Project Approaches to Learning in Engineering Education

The Practice of Teamwork

Luiz Carlos de Campos
Pontifical Catholic University of São Paulo, Brazil

Ely Antonio Tadeu Dirani
Pontifical Catholic University of São Paulo, Brazil

Ana Lúcia Manrique
Pontifical Catholic University of São Paulo, Brazil

and

Natascha van Hattum-Janssen (Eds.)
University of Minho, Braga, Portugal

Project approaches in engineering education are a relatively recent phenomenon in Portugal, Spain and Latin-America. Teachers, educational researchers and managers in engineering education are discovering the added value of team work, solving interdisciplinary open-ended problems in a meaningful learning environment that is similar to the professional context of future engineers. This book seeks to present a wide range of experiences of project approaches to engineering education, varying from mature to starting. It discusses different aspects of project approaches like project management, teacher training, assessment and institutional support. It also describes experiences taking place in a number of countries – Portugal, Brazil, the Netherlands, Denmark, Germany, Spain and Australia – in order to provide an overview of project approaches in different cultural backgrounds. It aims to encourage those who are considering project approaches in their own engineering education context, taking into account the advantages of training future engineers through project work, while being aware of the challenges that a shift from traditional education to a project may bring.
Project Approaches to Learning in Engineering Education
Project Approaches to Learning in Engineering Education

The Practice of Teamwork

Luiz Carlos de Campos, Ely Antonio Tadeu Dirani and
Ana Lúcia Manrique

Pontifical Catholic University of São Paulo, Brazil

Natascha van Hattum-Janssen (Eds.)

University of Minho, Braga, Portugal
TABLE OF CONTENTS

Foreword vii

Introduction 1
Luiz Carlos de Campos, Ely Antonio Tadeu Dirani, Ana Lúcia Manrique & Natascha van Hattum-Janssen

1. Challenges of the Implementation of an Engineering Course in Problem Based Learning 5
Luiz Carlos de Campos, Ely Antonio Tadeu Dirani & Ana Lúcia Manrique

2. The European Project Semester: A Useful Teaching Method in Engineering Education 15
Arvid Andersen

3. PLEE Methodology and Experiences at the University of Twente 29
Wim Weenk & Maria van der Blij

4. A Project Management Framework for Planning and Executing Interdisciplinary Learning Projects In Engineering Education 53
Rui M. Lima, Dinis Carvalho, Rui M. Sousa, Anabela Alves, Francisco Moreira, Diana Mesquita & Sandra Fernandes

5. Educational Innovation and Change for PBL 77
Alex Stojcevski, Xiangyun Du & Tomas Benz

6. Design-based Learning in Mechanical Engineering Education 89
Sonia M. Gómez Puente, Corinne Jongeneelen & Jacob Perrenet

7. The EPS experience at UPC-Barcelona Tech 109
Jordi Segalàs

8. Portuguese Versions of PBL for Engineering Education at University Level 125
Júlio Barreiros Martins

9. Student Assessment in Project Based Learning 147
Sandra Fernandes, Maria Assunção Flores & Rui M. Lima

10. The Role of Teachers in Projects 161
Natascha van Hattum-Janssen
FOREWORD

Engineering is the main pillar sustaining civilized life on earth. Engineers invent the tools that enable us to move faster and produce more than we ever could with our bare hands. To keep our economies going we need engineers to maintain and to innovate our machine park. Therefore it is of utmost importance to continuously train new generations of engineers.

The engineering profession is rooted in practice and in practice engineers have always been working in teams on projects. Utilising projects in the formation of young engineers makes a lot of sense and not surprisingly it is applied in one or another variety in many places around the world. Still there are huge differences between an engineering project and the pedagogical utilisation of projects in an engineering curriculum. In an engineering project all that counts is to find an optimal solution, trading of time, money and other resources. Sometimes a quick fix needs to be made and if the necessary expertise to solve a particular problem is not available in the team, it is hired from outside. This is acceptable in a real engineering firm, but not from a group of students working in small teams on authentic engineering problems. The students should aim to understand how things work, not just solve a problem and they should be reminded by their teachers that they should utilize the opportunity for building their own knowledge base. Rather than assigning jobs to the ones who are good at it, as is common practice in a real engineering firm, the students should rotate and each practice the aspects where they lack expertise.

This book offers the reader an overview of interesting practices of applying the project method in engineering education. With examples from different study domains and from diverse countries, the book covers a wide range of project applications in relation to various cultural backgrounds. It is a good start the get oriented on the possibilities of learning from projects in engineering and to get inspiration for the development of new varieties of project-organized learning adapted to local needs and circumstances.

Prof. dr. Erik de Graaff, Aalborg University
Associate Professor Delft University of Technology
Editor-in-Chief of the European Journal of Engineering Education
INTRODUCTION

Engineering Education in Europe has been facing many changes, especially due to the implementation of the Bologna Declaration that did not only aim to harmonise systems of Higher Education across Europe, but also to stimulate a more student-centred education. Anticipating the shift from teacher-centred to learner-centred education, a group of teachers at the Industrial Management and Engineering degree programme of the University of Minho (Portugal) started to transform a rather traditional first year semester into a project that was based on a theme related to the future professional practice of the students. The project method as used in the approach was based on Powell & Weenk (2003) and adapted to the local context. Although in the north of Europe, project-based learning has a long tradition, in Portugal it is relatively new and teachers and educational researchers involved in this experience could not yet rely on experiences of colleagues at the same university or other national universities. The project semester though became an enriching and rewarding part of the first year programme and the teachers and researchers decided to make the project a recurring element of the first year. They also started working on continuous improvement of the project semester, by evaluating and implementing changes.

Project approaches such as the one at the Industrial Management and Engineering degree programme of the University of Minho (UM) show that the learning process of students changes. They become more motivated, they learning to solve open-ended, ill-defined problems in a multidisciplinary context, they learn to work in teams and they get a more realistic notion about the professional future as an engineer. They learn in a different way and through the different method not only changes the level of learning –from rather superficial to deep- but also the knowledge and skills. Students are no longer preoccupied about specific technical knowledge and skills, but also work on the development of transversal competencies. Through working in teams on interdisciplinary open-ended problems, students learn more about team work, project management, communication, writing reports, giving presentations, time management etc. The added value of team work was the title of the First Ibero-American Symposium on Project Approaches in Engineering Education, organised by the Department of Production and System and the Research Centre in Education, both of the University of Minho, and the SEFI Curriculum Development Working Group held in Guimarães, Portugal, in July 2009. The symposium served as a platform for the exchange of experiences, research results and discussion of ideas for future
implementation of project approaches in especially Portugal, Spain and Brazil, countries in which projects are not as self-evident as in countries like e.g. Denmark, Sweden, the Netherlands and Australia. Presenting experiences from less and more experiences contexts, the book seeks to presents experiences and challenges encountered in changing engineering education.

