que os progressos do tutor são de natureza **reestruturante".**

Quanto ao tutorado, vários fatores podem intervir em novas aquisições de conhecimento. Em primeiro lugar, o tutorado realmente precisa querer aprender o conteúdo a ser ensinado e, se as condições forem favoráveis, certamente, a proximidade dos conhecimentos pode favorecer a aprendizagem. Contudo, ambos podem ter prejuizos se a tutoria, como já dissemos, se tornar uma forma de autoritarismo na escola transferido aos pares fato que não permitiria a formação de pessoas autônomas.

5 Tecendo algumas considerações

Considerando que a transmissão direta pelo professor é pouco eficaz para a compreensão e tomada de consciência dos conhecimentos científicos e mesmo referentes às relações interpessoais e à sensibilidade moral necessária a se respeitar os outros e a si mesmo, todas as ações constitutivas do ambiente democrático podem permitir que de fato, se formem personalidades éticas capazes. Os procedimentos práticos construídos ao longo de vários anos pelas pesquisadoras que se dedicam ao Ensino Básico e Superior, refletidos neste artigo parecem-nos dar corpo ao que diferentes pesquisas nas diversas ciências têm encontrado como respostas a como se forma para a cidadania. Assim, sabemos que cada aluno apresenta particularidades e se encontra em um determinado estágio de aprendizagem, assim como, cada educador se encontra em um estágio de desenvolvimento de sua prática pedagógica. Alguns professores estão iniciando seu trabalho e necessitam mais da troca com outros professores e com o coordenador pedagógico. Outros, que já desenvolvem o trabalho podem colaborar com as trocas e, ao mesmo tempo, enriquecer sua prática. Portanto, a transformação das relações estabelecidas nesse ambiente, bem como a implmementação de tais práticas, não é tarefa fácil.

Tais discussões também corroboram a superação de grandes equívocos presentes no cotidiano dos professores quanto aos processos pedagógicos. Um equívoco muito comum é o de acreditar que o trabalho em grupo, um pressuposto construtivista que contempla a necessidade da relação entre pares, é possível apenas ao se colocar os alunos sentados juntos. Por certo, as propostas ou organização das atividades a serem oferecidas precisam suscitar a necessidade da troca de opiniões e a colaboração entre os participantes. É preciso lembrar que todas as rotinas citadas só se tornarão procedimentos didáticos eficazes quando atenderem aos princípios subjacentes às concepções de que deve haver por parte do sujeito uma construção. Isso significa que só terão efeito quando houver preparação de atividades desafiadoras, quando tais propostas atenderem as necessidades dos alunos; quando houver uma intervenção efetiva e consciente do professor e quando ele reconhecer a importância do trabalho coletivo e quando alunos e professores tiverem espaços garantidos para o diálogo e as relações de confiança.

Nesse sentido, superar também a linguagem da escola tradicional que preconiza a competição e sua ênfase no processo de instrução acadêmica é uma urgente necessidade. A escola deixa a desejar, quando perde a transversalidade dos valores, quando pensa apenas em ações pontuais para a superação dos problemas nas relações interpessoais. Isso acontece porque uma pedagogia que assegure a implicação ativa dos alunos em torno da cooperação e da participação democrática na escola, com um currículo estruturado para tal, permitiria projetar o "espírito" cooperativo para além dos muros escolares, ampliando para outras instituições educativas formais ou não formais os laços cooperativos. Isso é que esperamos quando acreditamos na educação!

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Ensino de Informática de Gestão com recurso a simulação empresarial

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Abstract

This teaching project aims to introduce the Management Software key issues with particular focus on practical use of software for management support. Initially students are challenged to build a business plan and from the hypothetical implementation of a new company and then to implement computer applications necessary to support the business. These include applications for: general and analytical accounting, assets management, sales management and billing, purchasing and supplier management, Human Resources Management and Inventory Management.

This approach gives students a better understanding of organizational issues and the role of information technology in business support.

Keywords: Management Information Systems, Education, Case Study.

1 Introdução

Os Sistemas de Informação constituem uma importante área do saber nas Tecnologias da Informação, cada vez mais procurada pelas empresas, assumindo um papel decisivo e estratégico no seu sucesso (Trigo 2009).

À medida que a adopção de Tecnologias de Informação pelas organizações, de todas a dimensões e ramos de actividade se tem vindo a vulgarizar, o papel do profissional de Sistema de Informação tem, também, vindo a ganhar importância.

Uma vez que a informação está omnipresente em toda a realidade organizacional, a Gestão dos Sistemas de Informação cruza-se com toda a estrutura da organização, em qualquer dos níveis de gestão e operação, e em qualquer das áreas funcionais. Por esta razão o perfil de um gestor de Sistemas de Informação, desejavelmente, deve ser híbrido: por um lado conhecedor do negócio e por outro técnico (Amaral & Varajão, 2000).

Os profissionais de Sistemas de Informação devem ser capazes de, interagindo com as diferentes áreas da organização, analisar problemas e propor soluções criativas que ajudem a melhorar o desempenho da Organização. Para, tal o profissional de Sistemas de Informação deve ter competências que lhe permitam analisar, planear e organizar o processamento, o armazenamento e recuperação da informação e disponibilizá-la aos utilizadores.

A sua função principal é analisar e compreender os problemas das organizações e os tentar endereçar encontrando soluções com recurso das Tecnologias de Informação, através de ferramentas disponíveis no mercado ou produzindo os seus próprios sistemas.

Embora seja uma profissão relativamente nova, já conquistou um espaço relevante no mercado de trabalho (Peppard 2011). O perfil dos profissionais de Sistemas de Informação reúne conhecimentos de diversas áreas gestão, economia, tecnologias da Informação, ampliando a sua versatilidade e abrindo um leque de oportunidades de evolução.

As empresas sentem a necessidade de ter profissionais capazes de pensar, adaptar, construir, gerir sistemas de informação adequados aos seus negócios. O ensino da denominada área de "Informática de Gestão", tem por objectivo preparar profissionais e quadros para suportar situações de trabalho organizacional e a definição, instalação, configuração e manutenção de aplicações informáticas de gestão e projectos de mudança organizacional que visem melhorar o funcionamento da organização pelo aproveitamento das potencialidades das Tecnologias da Informação e das suas aplicações.

Acompanhar a evolução do perfil profissional de Sistemas de Informação, enquadrar a "Informática de Gestão" e perceber quais serão a melhores estratégias para o ensino prático e efectivo da utilização prática de aplicações informáticas de apoio à Gestão parece ser uma questão relevante.

O presente artigo, para além desta secção introdutória, estrutura-se em quatro outras secções: Sobre ensino da Informática de Gestão, A experiência pedagógica e Conclusões e trabalho futuro..

2 Sobre ensino da Informática de Gestão

Frequentemente, no final dos cursos de Sistemas de Informação, os alunos tem um bom conhecimento teórico sobre tecnologias e sistema de Informação mas, fruto do baixo ou inexistente contacto com a vida das organizações, um reduzido conhecimento sobre os contextos empresariais e sobre os reais desafios à aplicação de tecnologias na organizações.

Isto é especialmente importante porque os empregadores valorizam cada vez o "saber fazer" e não apenas os conhecimentos teóricos (Hoerner & Wehrley, 1995, O'Reilly, 1993). Não se trata apenas de capacidades técnicas de resolução de problemas ou de configuração de aplicações de suporte à gestão. Os alunos devem também desenvolver outros atributos como são exemplo os conhecimentos sobre contabilidade, gestão de salários, gestão de stocks, que são altamente valorizados no mundo do trabalho. Estes conhecimentos, podem ser melhor consolidados através de actividades práticas. Cribbs refere não haver dúvidas de que a aprendizagem de prática é importante, tanto na sala de aula como em outros ambientes de aprendizagem (Cribbs, 2000; Finlay & Marples, 1998; Yarks, 2000).

Na tentativa de proporcionar aos alunos experiências de aplicação significativa, de ferramentas informáticas de suporte à gestão, introduzimos, na Unidade Curricular "Informática de Gestão" do 2ª ano do primeiro ciclo em Tecnologias da Comunicação e Informação, uma estratégia predominantemente prática para o ensino da Informática de Gestão.

3 A experiência pedagógica

A Unidade Curricular "Informática de Gestão" tem como principais objectivos dotar os participantes com conhecimentos sobre a utilização e integração nas empresas dos principais tipos de aplicações de apoio à gestão.

No nosso entender tal objectivo dificilmente poderia ser atingido na sua plenitude apenas através de exposições teóricas e de demonstrações de "produto" uma vez que o alinhamento entre as aplicações informáticas e as organizações varia de caso para caso, de ramo de actividade para ramo de actividade e está, normalmente, sujeito às idiossincrasias de cada organização.

Com base nesta convicção tomou-se a opção de se introduzir as questões essenciais da Unidade Curricular com quase total enfoque na utilização prática de aplicações informáticas de apoio à Gestão.

Inicialmente os alunos foram desafiados a construir um plano de negócio e a partir da hipotética concretização da nova empresa a implementar as aplicações informáticas necessárias ao suporte do negócio, nomeadamente: aplicações de Contabilidade geral e analítica; Gestão de Imobilizado; Gestão de Vendas e Facturação; Gestão de contas correntes; Gestão de compras e fornecedores; Gestão de Pessoal e salários e Gestão de Stocks.

Na elaboração do plano de negócios de uma empresa exemplo em Excel foi pedido aos alunos que antecipassem o Capital Social, os Recursos Humanos a contratar, o investimento em bens imóveis (por exemplo em computadores) e em bens não duradouros. Tal como se exemplifica na Figura 1. Este Plano de negócios constituiu o primeiro elemento de avaliação na disciplina.

Plano de Negócios (a 5 anos)					
Receitas	Ano 1	Ano 2	Ano 3	Ano 4	Ano 5
Prestação de Serviços					
Distribuição de Publicidade	12.500,00 €	20.000,00 €	25.000,00 €	37.500,00 €	37.500,00 €
Distribuição de Correspondência	10.000,00 €	24.000,00 €	63.000,00 €	75.650,40 €	75.650,40 €
Distribuição de Encomendas	34.146,00 €	34.146,00 €	34.146,00 €	34.146,00 €	34.146,00 €
TOTAL	**56.646,00 €**	**78.146,00 €**	**122.146,00 €**	**147.296,40 €**	**147.296,40 €**
Despesas					
Recursos Humanos					
Funcionario 1	9.800,00 €	9.800,00 €	9.800,00 €	9.800,00 €	9.800,00 €
Funcionario 2	8.400,00 €	8.400,00 €	8.400,00 €	8.400,00 €	8.400,00 €
Funcionario 3	9.600,00 €	9.600,00 €	9.600,00 €	9.600,00 €	9.600,00 €
Funcionario 4	9.100,00 €	9.100,00 €	9.100,00 €	9.100,00 €	9.100,00 €
Funcionario 5	9.100,00 €	9.100,00 €	9.100,00 €	9.100,00 €	9.100,00 €
Funcionario 6	9.380,00 €	9.380,00 €	9.380,00 €	9.380,00 €	9.380,00 €
Funcionario 7	9.100,00 €	9.100,00 €	9.100,00 €	9.100,00 €	9.100,00 €
Funcionario 8	7.812,00 €	7.812,00 €	7.812,00 €	7.812,00 €	7.812,00 €
Funcionario 9	7.812,00 €	7.812,00 €	7.812,00 €	7.812,00 €	7.812,00 €
Veiculos					
Veiculo 1	3.000,00 €	3.000,00 €	3.000,00 €	3.000,00 €	3.000,00 €
veiculo 2	2.880,00 €	2.880,00 €	2.880,00 €	2.880,00 €	2.880,00 €
veiculo 3	7.010,00 €	7.010,00 €	7.010,00 €	7.010,00 €	3.860,00 €
veiculo 4	6.170,00 €	6.170,00 €	6.170,00 €	6.170,00 €	3.770,00 €
veiculo 5	6.170,00 €	6.170,00 €	6.170,00 €	6.170,00 €	3.770,00 €
veiculo 6	6.170,00 €	6.170,00 €	6.170,00 €	6.170,00 €	3.770,00 €
veiculo 7	5.520,00 €	5.520,00 €	\	5.520,00 €	5.520,00 €
veiculo 8	8.280,00 €	8.280,00 €	8.280,00 €	8.280,00 €	8.280,00 €
TOTAL	**125.304,00 €**	**125.304,00 €**	**119.784,00 €**	**125.304,00 €**	**114.954,00 €**
Lucro Anual	**- 68.658,00 €**	**- 47.158,00 €**	**2.362,00 €**	**21.992,40 €**	**32.342,40 €**

Figura 1 - Exemplo de Plano de Negócios

Em seguida, após uma breve explicação sobre os rudimentos da Contabilidade Geral iniciou-se a experimentação de uma aplicação de gestão contabilística - neste caso o SAGE – procedendo à abertura do POC em consonância com os dados do plano de negócios e à realização de lançamentos contabilísticos também em consonância com plano (por exemplo – os referentes à compra do Computador).

Na figura 2 apresenta-se um dos ecrãs da aplicação de gestão contabilística.

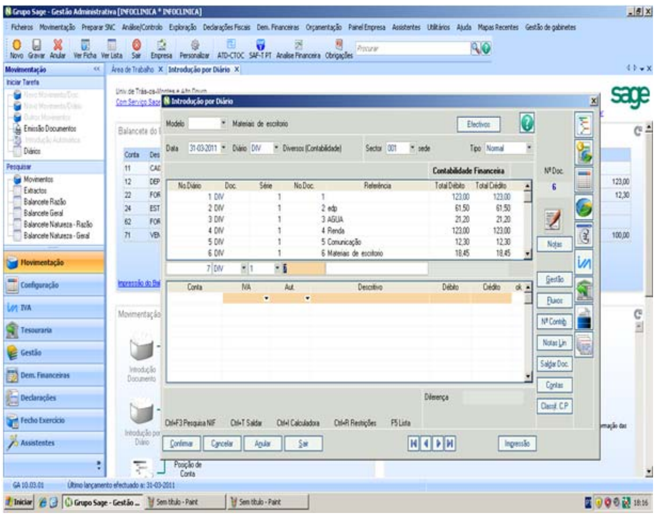

Figura 2 - Exemplo de ecrã da aplicação de gestão contabilística

Após a utilização da aplicação de gestão contabilística passou-se à experimentação da aplicação gestão de recursos humanos, procedendo à abertura de registos pessoais em consonância com os dados do plano e ao processamento de salários. Na figura 3 apresenta-se um dos ecrãs da aplicação de recursos humanos.

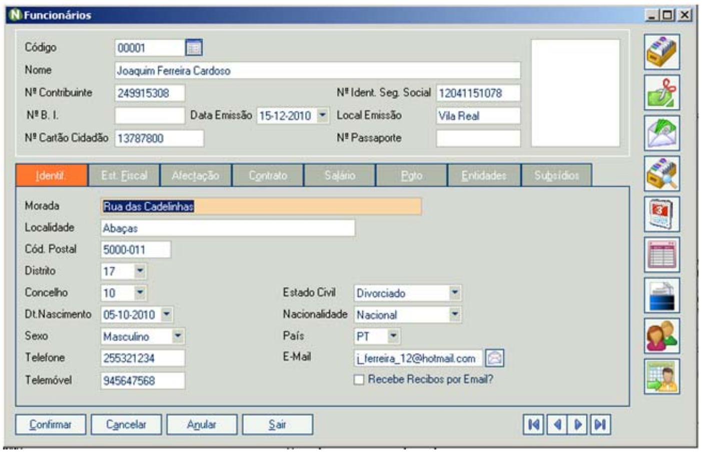

Figura 3- Exemplo de ecrã da aplicação de gestão de recursos humanos

O mesmo procedimento foi utilizado na experimentação de aplicação gestão de imobilizado onde ser realizou a abertura de registos de Imobilizado, também de forma coerente com o plano de negócios e efectivou-se o processamento de amortizações.

Na figura 4 apresenta-se um dos ecrãs da aplicação de gestão de imobilizado.

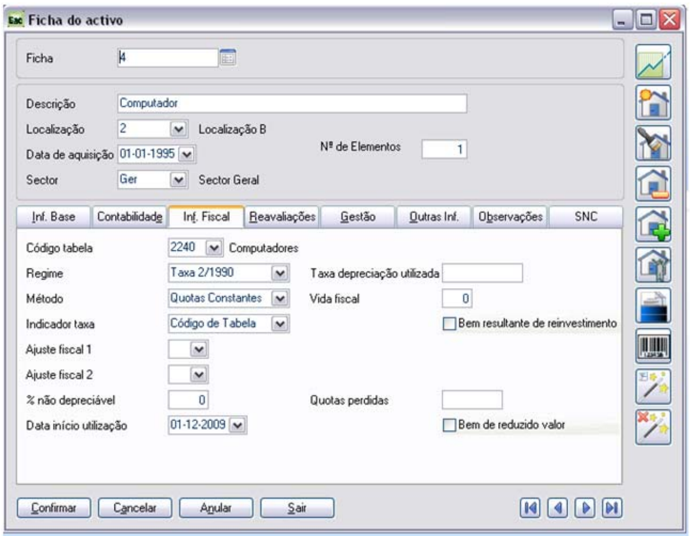

Figura 4 – Exemplo de ecrã da aplicação de gestão de imobilizado

Finalmente, os alunos realizaram uma experimentação de utilização da aplicação gestão de vendas procedendo à abertura de registos de Clientes e exemplos de processamento de venda.

Apresentamos um dos ecrãs da aplicação de gestão de vendas na figura 5.

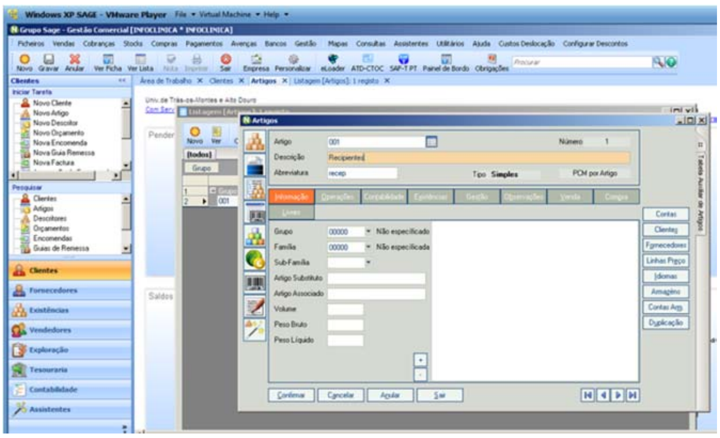

Figura 5 – Exemplo de ecrã da aplicação de gestão de vendas

Foi pedido aos alunos que entregassem no final de todas as etapas um relatório que ilustrasse a utilização que tinham feito das diferentes aplicações ao serviço da sua empresa fictícia. A avaliação destes relatórios teve um peso de 70% na nota final da disciplina sendo os restantes 30% foram obtidos através de uma prova teórica onde se procurou apurar a capacidade dos alunos reflectirem sobre a utilização deste tipo de aplicações ao serviço das organizações.

4 Conclusões e trabalho futuro

Com este artigo, pretende-se contribuir para o debate o ensino da Informática de Gestão propondo um modelo com particular enfoque na utilização prática de aplicações informáticas de apoio à Gestão. O modelo estrutura-se na simulação de uma empresa e na implementação prática de diferentes aplicações informáticas necessárias ao suporte do negócio da empresa como são exemplo: aplicações de Contabilidade geral e analítica; Gestão de Imobilizado; Gestão de Vendas e Facturação; Gestão de contas correntes; Gestão de compras e fornecedores; Gestão de Pessoal e salários e Gestão de Stocks.

Face ao bom *feedback* obtido por parte dos alunos e ao sucesso da avaliação tudo indica que esta abordagem confere aos estudantes uma melhor compreensão das problemáticas organizacionais e do papel da informática no suporte à vida das empresas.

Como trabalho futuro aponta-se o refinamento do modelo e extensão da sua aplicação ao ensino de outras aplicações de suporte à gestão como são o caso das aplicações de CRM e de comércio electrónico.