In chapter 1, Campos, Manrique and Dirani describe their experiences implementing a Biomedical Engineering course at the Pontifical Catholic University of Sao Paulo, using the Problem Based Learning (PBL). The curriculum structure, tutor profiles, assessment process and instruments, and analysing the course’s first evaluation are some of the main challenges that the team is facing. To overcome these challenges, according to the team, a teaching and staff management model must be developed.

Arvid Andersen describes the European Project Semester (EPS) he created in 1995, in Helsingor, Denmark, in chapter 2. EPS is a program for engineering students, with groups of international students who work, for one semester, on carefully selected interdisciplinary projects in order to meet the real needs of companies, aiming to develop technical as well as transversal competencies. Ten European universities are currently involved in this program.

Chapter 3, by Weenk and Van der Blij, discusses the implementation of Project-Led Engineering Education (PLEE) in the Mechanical Engineering course at the University of Twente, Netherlands, focused on teamwork.

In chapter 4, Lima et al. discuss the applicability and present their assessment of the management structure of an interdisciplinary engineering project coordination team, focused on time, team and communication management, conducted since 2004 by the Production and Systems Department of the University of Minho’s School of Engineering, in Portugal.

In chapter 5, Du, Stojcevski and Benz present an educational innovation founded on problems, projects and practices in engineering education by examining issues at an institutional, community and business level, showing cases of implementation in a range of contexts and engineering teaching institutions.

In chapter 6, Puente, Jongeneelen and Perrenet describe the project of running a support group for developing teaching skills for lecturers at Eindhoven University of Technology (TU/e) within a concept of technological innovation called Design-Based Learning (DBL).

Chapter 7 describes the implementation of the European Project Semester at the Polytechnic University of Barcelona at Vilanova i la Geltrú, coordinated by Segalás and Esbrí, focusing especially on sustainability in the programme.

In chapter 8, Martins provides a historical description of engineering education in Portugal since the 1950s, covering the effects of the 1974 revolution on higher education methods until the implantation of the Bologna Process. The chapter also discusses difficulties implementing the process in engineering education and the importance of the PBL method within the Bologna Process.

Chapter 9 presents a project developed by Fernandes, Flores and Lima, discussing assumptions regarding assessment in a pedagogical innovation experiment, the Interdisciplinary Project Based Learning method. The chapter
INTRODUCTION

examines not only technical issues regarding the way in which assessments are conducted, but also the importance of reflecting on certain ethical principles regarding assessment in the process of learning.

Finally, in chapter 10, Van Hattum-Janssen provides an overview of approaches in engineering education projects, discussing characteristics that aid student learning, changes in the role of educators and their preparation face the new context of teaching and learning.

By presenting these works in progress in this book, some of which have already yielded results that have been assessed, others of which are still in experimental phases, the authors’ hope to create an environment of discussion and reflection on the new approaches in engineering education being developed at present.

REFERENCE


AFFILIATIONS

Luiz Carlos de Campos  
Faculty of Science and Technology  
Pontificiate Catholic University of Sao Paulo, Brazil

Ely Antonio Tadeu Dirani  
Centre for Science and Technology  
Pontificiate Catholic University of Sao Paulo, Brazil

Ana Lúcia Manrique  
Centre for Science and Technology  
Pontificiate Catholic University of Sao Paulo, Brazil

Natascha van Hattum-Janssen  
Research Centre in Education,  
University of Minho, Portugal
1. CHALLENGES OF THE IMPLEMENTATION OF AN ENGINEERING COURSE IN PROBLEM BASED LEARNING

A PBL (PROBLEM BASED LEARNING) COURSE PROJECT

Nowadays, there are more than a thousand engineering courses in Brazil and the number of scientific studies involving problem-based learning in engineering is endless. These initiatives are rather recent and mostly restricted at least in some courses of the specific engineering. Within the PBL line, other variations on the methodology have been developed. Eberlein et al. (2008) present the characteristics of three common methodologies used in teaching science, comparing and contrasting them in order to enable a possible choice or combination in particular situations. The three methodologies that these authors present are: Problem-Based Learning (PBL), Process-Oriented Guided Inquiry Learning (POGIL) and Peer-Led Team Learning (PLTL), all of them being based on active learning and student-centred.

In Helsingor, Denmark, Andersen (2009) created a programme for engineering students, the European Project Semester (EPS), with groups of international students who work on carefully selected interdisciplinary projects to develop abilities and specializations, in addition to inter-cultural communication and teamwork skills.

Segalàs (2009) coordinates the EPS programme at UPC-Barcelona Tech’s School of Engineering of Vilanova i la Geltrú (EPSEVG). This project introduced a PBL curriculum structure at EPSEVG, as well as technical teaching in English and the intercultural factor. Another important aspect was the inclusion of competency in sustainability. The projects of this programme are proposed by regional companies and a student group works on a real project for one semester, guided by an academic tutor and supervised by a professional from the company. The groups include students with different sets of knowledge, from several countries. The programme also involves individual and group seminars throughout the semester. EPS is spreading throughout Europe and, at the end of the course, if their assessment has been accepted, students receive a certificate worth 30 ECTS (European Credit Transfer System), which corresponds to a student work load of 750 to 900 hours.

Puente, Jongeneelen and Perrenet (2009) coordinate a support group for developing teaching skills for lecturers at Eindhoven University of Technology (TU/e) within a concept of technological innovation called Design-Based Learning (DBL).
Weenk and Van der Blij (2009) work at the University of Twente, Netherlands, with the PLEE (Project-Led Engineering Education) project, focused on teamwork. At Victoria University, Australia, Du and Stojcevski (2009) are developing an educational innovation founded on problems, projects and practices of the teaching of engineering by examining issues at institutional, community and company levels.

At the University of Minho, Portugal, Lima et al. (2009a, 2009b) coordinate a work group of engineering students that is very interactive with the industry.

According to Newstetter (2006), PBL has been used as a means of integrating basic science education with engineering education. In this approach, learning is not linear, but leads students to explore the space of a problem. If different student groups face the same problem, they will probably choose different approaches and will most likely suggest different solutions. In this process, multiple topics and knowledge domains are found, helping students build a more extensive, integrated and flexible knowledge base.

In order to seek solutions for the problems identified in engineering courses, PUC-SP decided to innovate by adopting an active, collaborative and integrative teaching methodology in the biomedical engineering course. The one chosen was PBL – Problem Based Learning. The authors of this chapter that teach in this course have shared their experiences with a number of tertiary institutions in Europe, Asia, Australia, the United States and Latin America, presenting their work at international events.