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Paper Session C3

Análise da capacitação docente dos professores do curso de Engenharia Biomédica da PUC – SP na implementação da aprendizagem baseada em problemas

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Abstract

The aim of this work is to carry out a study and an analysis about the training processes used by the staff of the engineering biomedical course at PUC-SP in order to give the teachers' background. This is the first course in engineering education at Brazil that uses the PBL methodology. The change in the method of teaching is the great challenge faced by the staff and teachers. It is very important to know how the educators are inserted in this new educational context. How to prepare the engineers to solve all kind of problems, willing to work with technologies not yet invented, manage companies that are springing up at an extremely fast rate, as well as have oral and written communication skills beyond been able to work on teams? Thus, new teaching tools and methodologies must be adopted. Based on this reality it is necessary to invest in the teachers' training in order to obtain the expected results in the teaching and learning processes.

In order to obtain all the information about the dynamic of the course, a qualitative research through open questions it was applied at the staff and teachers. The diagnostic of their challenges, difficulties and needs to implement the PBL methodology on an engineering course will be analyzed.

Keywords: active methodology, engineering education, educators, problem based learning

1 Introdução

1.1 O Ensino Superior no Brasil

Segundo Masetto (2003), o modelo de ensino superior no Brasil teve sua origem com a vinda da família real portuguesa, no ano de 1808, e seguia na época o modelo de universidade da França. Não se priorizava a integração das disciplinas, era um modelo fechado de prática curricular.

Os currículos eram inflexíveis, compactados, fragmentados determinando a impossibilidade de mudanças, o que se estendeu por um longo período de tempo. Estes, nunca tiveram o objetivo de inovação, longe disto, sempre foram mantenedores de uma estrutura rígida.

O conhecimento estava centralizado na universidade, onde os professores o transmitiam aos alunos através da atualização da ciência, agregado ao conjunto de experiência profissional de mais sucesso. Na época estes eram os pré-requisitos para ocupar o cargo de docente. Para os candidatos ao professorado se exigia apenas, o bacharelado e a prática competente de sua profissão.

Desta maneira, os professores eram considerados sujeitos especialistas, onde eram apresentados aos alunos como a última instância do conhecimento.

Neste cenário para desenvolver as práticas educativas, não se julgava necessário o reconhecimento de outra habilidade e competência que não fosse ministrar o conteúdo da disciplina na sala de aula, e ao final do processo a aplicação de avaliação para certificar que os alunos estavam aptos para prosseguirem no curso.

As transformações sócio-econômicas e políticas abriram caminho para uma nova demanda social que tem acesso, atualmente, ao ensino superior. Muitas instituições emergiram nesse contexto educacional e muitos profissionais estão sendo solicitados, mas devemos refletir sobre a qualidade deste ensino e tudo que o envolve, como os seus participantes: universidade, professor e aluno.

O ensino superior atual no Brasil, na maioria das instituições, ainda está baseado na metodologia de ensino centrada no professor, onde a transmissão do conhecimento ocorre de maneira linear. Os currículos atuais estão estruturados de uma maneira que os conhecimentos estão compartimentados em disciplinas estanques, não atendendo as demandas em razão da multidisciplinaridade da formação exigida dos novos profissionais.

1.2 Papel docente no atual contexto da educação

De acordo com Feldmann (2003, p. 149)

> *"o professor do século XXI, necessita mudar sua postura perante o conhecimento. De pretenso dono do saber, o educador passa a ser um mediador entre o conhecimento sistematizado e as necessidades dos alunos, na possibilidade de ampliar e diversificar formas de interagir e compartilhar experiências em novos tempos e espaços".*

Hoje, alguns aspectos devem ser levados em consideração juntamente com o papel do professor, tais como: questões da diversidade, as novas tecnologias, a sustentabilidade, a responsabilidade social e a globalização. A sociedade contemporânea, dita também sociedade do conhecimento, está transformando de maneira urgente os padrões estabelecidos como insuperáveis.

A globalização, fenômeno que envolve alterações significativas na vida humana, implica numa série de fatores como: a ligação entre a economia mundial e os avanços tecnológicos, diferentes culturas e sociedades, comunicação, ética, políticas locais, regionais e mundiais. Todos estes aspectos influenciam direta e indiretamente os rumos da educação neste século, sejam em relação às metodologias de ensino, aos currículos, políticas públicas, avaliação e principalmente à formação docente dentro da nova realidade.

Segundo Nóvoa (2009), os princípios que devem nortear a capacitação docente e o desenvolvimento profissional dos professores são: perspectiva de aprendizagem ao longo da vida, atenção aos anos iniciais da profissão e inserção de jovens professores nas escolas, valorização do professor reflexivo e do trabalho em equipe, acompanhamento e supervisão destes docentes.

Neste contexto compete aos docentes de todos os níveis da educação: se reinventar, inovar, criar, transformar o conhecimento em algo interdisciplinar, que integre não somente as ações, mas também os seus agentes. É preciso entender estas transformações como positivas e inerentes ao processo de formação docente para atender as demandas do mundo globalizado.

1.3 O ensino de engenharia no Brasil

Até o início da década de 1990, as áreas de graduação em engenharia, no Brasil, eram regulamentadas pela Resolução 48/76 do Conselho Federal de Educação (CFE/MEC/1976), que introduziu o currículo mínimo para cada uma das seis grandes áreas de habilitação: Civil, Elétrica, Mecânica, Química, Minas e Metalurgia. Embora esta estrutura admitisse alguma flexibilidade através das habilitações com ênfases específicas, e ainda através de algumas habilitações especializadas derivadas das áreas básicas, a Resolução 48/76 tornou-se inadequada para as novas exigências sócio-econômicas e precisava ser substituída por um instrumento mais flexível, de forma a permitir a formação de engenheiros que pudessem seguir mais de perto as evoluções tecnológicas e as necessidades do mercado de trabalho.

Na década de 1990 e decorrente da necessidade de atualização do perfil profissional do engenheiro, a Comissão de Especialistas em Ensino de Engenharia do Ministério de Educação (MEC) apresentou, em relatório de 1993, um conjunto de características que tornaria à época, e com muita pertinência para os tempos atuais, o perfil geral desejado dos engenheiros: cultura científica, sólido conhecimento básico, cultura geral, preocupação social, adaptação às situações de demanda, habilidade e criatividade para enfrentar situações novas, capacidade de atualização contínua, interpretações dos fatos da natureza e das organizações e consciência de ser agente da evolução econômico social. Estas características refletiam a preocupação com a integração da formação técnica e humana do engenheiro, e de suas possibilidades de atualização e enfrentamento de novas situações e desafios. Atendendo este esforço de atualização do ensino de engenharia, em 2002 foram aprovadas as Diretrizes Curriculares Nacionais para a Engenharia (CNE/CES, 2001), consideradas avançadas no campo da educação (Campos, Manrique, Dirani, 2011).

Essas diretrizes, se efetivamente aplicadas, promoveriam mudanças nos currículos que poderiam resolver as deficiências já encontradas à época e citadas em documento da Confederação Nacional da Indústria (CNI, 2006).

1.4 Aprendizagem baseada em problemas na PUC-SP

Atenta às perspectivas de mudanças na educação a metodologia Aprendizagem Baseada em Problemas (PBL) se apresenta como uma alternativa para potencializar a aprendizagem, permitindo aos alunos o desenvolvimento das competências e habilidades exigidas pela sociedade do conhecimento e aos docentes a responsabilidade para a formação de um novo profissional.

Nesta metodologia extingue-se o foco da figura central do professor como detentor do conhecimento, transferindo a aprendizagem para a prática de solução de problemas do cotidiano pelos alunos. Além disso, ela contempla o princípio educativo de que pesquisar é um processo básico para uma educação emancipatória, capacitando os aprendizes a resolver, no futuro, problemas complexos (Freire, 1996).

No Brasil as primeiras instituições que adotaram a metodologia PBL foram a Faculdade de Medicina de Marília, em 1997, e a Faculdade de Ciências Médicas da Universidade Estadual de Londrina, em 1998, para os cursos de medicina.

Na Pontifícia Universidade Católica de São Paulo – PUC/SP, atualmente existem três cursos de graduação adotando essa metodologia: Medicina (2006), Enfermagem (2007) e Engenharia Biomédica (2009), sendo este último o primeiro curso de engenharia no Brasil a adotar a metodologia.

1.5 O projeto de um curso de engenharia em PBL no Brasil

O ensino tradicional de engenharia no Brasil não atende às novas demandas das necessidades profissionais do mundo globalizado. A metodologia PBL apresenta um modelo de aprendizagem mais participativa, mais atrativa para os alunos e centrada na aquisição de competências transversais associadas ao conhecimento especializado. Dentro deste contexto foi criado o curso de Engenharia Biomédica da PUC/SP utilizando-se a metodologia Aprendizagem Baseada em Problemas (PBL). A proposta do curso nasceu de um estudo estratégico de mercado visando atender a necessidade de profissionais com habilidades em ciências exatas, conhecimentos dos fundamentos das ciências da saúde, conhecimento de gestão e de conteúdos disciplinares diferentes interligados na busca de uma formação humanista, integral com ênfase na moral, na ética e na responsabilidade social e preocupação com a sustentabilidade do planeta.

Na metodologia adotada, o ensino está centrado no aluno e não no professor, e há uma forte ligação com os problemas reais da profissão, das necessidades da sociedade e das empresas. A proposta curricular deixa de ser organizada por disciplinas e passa a priorizar uma organização multidisciplinar em módulos, permitindo a inter e a transdisciplinaridade. Este fato levou à escolha das áreas temáticas propostas para o curso, contemplando as áreas de atividades para os engenheiros biomédicos, de acordo com a Sociedade Brasileira de Engenharia Biomédica (SBEB, 2007).

O curso está estruturado em cinco áreas temáticas, que são tratadas de maneira progressiva, complementar e integradas (Campos, Manrique, Dirani, 2010). Os conteúdos estão distribuídos em diferentes problemas produzidos para, durante a discussão em grupo, fazer com que eles sejam identificados pelos estudantes no estudo dirigido.

O projeto pedagógico do curso estabeleceu os tutores como a espinha dorsal do curso. Para ser um tutor deve-se adquirir um conjunto de novas habilidades diferentes daquelas de um professor que ensina vários assuntos na forma de aulas expositivas. Ele precisa mudar a postura e guiar os estudantes ao longo do processo de aprendizagem, permitindo que eles determinem o que precisam aprender e ao mesmo tempo busquem os recursos oferecidos pela instituição para a solução dos problemas propostos. Existem muitos desafios relacionados com os novos papeis dos tutores em termos da implementação do curso. Assim como a maioria dos professores universitários, as suas graduações não se envolvem com questões de natureza didática e pedagógica. Dessa forma, os professores interessados em desenvolver as atividades inerentes à metodologia PBL devem ser capacitados/treinados, num ambiente propício para a aquisição das competências tutoriais, mediante oficinas e seminários. Esse trabalho de qualificação permite desenvolver nos docentes a consciência de repensar as habilidades necessárias para uma educação de sucesso com esta metodologia.

1.6 A necessidade da capacitação dos docentes de um curso de Engenharia para implementação do PBL

Para a adoção e implementação do PBL num curso de engenharia é necessário desenvolver um currículo apropriado assim como disponibilizar os recursos de infraestrutura básica, pela instituição de ensino, com um número de salas adequadas aos trabalhos em equipe, laboratórios e espaços nas bibliotecas, buscando evitar falta de motivação dos estudantes. Em relação ao material humano, as mudanças nas novas formas de transmissão do conhecimento requerem um tempo e disposição dos professores em adaptarem à nova metodologia. De acordo com Masetto (2009), a quebra de paradigma das funções da docência destaca-se 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 de experiências dos alunos nos estágios, integrando efetivamente a teoria à prática.

Segundo van Hattum-Janssen (2009), o apoio aos professores consiste principalmente no oferecimento de treinamento intensivo que os prepara para um projeto específico. Os professores devem participar, em grupos, de sessões de treinamento durante as quais realizam tarefas com o objetivo de definir o conceito de um problema (ou projeto) dentro das configurações educacionais. As sessões de treinamento são importantes na preparação dos professores para uma abordagem do problema (ou projeto), não apenas pelo conteúdo do mesmo, mas principalmente quanto à abordagem da aprendizagem.

1.7 Análise da capacitação dos docentes do curso de Engenharia Biomédica da PUC/SP

O objetivo do nosso trabalho é analisar o processo de capacitação e treinamento dos professores do curso de Engenharia Biomédica da PUC/SP, levando-se em conta que este é o primeiro curso de graduação em engenharia no Brasil a adotar a metodologia PBL.

A metodologia utilizada neste trabalho está fundamentada na abordagem qualitativa. As técnicas adotadas estão baseadas nas seguintes etapas de coletas de dados: revisão bibliográfica, análise documental e pesquisa de campo baseada num inquérito por questionário.

A revisão bibliográfica utiliza-se de variadas fontes como: artigos, livros, dissertações e teses; é considerada como o ponto de partida para o planejamento metodológico, assumindo a função de exploração do tema que permeia este estudo e estabelecendo um conhecimento das práticas desenvolvidas em outras instituições que estão implementando a metodologia PBL.

Segundo Lüdke & André (1986), a análise documental constitui um dos métodos de coleta de dados mais adequados para recolher informação já existente sobre uma determinada organização, grupo ou comunidade, fornecendo indicações relevantes sobre os traços que as têm caracterizado tanto no passado como no presente.

Neste sentido, sua inserção nesta investigação está vinculada ao Projeto Pedagógico do Curso de graduação em Engenharia Biomédica. A análise documental procura agregar as informações obtidas por outras técnicas de coleta de dados, evitando o subjetivismo que pode resultar de uma análise de informações que pecam pela parcialidade (Lüdke & André, 1986). Deste modo, a análise documental permite cruzar as informações derivadas, com outras obtidas através de outros métodos de coleta de dados, aumentando a objetividade da interpretação e a validade dos métodos.

A pesquisa de campo foi realizada com o objetivo de compreender como os docentes estão sendo capacitados e treinados para utilizarem a metodologia ativa PBL e quais as implicações que podem ser observadas dentro desta concepção metodológica. Os dados foram coletados em apenas uma fase, ou seja, com a aplicação de um questionário único.

A aplicação do questionário tem caráter exploratório para mostrar como o professor é inserido nesta metodologia ativa. É um instrumento utilizado para mapear a ação docente.

Para tanto, foi elaborado um questionário de maneira objetiva e coerente sobre o tema a ser pesquisado e aplicado aos dez professores que estão trabalhando atualmente no curso de Engenharia Biomédica. Fazem parte do questionário a identificação da pesquisadora, a exposição do título e os objetivos da pesquisa, o caráter opcional do preenchimento e/ou devolutiva do questionário e o compromisso ético diante da preservação e sigilo dos dados dos docentes.

O questionário aplicado possui questões abertas e fechadas, referentes ao perfil dos docentes, tais como: sexo, tempo de atuação docente no ensino superior, tempo de experiência utilizando a metodologia PBL, conhecimento acerca da metodologia ativa PBL, facilidades, desafios e dificuldades encontradas na implementação da metodologia, vantagens e desvantagens da metodologia na educação em engenharia, em relação ao ensino tradicional.

2 Discussões Finais

Os dados obtidos através das respostas do questionário foram até o presente momento parcialmente analisados e mostraram que existe uma grande preocupação por parte dos docentes quanto aos resultados práticos da metodologia que está sendo utilizada, principalmente como efetuar a inserção de conteúdos das ciências básicas (matemática, física e química) nos problemas propostos.

Outro ponto a ser destacado diz respeito à dificuldade encontrada de como trabalhar com a falta de conhecimentos dos alunos ingressantes no curso, em relação à língua portuguesa, ciências e matemática, que deveriam ter sido adquiridos no ensino médio.

Os docentes entendem que esses assuntos devam ser discutidos e merecem atenção especial por parte da coordenação do curso para atender a essas deficiências.

Além disso, eles alertaram também quanto à necessidade de organização de um plano de treinamento aos docentes, mais efetivo e contínuo para sanar as dificuldades que enfrentam.

No entanto, os docentes destacam como vantagens da metodologia a inovação no processo de ensino/aprendizagem, as atividades integradas dos docentes e um maior comprometimento dos alunos e professores em relação à formação de um profissional que atenda as exigências e necessidades do mercado de trabalho. Outro ponto importante é que os docentes já estão aceitando os problemas e projetos como partes integrantes necessárias dentro da matriz curricular do curso.

O que se constata é que a metodologia PBL é intrigante, tanto para os docentes quanto para os alunos, e neste contexto uma gestão eficaz da sua implementação trará com certeza resultados promissores para a educação em engenharia.

A nossa pesquisa terá uma conclusão mais efetiva quando todos os dados obtidos forem tabulados, permitindo a análise final dos resultados da pesquisa de campo. Desta maneira, esperamos contribuir com propostas e sugestões para a melhoria da qualidade da educação em engenharia, utilizando a metodologia ativa PBL, em futuros estudos.

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A interdisciplinaridade como princípio pedagógico para elaboração do projeto curricular nos cursos de formação profissional

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Abstract

This communication discusses an experience of designing and implementing a training curriculum design. It aims to reflect on the theoretical and methodological work of teaching that is guided by the principle of interdisciplinarity. The methodology is the documental analysis, with the primary sources: Curricular projects of the courses in Physics and Geography, 2002, the Law 9.394/96, the CNE Opinion no. 16/1999 and Opinion CNE / CP 09/2001, guidelines for dealing with the training of teachers of Basic Education.

Keywords: Interdisciplinarity; Project course; vocational training.

1 Introdução

A comunicação proposta constitui de uma experiência vivenciada no Centro Federal de Educação Tecnológica do Rio Grande do Norte (CEFET-RN), atual Instituto de Educação, Ciência e Tecnologia do Rio Grande do Norte (IFRN), Brasil. A partir da publicação da Lei de Diretrizes e Bases da Educação Nacional – Lei 9.394/96 e do Decreto n° 2.406/97, o Ministério de Educação convocou o IFRN para ministrar cursos de formação de professores. Este fato provocou alteração na prática pedagógica e na missão social da Instituição, pois, historicamente, se dedicava ao Ensino Médio (parte da Educação Básica) e especialmente a educação profissional de nível técnico e tecnológico. Frente ao desafio, deu-se início a articulação entre gestores e professores, a fim de elaborar uma proposta curricular de curso com vista à formação profissional adequada aos desafios impostos pela sociedade do conhecimento. Considerou-se que esta exige um profissional com domínio de diferentes competências seja na área comunicativa, cognitiva ou operacional, como, por exemplo, capacidades de administrar, de gerenciar, de criar, de inovar e com uma visão mais ampla dos processos de trabalho (Antunes, 1995). Nesta perspectiva, a interdisciplinaridade foi assumida como princípio pedagógico norteador para elaboração da proposta curricular dos cursos de licenciatura em Geografia e em Física, a partir da articulação dos profissionais e das diferentes áreas do conhecimento. É este processo que tomamos como objeto de estudo neste texto, que está composto de introdução, enquadramento contextual e teórico da experiência, enquadramento operacional, considerações finais e referências.

2 Enquadramento contextual e teórico da experiência

O Instituto de Educação, Ciência e Tecnologia do Rio Grande do Norte (IFRN) é uma instituição federal de educação profissional que a mais de cem anos vem se dedicando ao ensino profissionalizante de nível técnico e recentemente também nos cursos profissionais básico e tecnológico. Além destas demandas educacionais, o Instituto atua na área da Educação Básica, de Formação de professores e nos cursos de Pós-graduação.

A Instituição, ao longo da sua prática educativa, tem procurado responder às demandas sociais de formação profissional, passando por processos de reestruturação curricular. As mudanças intensificaram-se a partir da última década do século XX devido o redirecionamento do Sistema Educacional Brasileiro, determinado pelas políticas educativas e curriculares. Para Silva (2007), essas mudanças educacionais se dão sob influências do processo de globalização, da reforma do Estado, do neoliberalismo e das transformações no mundo do trabalho provocadas pelos avanços científicos e tecnológicos.

Cabral Neto e Castro (2005) ressaltam que o ideário neoliberal que se tornou hegemônico contempla um conjunto de estratégias que resultaram no redimensionamento do papel do Estado e das políticas educacionais, associado ao paradigma econômico centrado no novo sistema tecnológico. A educação e o conhecimento assumem um caráter fundamental no processo de desenvolvimento dos países e nas práticas do mercado cada vez mais competitivo. Neste sentido, os sistemas de educação e as instituições vêm passando por constantes ajustamentos com base nos princípios de equidade, eficiência e eficácia. Nesse quadro, as instituições de educação são incumbidas pela elaboração de projetos curriculares que atendam às necessidades atuais.

É neste processo contraditório, em que o Estado orienta para uma formação pragmática, ainda que fundamentada pelos princípios da contextualização e da interdisciplinaridade, que os profissionais buscam articular propostas de educação no interior das instituições que possam contribuir com uma formação profissional para além das necessidades imediatas de mercado. Em termos teóricos e práticos, busca-se assegurar a formação de um sujeito profissional em condições de situar-se nas complexas relações sociais e do trabalho, bem como atuar de forma consciente e cidadã.

Na realidade brasileira, a Lei de Diretrizes e Bases de Educação Nacional, nº 9.394/96, além de explicitar "a incumbência da escola de elaborar sua proposta pedagógica (art.12, I), define também como responsabilidade dos professores participar desta elaboração a partir das diretrizes curriculares emanadas do Ministério da educação.

A possibilidade de (re) invenção do Projeto de formação pelas instituições emerge no contexto da autonomia curricular, da autonomia das instituições e dos profissionais e da compreensão do currículo como construção social (Young, 2010, Goodson, 2001), e, como um projeto, cujo processo de construção e desenvolvimento é interativo, que implica unidade, continuidade e interdependência entre o que se decide ao nível do plano normativo, ou oficial, e ao nível do plano real, ou do desenvolvimento curricular, que envolve o processo de ensino-aprendizagem (Pacheco, 2001).

Podemos inferir, portanto, que a interdisciplinaridade implica autonomia dos professores e das instituições no fazer pedagógico. Para Veiga (2008), a autonomia pedagógica consiste na liberdade institucional quanto ao ensino e a pesquisa, envolvendo poder de decisão quanto à melhoria do aprender e ensinar e está estritamente relacionada à identidade, à função social, à organização curricular, aos processos de avaliação e aos resultados.

Existe uma relação direta, portanto, entre a autonomia curricular exibida pelo professor e a responsabilidade que lhe é atribuída. Neste sentido, esta autonomia encontra-se, normalmente, referenciada com uma base nos aspectos do processo de ensino: objetivos, conteúdos, atividades e recursos didáticos, manuais escolares ou livros de texto ou ainda em relação a avaliação do rendimento dos alunos. Em cada um destes aspectos a autonomia do professor sofre variação quer em grau no tocante a amplitude desta autonomia, quer seja ao nível do indivíduo e da coletividade (Morgado, 2000).

Schön (2000) argumenta que quando os professores têm oportunidades de encontrar graus de liberdade para refletir durante e após a sua prática, dão sentido ao seu trabalho e põem assim à prova sua própria compreensão do processo no qual estão imersos.

No Brasil, o discurso da interdisciplinaridade flui nos sistemas educativos, na década de 1990, primeiramente, como um princípio pedagógico das práticas educativas proposto pelos educadores que defendiam uma educação de qualidade para todos e que denunciavam as práticas tecnicistas e a fragmentação do conhecimento presente nos currículos. Posteriormente, essa discussão é agregada aos documentos normativos, inicialmente, nos Parâmetros Curriculares do Ensino Fundamental e do Ensino Médio e nas diretrizes curriculares para educação profissional (Parecer, CNE nº 16/1999). Posteriormente, as dimensões da interdisciplinaridade foram incorporadas aos cursos superiores de formação docente, por meio do Parecer CNE/CP 09/2001, que trata das diretrizes para formação de professores da Educação Básica.

O Parecer CNE/CP 09/2001 Diretrizes Curriculares Nacionais para a Formação de Professores da Educação Básica, em Nível Superior sugere uma organização curricular por área de conhecimento e um currículo integrado, de maneira a facilitar a articulação dos conteúdos e das práticas docentes, fundamentada pelo princípio interdisciplinar. Assim, o Parecer CNE/CP 09/2001 destaca que,

> Na formação de professores para as séries finais do ensino fundamental e para o ensino médio, devido a organização disciplinar presente nos currículos escolares, predomina uma visão excessivamente fragmentada do conhecimento. A interdisciplinaridade e a transdisciplinaridade previstas na organização curricular daquelas etapas da educação básica requerem um redimensionamento do enfoque disciplinar desenvolvido na formação de professores. Não se trata, obviamente, de negar a formação disciplinar, mas de situar os saberes disciplinares no conjunto do conhecimento escolar. No ensino médio, em especial, é requerida a compreensão do papel de cada saber disciplinar particular, considerada sua articulação com outros saberes previstos em uma mesma área da organização curricular. Os saberes disciplinares são recortes de uma mesma área e, guardam, portanto, correlações entre si.

O referido Parecer determina um novo paradigma de formação profissional docente assentado pelos princípios da interdisciplinaridade e da contextualização, considerados nucleares do currículo. O primeiro, entendido como articulador das diferentes práticas e conhecimentos e o segundo pressupõe considerar, no processo de formação, os diferentes contextos sociais e laborais dos estudantes.

Para Silva e Leite (2009, p.3) a construção do conhecimento na perspectiva de uma epistemologia da interdisciplinaridade está mediada e/ou prevista pela participação dos estudantes em debates com licenciados das diversas áreas do saber, assim como, "pela afirmação de que há-de objectivar a percepção e o questionamento crítico da realidade sócio-educativa, como também, a adopção de metodologias de trabalho com responsabilidade, autonomia, cooperação e comunicação".

Para alguns pesquisadores (Dencker, 2002, Morin, 1999), do final do século XX e início deste século, vive-se num contexto de mudanças de paradigmas que têm interferido na forma de conceber a produção científica e a organização do conhecimento. Neste sentido, "enquanto a ciência clássica trabalhava com a idéia de simplificar a compreensão dos fenômenos por meio da separação e da redução racionalista, o cientista atual depara-se com a noção de complexidade, interdisciplinaridade, transdisciplinaridade e outras" (Dencker, 2002, p. 25).

A interdisciplinaridade ou a ação interdisciplinar parte do pressuposto da existência de disciplinas e propõe uma ruptura do saber dicotomizado para uma possibilidade de integração dos diferentes saberes e das diferentes áreas do conhecimento, respeitando as especificidades ou as fronteiras do saber, mas estabelecendo uma relação de complementaridade em volta do conhecimento construído. Esta discussão articula-se com as propostas da pedagogia de projeto e o trabalho por projeto que busca uma visão mais global, complexa, íntegra e contextualizada do processo de formação, implicando mudança de postura metodológica (Abreu, s/d).

Segundo Santomé (1998), uma disciplina é uma maneira de organizar e delimitar um território de trabalho, de concentrar a pesquisa e as experiências de um determinado ângulo de visão. A Interdisciplinaridade busca a integração das disciplinas numa atuação integrada, tendo a compreensão de que nada funciona isoladamente, pois tudo tem que ser ajustado com tudo. Morin (1999, p. 27) entende disciplina como "categoria que organiza o conhecimento científico e que institui a divisão e especialização do trabalho, respondendo à diversidade de domínios que as ciências recobrem".

A organização do conhecimento em torno das disciplinas, porém, contribuiu para legitimação e marcação de território e de hierarquias dos conhecimentos e dos profissionais conforme as diferentes especializações, com fronteiras delimitadas e sem qualquer hipótese de transgressão. Admite-se, entretanto, que no atual estágio de desenvolvimento da ciência que envolve processos dinâmicos do conhecimento, torna-se quase uma ilusão se pensar na possibilidade de um sujeito apropriar-se do conhecimento na sua totalidade. Mas pode haver uma aproximação dessa totalidade em torno de um objeto de estudo. A interdisciplinaridade se caracterizaria pela intensidade das trocas entre os especialistas e pelo grau de integração real das disciplinas, no interior de um projeto específico (Japiassu, 1976). Nesta perspectiva, a Interdisciplinaridade pode ser entendida como "uma nova atitude diante da questão do conhecimento, de abertura à compreensão de aspectos ocultos do ato de aprender e dos aparentemente expressos, colocando-os em questão" (Fazenda, 2002, p.11).

3 Enquadramento operacional da experiência

A experiência refletida teve início com a constituição de uma equipe multi e interdisciplinar para elaboração dos projetos curriculares dos cursos de licenciaturas do IFRN. Postulava-se, uma flexibilidade nas fortes hierarquias do conhecimento e dos profissionais e a superação da visão fragmentada em torno do currículo. Postulava-se, ainda, que as mudanças nas práticas pedagógicas deveriam envolver os professores e um maior envolvimento dos estudantes no decorrer do seu processo de formação.

Para elaboração dos projetos curriculares de formação docente, no IFRN, foi constituída uma equipe multidisciplinar, composta por treze professores e uma pedagoga para trabalhar de forma interdisciplinar, envolvendo os profissionais das diferentes áreas da formação geral (humanística) e da área específica. Esta equipe organizou-se conforme o princípio de representatividade, havendo uma representação de professores das diferentes áreas do conhecimento, que em discussão com seus pares e com o grande grupo contribuía na construção da proposta curricular. Esta equipe de treze profissionais, portanto, era responsável pela sistematização das ideias discutidas e da fundamentação teórica e metodológica.

Na definição do plano de trabalho e de estudos acerca da organização de uma proposta curricular, a equipe passou a realizar reuniões de forma sistemática, semanalmente, com todos os professores das três áreas do Ensino Médio (Área de Linguagens e Códigos e suas tecnologias, Área de Ciências da natureza e da Matemática e suas tecnologias e Área de Ciências Humanas e suas tecnologias), uma vez que a formação profissional destinava aos professores ou aos futuros professores da Educação Básica (últimas séries do Ensino Fundamental e do Ensino Médio).

No final de cada sessão de reunião, a equipe se agrupava para sistematizar o conteúdo, avaliar os trabalhos realizados e coletar subsídios para os próximos encontros, conforme os indicativos do encontro anterior. A proposta curricular enquanto texto e intenção foi processualmente se constituindo, sendo concluída ao final de oito meses de trabalho e posta em execução no ano letivo 2002.

Os cursos propostos assumiram uma estrutura curricular sequencial modular, com uma carga horária de aproximadamente 3.252 horas, distribuída em duas bases: Base Científica Tecnológica Geral, Base Científica Tecnológica Específica e um componente curricular denominado de Prática Profissional. A Base Científica Tecnológica Geral constitui-se de um conjunto de conhecimentos comuns, considerados indispensáveis à formação global do professor, com a finalidade de romper com o distanciamento no processo de formação docente entre o saber pedagógico e o saber específico da área de conhecimento, de forma a propiciar uma visão mais abrangente do trabalho docente.

A Base Científica Tecnológica Geral do currículo encontrava-se organizada em dois núcleos interdependentes: o núcleo estrutural e o contextual, assentados no enfoque interdisciplinar do conhecimento e das práticas. O núcleo estrutural constituía-se de conteúdos curriculares, sua organização sequencial, os métodos adequados ao desenvolvimento do conhecimento em pauta, sua integração e adequação ao processo ensino-aprendizagem. O núcleo contextual visava a integração de diferentes saberes acerca da compreensão do processo ensino-aprendizagem referido à prática da escola, enfatizando as relações que se passam no seu interior, bem como, as relações da instituição formadora com as instituições de estágio supervisionado, de atividades com projetos, de pesquisa e de extensão.

A Base Científica Tecnológica Específica constituía-se das disciplinas específicas de cada área de formação profissional e eram ministradas simultaneamente às disciplinas da base de conhecimento geral. O componente curricular Prática profissional envolvia atividades de pesquisa com elaboração de projetos interdisciplinares, projetos de trabalho, atividades de extensão junto à comunidade e o estágio supervisionado. Estas atividades tinham início já no primeiro semestre de curso e decorria-se até o final dos três anos de formação.

Na fase de execução da proposta curricular, a equipe de sistematização assumiu a coordenação do Núcleo pedagógico, equipe responsável em acompanhar à Prática profissional, como forma de acompanhar e avaliar o andamento da proposta curricular. Ressalta-se, entretanto, os constrangimentos encontrados neste processo como por exemplo, resistências por parte de alguns professores, que alegavam preocupação com a carga horária de suas disciplinas e a programação dos conteúdos, pois compreendiam ser indispensável. Além destas questões concorriam também às questões técnicas de caráter institucional e macro do sistema, por exemplo, o encolhimento do quadro docente, à época, pelas políticas neoliberais que terminavam por sobrecarregar os professores. Neste sentido, trabalhar numa perspectiva interdisciplinar se constitui de desafio político e pedagógico e um espaço de negociação dos conflitos, perpassando pelas relações dos sujeitos nas suas diferentes dimensões.

3 Considerações finais

A experiência aponta que trabalhar de forma interdisciplinar não é o único caminho a percorrer num processo de formação, mas um dos caminhos possíveis, pois ao final de três anos os estudantes, concluintes dos cursos, foram submetidos aos processos de avaliação externa encaminhados pelo Ministério da Educação, ficando nos primeiros lugares a nível nacional (Relatório Avaliativo dos Cursos Superiores, 2006). Salienta-se, entretanto, que o desempenho satisfatório dos estudantes em processos de avaliação ou de exames externos não constituía a questão pedagógica central, mas perspectiva-se como uma provável consequência ou possibilidade. Todo processo de construção e implementação dos projetos de curso, com foco na interdisciplinaridade, centravam-se na formação dos futuros professores com capacidades teórica-metodológicas no exercício de sua profissão e da cidadania.

Por fim, trabalhar de forma interdisciplinar pressupõe estar aberto ao outro e às contribuições deste outro e acreditar numa postura interativa construtiva. É preciso aprender com os erros e com as limitações que se impõem no processo e acreditar, ainda, que é possível construir um rumo educacional que busque a formação de um sujeito mais interativo e integral num contexto de tantas desintegrações.

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Análisis, Prevención y Tratamiento de Factores de Riesgo: Una Perspectiva a Través del Juego Didáctico

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Abstract

In workplaces there are risk factors that constantly threaten the health of workers and potentiate accidents, these events involve cost and the productivity of the organization can be highly affected. The following project shows a game-based learning in which participants impersonate roles and make decisions, putting into practice systems and information and security media through a poker game, allowing the display and teaching in a didactic way the control of negative effects of risk factors and their future prevention. By bringing these management topics to simulated environments through a didactic methodology, the students are able to view the conditions that they will experience in the future, deciding with confidence and generating interest about the subject in particular, contributing to their formation as professionals.

Keywords: Game-based Learning, Risk, Risk Management, Risk Prevention System.

Resumen

En los puestos de trabajo existen factores de riesgo que amenazan constantemente la salud de los trabajadores y potencializan accidentes de tipo laboral, estos eventos implican costos y afectan en gran medida la productividad de la organización. El presente proyecto muestra un juego didáctico en el cual los participantes personifican roles administrativos y toman decisiones, poniendo en práctica sistemas y medios de información y seguridad, a través de una partida de póker, permitiendo mostrar y enseñar de forma didáctica el control de los efectos negativos de los factores de riesgo y su prevención futura. Al llevar estas temáticas de tipo empresarial a ambientes simulados por medio de la didáctica, los estudiantes pueden visualizar las condiciones a las que posiblemente se expondrán en un futuro, decidir sin temor a equivocarse y generar interés sobre la temática en particular, contribuyendo a su formación como futuros profesionales.

Palabras clave: Juego Didáctico, Riesgo, Gestión de Riesgos, Sistemas de Prevención de Riesgos.

1 Introducción

Las metodologías de enseñanza alternativas en los últimos años han sido un tema muy estudiado, éstas han despertado el interés de las diferentes Instituciones educativas hacia el uso de herramientas más didácticas y tecnológicas, que logren motivar y generar interés en un grupo concreto de personas, tal es el caso de herramientas como: estudio de casos, objetos virtuales de aprendizajes, juegos didácticos, entre otros.

Al proyectar temáticas de tipo empresarial a ambientes simulados por medio de la didáctica, los estudiantes podrán conocer las condiciones a las que se expondrán posiblemente en un futuro al ingresar al ambiente laboral y tomar decisiones de tipo organizacional sin temor a equivocarse, contribuyendo a su formación como futuros profesionales.

En los puestos de trabajo existen factores de riesgo que amenazan constantemente la salud de los trabajadores y que potencializan los accidentes laborales; estos últimos eventos, implican costos asociados y afectan de manera significativa en la productividad. La gestión de riesgos tiene como objetivo minimizar los riesgos, con la finalidad de mejorar el desempeño de las organizaciones; esto se alcanza mediante la plena identificación de las situaciones riesgosas dentro de un contexto determinado, para establecer controles y/o mejorar los existentes. De igual manera, la gestión de riesgo busca conocer la capacidad de respuesta de la organización ante la manifestación de dichas situaciones, y atacar las posibles causas del evento o mitigar sus consecuencias (Atehortúa, 2005).

Por lo anterior, es indispensable conocer los sistemas de información y seguridad, y las acciones de prevención y control requeridas que nos permitirán evitar eventos indeseados asociados a estos factores de riesgos. Para ello, la siguiente investigación tiene como objetivo el diseño e implementación de un juego didáctico en el cual los participantes puedan identificar los factores de riesgo existentes en las empresas y poner en práctica los sistemas de información y seguridad que minimicen los efectos negativos ante ciertas situaciones. Éste escenario simulado de tipo empresarial, es representado por medio de una mesa de Póker, en la cual los participantes personifican gerentes y administradores de una organización que deberán enfrentar una serie situaciones y eventos que atentan contra su integridad y la integridad de sus trabajadores.

2 Marco Teórico

2.1 Juegos Didácticos

Oblinger en Montes, et al. (2010) señala que el juego didáctico es una técnica participativa de la enseñanza encaminada a desarrollar en los estudiantes métodos de dirección y conducta correcta, estimulando así la disciplina con un adecuado nivel de decisión y autodeterminación; es decir, no sólo propicia la adquisición de conocimientos y el desarrollo de habilidades, sino que además contribuye al logro de la motivación por las asignaturas. Esto es una forma de trabajo docente que brinda una gran variedad de procedimientos para el entrenamiento de los estudiantes en la toma de decisiones para la solución de diversas problemáticas; además, permite a los jugadores probar hipótesis y aprender de sus acciones.

Los objetivos de los juegos didácticos en las instituciones educativas según Argumedo y Castiblanco (2008) son: Enseñar a los estudiantes a tomar decisiones, Garantizar la posibilidad de adquirir una experiencia práctica del trabajo colectivo y el análisis de las actividades organizativas de los estudiantes, Contribuir a la asimilación de los conocimientos teóricos de las diferentes asignaturas.

Para estos autores, los principios básicos que rigen su estructura y aplicación son:

- ✓ La participación: es el principio básico que expresa la manifestación activa de las fuerzas físicas e intelectuales del jugador, en este caso el estudiante.
- ✓ El dinamismo: que expresa el significado y la influencia del factor tiempo en la actividad lúdica.
- ✓ El entretenimiento: que refleja las manifestaciones amenas e interesantes de la actividad lúdica, que ejercen un fuerte efecto emocional en el estudiante y puede ser uno de los motivos fundamentales que propicien su participación activa en el juego.
- ✓ El desempeño de roles: basado en la modelación lúdica de la actividad del estudiante y que refleja los fenómenos de la imitación y la improvisación.
- ✓ La competencia: que, basada en que la actividad lúdica, reporta resultados concretos y expresa los tipos fundamentales de motivaciones para participar de manera activa en el juego.

Marín et al.,(2010) señala que han sido escasos los intentos de clasificar los juegos didácticos. Sin embargo, debido a la práctica de su estructuración y utilización, se pueden considerar tres clases de juegos:

- ✓ Para el desarrollo de habilidades.
- ✓ Para la consolidación de conocimientos.
- ✓ Para el fortalecimiento de los valores (competencias ciudadanas).

La selección adecuada depende de los objetivos y del contenido de la enseñanza, así como de la forma en que se determine organizar el proceso pedagógico.