Within this approach, the curriculum is not organized by discipline; rather, it is divided into multidisciplinary modules, allowing for inter and trans-disciplinarity. The modules are planned units designed to be joined or adjusted to other analogous units in several ways, forming a functional whole. They are thus complete units designed for full-time learning, focused on a central theme encompassing content from different disciplines.

The course is structured to cover five different thematic areas, which are treated in a progressive, complementary and integrated manner throughout the course (five years). The thematic areas are:

1. Medical Images: an area of biomedical engineering that studies the principles, forms and mechanisms involved in obtaining images of the human body.
2. Medical Electronics: an area of biomedical engineering that studies the application of electricity in medicine and health, the design and development of diagnostic equipment, therapies, control systems and data collection systems, as well as analyses of biomedical signals and sensors.
3. Medical Informatics: an area that integrates computer sciences with biomedical information, system development, information management, simulations and data processing.
4. Biomechanics and Rehabilitation Engineering: this area examines the mechanics of living beings, analysing movements and structures from a mechanical point of view, studying and developing prostheses, orthoses and mechanical efforts, as well as materials and their properties.
5. Clinical Engineering and Health Management: a specialised area responsible for applying and managing biomedical technology in health optimization, and managing personnel, physical and financial resources in hospitals, clinics and companies to ensure quality in health systems.

Each area is treated in a specific way in each year of the course, with different concepts and degrees of depth.

- In the first year students are introduced to the area and learn about the basic applications of the associated technology in healthcare.
- In the second year more specific current applications of technology in healthcare are analysed and discussed.
- In the third year applications are presented and discussed with a focus on the development of healthcare technology.
- In the fourth year state-of-the-art technology related to healthcare is discussed and analysed.
- In the fifth year technological research in healthcare and applications in everyday clinical practice are presented and discussed.

This teaching methodology allows students to acquire a range of skills, such as: teamwork, intercultural competencies, effective communication, continuous learning, project and team management, and ethical, social and environmental responsibilities.

This skill set is consistent with a professional profile capable of performing in an innovative way in companies: building specialised, cooperative environments for innovation, developing fundraising projects for research using the different sources of financial support, and seeking technological development and innovation.

This chapter discusses the challenges faced by the team of educators working with this methodology and examines, among other things, the assessment processes that are being implemented in the Biomedical Engineering course at PUC-SP.

IMPLEMENTATION CHALLENGES: TUTORS

The thematic areas are structured into central and associated modules. The central modules are determined by the theoretical and practical content of the thematic areas of each academic period. The associated modules complement the content of the central modules and cover topics such as communication and expression, administration, legislation, entrepreneurialism, bioethics, social inclusion and sustainability.

Each module comprises a group of problems and their themes. The themes must allow for horizontal integration (correlation of a same topic of several contents) and vertical integration (correlation within and between basic and professional contents, in the different phases of the course).
The contents are distributed across different problems in such a way that they will be accessed by the students during group discussions in the guided study. They are distributed throughout the years of the course and learned according to their importance in problem solving.

The problems that make up each module privilege technical, ethical and humanistic aspects, and the most important or common situations, with the greatest potential for intervention.

The pedagogical project of the course defined the tutors as the spine of the course. In order to be a tutor, one must acquire a completely new set of skills, compared to those of lecturers in courses structured according to disciplines. Instead of giving students all of the information and data in classes and notes, they must learn to facilitate learning and guide their students’ learning process indirectly. They must allow students to determine, by themselves, what they need to learn and, at the same time, know what resources they will need, especially the school’s human resources. Instead of telling students exactly what they should learn and in what sequence, tutors should help them determine such things independently. The role of the tutor must be to ensure that learning is student-centred rather teacher-centred. It is facilitating learning as opposed to offering pre-packaged knowledge. Tutors should constantly give students the opportunity of learning to learn.

During the implementation of the course, challenges arose regarding these aspects of the tutors’ role. In the first place, the lecturers on the biomedical engineering course got their own bachelor’s degrees in traditional courses, such as engineering, mathematics, physics and medicine. Their schooling, as with the majority of lecturers in tertiary institutions, did not involve issues of a didactic or pedagogical nature. As such, the educators who took an interest in working with this methodology were those who had successful classroom experiences, and not necessarily theoretical reflections about what should be done in tutorial sessions. Tutor training, which took place beforehand, was essential in order to stimulate reflection and raise awareness about these skills. However, it became clear that there was a need for continuing training and reflection on the activities carried out in tutorials.

In order to provide adequate supervision and answer questions about new theories posed by students as they attempt to solve a given problem, it is essential that tutors always seek to remain up-to-date in their knowledge.

In problem-based learning, you never know what students’ questions are going to be, but they all oblige their tutors to be up-to-date. (Enemark and Kjaersdam, 2009, p.19).

The need to solve a given problem and identify its requirements brings students into contact with other ideas and people. Creative and innovative solutions, that do not merely reproduce pre-defined models, spring from this interaction. This means that tutors must aim to foster a capacity for autonomous learning in their students. According to Rué (2009), efficient information and available time management; work, study and research, both individual and in groups; attitudes such as flexibility, imagination, openness to new information and methods; and self-
regulation of one’s own work are fundamental in order to develop autonomy in learning.

The challenges encountered in the implementation of the course require tutors who are also committed to teaching, research, development and innovation. Such tutors should have an academic background with experience in defining problems, analyses, theories, experiments, syntheses, possible and acceptable solutions, as well as conclusions, assessments and consequences.

**PROCESS ASSESSMENT AND ANALYSIS**

An education that provides knowledge and skills that favour the routine solving of professional problems – which presupposed a more dynamic style of teaching and learning – is now required of engineering graduates. On the one hand, the curricula of engineering courses in Brazil today, structured in such a way that knowledge is compartmentalized into stagnant disciplines, which do not meet such demands, due to the multidisciplinary education required of today’s engineers. On the other hand, assessment methods prioritise the reproduction and memorization of information and the acquisition of minimum requirements for approval, as well as limiting students’ studies to that which is considered most essential, instead of relating ideas to one another, establishing of connections with students’ past experiences and debating different points of view with other students (Ruè, 2009; Manrique, Dirani, Campos, 2010a, 2010b).

The big challenge of PBL is doing justice to basic, advanced and specific professional contents, according to the Curriculum Guidelines for Engineering Courses. To overcome these and other challenges, continuous assessment tools were used and critically analysed by the course coordinators and discussed with the teaching staff, so that their interpretations could be used to improve the course and overcome the challenges that constantly crop up within this methodology.

The system for assessing PBL is important for the improvement and maintenance of the course. If we consider, like Enemark and Kjaersdam (2009), that students need: to develop skills in order to face unknown problems in their future profession; the ability in learn to learn; cooperation and project management skills; practice communicating with tradesmen, businessmen and industrialists to solve problems that arise during projects; and an exchange between teaching and research to encourage innovation, then the course assessments need to address issues related to students, staff, coordinators and the curriculum itself so as to foster the discussion and reflection needed in order to improve the course.

The proposed assessment tools take into consideration new assessment methods involving not only students, but also the teaching staff and the course itself. Assessment sheets, portfolios and tests were developed, and student-teacher meetings were held. The purpose of these assessments and their analyses was to foster continuous reflection regarding all of the guiding principles of the new curriculum, and frequently rethink them. The objective of the different assessment tools employed was to contemplate the formative and summative nature of the assessment processes, set forth below.
Formative assessment should be used to monitor the teaching-learning process and provide continuous feedback for both student and teacher. For students, it reinforces successful learning and allows difficulties to be identified and paths to be corrected. For teachers, formative assessment, through constant student feedback, allows them to rethink the way they go about things. No concepts or scores are attributed to these tools. The tools used for formative assessment at different pedagogical stages were: structured models, portfolios and progressive tests.

The structured models have pre-defined topics that assess the quality of student and teacher participation and the problems used in tutorial sessions. Assessment by problem involves filling in sheets for student self-assessment; tutor assessment of students and the group; and problem assessment by the group. Assessment by module involves sheets for tutor self-assessment; assessment of the tutor by students; and assessment of the group by their members.

The portfolio is a collection of a student’s work including the different activities carried out during the week. It is intended to be a means for students to learn as they create. It must be both a strategy to facilitate learning and to allow for its assessment. Workshop support portfolios, theoretical support portfolios and tutorial portfolios were produced.

Students include information in their files that present an overview of the strong and weak points of their development in the course. These files contain the results of experiments conducted in the different workshops, their research in books and magazines, the problems solved during the modules, and the exercises and theoretical references studied. In this manner, the file is used to encourage them to reflect on their learning objectives and experiences throughout their education and to consider what they have gained from them. (Deelman and Hoeberigs, 2009, p. 90).

The progressive tests are once a year multiple-choice tests for cognitive evaluation. They have yet to be applied, since the first year of the course still has not finished.

Summative assessments are applied to determine students’ readiness for advancement. They also help classify them at the end of a learning period (year, semester, month, module), according to how much they have or have not learned. The tools used for summative assessment at different pedagogical stages were written tests, triple jumps and final reports.

The written tests were considered cognitive assessment tools and encompassed discursive, interpretative and multiple-choice questions. Their objective was to evaluate students’ individual capacity to analyse and summarise answers to questions based on the content of the units studied.

In the first stage (first jump) of the triple jump assessments, students provide an individual written assessment of a problem situation in the same way they do in tutorial sessions. In the second stage (second jump), they look for and select learning materials related to the situation. In the third stage (third jump) they answer questions about the content of the problem.
From the partial reports drawn up after analysing the portfolios, tutors then write up a final report at the end of the educational stages in which this tool is used. The assessment is the sum of all these tools, indicating, in addition to whether or not the student has passed, any redirection necessary in the development of the course.

This assessment system aims to foster competency in cognitive autonomy and personal responsibility in students. According to Rué (2009, p.162), what makes a student autonomous is:

- having a clear idea of their own learning style and strategies;
- adopting a communicative focus in the tasks they carry out;
- being willing to take risks and make mistakes;
- doing homework and personal tasks, regardless of whether or not they are being assessed;
- recognising the importance of formal concepts and their assimilating.

In addition, Rué (2009) distinguishes three possibilities for the concept of autonomy: one of which emphasises the technical nature of the autonomy of the person learning; another that strengthens the cognitive dimension, and a third that stresses the ability to be the agent of one’s own learning, emphasizing a political dimension.

It can be seen in the implementation of the course that not all learning situations foster autonomy in students, in spite of the course coordinators’ intentions. Another issue that arises is how motivated and interested students are in being autonomous in their learning when the conditions allow for it. And lastly, it should be noted that even certain potentially favourable contexts for the development of student autonomy do not produce the same effect in all students.

As such, this analysis considers determinant in the implementation of the course: efficient management of the coordinators’ assessment process; the time available for students to learn and work on problems; the teaching staff’s study and research, group and individual work proposals; and the development of self-regulating tools for everyone’s work.

The challenges faced by the teaching staff in implementing the assessment tools presented reveal that the assessment and its analysis are crucial to the development of a course structured in PBL methodology. The purpose of such assessments and their analysis is to foster ongoing reflection on the guiding principles of the new curriculum and to encourage them to be frequently revisited.

Proposed changes to assessment methods tend to be forgotten, altered or omitted.

Often, maintaining ‘old’ assessment methods leads staff to pretend that the new model works, when they are, in fact, following the assessment criteria of the old system. This is counter-productive and should be taken seriously, so that the assessment method can be adjusted to the new teaching and learning philosophy. (Moesby, 2009, p. 55).
In the first assessment of the process positive and negative points were identified. Some of the positive points were: the themes approaches were handled in a pleasant, relaxed manner; there was a great deal of interaction in the student work groups; the students were involved in dealing with complex problems and developed an interest in research, acquiring the skills necessary to solve the proposed problems.

Some of the aspects that need to be rethought so that changes may be made to the organization of the course and to better meet educational objectives were: diagnosis of students’ previous knowledge in basic sciences and mathematics; a better interaction between teachers in the work groups; students’ preparation to understand the new methodology; the planning of practical tutorial sessions and workshops and the process of assessment results.

REFLECTIONS

According to Possa et al. (2008), biomedical engineering courses in Brazil are a recent phenomenon. The thematic areas in the PUC/SP course were thus chosen to cover the areas of activity of biomedical engineers as defined the Brazilian Society of Biomedical Engineering (SBEB, 2007).

One of the challenges we are facing in implementing the PBL curriculum is deciding how to cover the basic sciences in the problems proposed in each thematic area, bearing in mind that the course must be completed in five years. This difficulty is related to the learning objectives that must be met by the tutor’s propositions, and which are not easily identified and understood by the students.

To overcome the different challenges presented it is essential that we develop a teaching and staff management model. This model must be consistent with the principles of PBL and the kind of innovative engineer that we want to send into the market.

This management model presupposes that the coordinators of the courses are efficient in the planning of staff activities and determining how much time to dedicate to administrative tasks. It is the course coordinators’ role to adopt principles that allow projects to be developed in meetings and committees without taking up too much of the teachers’ time. According to Branda (2009, p. 221), these principles are:

1. ensures that everyone has the opportunity to be heard;
2. respect all participants and their legitimate interests;
3. correspond to an interdependent thought system;
4. to speak clearly, without ambiguity or repeating what has already been said;
5. to be willing to express disagreement when necessary;
6. know how to differentiate brainstorming and decision-making meetings;
7. take decision-making based on consensus, such that decisions correspond to the group’s needs.