2.2 Peligro y Riesgo

Según la norma actual OHSAS 18001: 2007 se define peligro como fuente, situación o acto con el potencial de daño en términos de lesiones o enfermedades, o la combinación de ambas. Esta definición excluye el daño a los bienes o al ambiente del lugar de trabajo, estos se incluyen en el campo de la gestión de activos. Por otro lado la norma define riesgo como combinación de la probabilidad de ocurrencia de un evento o exposición peligrosa y la severidad de las lesiones, daños o enfermedad que puede provocar el evento o la exposición.

La GTC 45 define un factor de riesgo como todo elemento cuya presencia o modificación, aumenta la probabilidad de producir una daño a quien está expuesto a él. Los factores de riesgo pueden ser:

- ✓ **Factores de riesgo físico:** son todos aquellos factores ambientales de naturaleza física que pueden provocar efectos adversos a la salud según sea la intensidad, exposición y concentración de los mismos.
- ✓ **Factores de riesgo químico**: toda sustancia orgánica e inorgánica, natural o sintética que durante la fabricación, manejo, transporte, almacenamiento o uso, puede incorporarse al aire ambiente en forma de polvos, humos, gases o vapores, con efectos irritantes, corrosivos, asfixiantes o tóxicos y

en cantidades que tengan probabilidades de lesionar la salud de las personas que entran en contacto con ellas.

- ✓ **Factores de riesgo biológicos**: todos aquellos seres vivos ya sean de origen animal o vegetal y todas aquellas sustancias derivadas de los mismos, presentes en el puesto de trabajo y que pueden ser susceptibles de provocar efectos negativos en la salud de los trabajadores. Efectos negativos se pueden concertar en procesos infecciosos, tóxicos o alérgicos.
- ✓ **Factores de riesgo psicolaborales:** se refiere a aquellos aspectos intrínsecos y organizativos del trabajo y a las interrelaciones humanas que al interactuar con factores humanos endógenos (edad, patrimonio genético, antecedentes sicológicos) y exógenos (vida familiar, cultural...etc.), tienen la capacidad potencial de producir cambios sociológicos del comportamiento (agresividad, ansiedad, satisfacción) o trastornos físicos o psicosomáticos (fatiga, dolor de cabeza, hombros, cuello, espalda, propensión a la úlcera gástrica, la hipertensión, la cardiopatía, envejecimiento acelerado).
- ✓ **Factores de riesgo por carga física**: se refiere a todos aquellos aspectos de la organización del trabajo, de la estación o puesto de trabajo y de su diseño que pueden alterar la relación del individuo con el objeto técnico produciendo problemas en el individuo, en la secuencia de uso o la producción.
- ✓ **Factores de riesgo mecánico:** objetos, máquinas, equipos, herramientas que por sus condiciones de funcionamiento, diseño o por la forma, tamaño, ubicación y disposición del último tienen la capacidad potencial de entrar en contacto con las personas o materiales, provocando lesiones en los primeros o daños en los segundos.
- ✓ **Factores de riesgo eléctricos**: se refiere a los sistemas eléctricos de las maquinas, los equipos que al entrar en contacto con las personas o las instalaciones y materiales pueden provocar lesiones a las personas y daños a la propiedad.
- ✓ **Factores de riesgos locativos:** condiciones de las instalaciones o áreas de trabajo que bajo circunstancias no adecuadas pueden ocasionar accidentes de trabajo o pérdidas para la empresa.

2.3 Sistema de Seguridad y Salud Ocupacional

Castillo (2009) define al sistema de seguridad y salud ocupacional como el conjunto de medidas técnicas y procedimientos establecidos para disminuir el riesgo antes de que se produzca algún daño derivado del trabajo, creando un ambiente de seguridad física, una situación de bienestar personal, un círculo de trabajo idóneo, una economía de costos importantes y una imagen de modernización y filosofía de vida humana, en el marco de la actividad laboral contemporánea.

En el artículo 80 de la ley 9 de 1979 de Colombia se mencionan ciertas obligaciones por parte de las organizaciones para preservar, conservar y mejorar la salud de los individuos en sus ocupaciones. Ciertas normas hacen referencia la prevención de daño para la salud de las personas, la protección frente a agentes de riesgo de tipo biológico, orgánico, mecánico y otros. La eliminación o control de todo tipo de agentes nocivos para la salud en lugares de trabajo, y la protección de la salud frente a radiaciones y sustancias peligrosas. Estas pautas dan inicio a la implementación de un sistema de seguridad y salud ocupacional en la empresa.

2.4 Gestión de Costos de Accidentes y Enfermedades Laborales

Narocki (1999) menciona que el verdadero volumen de los costes que le generan los accidentes laborales y enfermedades laborales es superior al que se suele reflejar en las cuentas empresariales, quedando una parte de esos costes oculta bajo diversos epígrafes contables. Estos son los llamados costes ocultos o indirectos de la siniestralidad, que a semejanza de los icebergs, esconden la mayor parte de su volumen. Es necesario que las empresas conozcan los costes derivados de la siniestralidad laboral, pues el montante de estos costes pasa a constituir un incentivo potencial para un cambio en la asignación de recursos, hacia un modelo preventivo, el coste de los accidentes se convertiría así en un elemento de motivación.

3 Metodología

3.1 Planteamiento del Problema

De acuerdo con Rodas, las nuevas generaciones de estudiantes que acceden a las aulas universitarias pertenecen a la llamada Era de la Información. La aplicación de los métodos tradicionales de enseñanza-aprendizaje parece no conseguir los resultados esperados. Una manera alternativa de manifestar distintas temáticas son los juegos didácticos, los cuales pueden convertirse en aliados fundamentales de las clases magistrales en el proceso de enseñanza-aprendizaje.

El interés de este trabajo por la identificación de los factores de riesgos, radica en que hoy en día las organizaciones buscan un mejoramiento continuo y un equilibrio apropiado para obtener oportunidades de ganancia y minimizar las pérdidas, y una adecuada gestión de riesgos contribuirá al cumplimiento de los objetivos organizacionales y al establecimiento de conductas básicas entre miembros para enfrentarse a diversas situaciones riesgosas.

Con base a lo anterior, nos planteamos el siguiente interrogante: ¿Cómo diseñar e implementar un juego didáctico que facilite la identificación de factores de riesgo y sus respectivos medios de prevención en el ambiente empresarial a través de un escenario simulado?

3.2 Objetivo

Diseñar e implementar un juego didáctico que facilite la identificación de factores de riesgo y sus respectivos medios de prevención en el ambiente empresarial a través de un escenario simulado.

3.3 Diseño y Desarrollo de la experiencia innovadora lúdica

El juego didáctico hace alusión a un escenario de tipo empresarial, representado por medio de una mesa de Póker, en la cual los participantes personifican gerentes y administradores de una organización que deberán enfrentar una serie situaciones y eventos que implican riesgos de tipo psicosociales, físicos, químicos, ergonómicos, mecánicos, entre otros, que atentan contra su integridad y la integridad de sus trabajadores. Para tal travesía cuentan con recurso financiero, sistemas de información, elementos de protección individual (EPI) y otras herramientas que contrarrestan estas situaciones (Ver figura 1).

Figura 14: Logotipo del Juego y Visualizacion del escenario. Fuente: Diseño propio de los autores.

Para la presentación de esta lúdica es importante tener en cuenta:

3.3.1 Recursos

En la ejecución del juego didáctico es necesario ciertos elementos divididos en tres grupos: **Materiales** como mesas, sillas, computador, video beam, la baraja de cartas de riesgos, la baraja de cartas de protección y el dinero didáctico. **Participantes** que tomen el rol de Directores, personas encargadas en la orientación de la lúdica, y Gerentes o Administradores, encargados de tomar las decisiones para prevenir y/o combatir los riesgos. Por último, se requiere recurso **Físico** para el desarrollo de la lúdica, lo ideal es un espacio físico distribuido como se muestra en la figura 2.

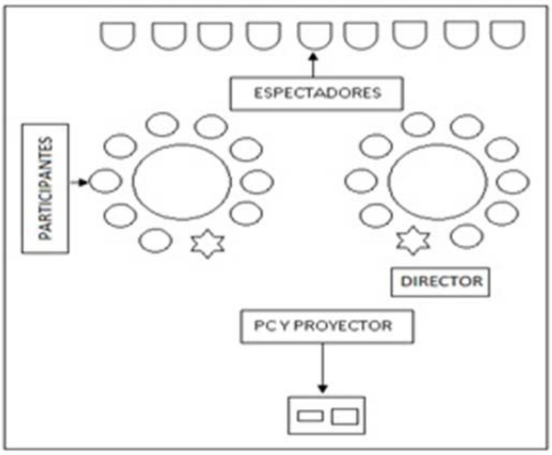

Figura 2: Distribución del espacio Físico. Fuente: Diseño de los autores.

3.3.2 Procedimiento

Para el desarrollo de la lúdica, inicialmente se realiza una introducción al tema dando a conocer los conceptos relevantes en lo relacionado con la gestión de riesgos y las reglas la experiencia innovadora lúdica. Luego, se invita al público a ser partícipe del escenario simulado, el cual se desarrolla de la siguiente forma:

1. La partida inicia al proporcionarle a cada jugador un capital inicial y dos cartas, en este caso las cartas corresponden a herramientas de protección.

2. Se colocan en la mesa dos cartas asociadas a situaciones de alto riesgo, los participantes arriesgan la cantidad de dinero que suponen tendrían que costear en caso de caer en estas situaciones.

3. Se ubica en la mesa una tercera carta de riesgo, se realiza el aporte por cada jugador.

4. Se sitúa una cuarta carta en la mesa de riesgo, se procede a la respectiva contribución.

5. Posteriormente, cada jugador muestra las cartas de protección que posee y se debate el ganador de la partida, al analizar las cartas de todos los jugadores. El ganador es aquel participante cuyas cartas lo protegen de mejor manera ante estas situaciones riesgosas.

6. La lúdica finaliza luego de varias corridas, ya que puede visualizarse un ganador, el cual es aquel gerente que posea más capital y el que ha incurrido en menos costos asociados debido a los riesgos, como resultado de su excelente gestión dentro de la organización. Luego de esto, se procede a escuchar sus observaciones y conclusiones, así como las conclusiones de los demás participantes.

Para un mejor entendimiento procedemos a definir los elementos correspondientes de esta lúdica o escenario simulado, los cuales son:

La baraja o naipe, compuestas por cartas de riesgos y cartas de protección. Las cartas de riesgo, mostradas en la figura 3, simbolizan esas situaciones que comúnmente se presentan en la vida laboral, que afecten la salud de los trabajadores y que, por consiguiente tenga repercusiones sobre la productividad, por ejemplo, el caso de posturas inadecuadas por parte de los trabajadores, puestos de trabajo mal diseñados, agentes biológicos que atenten con la salud, manejo inadecuado de sustancias químicas, condiciones físicas inadecuadas para trabajar, horarios de trabajo muy extenuantes, exceso de asignación de responsabilidades a un cargo, entre otras. Para enfrentar y prevenir estas situaciones existen una gran variedad de técnicas, sistemas y elementos que los participantes como gerentes y administradores podrán utilizar, como los son los elementos de protección personal, capacitaciones respecto a buenas posturas dentro del puesto de trabajo, técnicas para mitigar el estrés en los trabajadores, etc., éstas técnicas hacen referencia a las cartas de protección mostradas en la figura 4.

Figura 3: Cartas de Riesgos. Fuente: Diseño de los autores.

Figura 4: Cartas de Protección. Fuente: Diseño de los autores.

Otro elemento es el **capital de inversión**, el cual hace alusión al presupuesto destinado para implementar los planes de acción contra los riesgos. Este capital representa la importancia económica de realizar una adecuada gestión de riesgos dentro de las organizaciones y será fiel indicador de cómo una falla dentro del programa de salud ocupacional de una empresa puede llevar consigo graves pérdidas monetarias, un ejemplo podría ser el hecho de una demanda realizada por un trabajador que sufrió un accidente de trabajo o una enfermedad profesional por negligencia de la organización, o una significativa disminución de la productividad debido a los constantes accidentes o a los inadecuados métodos llevados a cabo dentro del proceso productivo.

Este capital de inversión, se ve reflejado en siete costos mencionados por Narocki (1999). Los cuales son (ver figura 5) :

- ✓ Perdida de la buena imagen corporativa
- ✓ Gastos Salariares por contratación de nuevo personal
- ✓ Productos defectuosos
- ✓ Disminución de la productividad
- ✓ Gastos extras no cubiertos por las aseguradoras
- ✓ Gastos administrativos por papeleo e investigación
- ✓ Huelgas y desmotivación de los empleados

Figura 5: Capital de Inversión. Fuente: Diseño de los autores.

4 Resultados

En este proyecto fue posible diseñar e implementar un ambiente empresarial que permitiera a los participantes hacer las veces de encargados del sistema de salud ocupacional de su organización. En este juego didáctico se podían evidenciar de manera más perceptible los factores de riesgo a los cuales están expuestos los trabajadores, propiciando la toma de decisiones y el uso de sistemas de prevención, protección e información de riesgos, así como demás técnicas o estrategias que minimicen la probabilidad de ocurrencia o que eviten un posible accidente o enfermedades de tipo profesional.

La recreación de escenarios empresariales permite a los participantes tomar decisiones e involucrarse en las diferentes situaciones sin temor a equivocaciones, esto permite un aprendizaje más didáctico y rápido de las temáticas recreadas, ya que se pueden observar las consecuencias inmediatas de lo que puede suceder si se toman decisiones precipitadas o meditadas.

Se logró apreciar el intercambio de ideas entre el expositor y los participantes al momento de recrear el juego didáctico, además de esto, el público hizo recomendaciones y conclusiones, por lo cual se manifiesta tentativamente que es posible hacer llegar esta temática de una manera más práctica; alternativa o como apoyo a las clases magistrales.

5 Conclusiones

Una apropiada identificación de factores de riesgos en los puestos de trabajo y su posterior prevención, utilizando herramientas de protección, sistemas de información y demás técnicas sencillas, nos evitarán incurrir en costos elevados asociados a accidentes de trabajo y enfermedades profesionales. Con la implementación de la lúdica los participantes fueron capaces de visualizar los sietes costos asociados a la gestión de riesgos, los cuales en nuestro mundo empresarial son ignorados y normalmente son cargados a los costos de operación por la debida falta de conocimiento y la difícil visualización de los mismos. De igual manera pudieron observar como estos sietes costos afectan de manera significativa el desempeño normal de toda la organización.

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Objeto Virtual de Aprendizaje para la Enseñanza y Toma de Decisiones en Modelos de Líneas de Espera

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Abstract

In recent years, alternative teaching methodologies have been widely studied and they have attracted the interest of many institutions. Nowadays, information spreads at an extraordinary rhythm and the requirement for quick responses has caused some changes in our educational system and an appetite for the implementation of educational and technological tools like: learning games, virtual learning objects, simulated environments and so on. Thus, the following project shows the implementation of a virtual learning object, taking the best of its characteristics (usability, adequacy, feedback, feedback, reusability and design) for the contribution in teaching-learning processes applied to the particular topic of waiting lines and decision-making in these systems.

Keywords: Virtual Object of learning, Waiting Lines, Teaching-learning Methodologies Decision-making.

Resumen

En los últimos años, las metodologías de enseñanza alternativas han sido un tema muy estudiado y que ha despertado el interés de las diferentes Instituciones. La velocidad extraordinaria con que se mueve la información actualmente y la necesidad de respuestas casi inmediatas, ha ocasionado ciertas evoluciones en nuestro sistema educativo y un apetito por el uso de herramientas más didácticas y tecnológicas, que logren motivar y generar interés en un grupo concreto de personas, tal es el caso de herramientas como: juegos didácticos, Objetos virtuales de aprendizaje, escenarios simulados, entre otros. De esta manera, el presente proyecto muestra la utilización de un objeto virtual de aprendizaje, aprovechando sus características (usabilidad, adecuación, retroalimentación, reusabilidad y diseño) para la contribución en los procesos de enseñanza-aprendizaje aplicado en la temática particular de líneas de espera y la toma de decisiones en estos sistemas.

Palabras clave: Objeto virtual de aprendizaje, Líneas de espera, Metodologías de enseñanza-aprendizaje, Toma de decisiones.

1 Introducción

Los objetos virtuales de aprendizaje son recursos digitales, autosuficientes y reutilizables, con propósitos educativos y constituidos por tres elementos principales: contenidos, actividades de aprendizaje y elementos de contextualización. Para la implementación de este tipo de herramientas como alternativas a los procesos de enseñanza aprendizaje se debe garantizar el cumplimiento de ciertas de especificaciones manteniendo una perspectiva constructivista. Esto implica construir conocimiento a través de modelos conceptuales cuya producción encaje dentro de los modelos mentales de los estudiantes y los amplíen. También implica tener en cuenta las características del estudiante, sus estilos cognitivos, sus necesidades educativas especiales, entre otros, para adaptar esos entornos y hacer posible que cada cual pueda implementar las estrategias de aprendizaje más pertinentes para la adquisición del conocimiento, favoreciendo aquellas dinámicas y actividades colaborativas que constituyan un aprendizaje activo a través del consenso (Del Moral y Cernea, 2005).

Por su parte, el estudio de las líneas de espera resulta de transcendental importancia, las colas se presentan en prácticamente todos los sistemas conocidos, en cualquier momento de nuestras vidas hemos hecho parte de una cola, en un consultorio médico, la peluquería, un lavado de autos, en líneas telefónicas, incluso en la internet, he aquí la trascendental importancia de conocer y analizar estos sistemas con el fin de establecer un balance óptimo entre la capacidad del sistema (servicio) y los costos asociados a esta capacidad. De esta manera, el presente proyecto tiene como objetivo el diseño y la utilización de un objeto virtual de aprendizaje, aprovechando sus características (usabilidad, adecuación, retroalimentación, reusabilidad y diseño) para la contribución en los procesos de enseñanza-aprendizaje aplicada en la temática particular de líneas de espera y la toma de decisiones en estos sistemas.

2 Marco Teórico

2.1 Objetos Virtuales De Aprendizaje (OVA)

Se denominan Objetos Virtuales de Aprendizaje (OVA), cuando corresponden a “archivos o unidades digitales de información, dispuestos con la intención de ser utilizados en diferentes propuestas y contextos pedagógicos. Se trata de archivos digitales o elementos con cierto nivel de interactividad e independencia, que podrán ser utilizados o ensamblados, sin modificación previa” (Vega y Chica, 2010).

Según Guerrero y Medina (2009) el OVA es una herramienta de tecnología de información cuyo principal objetivo es el de convertirse en apoyo del proceso de enseñanza aprendizaje. Por tanto será entonces un mecanismo de interacción e influencia en la educación, ya que no solo se limita a las actuaciones sincrónicas y presenciales, sino al conjunto de todas aquellas actuaciones que profesores y estudiantes desarrollan sin estar ambos presentes, en un mismo espacio o coincidir en el tiempo.

2.1.1 Características

De acuerdo con Akpinar (2008) existen una serie de factores o características relevantes, los cuales se toman como indicadores para medir su calidad:

- ✓ Calidad de los contenidos: veracidad, exactitud, presentación equilibrada de ideas y nivel adecuado de detalle.
- ✓ Adecuación de los objetivos de aprendizaje: coherencia entre los objetivos, actividades, evaluaciones, y el perfil del alumnado.
- ✓ Feedback (retroalimentación) y adaptabilidad: contenido adaptativo o feedback dirigido en función de la respuesta de cada alumno/a y su estilo de aprendizaje.
- ✓ Motivación: capacidad de motivar y generar interés en un grupo concreto de alumno/as.
- ✓ Diseño y presentación: el diseño de la información audiovisual favorece el adecuado procesamiento de la información.
- ✓ Usabilidad: facilidad de navegación, interfaz predictiva para el usuario y calidad de los recursos de ayuda de la interfaz.
- ✓ Accesibilidad: el diseño de los controles y la presentación de la información está adaptada para discapacitados y dispositivos móviles.
- ✓ Reusabilidad: capacidad para usarse en distintos escenarios de aprendizaje y con alumno/as de distintos bagajes.
- ✓ Cumplimiento de estándares: Adecuación a los estándares y especificaciones internacionales.

2.2 Teoría de colas

Es el estudio de los fenómenos de la creación de líneas de espera, que forman clientes o unidades, al llegar de manera aleatoria en demanda de algún servicio, un sistema de línea de espera puede estar formado por: una cola y varios servidores en paralelo, Varias colas y varios servidores, cada cola asignada a cada servidor, Sistema de etapa múltiple en el cual se presentan servidores en serie antes de salir del sistema. Cada sistema posee sus propias características y debe ser analizado en su caso particular. (Barbosa, 1995).

- **Cliente.** Unidad que llega requiriendo la realización de algún servicio. Los clientes pueden ser personas, máquinas, partes u otros.
- **Cola.** Número de clientes que esperan ser atendidos. Normalmente, la cola no incluye el cliente que está siendo atendido.
- **Canales de servicio.** Es el proceso o sistema que está efectuando el servicio para el cliente. Este puede ser simple o multicanal.
- **Tasa de llegada.** Tasa (clientes por período de tiempo) a la cual llegan clientes para ser atendidos.
- **Tasa de servicio.** Tasa (clientes por períodos de tiempo) a la cual un canal de servicio puede suministrar el servicio requerido por el cliente.

2.3 Aprendizaje en entornos virtuales

Aunque no hay una definición de aprendizaje plenamente satisfactoria y absolutamente compartida por todos los especialistas, sí existe una definición que recibe el máximo consenso, y es ésta: se entiende por aprendizaje "un cambio más o menos permanente de conducta que se produce como resultado de la práctica” concepto mencionado Kimble, y Beltrán, citado por Beltrán (1993).

La actividad mental constructivista desarrollada por el alumno no asegura, necesariamente, una construcción optima de significados y sentidos en torno al nuevo contenido de aprendizaje. Por un lado, porque el alumno puede no disponer de los recursos cognitivos más adecuados para asimilar el nuevo contenido. Por otro, porque, incluso si los tiene, puede no activarlo, o no establecer relaciones más significativas y relevantes posible entre esos recursos y el contenido en cuestión. La interacción entre el alumno y el contenido, por tanto y dicho en otros términos, no garantiza por si sola formas optimas de construcción de significados y sentidos (Bedoya, 2010). De acuerdo a lo anterior es necesario diseñar métodos o herramientas de aprendizajes que faciliten el proceso de enseñanza aprendizaje al adaptar las temáticas al estilo de aprendizaje de los estudiantes.

2.4 Enfoque Constructivista Del aprendizaje

El papel del estudiante corresponde al de un ser autónomo, auto-regulado, que conoce sus propios procesos cognitivos y tiene en sus manos el control del aprendizaje. En esta interpretación el aprendizaje resulta eminentemente activo e implica una asimilación orgánica desde dentro. El estudiante no se limita a adquirir conocimiento, sino que lo construye usando la experiencia previa para comprender y moldear el nuevo aprendizaje. Consiguientemente, el profesor, en lugar de suministrar conocimientos, participa en el proceso de construir conocimiento junto con el estudiante, se trata de un conocimiento construido y compartido. De acuerdo con esto la instrucción está centrada en el estudiante. Como dice Dewey, en este tipo de instrucción la persona es el punto de partida, el centro y el final. En la instrucción centrada en el estudiante, la evaluación del aprendizaje es cualitativa, y en lugar de preguntar cuántas respuestas o conocimientos se han adquirido, hay que preguntar sobre la estructura y la calidad del conocimiento, y sobre los procesos que el estudiante utiliza para dar respuestas.

Aunque el estudiante como constructor de significado parece una interpretación nueva, ha estado en realidad asomándose de forma vacilante durante las últimas décadas. Es más, el proceso de cambio no ha terminado todavía, si bien las líneas generales de la teoría cognitiva están bastante bien trazadas. La clave de esta última metáfora es, desde el punto de vista del estudiante, aprender a aprender. (Beltrán, 2002).

3 Metodología

3.1 Planteamiento del Problema

Cada profesor, al igual que sus estudiantes, tiene un estilo de aprendizaje desarrollado mediante los conocimientos, las experiencias y la conducta en sus diferentes etapas de desarrollo y ambiente en general. Por ende, al realizar la ardua tarea que es enseñar, utilizará un estilo de enseñar basado en sus estilos de aprender. Será necesario que los profesores identifiquen y entiendan las posibilidades y limitaciones de su estilo de enseñar de manera que pueda enjuiciar objetivamente su impacto en el proceso de enseñanza-aprendizaje (Cruz, 2001).

En los últimos años, las metodologías de enseñanza alternativas han sido un tema muy estudiado y que ha despertado el interés de las diferentes Instituciones educativas y de la sociedad en general, debido a que se busca que los estudiantes comprendan de diferentes maneras y fácilmente, el comportamiento de los sistemas de la vida real, tal es el caso de las líneas de espera, un sistema común del cual todos hemos participado alguna vez, pero que muchos no se percatan de cómo funcionan y como se puede influir para su mejora.

Estudios realizados señalan que los objetos virtuales son métodos dinámicos, constructivos, innovadores y atractivos en la enseñanza de diversas temáticas por ejemplo: enfermería (Álvarez y Sasso, 2011), Investigación operativa (Vega y Chica, 2010), programación (Guerrero y Medina, 2009)

A partir de lo anterior nos hemos planteado lo siguiente: ¿Cómo diseñar un objeto virtual de aprendizaje para la enseñanza y toma de decisiones en modelos de líneas de espera?

3.2 Objetivo

Diseñar un objeto virtual de aprendizaje para la enseñanza y toma de decisiones en modelos de líneas de espera.

3.3 Diseño y Desarrollo de la experiencia

3.3.1 Aspectos Generales del OVA

El OVA hace alusión a situaciones que tienen lugar en una cafetería de una universidad determinada, el aplicativo es un video juego diseñado y programado en Adobe Flash Player cuya finalidad es la enseñanza de los conceptos básicos de los modelos de líneas de espera, toma de decisiones en estos sistemas, y en el mismo sentido, gestión y mejoramiento de sistemas de colas.

La hipótesis es, que en la medida que el juego capta la atención del usuario, este se encuentra motivado y dispuesto a asimilar la mayor cantidad de conocimientos, en este sentido el jugador puede aprender divirtiéndose, generando interés por la profundización del tema detallado.

El objetivo principal del juego es alcanzar la mejor utilidad para la cafetería, el jugador deberá tomar constantes decisiones para mantener en todo momento el sistema encausado. Un cliente no satisfecho podría traer para la organización altos costos de penalización. Para tal travesía el juego propone variar tanto en incremento y disminución la capacidad de servicio y demanda, en base a las siguientes estrategias:

Estrategias para la variación de tasa de servicio:

1. Contratación de nuevos servidores
2. Capacitación
3. Incentivos
4. Pago de horas extras
5. Despidos
6. Contratos por media jornada laboral
7. Autoservicio

Estrategias para la variación de la tasa de demanda:

1. Contratos
2. Promociones

La variación en la demanda, el número de servidores, el tamaño de la población y la política de servicio definen el modelo de línea de espera. En una cafetería las condiciones variantes permiten visualizar muchos de los modelos comúnmente expuestos en las clases magistrales desde sistemas con un servidor y tasa de servicio y arribo markovianas (modelo M/M/1) hasta sistemas con tasas ajustadas a distribuciones generalizadas, múltiples servidores y poblaciones infinitas (modelo G/G/s: infinito).

Los costos que definen el sistema son:

1. Costos de personal: se refiere a los costos salariales, particularmente a los servidores del sistema.
2. Costos de Perdida de oportunidad: costo intangible por la pérdida de un cliente, muchas veces el cliente renuncia al sistema debido a que los tiempos de espera promedio resultan ser demasiado largos.
3. Costos de aplicación de estrategias: al variar la capacidad del servicio (contratar o despedir) o aplicar estrategias de mercadeo, se generan costos que son adsorbidos por el sistema.

3.3.2 Descripción del Escenario

La aplicación se inicia con una introducción acerca del sistema y los elementos que lo conforman, dando a conocer los conceptos relevantes en lo relacionado con líneas de espera y las reglas básicas del juego (tutorial). En esa introducción el jugador podrá conocer el entorno grafico del programa, las condiciones del sistema, indicadores, opciones y estrategias. Luego, se inicia juego y el usuario deberá a partir de este momento gestionar el escenario simulado (cafetería).

Los clientes entran, son servidos y abandonan la cafetería, el tiempo en que demoran es determinado por la tasa de servicio de los servidores, y de la cantidad de clientes que demanda el servicio. Las condiciones dinámicas de la demanda pueden ocasionar que la capacidad del sistema no sea suficiente ante las necesidades de los clientes, causando un colapso en el sistema y abandonos por parte de los clientes.

Ante estas situaciones el usuario cuenta con opciones para mejorar en cierta medida las condiciones de servicio que enfrenta el sistema, el puede contratar más personas prestadoras del servicio por medio de un banco de empleados que poseen características que los hacen particulares, capacitar al personal existente de tal manera que refuercen y mejoren sus habilidades de servicio, organizar programas de incentivos, entre otras. Así, el jugador deberá determinar a cada instante del juego, cuantos servidores mantener, de tal forma que el sistema esté lo suficientemente preparado y sin exceder los costos de personal. (Ver Figura 1).

Figura 1: Servidores del Sistema. Fuente: Diseño de los autores

En muchas ocasiones la demanda disminuye significativamente, en estos casos el factor de utilización de los servidores podría ser demasiado bajo, por tanto los ingresos no serían suficientes para justificar su presencia en el sistema; el jugador debe buscar la manera de establecer un equilibrio entre satisfacción y costos. Para mejorar esta situación se podría influir en la demanda del servicio a través del establecimiento de políticas de mercadeo que propicien el aumento de clientes en periodos de tiempo determinados; por ejemplo, se pueden vender bonos y aplicar promociones que propicien una demanda mayor, acumulación de puntos, expandir la buena imagen a través de la publicidad, entre otros.

Cabe anotar, que las variaciones con respecto la tasa de servicio y la tasa de arribo, son ocasionadas por distribuciones estadísticas generadas en la aplicación.

Al observar los continuos cambios en la línea de espera y los indicadores de rendimiento del sistema (factor de utilización, costos, entre otros), el jugador podría tomar decisiones con enfoques más sistémicos y globales. Como complemento, las consecuencias de sus decisiones podrían reflejarse de manera casi inmediata facilitando su visualización.

El jugador podrá administrar el sistema de la forma que así lo considere, tomando las decisiones que le parezcan más pertinentes sin miedo a equivocaciones. En la medida en que el juego avance será más consciente de las consecuencias; en este sentido es libre de mantener o cambiar sus estrategias. La experiencia del jugador le permitirá alcanzar calificaciones más altas y sin duda mayor entendimiento de la temática, al finalizar la partida se espera que el estudiante sea capaz de manejar los conceptos fundamentales de la teoría de colas y toma de decisiones en estos sistemas. Si su gestión no fue adecuada y sus utilidades fueron demasiado bajas en el juego, podría oprimir el botón de reinicio y comenzar de nuevo. El aprendizaje continuo le permitirá evitar los errores del pasado y alcanzar así mejores resultado.

Si bien es cierto que el estudiante al final del juego no estará lo suficientemente capacitado para gestionar sistemas reales, lo que se espera en realidad es que este haya asimilado los conceptos fundamentales de estos sistemas y que muchas veces se hacen tan confusos y abstractos en las clases magistrales.

4 Resultados

Si bien sabemos que las metodologías de enseñanza tradicional, como la clase magistral, priman en nuestro sistema educativo, muchos autores han sostenido en los últimos años, que los resultados arrojados con estas metodologías no resultan ser los esperados, esto ha ocasionado el creciente interés por el uso de herramientas alternativas o complementarias. Se diseñó entonces un objeto virtual de aprendizaje que aprovecha las características principales de estos recursos para así cautivar la atención de los estudiantes y generar interés por la profundización de la temática. Aunque aún no se han realizados las validaciones estadísticas, en los primeros experimentos se pudo evidenciar que los jugadores alcanzaban mejores resultados a medida que avanzaban en el juego, además realizaron conclusiones y aportes a la temática, cabe notar que estos estudiantes no habían tenido acercamiento previo a la temática propuesta, por lo cual podríamos decir tentativamente que hubo una transmisión de conocimientos y además se generó una motivación por el estudio de la temática, lo que muchas veces no se logra en las clases magistrales.

5 Conclusiones

La adaptación de situaciones empresariales reales a escenarios simulados, para el caso especifico en un Objeto Virtual de Aprendizaje (OVA), motiva al estudiante al estudio y profundización de la temática, y le permite tomar decisiones sin temor a equivocaciones y observar las consecuencias de una manera mucho más rápida. La utilización de estas técnicas propicia la creación de conocimiento por el estudiante mismo generando un enfoque constructivista (Aprende a aprender), desarrollando sus capacidades de análisis y proposición.

El estudio de las colas es un tema bastante estudiando, pero se debe direccionar la temática no solo a la contextualización y entendimiento de los conceptos y características del sistema, sino también, a la aplicación del conocimiento en la toma de decisiones siempre en busca de dos objetivos fundamentales: la satisfacción del cliente como prioridad y los costos asociados al servicio.

Las instituciones de educación deben estar pendiente de los cambios que se presentan en los entornos educativos, para realizar continuamente los ajustes necesarios y así atender las necesidades de los individuos que reciben educación, debido a que éstas tienen la responsabilidad mayor de preparar a los estudiantes mediante la oferta de actividades curriculares, metodológicas y extra curriculares que contribuyan a su desarrollo integral. Es así, que se hace necesario un reconocimiento de las diferentes metodologías de enseñanza–aprendizaje utilizadas en la educación superior, con la finalidad de identificar fortalezas y debilidades en cada una de las instituciones en la aplicación de este tipo de metodología.

Con este Objeto Virtual de Aprendizaje se pretende mostrar cómo transmitir nuevos conocimientos a un público de una manera más rápida y clara a través del uso de herramientas virtuales de fácil manejo y variadas aplicaciones. Además de esto, se busca promover los objetos virtuales de aprendizaje como soporte de las clases magistrales llevadas a cabo en todos los cursos que tenga que ver con la temática en general.

Recomendaciones

En una fase posterior del presente proyecto es importante realizar la validación del objeto virtual de aprendizaje en cuando a calidad (a partir de características relevantes, usabilidad, diseño, entre otras) y a los supuestos educativos en lo concerniente a la gestión de líneas de espera y a la toma de decisiones en estos sistemas. De igual manera, introducir la recreación de escenarios empresariales como éste en los métodos de enseñanza actuales facilitará de manera sorprendente la interacción entre el expositor y los participantes, propiciando la transferencia de información y la toma de decisiones sin temor a las consecuencias.

Agradecimientos

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PAEE'2011 Students' Best Project Award

Interdisciplinaridade em projectos de aprendizagem em engenharia: um exemplo de aplicação numa empresa de produção de molduras

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Abstract

This paper presents a selection of the output of the Integrated Project on Entrepreneurship and Innovation, carried out during one semester by eight engineering students of University of Minho. This project was conducted in a wood frames factory and its objectives were the development of innovative products and the suggestion of improvements to the production system. To do so the students had to combine their technical skills as well as their soft skills, such as communicational and organizational skills, people skills, critical thinking and initiative, due to the required interdisciplinary approach to the problems on hand. In this paper it's shown an example of said approach when the students tried to increase the production system's efficiency by designing an automated drying system.

Keywords: PLE (Project Led Education), interdisciplinarity, wood frames, infrared radiation

1 Introdução

Este artigo apresenta parte do trabalho realizado durante o primeiro semestre, pelo grupo 3, no âmbito do PIEI – Projecto Integrado em Empreendedorismo e Inovação. Vai ser apresentada a parte do trabalho que se considera de maior relevância tendo em conta o tema deste simpósio.

Os objectivos do projecto passaram pela apresentação de produtos inovadores e de propostas de melhoria do processo produtivo de uma empresa de produção de molduras.

O PIEI é um método de ensino/aprendizagem que consiste numa educação centrada no aluno e no desenvolvimento de projectos em grupos de trabalho multidisciplinares, envolvendo alunos de quatro cursos de mestrado integrado da Escola de Engenharia da Universidade do Minho: Eng.ª Electrónica Industrial e de Computadores, Eng.ª e Gestão Industrial, Eng.ª Mecânica e Eng.ª de Polímeros. Neste sentido, a realização deste projecto permite relacionar conteúdos interdisciplinares fazendo uso das competências técnicas dos elementos da equipa de trabalho, na resposta a um projecto cuja definição é suficientemente abrangente para permitir uma grande diversidade de soluções. Ao mesmo tempo, esta característica do projecto torna necessária a tomada de decisões com base em informação incompleta, redundante ou difusa, o que faz com que os alunos desenvolvam diversas competências transversais, como por exemplo capacidade de comunicação, organização e relacionamento interpessoal, desenvolvimento de espírito crítico e de iniciativa (Lima, et al., 2009). Desta forma, o PIEI engloba-se na metodologia de aprendizagem PLE – *Project Led Education*.

A realização de um projecto desta natureza implica a aplicação de conceitos fundamentais para a formação de futuros engenheiros, pois inclui aspectos relacionados com o desenvolvimento de um produto, organização de um sistema produtivo, bem como planeamento e controlo de projectos e trabalho em equipa.

Nos projectos desenvolvidos em engenharia faz sentido a confluência simultânea de conhecimentos técnicos de diversas áreas, no desenvolvimento de produtos cada vez mais complexos (Russell, et al., 2003). O facto deste projecto permitir aos alunos interligarem os conhecimentos dos diversos cursos aproxima-o da realidade.

Os objectivos deste projecto passaram pela definição de uma solução inovadora e criativa que possa competir com o mercado de molduras existente. Para tal, é necessário que quer a relação preço/qualidade, quer as características físicas do novo produto sejam semelhantes ou superiores aos produtos em madeira. Assim sendo, é fundamental analisar a viabilidade económica da proposta destes novos produtos e do seu processo de fabrico, ao mesmo tempo que deve ser analisado o sistema produtivo actual da empresa procurando ineficiências que possam ser colmatadas. Designadamente, diminuição do tempo de secagem da tráfila, diminuição do tempo de mudança do reservatório da tráfila aplicando uma calha com dois reservatórios, e a implementação de um sistema de controlo de qualidade que permita uma avaliação quantitativa das não conformidades.

Este artigo apresenta a análise feita ao sistema produtivo e as respectivas conclusões. Este artigo aborda esta parte do trabalho, uma vez que foram imprescindíveis os conhecimentos técnicos das diferentes áreas de conhecimento dos elementos do grupo, para alcançar os objectivos iniciais do projecto. A necessidade de diminuir o tempo de secagem, que por sua vez diminuiria o stock intermédio, conseguindo manter a qualidade dos produtos finais, uniu os conhecimentos de engenharia mecânica, com engenharia de gestão industrial e engenharia electrónica industrial e de computadores (Figura 13).