To measure the results of this management, a number of levels of assessment are necessary. The first level, already present in many undergraduate courses, involves
assessment of students and course contents, format and organisation. The second level, which is on the agenda of tertiary institutions, is the assessment of the teaching staff and the implantation of the pedagogical project. The last level, which has yet to be included in the evaluation of teaching and staff management results, is the assessment of the course coordination, which deserves special attention from the course educational committees and university administration.

REFERENCES


AFFILIATIONS

**Luiz Carlos de Campos**
Faculty of Science and Technology
Pontifical Catholic University of Sao Paulo, Brazil

**Ely Antonio Tadeu Dirani**
Centre for Science and Technology
Pontifical Catholic University of Sao Paulo, Brazil

**Ana Lúcia Manrique**
Centre for Science and Technology
Pontifical Catholic University of Sao Paulo, Brazil
2. THE EUROPEAN PROJECT SEMESTER: A USEFUL TEACHING METHOD IN ENGINEERING EDUCATION

The EPS Formula

INTRODUCTION

For some years engineering has been in trouble. Fewer students have applied in general and the consequences have been merging and closing down of universities and departments. However, an initiative known as EPS (European Project Semester) was started in 1995 by this author. Students come together to work on multidisciplinary projects in international teams. This has shown to be an effective way to attract students and to give them international experience and develop their enhanced technical skills. Students of both gender from engineering, business and technology feel attracted to participate in this international semester. Many engineering schools have been inspired to provide the same set-up at their own institution. Several universities in Europe i.e. in Denmark, the Netherlands, Norway, Poland, Germany, France, Finland, Belgium, Portugal and two universities in Spain are now offering this international semester course at their universities. Future competition will be fierce and we need engineers in our companies. Industry must find or invent responsible ways to increase production without environmental consequences. This ought to inspire our students to consider a career in engineering. Obviously, the present engineering education needs some adjustment in order to satisfy industry’s requirements and the wishes of future students. The required skills base has changed. A continuous intake of engineering students is needed in our societies to create new developments and to have somebody to take over where others finish. We must persuade people to choose engineering. In that regard a big credit should be given to The Smallpeice Trust, Warwickshire, England. The Trust has for years done a tremendous work trying to attract young people into engineering.

THE NEED FOR AN INTERNATIONAL PROJECT SEMESTER

It is interesting to consider people’s perception of knowledge, insight and creativity. Most people initially believe knowledge to be paramount, and tend not to make a distinction between insight and skills. At a certain stage of an education students should be given time and possibilities to wonder. Work by Tranter and Bond (1997) mentioned in the reference list, has shown the value of Design Project
Skills to an Engineering early career. This enables the students to make original and creative contributions as responsible team members. This is what we should try to encourage. We already provide students with a good basic knowledge of engineering, economics and management. Further as companies adopt new management structures the need for technical specialists working as consultants will increase. It is likely, as national borders blur, that opportunities to work outside home countries will increase sharply, making mobility part and parcel of a technical career. Many engineers will work in more than one country on short time basis requiring many more skills than we teach them to-day. Engineering has become a more integrated part of the international society. To really understand what integrated engineering work is, one must be involved in group project work, where autonomous learning is facilitated and the ability to work within a team on a project is promoted and emphasised. Engineers should be equipped with the appropriate entrepreneurial and social skills to be able to work successfully across borders with people of different mindsets. Teamwork is group performance with regard to the product produced, the project process executed and the people involved. Project work in that sense is social rather than solitary. Students should be involved actively in order to learn to dare and to do. Perspectives on future engineering education are discussed.

THE EPS FORMULA

The international teamwork semester known as EPS, has developed to become a trademark. A consortium of universities in Europe as well as outside Europe has approved the concept, the structure and the content. Presently 11 universities in ten countries have formed a providers group by implementing the EPS concept at their own universities (http://www.europeanprojectsemester.eu). The team-based project work carried out during this semester is an interdisciplinary activity that requires a collective effort of specialists with different kind of expertise and cultural backgrounds. It is not enough for engineers just to have a working knowledge of another language. To work in a foreign country requires many more skills. Therefore to remedy many deficiencies in existing engineering courses, the EPS providers have decided to run the European Project Semester Course, designed to train engineering and business students to work in international teams. A team is often defined as a group of people working together to achieve objectives that are shared. It is also a task-tuned group of people deliberately designed. Teamwork on EPS is defined as follows:

Teamwork is the ability to work together towards a common vision. It is the ability to direct individual accomplishment towards organisational objectives. It is the fuel that allows ordinary people to attain extraordinary results.

The following table shows a typical EPS Timetable:

**Week 1:** Introduction. Teambuilding/teamwork. Company presentations. Team meetings with companies. Communication. Systematic innovation.

**Week 2:** Environmental subjects. European law. Group project work.
THE EUROPEAN PROJECT SEMESTER

Week 3: Cross cultural communication and understanding. International marketing. Group project work. Language.
Week 4: Project management. Project review 1. Group project work. Language.
Week 5, 6, 7: Group project work. Language.
Week 8: Group project work. Language. Submission of interim report.
Week 9: Group project work. Language.
Week 10: Group project work. Language. Project review 2.
Week 11–16: Group project work. Language.
Week 17: Group project work. Submission of Final Project Report.
Week 18: Exam. Graduation.

ASSESSMENT: PROJECT REPORT AND ORAL EXAM.

Project Characteristics

Projects should preferably be real industrial problems. If it proves difficult to persuade industrial firms to provide “live” projects because of worries about commercial confidentiality, it will be necessary to provide College based projects. Doing a group based project together with students from other countries easily compensates for any differences from the home-based degree.

Choice of Project:

Before each semester projects are solicited from industry. This result in a number of project proposals jointly worked out and described on standard form. The proposals are sent to all accepted participants on EPS in plenty of time before semester start. On the project-proposal form is indicated which area of specialisation or study that we find useful on the particular project. All project groups are interdisciplinary and internationally mixed. We now leave it to the students to choose a project of interest and motivation. Normally students choose a project where he/she can use his/her area of study. The home university supervisor is informed of his students choice of project.

Problem Formulation and Team Exercise:

It is very important that all members of the project group understand the project description given to them by the project provider. If necessary the project group should re-write the text and have their own problem formulation conferred with the project provider and the project academic supervisor.

FORMATION OF AND DEVELOPMENT OF PROJECT GROUPS:

All students are asked to return at least three project choices of their own and prioritise them 1-2-3. This gives us at the guest university a good idea on how to form each group with an interdisciplinary and international mix. Although all
ANDERSEN

projects are based in engineering they also contain business, economic and marketing elements. From this experience students learn what work in an integrated context really means. In addition students join team design and teambuilding courses. Here they take a self-perception inventory test and learn the value of diversity of roles in a team. Also the meaning of cognitive and political problems in teamwork is given.

In teamwork teaching, it must be clear what is expected of the participants. Such as: It is expected that you all show responsibility, take initiatives whenever needed. Try to take ownership of your project and your time. Try to develop a we-attitude in your team. Ask yourself how you can join your own effort with the effort of others to achieve a greater success? Remember that the whole is greater than the sum of the parts. Also remember: Dependent people need others help to get what they want. Independent people can get what they want through their own effort. Interdependent people want to combine their effort with the effort of others to achieve a greater success (Covey, 1989). Dependence is the paradigm of YOU. Independence is the paradigm of I. Interdependence is the paradigm of WE.

Typical Group Development Stages:

In order to develop interpersonal skills it is important to know that teams develop following typical and predictable development stages. Knowing this makes it possible to do something about it and take appropriate measures.

Stage 1: FORMING (Uncertainty)

The insecurity phase is where you are building or forming the team. This initial stage is characterised by insecurity and caution, politeness and tentativeness. The group is not really a team yet. Everybody needs attention, help and concern. You can facilitate this situation by socialising with each other. Have a chat with each other under more relaxed circumstances. Tell who you are, where you are coming from and why you have chosen to join this project. Have a beer together in the student pub.

Stage 2: STORMING (Individualism)

This phase is full of storm and resistance. You try to hide and use a lot of energy trying not to come out in the open with your real personal opinion. Sometimes personalities clash acrimoniously. Nobody seems to speak the language as you. Who is actually responsible for this situation? Team members should have a clear understanding of this situation and of the issues in question. They should try to develop a shared understanding of what is going to happen and why. Everybody have to adjust and adapt to the group environment. All members of the group should give up some of their autonomy. The group should try to develop a shared commitment and work collectively to achieve it. Try to take initiative. Think positively and help create a situation where you can agree about something. Try to break the ice with an unexpected proposal.

Stage 3: NORMING (Invitation)

Everything seems to be more relaxed. You tend to think that the storm is over, but it might all be harmony at the surface. You tend at this stage to discuss things that
you agree upon. You try to escape conflicts although you sense tension. All team members are getting more deeply involved. All feel that time has come for no compromising any longer. Let us get some work done. We have to find solutions to solve our problems. Try to think positively and take initiatives.

Stage 4: PERFORMING (Implementation)
This stage is also called the stage of productive work. The group has now come to a stage where they feel that they know the strengths and weaknesses of each other. Usually you now know who is doing what and why. All team members seem to be engaged and committed. Try to pull your part of the agreed workload.

Research has shown very clearly that we cannot just take a group of highly creative individuals, put them together, and expect them to do better than other teams.

PROJECT MANAGEMENT
Here students learn how to manage engineering projects. Each team is involved in defining, systematising, planning and navigation of their own project. A supervisor is allocated to each team. On compulsory weekly meetings things such as project development, teamwork problems, communication difficulties and, if necessary, cognitive and political problems are discussed. In brief the three P’s i.e. the Project, the Process and People are kept in focus. From those weekly meetings students learn good meeting techniques and disciplined behaviour. Further they learn to work out minutes and to make a good agenda. Abilities such as self-confidence, responsibility and communication in English are improved. Also the ability to listen and negotiate solutions in place is developed. Company advisors do participate in the weekly team meeting as far as their busy timetable allows. Once a month all supervisors meet to discuss matters of concern.

Courses Taught:
During the first four weeks a number of relevant, short, intensive and project supportive courses are taught, see EPS timetable mentioned earlier. All courses are compulsory and equal to 5 ECTS credit points (European Credit Transfer System). The project work is 21 ECTS credits and languages 4 ECTS. In total one semester equals 30 ECTS credit points. The purpose of the short intensive courses is to break down barriers and to promote a common approach. In parallel with the project work students participate in a programme studies held in English. The first four weeks of the semester 70% of time is spent on team-based group project work and the remaining 30% of the time on study programmes. During subsequent weeks 90% of the time is spent on group project work and the remaining 10% of time on study programmes.
Milestones:

By the end of week 4, the first status report is due defining aims, objectives, design specification and also a time plan i.e. a Gantt chart is required. As mentioned earlier also the project development and the teamwork process, is discussed. At midterm, in the beginning of week 8 an interim report is submitted to the main supervisor. The report must contain work results, and a description of the teamwork executed. Also adjustment of the time plan if any and recommendations for further work to be done in the remaining project period. In addition the following four questions must be answered in writing by each team member:

1. What is your professional contribution to the work done?
2. What is your opinion of the group performance?
3. What is your contribution to the teamwork?
4. What is your opinion of the work done?

The final group report is submitted by the end of week 17.

Product and Process Evaluation:

The group project report is assessed by the results produced and the process executed. It is essential that the team can describe what they have learned from teamwork. The participants know from the very start that teamwork on EPS is situations where they are practicing cooperation and communication in multidisciplinary and cross-cultural project groups. Team members also know from the beginning that they are to do self and peer assessments and why, they are taught to focus on the three P’s, the People involved, the Process executed and the Product produced that is the result presented in the submitted group project report.

GUIDANCE FOR PERFORMANCE OF EPS PROJECTS

Project work involves collective activities in which decision-making should proceed through stages of identification, development, selection and implementation. It is important that, at any given time, each member knows what the other members are doing and why. In order to meet the aims and objectives of the team-based project, specified in the syllabus, students are advised to adopt the following procedures.

a) Problem identification, project formulation, aims, objectives, tasks to be carried out and specification.
b) Analysis of available knowledge, techniques, constraints and resources.
c) Synthesis of the relevant components of this information to indicate possible routes to problem solution.
d) Evaluation of possible routes and a decision made upon the optimum route to be adopted (methodology).
e) Production of a planned timetable of goals and milestones to be reached at various stages in the activity in order to meet the problem specification.
f) Execution of the plan with modifications made for obstacles to progress not foreseen at the beginning.
g) Careful documentation of results and evaluation of their importance.

h) Comparison of the results with the initial problem specification and the expected results.

i) Communication of the entire project activity for assessment, in terms of the documentation and presentation requirements.

*Project Performance/Implementation*

In each stage of the problem-solving strategy outlined above, there are well-defined tasks that must be performed, skills to be learned, and attitudes to be developed and tested. Furthermore, it is crucial that the standard of assessment can be harmonised.