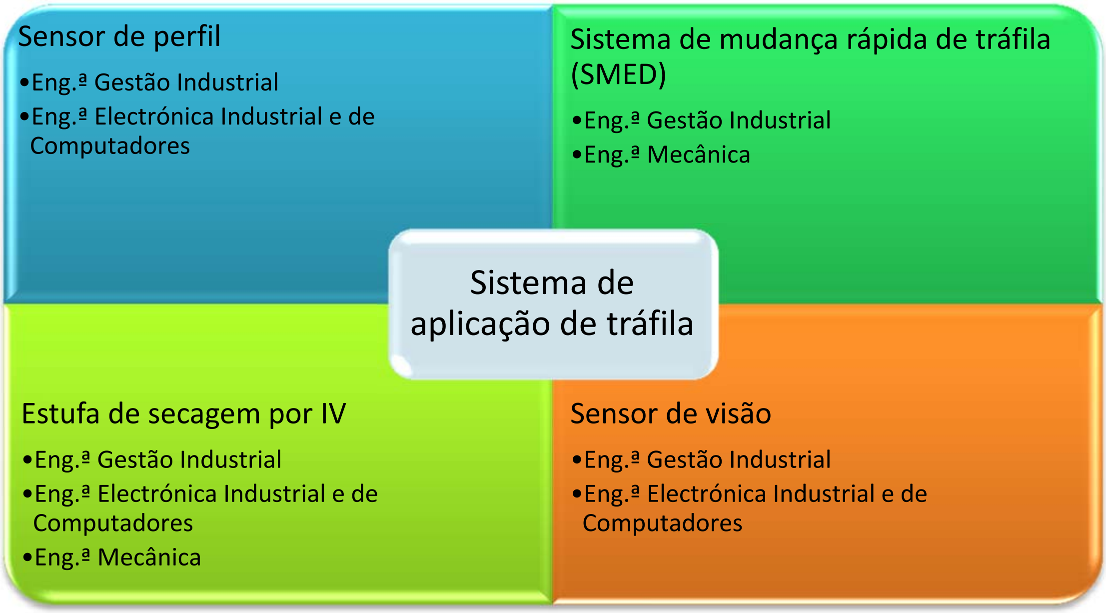

Figura 13: Interdisciplinaridade no projecto do sistema de aplicação da tráfila

Após este primeiro capítulo introdutório, onde se apresenta o âmbito, objectivos e a equipa de trabalho afecta ao projecto, encontra-se um capítulo dedicado à contextualização do trabalho desenvolvido, através da descrição da empresa. De seguida, no terceiro capítulo é possível seguir as propostas para o sistema produtivo. As propostas para o sistema produtivo são suportadas pelos resultados do trabalho experimental descrito e fundamentado no capítulo quarto. Para finalizar, no quinto capítulo apresentam-se as conclusões do trabalho realizado.

2 Contextualização

A empresa em estudo dedica-se à comercialização de molduras em madeira, produtos de decoração (espelhos, quadros, estampas, porta-fotos) e produtos de belas artes (pintura, acessórios de pintura e *hobby*). Actualmente, 70% da produção é destinada ao mercado nacional e os restantes 30% dirigem-se ao mercado internacional.

Os produtos da empresa percorrem diferentes processos de fabrico consoante as características que apresentam, nomeadamente o tipo de acabamento superficial das molduras em vara, que pode ser anilina, massa e filme, filme ou lacado. Para além dos fluxos correspondentes a estes quatro tipos de acabamentos existe a produção de telas para quadros, para a qual existe um fluxo operatório específico.

O contacto com a realidade da empresa e a análise dos seus produtos, sistema produtivo e o mercado em que se insere, permitiu a identificação de diversos aspectos a corrigir no sentido de melhorar o desempenho global da empresa. Desta forma, apresentam-se alguns problemas que foram considerados relevantes após a análise efectuada: falta de inovação dos produtos, limitações inerentes à produção das molduras com ornatos (qualidade dos acabamentos), elevado trabalho em curso de fabrico (devido ao elevado tempo de secagem e elevado tempo de preparação das máquinas).

3 Descrição do trabalho desenvolvido

Do trabalho desenvolvido no PIEI, é apresentada neste capítulo a abordagem à melhoria do sistema produtivo da empresa. Esta decisão fica a dever-se, não só à limitação da extensão deste artigo, mas fundamentalmente à relevância que este assunto tem para a temática da aprendizagem de engenharia por projectos, devido à natureza colaborativa do trabalho realizado por estudantes de engenharia de áreas diversas.

Um dos principais problemas desta empresa é o elevado trabalho em curso de fabrico, provocado pelo elevado tempo de secagem da tráfila e pelo elevado tempo de mudança do reservatório de aplicação da tráfila. Para solucionar este problema foi proposta uma estufa de secagem com recurso a lâmpadas de radiação infravermelha e um novo reservatório de tráfila de mudança mais rápida (foi seguido o método SMED - *Single-Minute Exchange of Die*). Para controlo de qualidade sugerem-se dois sensores, um de perfil e outro de visão. Na Figura 14 é possível observar estas propostas para o sistema de aplicação da tráfila.

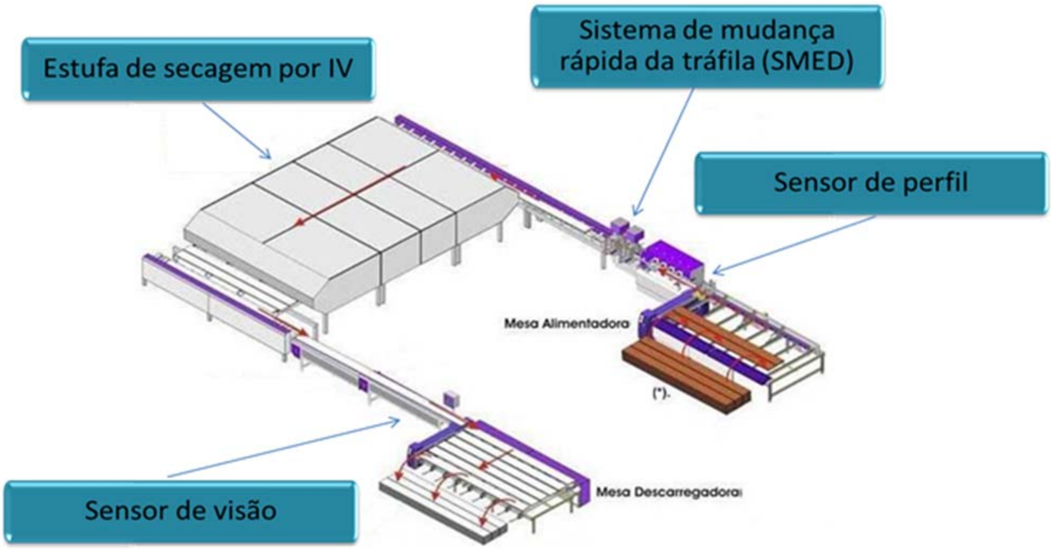

Figura 14: Proposta para o sistema de aplicação da tráfila

3.1 Sistema de Secagem IV

Este sistema foi desenvolvido aplicando os conhecimentos das diferentes áreas de engenharia dos elementos do grupo, e é a prova da relevância da interdisciplinaridade do projecto, uma vez que, individualmente não teria sido desenvolvido um protótipo tão realista. O sistema de secagem pode resumir-se a dois grandes blocos: o primeiro bloco corresponde ao sistema de aplicação da tráfila, no segundo bloco (estufa), acontece a secagem propriamente dita. No segundo bloco, as varas de madeira já trafiladas são conduzidas paralelamente, com o objectivo de diminuir a quantidade de lâmpadas necessárias, mas principalmente o tamanho da estufa. A estufa é constituída por cinco partes: a passadeira, que determina o tempo que as varas demorarão a atravessar o interior da estufa e, consequentemente, o tempo que estarão sujeitas a radiação IV; a ventilação, que tem como objectivo refrigerar o interior e retirar vapores tóxicos; as lâmpadas de IV; o regulador da altura da passadeira, porque as varas têm alturas diferentes; um controlador que permite manter a temperatura interior de tal forma que seja possível secar a tráfila, sem inflamar os solventes que a constituem.

Foi feita uma estimativa do número de lâmpadas necessárias para a estufa e, para efeitos de cálculo, considerou-se que a variação da intensidade da radiação emitida pelas lâmpadas é linear, entre os -25º e os 25º de ângulo de incidência, sendo desprezável a radiação emitida fora deste intervalo. Atendendo a que se pretende secar não só a parte superior mas também a parte lateral do perfil, as lâmpadas podem estar inclinadas (cerca de 30º). Pode estimar-se, então, o número de lâmpadas necessário para a estufa. Cada moldura em vara deve receber a mesma quantidade de radiação ao longo de todo o seu comprimento. Considerando uma altura de cerca de 600 mm, o raio de acção é dado por: $r_{ac} = 600 \times \tan 25^{o} \approx 300\ [mm]$. Tendo em conta o perfil de distribuição da radiação simplificado, pode estimar-se o número de lâmpadas que deve incidir ao longo de cada moldura em vara. Como cada moldura em vara tem 3 m, precisa-se de 10 lâmpadas. As lâmpadas ficam distribuídas de 30 cm em 30 cm; as lâmpadas dos extremos devem distar cerca de 15 cm da parede pois esta reflecte a radiação (o revestimento em alumínio facilita a reflexão da radiação).

3.2 Controlo de qualidade

Por forma a garantir a qualidade dos produtos, foram também sugeridos dois sensores. Estes sensores reúnem as características necessárias, analisadas e propostas pela engenharia e gestão industrial, tento a pesquisa de mercado sido feita pelos elementos do grupo de engenharia electrónica industrial, que são mais entendidos nesta área.

O primeiro é o sensor de perfil 3D OMRON FZD-LTPW que será colocado antes das varas serem trafiladas, com o objectivo de permitir não só comparar os perfis com modelos CAD para realizar a separação de produtos defeituosos, mas também digitalizar perfis. A digitalização de perfis é útil para o desenho dos moldes do reservatório da tráfila. O segundo sensor é o sensor de visão simples FQ, também da OMRON. Este sensor fará a comparação das varas trafiladas com o modelo que for "ensinado" pelo utilizador, fazendo assim, tal como o primeiro, separação de produtos defeituosos (OMRON,2010).

3.3 Sistema SMED de mudança rápida do reservatório da tráfila

O elevado tempo na preparação da máquina de aplicação da tráfila para um novo tipo de perfil foi também um problema estudado pela engenharia e gestão industrial, e a solução encontrada pela engenharia mecânica foi um sistema que permite a substituição e preparação rápida do reservatório da tráfila. Este novo mecanismo foi desenvolvido de acordo com o método SMED, cujos princípios podem ser aplicados a qualquer tipo de *setup* (Courtois, et al., 2006). Numa primeira fase devem identificar-se as operações internas e externas. As operações internas são aquelas que só podem ser efectuadas com a máquina parada, enquanto as externas podem e devem ser realizadas com a máquina em funcionamento. De seguida, as operações internas devem ser transformadas em operações externas, ou seja, o processo de mudança de série deve minimizar o tempo de paragem da máquina.

Actualmente, o procedimento de substituição e preparação do reservatório da tráfila é levado a cabo com a máquina parada, isto porque as máquinas de aplicação de tráfila apenas têm um reservatório. Para melhorar esta situação, o que se propõe é a incorporação de um sistema com dois reservatórios na máquina de aplicação de tráfila. A incorporação desse sistema permite a aplicação de tráfila com um reservatório, enquanto o outro é limpo, de modo a ser possível mudar a tráfila e o tipo de perfil que se vai trafilar no lote seguinte. Por outro lado, as duas caixas podem estar preparadas concomitantemente para produtos diferentes. Desta forma, um reservatório realiza a aplicação da tráfila enquanto o outro fica em espera durante o tempo de secagem do respectivo produto. A prévia afinação da máquina de aplicação da tráfila é feita antes da colocação da calha em funcionamento.

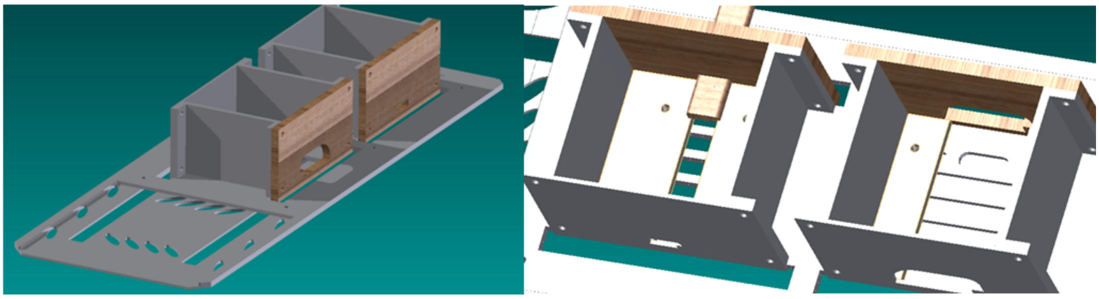

Figura 15: Sistema SMED de mudança rápida do reservatório

4 Procedimento experimental

A secagem de solventes é uma tarefa complexa pois cada tipo de solvente tem as suas especificidades. A título de exemplo, os solventes miscíveis em água são os mais difíceis de serem secos (Ferreira, 1992). Apesar disso, este estudo centra-se na diminuição do tempo de secagem, pois nas condições actuais do sistema produtivo, cada demão de tráfila demora uma hora a secar. A diminuição do tempo de secagem é possível com recurso a vários métodos, nomeadamente: radiação ultravioleta (UV), radiação infravermelha (IV), microondas e convecção de ar quente. A empresa já tinha utilizado a radiação ultravioleta e a radiação electromagnética por microondas, mas sem resultados satisfatórios relativamente à qualidade final dos produtos. A convecção de ar quente tende a provocar encurvamento nas varas em madeira (Jankowsky, 2010). Assim, este trabalho centrou-se no estudo da radiação IV. Esta radiação tem uma gama de comprimentos de onda que varia entre 700 nm e 1000 µm (= 1 mm).

A secagem por IV promove a evaporação da água e dos solventes voláteis. A cinética da secagem pode ser medida com recurso à gravimetria (conjunto de análises químicas com base na variação quantitativa da massa) e por fotoionização (processo físico no qual a incidência de um fotão provoca a libertação de um ou mais electrões). O coeficiente de transferência de massa (durante a secagem de solventes) é maior usando infravermelhos do que pelo aquecimento dos próprios solventes (M.A. Rösler, 1994), nomeadamente através da convecção de ar quente (apesar de a radiação IV provocar o aquecimento da superfície onde incide).

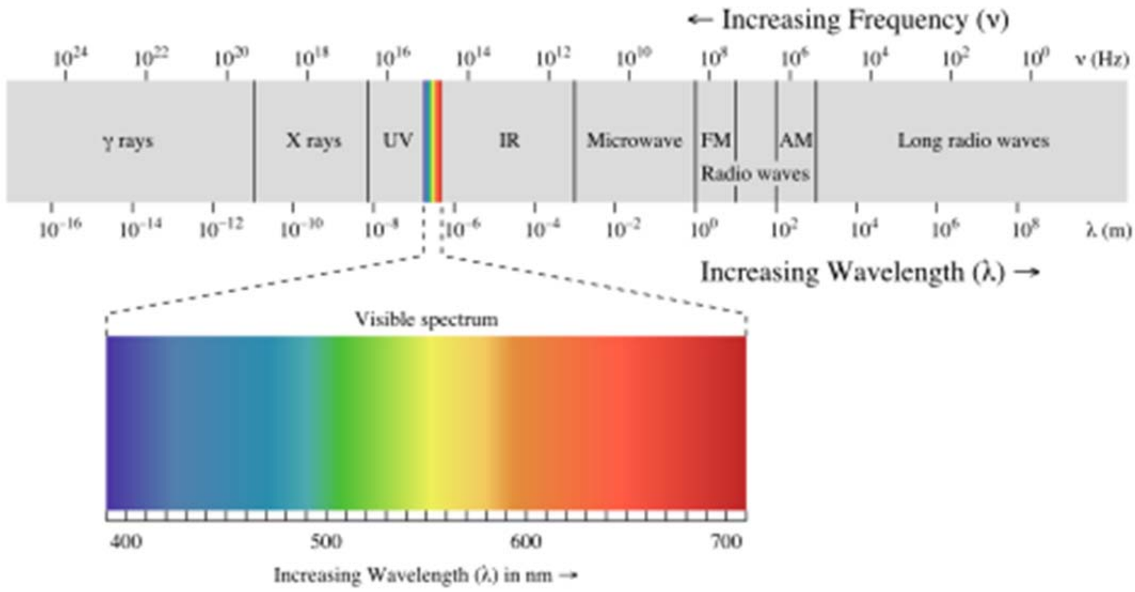

Figura 16: Espectro electromagnético (FLICKR)

A radiação electromagnética com comprimentos de onda entre 0,1 e 1000 μm tem efeitos térmicos. Isto significa que a luz visível e parte da luz ultravioleta também emitem energia térmica. Todavia, a radiação infravermelha ocupa quase toda a gama de energia térmica (Lienhard IV, 2008 p. 28). A energia térmica associada à radiação IV pode ser calculada pela lei de Stefan-Boltzmann (Lienhard IV, 2008 p. 30). A energia infravermelha é convertida em calor na superfície onde incide a respectiva radiação. Contudo, o calor interior do corpo é determinado por condução. Isto significa que os materiais com baixa condutividade térmica (como a madeira e os plásticos) podem desenvolver temperaturas consideráveis à superfície sem que as temperaturas internas aumentem consideravelmente. Esta é uma grande vantagem para a secagem de solventes (HIGHER, 2010). Actualmente, este tipo de secagem é usado em várias aplicações da indústria, por exemplo, na indústria automóvel.

Como todos os corpos emitem radiação IV, todos recebem radiação de outros corpos de acordo com a emissividade de cada um. Um corpo negro (em sentido absoluto) tem uma emissividade de 1, e por isso, absorve toda a radiação que recebe. Uma superfície rugosa tende a ter um índice de emissividade superior. Contudo, a emissividade pode variar com a temperatura (Engineeringtoolbox).

Atendendo às características da secagem observadas na empresa, constata-se que as molduras que são colocadas na parte superior dos pentes (estruturas de suporte de molduras para transporte e secagem das mesmas) secam mais rapidamente. Ora, verifica-se que as molduras da parte superior dos pentes recebem mais radiação por causa do espaço envolvente: maior luminosidade (quer natural, quer artificial) e contacto com condutas de aquecimento. Isto significa que a tráfila tende a secar melhor com o aumento da radiação infravermelha. Para verificar esta teoria, e analisar os respectivos efeitos, foram realizadas três experiências de secagem por IV na empresa.

A experiência realizada a 10 de Dezembro de 2010 não mostrou resultados conclusivos, porque: a tráfila usada era semi-transparente; e as indentações foram realizadas após a segunda demão (pelo que a espessura de tráfila não era suficiente para suavizar os poros da madeira). Estas razões inviabilizaram a análise das indentações. Os sulcos que estas provocaram confundiam-se com os poros naturais da madeira, o que impedia que a indentação fosse mensurável.

Contudo, foi realizada uma nova experiência a 21 de Dezembro de 2010 onde se usou uma estrutura de madeira preparada para secagem das molduras em vara. Esta estrutura foi revestida de alumínio (para maximizar a incidência da radiação na moldura) e forrada na base com geotêxtil (para dificultar a desumidificação da madeira). O perfil de moldura usado na experiência tinha como referência o número 099856. A lâmpada de infravermelho (OSRAM, SICCA R125 Red 150W) foi colocada por cima da vara para que a radiação incidisse directamente para a moldura em vara. Ao longo do decorrer da experiência efectuaram-se medições da temperatura ambiente e da humidade relativa (Tabela 1).

Tabela 1: Valores da temperatura ambiente e da humidade relativa ao longo da 3ª experiência

Hora	Humidade Relativa	Temperatura
15h00	70%	22,0 °C
16h15	60%	19,9 °C

Nesta experiência, fizeram-se várias indentações para averiguar a evolução da secagem e mediram-se as condições ambientais. As indentações foram feitas com recurso a um indentador construído propositadamente para o efeito.

Tabela 2: Valores das medições das indentações feitas na 3ª experiência (valores em µm)

Tempo de secagem	Secagem por Infravermelhos	Secagem Normal
5 min	540x580	
10 min		800x900
25 min		700x800
35 min		660x700
45 min		620x660
55 min		600x600

A Tabela 2 mostra os resultados da análise das indentações. A Figura 17 e a Figura 18 mostram algumas das indentações vistas ao microscópio óptico (Zeiss Axiotech 100 do laboratório de Metalurgia da Universidade do Minho).

Nas condições em que a experiência ocorreu, o tempo de secagem da tráfila foi cerca de 3 minutos. O resultado da secagem foi comprovado não só pela analise microscópica das indentações no laboratório de Metalurgia da Universidade do Minho, mas também pela opinião baseada na experiência do especialista em pintura e secagem da empresa.