*Consideration of Self and Peer Assessment*

To follow and assess the group process is difficult but important. During the course the teamwork i.e. the PROCESS performed is followed closely to make sure that the advantage of working in a group is sustained. The difficulty lies in apportioning credit for the team submission to individual team members. In an ideal situation, equal credit is given to each member of the team. In practice, however, each member’s individual contribution will vary both in quality and in quantity. For this reason a system of self and peer assessment and a system of point distribution among team members is used to accomplish the apportioning of credit and to achieve a fair spread of marks. A compulsory weekly meeting is held between a project group and its supervisor. This gives the supervisor the opportunity to work closely with the team. Minutes are made of all meetings and a copy is kept in the group Log Book. Every month during the semester the supervisors meet to discuss matter of concern experienced with the project groups.

*Supervision:*

The main contribution of the company advisor and the academic project supervisor on EPS is to be a coach to help all members of a project group to understand the content of their project and ensure that progress is made. It is also to nurture and facilitate the group work, the project performance and the project process. Above all, it is important that all people involved in teamwork, try to make sure that the advantage of working in a group is sustained. It is important to be especially aware of cognitive and political problems in the team. He must also help the team members develop shared commitments and make sure that they work collectively to achieve them. Students of today take a different attitude towards the lecturer and the supervisor. It is no longer expected of him to be autocratic as such but it is required of the supervisor to be qualified to answer questions. It is crucial that the supervisor shows a real interest in the group. He must pay attention to the group and lead it in the right direction. It is suggested that a good supervisor should possess the following qualifications:
The international project semester EPS has demonstrated that to expose engineering students to international teamwork is profoundly useful. To require and expect a team of 4-6 students to execute an Integrated Engineering and Business project is appropriate to their fast-track development. The project examiners were very impressed by the project reports and vivas. But most importantly, the students thoroughly enjoyed the course and the opportunity to work with team members from other countries. They all regard the experience as being beneficial. They all learned things they would never have experienced at their home university in their regular study. They learned that it is immensely important that one is able to tackle problems alone and solve them in a team together with other persons, to seek out information and to communicate with persons having the same or a different cultural and educational background. Each project group comprises 4-6 students to permit effective management and delegation, collective authority and responsibility. A means of assessing fairly the individual performance of each member is important. It is essential for the project supervisor to guide by example and have regular feedback through tutorial discussion sessions. Although this is demanding of time and commitment from the project academic supervisor, we have found this very valuable to all persons involved. In accordance with the milestones indicated, each project group submits an interim report, together with an oral presentation. All members will be expected to answer questions on the report and each student is assessed separately on his/her response to questions. Rotation of presenter ensures equally responsibility and assessment. In total a high percentage of the overall project mark are obtained from these interim assessments. The remaining marks come from the final presentation.
THE EUROPEAN PROJECT SEMESTER

Statements

In the following are given two typical statements one from an international team of four students from Spain, Germany, Poland and United States and an opinion from an EPS partner. The group concluded:

The EPS, European Project Semester, is a great way to learn efficient team working skills and gain a large amount of practical experience. Too many students seem to go to school to obtain a degree without participating in any practical experience. The practical experience though, is most important, and that is why the EPS is such a good programme to participate in. The semester has contained much project work, but also great amounts of cultural experiences and new friends. This is what makes EPS such a unique programme; it provides students with practical experience in a setting less formal than an actual career setting would be. On the other hand, students are treated as responsible adults who can produce a project with the same amount of quality as professionals. This creates a working atmosphere much better than, say, when a worker is just given a task by their supervisor to be completed in a timely manner. This is more desirable, and thus completed with much more effort than in the later case. Overall, The EPS creates a working environment for individuals to grow; to grow in their team working skills, work abilities, and also in the social sense. These attributes can be applied, in the future, to all aspects of life.

From EPS partner:

EPS is a unique concept and beneficial to all students who participate in the programme, says Professor Duane L. Abata former President of American Society for Engineering Education (ASEE). EPS is an outstanding opportunity for students to gain valuable international experience, which is very much needed in the global economy of today. The friendships today established among EPS students forms a valuable international network that will last a lifetime and serve them well in their professional careers as engineers of tomorrow. EPS students learn how engineering problems are tackled in other countries. In the global economy this is a valuable experience, an engineering problem does not necessarily has a single solution, but rather, many approaches and differing but effective and creative solutions.

Conclusion

On EPS we say that teamwork is group performance with regard to the product produced, the project process executed and the people involved. Group performance is as we see it a collective performance of people working on a project as members of an international team. Project work in that sense is social rather than solitary. In doing international teamwork on this course, participants learn what synergy means and they learn to value and appreciate diversity and
differences, which is necessary to make a successful group-project. After sixteen years with this teaching concept we find it inconceivable to contemplate former learning and teaching methods.

Epilogue/postscript

By the end of 2008 the three year TREE (Teaching and Research in Engineering in Europe) programme ended (www.unifi.it/tree). I participated in the SIG B3 (Special Interest Group). A final report of this work was published with the title: “Facilitating Multidisciplinary Projects in International Teams” (Macukow et al., 2008). From this report the following is quoted: “Modern engineering education should be focused, among others on some generic competencies. Some of these competencies like: Teamwork, interpersonal skills, the ability to work in an international team with students of different disciplines, nationalities and study levels are of special importance. An engineer today must be able to cope with a broad scope of disciplines such as: economics, management, communication, languages and a solid training in interdisciplinary and international teams. Further: “Many higher education institutions organise international teams of engineering students who carry out interdisciplinary projects. The experience gained so far and the opinion of students and employers allow us to draw a positive conclusion. The task is also to work out the detailed principles of creating and managing international teams of students, who on the basis of common tasks and projects, will be able to acquire unique skills and broad knowledge stemming from various disciplines, not necessarily from engineering. Also, the methods of evaluating work in teams should be worked out. Another element to be taken into account, while developing the skills of the supervisors, are psychological aspects of work in international student teams”. Most of the work will be based on many years of experience in running the European Project Semester (EPS) at engineering universities in Denmark, Norway, the Netherlands and at the Technical University of Łódz in Poland”.

Learning in Teams

It is required of people to-day that they can work in teams. Therefore students must during their study learn how to work in a team. Try to create a benign environment to stimulate learning. Allow time to develop knowledge, insight and skills. Help students develop their critical thinking skills, which will improve confidence and the ability to dare. However, do not spoon-feed students.