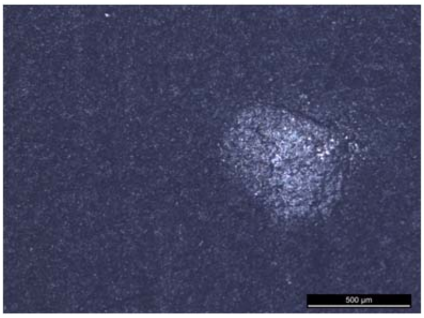

Figura 17: Visualização da indentação feita após 5 minutos de exposição à radiação infravermelha

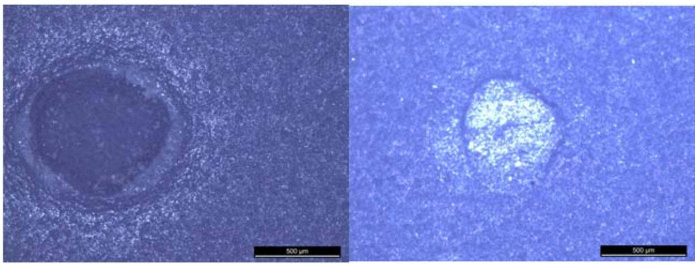

Figura 18: Visualização da indentação feita após 10 e 55 minutos de secagem normal

Os resultados vêm sustentar o desenvolvimento do projecto de uma estufa de secagem por IV. Porém, deve ser sublinhado que são necessárias mais experiências para confirmar os resultados obtidos e para averiguar o tempo de secagem sob condições diferentes (nomeadamente com outros tipos de tráfila).

Fez-se também um estudo da variação da temperatura ao longo da exposição à radiação. O aquecimento é feito de acordo com a lei de Stefan-Boltzmann, a qual, aplicada à análise da variação da temperatura de uma superfície, resulta na seguinte equação: $Q = F_\varepsilon F_g A\sigma(T_f^4 - T_i^4)$

Onde:
Q = Taxa de energia emitida pela fonte de IV [W];
F_ε = Factor de emissividade;
F_g = Factor geométrico (relativo ao ângulo de inclinação da superfície);
A = Área da superfície [m²];
σ = Constante de Stefan-Boltzmann (5,6704 x 10^{-8} W.m^{-2}. K^{-4});
T_f = Temperatura final do corpo [K];
T_i = Temperatura inicial do corpo [K].

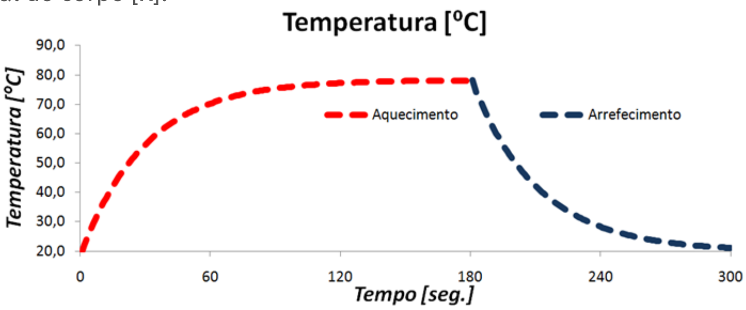

Figura 19: Estimativa do comportamento da temperatura (aquecimento de 3 minutos e arrefecimento de 2 minutos)

A Figura 19 mostra o comportamento (estimado) da temperatura ao longo da exposição à radiação (durante 3 minutos) e o consequente arrefecimento (ao longo de dois minutos, após a moldura em vara ser afastada da radiação). Os valores de entrada para esta análise são aproximados àquilo que é espectável, pelo que se prevê que a temperatura ronde os 70 a 80 ºC ao fim de 3 minutos. No entanto, não foi possível confirmar efectivamente o comportamento da temperatura ao longo da experiência pela dificuldade (e complexidade) de mensurar uma variação da temperatura ao longo do processo radiativo, por causa da diferente interacção que o termómetro tem com a radiação infravermelha.

5 Conclusão

A realização deste projecto conseguiu dar resposta aos objectivos apresentados: o desenvolvimento de um novo produto e melhoria do sistema produtivo, da empresa.

Este artigo mostrou os resultados do trabalho interdisciplinar conseguido ao longo do semestre.

Grande parte do tempo de produção é gasto no processo de aplicação e secagem da tráfila. A primeira preocupação da engenharia e gestão industrial foi tentar reduzir este tempo de secagem com o objectivo de diminuir o stock intermédio. A engenharia mecânica e a engenharia electrónica industrial estudaram e sugeriram que se recorresse aos infravermelhos para secagem da tráfila. As experiências indicam que é possível diminuir o tempo de secagem de 60 minutos para 3 minutos, contudo, o tempo de secagem vai variar com o tipo e a cor de tráfila. Para a implementação do sistema de secagem por IV, foi estudada pela electrónica industrial, uma estufa automatizada que permite a variação da velocidade do tapete, o controlo da temperatura interior da estufa e o funcionamento do sistema de extracção de gases. Além disso, os tempos de *setup* elevados, observados pela engenharia gestão industrial, melhoram substancialmente recorrendo a um sistema proposto pela mecânica, onde duas caixas trabalham sequencialmente deslizando sobre uma calha. Este aspecto é particularmente útil na produção de lotes menores de molduras.

No entanto, a qualidade dos produtos finais não podia ser condicionada pelas alterações que estavam a decorrer no sistema produtivo. Desta forma, a engenharia e gestão industrial idealizou a utilização de sensores que controlassem algumas propriedades que garantiam a qualidade dos produtos finai. A utilização de um sensor de visão 3D permite melhorar o controlo da qualidade, avaliando o perfil das molduras em vara antes de entrarem nas máquinas de aplicação de tráfila e prevenindo o encravamento, diminuindo as perdas de tempo e de recursos. Está prevista a utilização de um sensor de cor para controlar defeitos na cor das molduras em vara. O estudo dos sensores a utilizar foi feito, essencialmente, pelos estudantes de engenharia electrónica industrial.

Este projecto foi muito importante para o enriquecimento dos conhecimentos de todos os elementos do grupo. A experiência adquirida permitiu solidificar não só as bases técnicas e científicas, mas também fortalecer as capacidades de trabalho em equipa. A gestão de tempo, numa equipa com elementos de quatro cursos diferentes, com horários diferentes, é uma dificuldade que deve ser ultrapassada logo no início do projecto. A definição de horários, distribuição de tarefas e responsabilidades são aspectos cruciais para o bom funcionamento da equipa. A existência de um espaço de trabalho comum facilita o contacto, comunicação e proporciona a discussão de ideias e partilha de conhecimentos. A participação neste projecto permitiu adquirir e aprofundar técnicas de gestão de projectos que facilitaram o controlo do trabalho por forma a cumprir os prazos estipulados.

Esta empresa de produção de molduras possibilitou aos vários elementos do grupo alguma experiência profissional, o que, certamente, trará consequências positivas para o trabalho de cada futuro(a) engenheiro(a).

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Challenges and Benefits of Large Scale Software Projects

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Abstract

Large scale projects are a unique challenge in software development, especially in academic settings, where they are seldom explored. Therefore, the challenge arose to tackle a large-scale (19 people) software project in the context of the 2nd year MSc in Informatics at University of Minho. In a project of this size, a great deal of attention must be given to planning and management or the whole project will surely fall apart. Indeed, one of the main academic goals of the project was to foster precisely those kinds of skills in the students. In addition, there was a heavy entrepreneurship component to the project. The group was required to simulate most aspects of a start-up company and attempt to market itself and the project as though they were real business ventures. The theme for our project was a web group content management system (GMS) called Simon. A GMS is a new concept we invented that aims to provide a complete solution for an association in terms of activity and member management as well as an online presence. Simon was originally planned for the exclusive use of student associations but was later expanded to become a generic solution that can be instantiated according to the needs of any organization. This paper aims to give an account of our project and its outcome as well as present some of our thoughts on the overall experience. It will have a special focus on the management and planning aspects of the project.

Keywords: document Software, Management, Students, Large Scale Projects, Report.

1 Introduction

Our project was a part of the UCE15 course in the MSc in Informatics at the Department of Informatics of the University of Minho. The main goals of UCE15 are to give students learning experiences that they have not yet had in their academic training.

As for the project itself, the initial theme was to develop a system to manage student organizations. Our project and theme was actually self-proposed, as opposed to the other projects which were proposed by third parties.

Soon after analyzing the initial proposal we decided to expand the scope of the project somewhat. Rather than focusing solely on student organizations, we instead chose to develop a generic system to manage any organization or group. We named the project *Simon*, which has no real meaning but was simply a name we liked.

In our view, Simon is "the guy that knows what your group needs"'. We soon came upon this notion of Simon as almost an individual that would help a group become more organized, efficient and productive.

We believed there was some need for a system of this type. While there were plenty of ways for an association to keep track of its members, there was no one integrated solution that provided all the different functionalities needed by an association. Because of this, most associations end up using a mix of several different applications to handle their needs. Simon's aim was to offer a single solution for every single need.

Since the other projects of UCE15 all had specific clients, it was easy for them to simulate the business side of the project. To help our project keep up, we also had a specific client: the student association of the Medicine course at University of Minho (NEMUM). In addition, we attempted to market Simon to various other organizations.

1.1 Motivation

Large scale teams are a unique challenge in the context of software projects. In these projects, a much greater focus must be put on management tasks since they can become one of the key failure points for the entire project.

Throughout our academic career, we had never engaged in a project of this sort. Therefore, to complete our training, this kind of project arose naturally.

In this situation, in addition to all the regular trappings of a Software project, we had to pay careful attention to our team. This team was rather large (19 people) but most of us had never dealt with teams larger than 5-8 people.

Furthermore, all aspects related to planning, management and organization were placed entirely in the workgroup's hands. The only thing that was supplied was a project theme (in our case, the theme was actually self-proposed), and even that was pretty barebones.

Finally, there was an important entrepreneurship component to the project. We had to simulate as many aspects as possible of starting up a new company and business based around our project.

Because of the aforementioned aspects, this project presented some new and unique challenges and we feel we were able to meet them successfully.

2 Project Objectives

There were several objectives for our project. Some had to do with the application - Simon itself. Others were related to the organization and management or our team. And some were related to business and entrepreneurship components. We felt our list of objectives would allow us to fulfill every requirement for the UCE15 project. Our objectives for the project are presented, in broad strokes, below.

2.1 Primary Objectives

The key objectives for Simon are presented here. Most of these objectives were directly related to the application itself and were, in essence, what occupied most of our time. These can be considered our primary objectives.

- Develop a fully functional application for group management:
    - Support for member management including member groups and membership fees;
    - Support for management and planning of activities;
    - Supply the association with a web presence and communication features;
    - Validate the application with proper testing methodology;
    - Follow an established software development model;
    - Produce additional materials such as images, logos and manuals.

2.2 Management Objectives

In addition to the primary objectives, one of the chief goals of the UCE15 project was to teach students what it's like to work in large-scale teams and what it's like to manage them. This gave rise to a few objectives related to managing a workgroup and planning a project. They are listed below.

- Organize and manage the team to ensure a successful project:
    - Organize a large group of people into smaller groups so as to cover the project's various needs;
    - Choose, develop and follow a work methodology;
    - Track the progress of the project;
    - Use an internal review system to evaluate the performance of each member;
- Plan the project and its various activities
    - Split the project into several milestones;
    - Split each milestone into several required tasks;
    - Assign dates to tasks and allocate tasks to members;
    - Develop an overall timeline and roadmap for the project;
    - Anticipate problems and find ways to deal with them;

2.3 Entrepreneurship Objectives

The entrepreneurship component is possibly the second most important one (after the application itself). As such, we established several objectives specific to this component.

- Construct a complete business plan;
- Come up with ways to promote Simon;
- Attract additional potential clients;
- Produce additional business materials (presentations, pitches, questionnaires, etc.)

3 Project Planning and Management

In this section we will talk about our work methodology and how we went about organizing ourselves.

3.1 Management

3.1.1 Team Structure

One of the more important aspects of a project is organizing the members of the team. When the team comes together for the first time to work on a project, it is important that people be allocated across several different areas. To perform this allocation, we began by constructing a matrix of team members and their respective skills.

To construct this matrix and expedite matters, every member of the group was originally asked to send an email with his skill information to the group leader. Afterwards, the leader split people into subgroups and this distribution was presented at the first team meeting. This let us save quite a bit of time by not having everyone arguing over where they should go. All we needed to do were a few small adjustments here and there.

As for the groups themselves, we had to come up with several to cover all the expected needs of the project and be able to place people in areas they excelled at. On top of this, there were a couple of informal management teams that essentially consisted of the various team leads, distributed by area of responsibility (basically one team was responsible for leading development and another responsible for leading everything else). Our original team structure can be seen Figure 15.

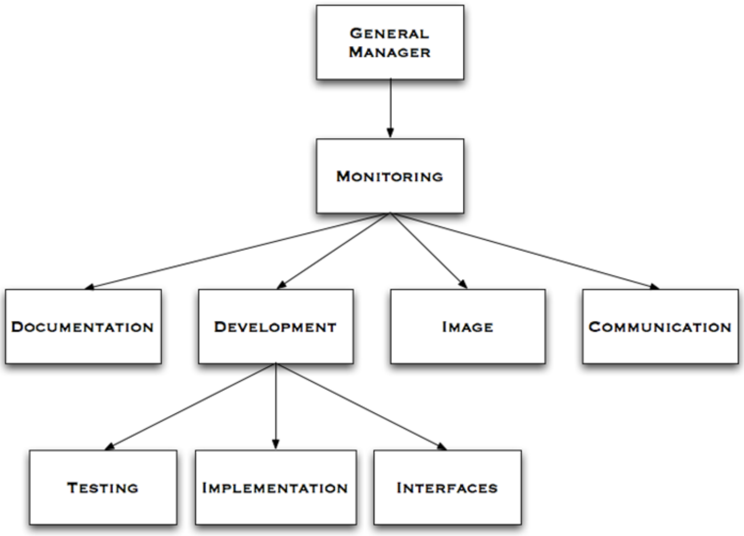

Figure 15: Original team structure

As time went by, we found some problems with our distribution. There was an excess of depth in some areas and a lack of clarity in terms of responsibilities. Also, some people were simply not being productive in the tasks assigned to their team.

As such, we began to move people and responsibilities around, slowly streamlining things. We eventually arrived at a simpler structure composed of 3 fairly independent teams. This structure can be seen in Figure 16.

The leader of each of the 3 teams was responsible for everything related to that team including planning and management. The overall project leader (the General Manager) set goals and milestones for each team in conjunction with its leader. The same was true for any overarching project decisions.

The new system was simpler but placed greater responsibility on each leader since there were no longer any teams dedicated to managing the project. However, this system ended up giving us much better results than the first one.

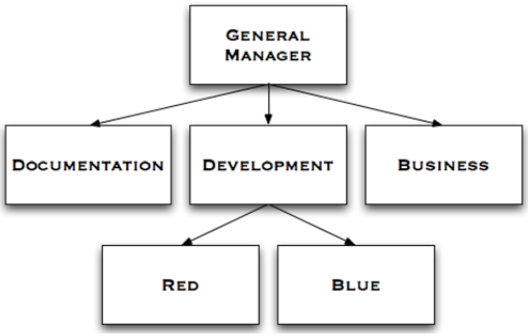

Figure 16: Revised team structure

3.1.2 Work Methodology

Organizing the team was not the only important management task in our project. It was equally important to develop a good working methodology. Our methodology evolved over time, just as the team structure did.

Our methodology was built on top of two concepts: **tasks** and **points**. Every week, each team had a set of planned tasks (as decided by its leader). The weekly performance of each team member was evaluated via an “effort point” system in accordance to the tasks he performed.

This methodology was simple to implement and track but is also gave us sufficient feedback on the project’s progress and each member's contributions. In order to implement this work model, we devised a simple questionnaire. The leader of each team had to answer the questionnaire every week. The questionnaire was made up of the following items:

- “What tasks were planned for this week?”
- “Which tasks were completed? (For any tasks not completed, please explain why)”
- “What tasks are planned for next week?”

To help with the tracking aspects, we had two systems in place: a weekly report and the point system. The report was simply a distillation of the questionnaire information. The point system consisted of two scores given weekly to each member: one for task completion (on a scale of “--” to “+'”) and another for the amount time spent on the project (numerical, on a curve). These two scores were used to track the contributions of each team member and also to help with a peer review process imposed by the UCE15 professors.

To help guide our work and ensure compliance with our established methodology, we devised the following model:

- **Thursday:** Team leaders responded to weekly questionnaire and delivered it to the person in charge of the weekly meeting.
- **Friday:** Weekly project meeting. Control and management of tasks.
- **Monday:** Weekly report written and posted to online project portal.

To further help the team members adhere to these rules, a more thorough explanation was written in a policy document and made available for the entire group.

3.2 Planning

In this section we will present the project roadmap. We will talk about what we planned to do, how those plans changed and how we adapted.

We originally divided our project into three major milestones with the caveat that Milestone 3 would mostly be used to compensate for lost time on the other two. Additionally, there were a couple of group management tasks that were considered important enough to be placed in the main roadmap. The original roadmap for the project is presented in Table 11.

Table 11: Original project roadmap

Date	Task
03-10-2010	Project Kickoff
30-10-2010	Teams and Tools chosen
02-11-2010	Simon 1.0 Requirements (Milestone 1)
11-11-2010	Simon 1.0 Specification (Milestone 1)
12-12-2010	Simon 1.0 Development (Milestone 1)
06-01-2011	**Milestone 2**
10-02-2011	**Milestone 3**

It has been said that no plan survives a first encounter with the enemy and this certainly happened in our case. As time went on, it became clear that our original plan was unrealistic. There was simply no time or way to achieve all the functionality we had planned, with the quality we wanted. While the project itself was progressing at a good rate, it was completely out of sync with our plans. Over time, we began to have a sense that things were slipping out of control.

On 07 December we held a status meeting where we decided to revise our plan. By that time we had gained a much better grasp on both our capabilities as a team and on the project's unique characteristics and challenges. Several changes came out of that meeting. We decided to get rid of the 3rd milestone and push the dates of the other two back. Both milestones were also redefined. The first milestone (Simon 1.0) was re-envisioned as a core platform upon which we would build basic functionality. It would also be highly extensible, allowing us to add functionality at later times via plug-ins. Milestone 2 became the development of one such plug-in to meet the remaining functional requirements. One of our development teams would handle Milestone 2 while the other took care of maintenance on Simon Core v1.0. An additional version (v0.5) was also developed to be delivered to our first client (NEMUM) on schedule. Finally, through interactions with the UCE15 professors, we came to realize the importance that would be placed on the business plan and so we added it to the roadmap. Parallel to these planning changes, we also implemented the team restructuring mentioned previously. The revised roadmap can be seen in Table 12.

Table 12: Revised project roadmap

Date	Task
08-01-2011	Simon Core Specification
14-01-2011	Simon Core v0.5 online
21-01-2011	Project Plug-in Specification
28-01-2011	Simon Manual
07-02-2011	Project Plug-in Development
08-02-2011	Business Plan and Project Report
11-02-2011	Simon Core Development
13-02-2011	Event Plug-in Prototype

This revised plan, although less ambitious, was far better than the original one. It was much more realistic in terms of functionalities and our own capabilities. All the core functionalities were still in place and additional ones were explored in the business plan. This roadmap also allowed us to focus more on the truly important project deliverables (such as the business plan, the NEMUM version and its maintenance).

4 Project Outcomes

In this section, we will talk a little about the outcomes of the project, both in terms of what we produced and what we learned.

Simon was a very large project with multiple components and disciplines involved. It is obvious that we cannot describe every single thing we did throughout the project. We will simply run through a few of the more important ones:

- The biggest deliverable of the entire project was the Simon platform. This includes the application itself (source code, configuration files, etc.) as well as a support manual. At the time of this writing, an example of Simon can be found online at http://www.nemum.com.
- Another major deliverable was the business plan. This document was the main outcome for the entrepreneurship component of the project. The business plan contained all the information related to launching an actual company based around the project.
- We also came up with a lot of promotional material to help advertise Simon. This includes things like flyers, t-shirts, posters, videos and etc. An example can be seen in Figure 17.

Figure 17: Promotional Simon t-shirts

- Another important aspect of promoting Simon was establishing its presence on the Web. We did this by creating a promotional website (at the time of this writing, it is available at http://simon.di.uminho.pt). Simon is also present in several major social networks such as Facebook and LinkedIn. Simon also has a YouTube channel where we placed several promotional videos (http://www.youtube.com/user/simongms2011).

Obviously, working on such a large project with such a broad scope, gave us a lot of experience in many different areas. All of us had worked on many, many projects over the course of our academic careers. But most of those projects had been done in small teams (usually 2-3, with the occasional 5 man team). Obviously, when we moved to 19 people, it was a completely different situation. Management became much more important. In our previous projects we had, to some extent, done things such as planning and structuring but they were usually very light. This time, the size of the team forced us to actually pay much greater attention to these activities. Until we worked on Simon, none of us could really claim to have any real management experience. Now, we can.

One activity that was pretty new to us was internal peer review and task tracking. The peer review system was a mandatory part of UCE15. The task tracking was something we chose to do ourselves. It was simply impossible for any one member to keep track of everything in an *ad hoc* way so we felt a system was needed. This was an area where we felt the experience gained was very useful since it is crucial to track the progress of a project and it is much easier to do so when you have an underlying system to do it with.

In addition to significant experience with various management activities, we also acquired quite a few other useful skills. Most projects we had done up until Simon typically only focused on the technical skills of software development. With Simon, we also learned a lot about entrepreneurship, developing business plans, marketing, design and branding and etc. Not everyone will have a need for these skills, but it is certainly beneficial to have become familiarized with them.

5 Conclusion

When we first began hearing about the UCE15 project, most of us thought it was quite daunting. The scope of the project, the size of the team and the coordination and organizational challenges seemed almost too much to handle. These things certainly proved to be quite problematic, but working on the project itself was far from a negative experience.

Throughout the course of the project we tried many styles of management. At first we were a bit naive. We believed that, with a hands-off management style, everyone would constantly step up and do what was needed. That did not happen. It was not simply a matter of lacking motivation or skill. There were too many people and too many tasks that had to be done. Things simply fell through the cracks. As we tightened the grip somewhat, things improved. But we eventually ended up erring in excess, by trying to exert too much control. While that control was useful, it simply tied up too many people in management tasks. Still, this is one of the first lessons we can take away from the project: with a team this large it would have paid off to have a few members exclusively devoted to organization and coordination from the beginning.

Planning was also something we learned as we went along. Our key problem was time estimation. The project's duration was 3 months. For us, this was a long time. Combined with the amount of people involved, it became very difficult to properly estimate the amount of time required for each task. This was one of the main reasons why we made such significant changes to our roadmap. Things cannot be set in stone. We now know that we need a process that is iterative and adaptable. It is very important to be able to change and correct things as the project moves along.

As the project reached its final phases, we felt we had struck a good balance in terms of management and control. It's never easy for peers to police themselves or deal with lack of productivity but we handled these problems as best as we could. In the end, we feel that everyone contributed something to the project. Surely, some gave more than others but this was to be expected. Most of all, for those who did commit to the project, the experience gains were tremendous.

But commitment really was a problem at times. By managing ourselves, we certainly learned a lot of new things. But a project like Simon would only work if everyone was committed. But at the end of the day we were still in an academic context so motivation was at times a problem. No one was really forced to do to they were told. They would only do it if they wanted to. And people only put in the amount of effort they wanted to. This wasn't a real company. Nobody was getting fired for lack of commitment. In theory, one could report such members to the professors and they might risk failing the course. But no one really does that. Students don't turn on each other. There should have been more direct intervention from the professors. In fact, there were a lot of members of our team that never once interacted with the professors.

But in spite of the problems mentioned above, this project was more than worth it. For starters, we feel the final product is quite good. Our project was unique since it was self-proposed. This allowed us to present something that was new and innovative. There are certainly options for associations to use for management and web presence but Simon is the first to be totally aimed at associations and offer a complete and integrated functionality set. It is also of high quality from a more technical standpoint. Source code quality was a big focus for us throughout the project and though it caused some problems at times, it has paid off in terms of the final product. It is also worth noting that the experience we gained by working with modern development tools and technologies was also quite worthwhile.

The fact that we were simulating an actual company made the project that much more *real* to us. By having to do everything on our own and not relying on our professors, we learned a great deal more than we would have otherwise. The fact that we were, in a sense, working on something that was ours (as opposed to developing software for a third party client) also acted as an additional motivating factor. That said, the entrepreneurship component is something that might not be suit everyone. We feel there should be some sort of alternative project that placed a greater focus on scientific and theoretical aspects. After all, this is a master's degree course.

As for the future, Simon is a project with tremendous potential. A big part of the business team's work was to lay the foundation to expand the project into a professional venture and maybe turn the team into a company. This is actually feasible and some members of the team are going forward with it. In that regard, and many others, we can say that the Simon project was a true success.

European BEST Engineering Competition (EBEC)

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Abstract

This paper describes the European BEST Engineering Competition project (EBEC), the biggest external project organised by the Board of European Students of Technology (BEST), which givesthe chance to European technical students to get an additional/complementary education, challenging them to solve engineering problems. The motivation for this event, the structure and some feedback are included on this document.

Keywords: engineering students, engineering education, cultural diversity.

1 Introduction

Board of European Students of Technology (BEST) has a nine-year-old history in organising Competitions. This idea came from the already existing Canadian Engineering Competition (CEC), organized by CFES, when some BEST members went to the event in March 2002. They came back to Europe very enthusiastic and started to promote the idea. Not surprisingly, competitions started to multiply around different Local BEST Groups, proving lots of potential on the complementary education and development of the technological students in an exciting way: exposing engineering problems to various teams of students and having them competing one again each other for the best solutions.

Various BEST Engineering Competition events have been taking place in BEST, but on the past two years, strong developments were made on this field in order to unite all those competitions and involve deeper universities, NGOs and companies. European BEST Engineering Competition project (EBEC) was born.

In 2008/09 the first edition of EBEC project under the present structure was held. Local BEST Group Ghent hosted the final round that collected the best teams from 51 local rounds.

In 2009/10, the project grew even more: 26 new competition rounds joined EBEC project. In the end, Local BEST Group Cluj-Napoca hosted the best teams qualified from Portugal, Spain, France, Italy, Belgium, Poland, Czech Republic, Serbia, Romania, Turkey, Estonia, Denmark and Ukraine. There, 104 of the best participants competed for becoming the best engineering competitors in Europe. All in all, five thousand European engineering students from 77 different universities were involved in the project that year.

This year's edition will involve students from more than 80 European Universities and, just like the previous years, it intends to help engineering students gaining experience and skills needed for a successful future career. BEST wants to raise awareness on the importance of non-formal education in the process of developing young people by involving in the project different local authorities and European, national and regional bodies that could improve the system and develop other activities in this direction for the future (BEST, 2011; EBEST (2011))

2 Scope

In the next lines, the scope of EBEC is specified. Besides the main goals of the project, the structure and the content of the event are also described.

2.1 Objectives

This EBEC project is under the core activity of BEST: providing complementary education.

The main objectives of the project are:

- Self-development of the students that will participate in this project which is ensured through the two competition categories they will be involved in: Case Study and Team Design.
- Promotion of Engineering and Engineering Education among students giving them the possibility to practice the theoretical knowledge gained during the academic courses, by finding new technical solutions for day to day problems that humanity is dealing with at the moment.

- Promotion of cultural diversity among students, collecting students from different countries in the competition rounds - BEST (2011).

2.2 Categories

In EBEC project there are two kinds of categories teams can participate in: Team Design and Case Study.

Both of categories have something in common: they push the students to put in practice what they learnt in the classes, usually approaching multidisciplinary engineering fields.

2.2.1 Team Design

The Team design category consists in solving a given technical problem in teams within a limited time. The outcome of the competition is a device that has to perform the needed actions to solve the problem (e.g. building a machine capable of drawing a specific shape, as you can see in the references - *Draw the BEST Logo*). Materials, tools and needed explanations are provided to the participants by the responsible organisers. In the Final round of the past two years, Team Design topic was given by the United Nations Environmental Programme and for the next edition it is also planned to involve them again and also have some new NGOs as partners (e.g. Engineers without border) (EBEST, 2011; EBEC, 2010a).

2.2.2 Case Study

The Case Study category consists in solving a technical or management real-life problem with no actual construction of any device or assembling of some materials, but using the information given to develop hypothetical solutions. In the end the teams shall give a presentation of the solutions they came up with. In the references, the *Traffic Management in Mumbai* is an example of a BEST Case Study. In the regional and final rounds, European industrial partners very often cooperate with BEST, bringing some Case Study topics to be solved during the competition (EBEST, 2011; EBEC, 2010b).

2.3 Structure

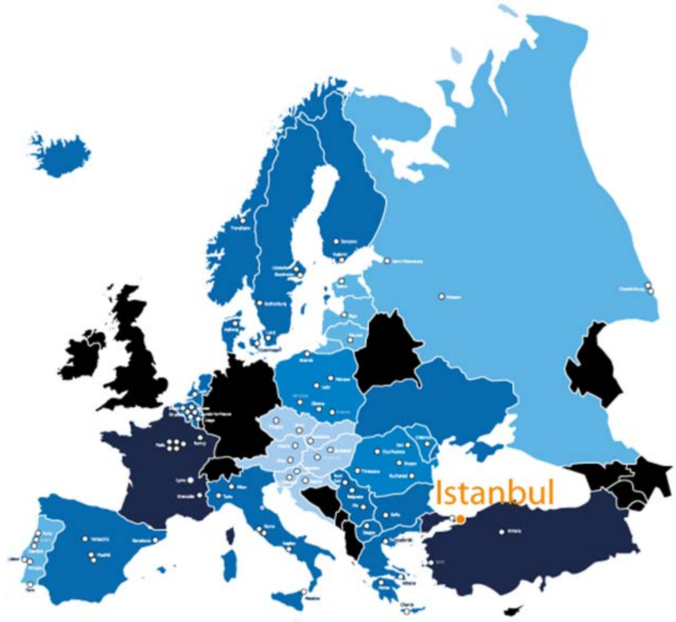

Figure 1: The map of European BEST Engineering Competitions: the spots represent the local rounds, the colours represent the regional rounds and, in a bigger plan, Istanbul is the host of EBEC Final 2011. Image source: EBEC - European BEST Engineering Competition - http://ebec.best.eu.org/nbec_rbec/

The EBEC project is developed through a pyramidal structure and it works as it follows:

- Local BEST Engineering Competitions (LBECs) are one day events organised by Local BEST Groups from different technical universities. This year, more than 80 Universities from 30 countries in Europe will host LBECs, involving more than 5000 students.
- National/Regional BEST Engineering Competitions (NBECs/RBECs) that are organised in 13 different countries in Europe will gather the winners of all LBECs that are part of each NBEC/RBEC. They usually last for 2-4 days and, in total, they collect around four hundred eighty eight students.

- Final round, EBEC Final, that takes place in Istanbul in August 2011. This year, it will gather 104 competitors from all over Europe. During 11 days, 6 of them are working days and the other ones are dedicated for other different topics, such as company day, cultural visits and social activities. In the last day of the event, the final decision to decide the winner is taken considering the points earned in each EBEC Final task. During the LBECs and NBECs/RBECs the same procedure for establishing the winners is used.

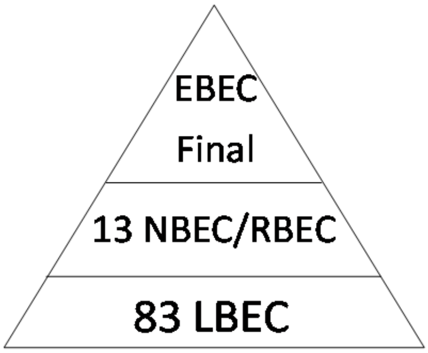

Figure 2: The pyramidal structure of European BEST Engineering Competitions: from the 83 LBECs, more than 500 participants go to the next National/Regional round. From those, 104 are qualified for the main event: EBEC Final.

During the competition rounds, students receive Team Design or Case Study tasks, depending on the category they're participating. These tasks challenge them to use their engineering abilities and soft skills. The tasks could last from one to four days, depending on its difficulty.

After each task, participants held a presentation in front of the jury, in order to evaluate the solutions, considering the task evaluation guidelines. Usually, the evaluation rounds are made in public (EBEST, 2011).

3 Target Stakeholders

European BEST Engineering Competitions project aims to engage main stakeholders in organisation of the event as supporters and partners able to provide tasks for participants.

By targeting companies for the event, BEST is giving the opportunity to provide tasks that are related to a specific category obtaining a solution to an engineering problem or to a business case from top engineering students. BEST is striving to associate them with the social awareness and cooperation with NGOs.

Through this project, BEST wants to involve the European universities in the process of developing students, by encouraging them to support students through non-formal education. By this cooperation BEST is promoting universities for foreign students by providing information about studies. The event aims to raise the awareness of universities regarding winners of competitions and help students to be recognised by universities.

BEST offers students the chance to meet and earn from one another, developing soft skills and teamwork. Participants have a unique chance to use the theoretical knowledge, that they gained throughout their studies and put them into practice by working on finding solutions for interesting and challenging topics. Through this project and its activities, students will become more tolerant and will learn how to formulate and sustain their own opinions, develop their personal and academic/technical skills, helping them in their future careers. The event will also help students to interact with different partners of the event and give them the chance to see the expectations from them for a future career. The participants will have the chance to experience intensive team work, cross cultural communication, and it will be an enlightening experience to improve themselves. Moreover, as this event is organised for students by students, EBEC is also an event that develop organisers working and soft skills.

One of the goals of EBEC is to increase social awareness among students and therefore collaborates with NGOs. Hence, by cooperating with NGOs BEST is supporting activities which aim in finding solutions to real life problems of the world environment and all in all – of all human kind.

4 Impact on Participants

The reason behind the idea of organizing such competitions among European engineering students was the fact that most of the students were complaining of not having the chance to practice their technical knowledge and that they do not have the experience of working alone and being responsible for a project before moving to the life as an employee. Undergraduate students have a strong desire to participate in “real-world” projects and this is what they should get the chance to work on and prepare them for the future.

Since the very beginning, when the first edition of EBEC took place in Ghent, Belgium, the goals of this project were oriented towards students and their development throughout the three rounds. The events that are part of EBEC pyramid give the students the opportunity to use their theoretical knowledge gained during the University, by being challenged to solve interdisciplinary tasks. In this way we make sure that EBEC is a project that targets all engineering students, no matter what their field of study is, and is able to offer them a good quality content that can help them develop themselves in an international environment.

Besides the technical skills that students have the chance to use and improve during the events, they also get the opportunity to develop their soft skills either through the trainings that they are delivered before the Final round or through the working methods that they need to use during the competition itself. During both Case Study and Team Design competitions, the participants compete in teams of 4 people and like this they learn how to work in a team, how to trust each other and communicate efficiently. As the evaluation of the EBEC Final 2010 shows, more than half of the participants from the Final event considered that they improved their team work skills during the participation to our project. For BEST this is a very important feedback, taking into consideration the fact that in the Campus 360 online survey conducted by “Tredence/Emerging” amongst recruiters in 20 countries worldwide, the soft skills were considered very important for an ideal graduate in order to succeed in a company. Moreover, almost 65% of the companies that participated to this survey considered the ability to work well in a team the most important aspect for a fresh graduate (Trendence, 2010).

In comparison to individual learning, where the focus is little or there is no attention to group formation, through competitions the students have the chance to assess how well the group is functioning and how good the quality of its work is.

Cooperative learning (CL) is a very effective learning tool for all learners when it is successfully used. It is not a new concept, but it needs to be used as often as possible in order to achieve the expected results. CL is a positive form of teaching and learning that benefits students. To successfully use CL, one may use the five elements of cooperative learning. As presented by Richard M. Felder and Rebecca Brent in the paper about CL in technical courses (Felder and Brent, 1994) the main elements for CL are:

- Positive interdependence
- Face-to-face promotive interaction
- Individual accountability
- Interpersonal and small group skills
- Group processing

Some of these elements can be reached through university projects, can be also achieved through different kind of teaching methods, but unfortunately not all the students have this great chance. Bonwell and Eison (1991) describe active learning in the following fashion: "When using active learning students are engaged in more activities than just listening. They are involved in dialog, debate, writing, and problem solving, as well as higher-order thinking, e.g., analysis, synthesis, evaluation."

Gathering all these elements into the working methods that such competitions put into practice, a healthy environment is created for those participating at the events, offering them the opportunity to experience different kind of situations that they might face in a near future.

All the working methods together with the activities that take place during the competition help the students improve personal skills like: project management, time management, presentation skills, they learn how to work and how to approach different kind of situations and all these things will prepare them better for a future engineering career. They are able to formulate and sustain their own opinions in front of an audience and in the future they will act more responsibly towards society. EBEC is also a way of attracting students to engineering and encouraging them to follow an engineering career, by showing them the advantages through interactive ways.

What we strive for is to promote the development of sustainable networks, the exchange of best practices as well as the recognition of non-formal education, which will create an even more important impact on students' life in the future.

Through the activities that we organise during the events part of the project, the students have the chance to establish connections with all the other participants and after the events they share their experience with friends and colleagues, encouraging them like this to be part of such projects. After the EBEC Final all the 104 participants receive a Competition Information Form that attests their work and skills that they proved during the whole project and will also be able to receive ECTS points from their universities when they go back home. Through this BEST encourage universities to recognise non-formal education and to value the students' skills that are so much appreciated in their future career.

Besides the academic part of the competitions (trainings and Case Study and Team Design competitions) during the events, the participants will be involved in social and cultural activities, helping them develop an international mindset. The students participating in EBEC have the great opportunity to meet other European students from different countries and cultures, but with the same interests.

5 Conclusion

The EBEC project is now approaching the Final event of the third edition and during these years we succeeded in organising it in cooperation with companies, NGOs and universities, we had the chance to improve ourselves as an organisation and as individuals, we had given the chance to more than 10 000 students from all over Europe to get involved in the project and develop their skills. Still, our main goal for the future is to improve the awareness of social responsibility among all the bodies involved:

- **Students**, because they have innovative ideas that could bring important changes for the humanity
- **NGOs and companies**, because they can help putting these ideas in practice and they can bring their contribution by supporting students to give life to their improvements.
- **Universities**, because they can get involved more in the process of developing students, making them use their knowledge in the right way and the right directions and these things will just lead to a development of the quality of the educational systems in Europe.

The project itself gives a great opportunity for students to implement their knowledge into practice and try themselves in totally new fields, where exchanging with their experience and upgrading. During the whole year students have a chance to be present at trainings related to soft skills. BEST gives chance for all European students to develop themselves in engineering sphere by involving in real life situations and finding solutions that can be implemented into real life cases.

We do realise that there are things to be improved, therefore we constantly wait for feedback from everyone involved in the project and like this we ensure the fact that EBEC project will grow, will be stronger and will offer more qualitative content to students, providing them complementary engineering education activities.

We believe that the best results can be achieved through a combination between traditional learning and new concepts of learning, more or less informal. Like this the students can get attracted to engineering education, before becoming students of a University, as well as during their undergraduate studies to encourage them to turn their attention to research and other such activities.

References

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General Information and Services

Conference Venue

All conference sessions will be held at the Pavilhão Atlântico, located at Rossio dos Olivais, Lote 2.13.01, 1990 - 231 Lisboa.

Symposium Registration and Sessions

Registration will be open on Saturday, October 1st, from 9:00 to 10:00am, at the Lobby of Pavilhão Atlântico. The Opening Reception, the Keynote Speaker sessions and the PAEE'2011 Student Best Project Award will be held at the Bussiness Center Auditorium. Workshops and Parallel Sessions will be held at the Business Center Rooms 1, 2 and 3.

Meals

Coffee breaks will be provided at the Business Center Hall during the Symposium. Lunch is also included in the registration fee and will take place at the Treaty of Lisbon Hall, in the Pavilhão Atlântico.

Symposium Dinner

The Symposium Dinner will be held on Saturday, October 1st, at 8:00 pm. It will take place at the Treaty of Lisbon Hall, in the Pavilhão Atlântico. It will be shared with IFEES Conference Dinner.

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.

Internet

Wireless internet access is available in the Symposium venue. Computers and multimedia projectors will be available during presentation sessions.

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