Integrated Engineering

Integrated engineering involves the inter-related work of several disciplines. Working in an integrated context emphasises development of personal competencies especially the ability to work within groups. A major supporting activity in all engineering courses, in almost all countries, is the use of an extended
project based activity. This is now considered to be such an important part of the
general technique of learning that it is being extensively employed. This teaching
and learning technique is based on the dual concepts often referred to in the
educational literature as collaborative learning and Scaffold Knowledge
Integration. It is recommended that the project group should do a Problem
Formulation Team Exercise to discuss the project brief initially handed to them by
the project provider. The result of this discussion should be a description of the
problem as perceived by the project group. Thereafter it should be conferred and
discussed with the project provider and the academic supervisor. The end result of
this work should be an approved problem statement and rules for working together.
Based on this the project group should develop and agree a time activity plan, a
GANNT chart for their project period. Project management software such as
Microsoft Project should be used to plan and run the project. These techniques are
particularly appropriate for project type activities. Collaborative learning refers to
students working together in teams where they share and distribute the
responsibility of learning. Through meetings team members support each other
through questioning and elaboration, providing alternative points of view and by
sharing expertise. Research has shown that cooperative settings produce positive
results in elaboration of ideas, analysis and problem solving. There is now demand
of a person to be proficient with open-ended problem solving and to be familiar
with multidisciplinary problems to demonstrate teamwork skills. As described in
the Scaffold Knowledge Integration Framework, autonomous learning is facilitated
by having students work in groups to allow them to serve as social support for each
other through sharing ideas providing feedback and providing some critical
assessment of other ideas. Assessments undertaken by the students should be
designed to make students listen to each other, to make mistakes in a benign
atmosphere, to argue, to discuss and to explain their ideas to other students, to
members of the academic staff and to industrial experts. Difficulties in the initial
stages of group working between students from different cultural backgrounds
need careful scrutiny by members of the project supervisor team. Working in
cross-cultural and multidisciplinary teams, we have to learn to cooperate with
different mindsets. Each of us has our own paradigm. Our cultural codes are
different. This is why it can be very cumbersome to deal with international project
teams. A number of the key issues are differences between a deal focused and a
relationship oriented way of conducting meetings and negotiating between
different suggestions. For example a British level of informality and the more
formality structured relationships encountered in several mainland Europe cultures
can cause strained relationships. Sensitivity to status differences and the rigid
hierarchies frequently displayed in a number of universities may also provide
initial uncertainty in students. The main contribution of the academic project
supervisor is therefore to help the students to understand the content of their
project and ensure they are making progress. It is also to nurture and facilitate the
group work and the group process. This should be done by holding compulsory
weekly meetings with an agenda determined by the project group. It is
recommended that the group work is organised with folders. Thomas Kuhn
introduced the paradigm shift in his book “The Structure of Scientific Revolution” and showed the significance of first break with tradition with the old way of thinking. Teamwork is group performance with regard to the product produced, the project process executed and the people involved. Project work in that sense is social rather than solitary. Participants learn what synergy means and they learn to value and appreciate diversity and differences, which is necessary to make a successful group project. Students should be involved actively in order to learn to dare and to do. The supervisor must make sure that the advantage of working in a team is sustained.

ASSESSMENT

The need for assessment is obvious. In assessing an integrated engineering project done as teamwork the following elements should be assessed: The product produced. The project process executed, and the people involved. Individual contribution in teamwork is always a key issue when talk is about group project work. To reflect the workload pulled by each member during the project execution and to prevent free riders, team members and team supervisors should be asked to assess this important point. Workload means each team member’s technical contribution in the major field of study. Also their contribution to make things work if something goes wrong. Further the individual contribution to the performance of the work process should be evaluated by asking questions such as: Willingness, understanding, leadership, attitude and initiatives shown. Finally, self and peer assessment, as well as assessment of supervisor qualifications should be considered.

Current engineering education does not respond adequately to the demands that need to be met. Engineers commonly describe themselves in terms of a single discipline, a convention increasingly misleading, as very few engineers work totally within the confines of a single discipline or industry. Changes in working attitudes, and greater emphasis on multidisciplinary and multinational environments, also highlight the need for a completely different approach to education and training. Traditional specialism no longer applies to a world dictated by a bigger overlap of engineering and science.

The accelerating evolution of technology accompanied by a growing amount of knowledge, much of which continuously become redundant, require a new approach to education and training and changes of the curriculum. Engineering education therefore has to provide a learning environment that stimulate deep learning and in which acquiring insight will take precedence over conventional specialist courses. Continuing education has become a more determinant factor in career development and is part of a through-career education and training. Easier access to knowledge through the ongoing advances in information technology should be coupled with improvements in teaching and assessment techniques. Accreditation boards should be aware of the changing conditions and adjust accordingly. They should appreciate the new professional equipped with a broad range of entrepreneurial skills.
CONCLUSION

In making a country a strong competitor in Europe and strong on the global market, we have to make sure that engineering and business students develop the right qualifications. Also the working conditions should be the best possible. Researchers predict that work in the future will merge with leisure making things more blurred. It is expected that engineers of tomorrow will be given a special task to solve, rather than being employed to work from nine to five. The employer will be more interested in short term contracts, buying competence and expertise rather than employing qualified people the way it happens today. This of course requires a solid basic engineering and business knowledge combined with the ability to tackle problems alone and yet solve them in cooperation with others. See reference list: Andersen, A. (PAEE 2009). Keynote on Project Management and Teamwork (Andersen, 2009). It will be an important part of the career of the future engineer. Basic understanding of a broader area of disciplines like economics and management and solid training in teamwork, communications and languages and good understanding of other cultures and their traditions and habits will be required.

Research indicates that an increasing number of people will be employed in the service industry. The manufacturing industry will, to a great extent, be highly automated with greater use of robotics. Engineers must therefore have a solid knowledge and understanding of those technologies. Knowledge of a specific technical field will be of less importance. Environmental awareness and a good understanding of an optimum use of resources will be features of future products and manufacturing processes. Industry must find or invent responsible ways to increase production without environmental consequences. Fast technological development leads to faster product shifts on the market. At the same time, the market becomes more global. No room for failures or mistakes, things simply have to be right first time. That means increasing attention must be paid to the development of high quality products. Product development will take place as an integrated process with collaborating skills such as design, planning, production, sales, marketing and recycling. Greater integration will be required and the developer must be able to overview the situation and make use of specialists and rely on their knowledge. The future engineer must be able to cope with frequent changes.

THE FUTURE

It is important that engineering students acquire an international dimension and it is important to strengthen links with the world outside the university i.e. the industry and the international society. The tendency to go abroad for one or two semesters should be supported, and in particular financially, and we should encourage our future engineers to be mobile. This will help to develop significant communication and contribute to develop our societies. Aims in education must comprise professional as well as personal development goals since true effectiveness requires both elements. The future businesses need persons who are
compotent, responsible and able to contribute constructively in business projects across borders. It’s extremely important therefore, that companies submit projects and allocate the necessary time to company advisors; this ensures recognition and probably the use of new skills which are to be acquired. Companies with an international organisation and the engineering universities must go hand in hand to develop future candidates with the right skills.

REFERENCES


