PBL across the disciplines

Research into best practice

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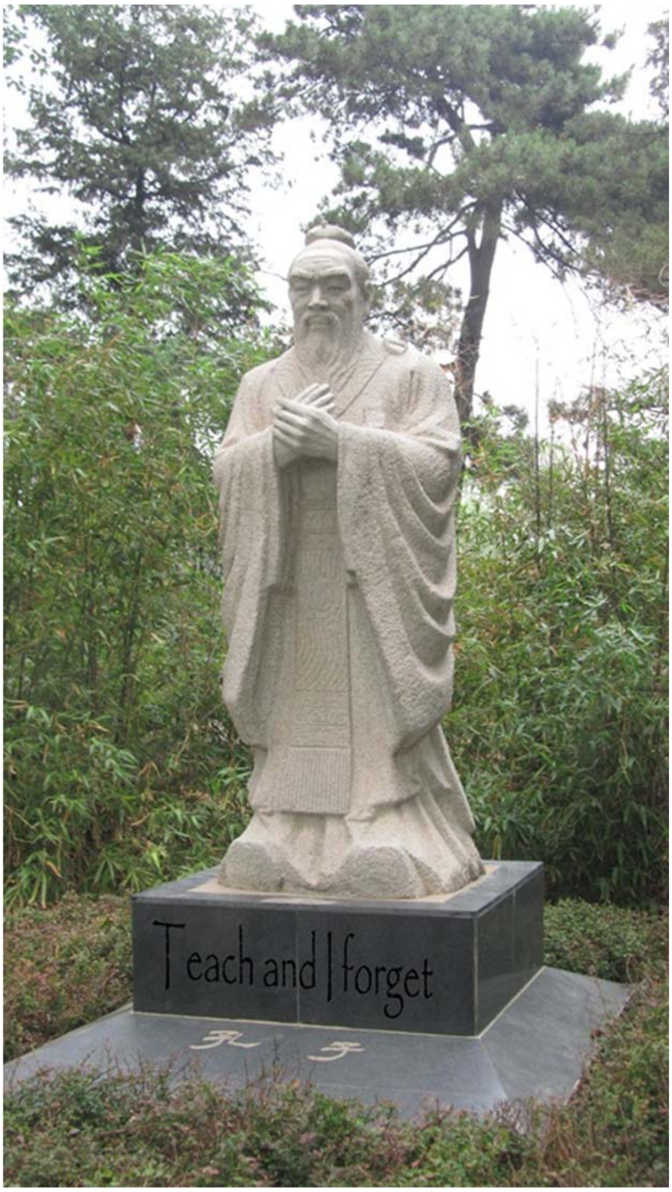
PBL ACROSS THE DISCIPLINES: RESEARCH INTO BEST PRACTICE

John Davies, Erik de Graaff,
and Anette Kolmos (Eds.)



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PBL across the disciplines: research into best practice
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PBL across the disciplines: research into best practice

Proceedings from the 3rd International Research Symposium on PBL 2011, Coventry University

John Davies, Erik de Graaff and Anette Kolmos

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Introduction

Problem Based and Project Based Learning (PBL) has come a long way. Following the success of PBL curricula in McMaster, Canada, Maastricht, the Netherlands and Roskilde and Aalborg University, Denmark, a great many institutes in higher education have introduced some form of PBL. The resulting diversity of PBL varieties provides ample opportunities for research focussing on practice.

The UNESCO Chair in PBL in Engineering Education at Aalborg University has started the initiative of organising a series of International Research Symposia on Problem Based Learning. Each symposium has had its own uniqueness and they reflect the development within the PBL research community. The first symposium was held at Aalborg University in June 2008 a year after the establishment of the UNESCO Chair and the second research symposium was held in Melbourne by Victoria University that was in the middle of an institutional change process to a PBL curriculum. The 3rd International Research Symposium on Problem-Based Learning hosted by Coventry University, 28-29 November 2011 focuses on collecting best practices across the disciplines. Coventry University is in the middle of a change process towards more PBL.

In a number of academic areas, including engineering, health and design, Coventry University has been using and developing approaches based on problem based and project based learning over many years. The overarching concept of Activity-Led Learning has been adopted in the Faculty of Engineering and Computing, and a new £55 million Faculty building is currently under construction to provide the innovative learning spaces needed to carry this forward.

An underlying objective of the research symposia was to move beyond the exchange of best practices. For many years, Aalborg University has been the place to visit for academic staff interested in educational change and was a showcase of best practice. At Aalborg University, the development of PBL is followed-up by educational research. Especially in engineering education, there has been a need for documenting and providing evidence of the effectiveness of PBL and therefore research positions and research projects on PBL related issues have been created. As a consequence, Aalborg has been able to disseminate deeper knowledge on what made this new PBL practice work, together with a new conceptual framework for understanding and analysing the PBL practices.

The clear message from the Aalborg staff has always been that visitors could get inspiration by looking at the example – but in implementing in their own institute they had to construct their own educational model. And as it should be noted that well-documented reflection loops are an important element in curriculum construction to be used for further improvements and a key factor in arguing for new methodologies. However, documentation in itself is only the first step in description of cases and best practices. There is a need for much more advanced research studies like researching questions such as: what is the impact of PBL on students' learning and competences? And what elements in PBL are essential for getting learning to work?

Another aspect that has made the research symposia very special has been the fact that the UNESCO chair in PBL has claimed to run both problem based and project based learning. Both models are based on the same learning theories although they are based on different curriculum models and practices. Joining these two models enriches both approaches and enlarges the possibilities for designing the curriculum in alignment with the learning outcomes. Furthermore, the PBL curricula have to be adjusted to cultural and institutional conditions.

Reading guide

This research symposium brings in new themes and research issues such as the online learning. The main themes are outlined below follow the structure of the symposium. The book opens with three papers exploring and comparing different PBL models. Next the main theme of the conference is addressed with six papers on PBL across the disciplines and emphasising the interdisciplinary approaches. This is followed by more subject oriented themes with the most popular theme of the conference being PBL in Engineering, with 9 papers. The next two sections contain three papers each which deal with Postgraduate PBL and Industry collaboration.

Focussing on specific aspects of the PBL process the following sections highlight Supporting PBL (three papers), PBL and ICT (three papers) and the PBL Learning process (five papers). Outcomes of the PBL curriculum are discussed in the next section with six papers on Competences and development of professional skills. Next, the aspects of Group work, Teachers and facilitators, and Assessment are represented with three papers each. The book closes with three papers on implementation of PBL and three papers on PBL issues in transition.

We hope the reader finds inspiration to go on experimenting with innovative student centred models and to research the outcomes of the educational innovations.

COMPARING PROBLEM BASED LEARNING MODELS: SUGGESTIONS FOR THEIR IMPLEMENTATION

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ABSTRACT

Problem Based Learning (PBL) has been referred to as some of the most powerful and innovative learning environments used today. At the Aalborg University two different PBL models are used: the problem based and project organised learning in engineering education and the case oriented PBL model in medical education. These models are normally regarded as two very different models within the PBL philosophy. The research questions of this study are: (i) what are the main advantages and disadvantages of the two PBL models used at Aalborg University? and (ii) what can be learnt from the comparison of these two models?

A framework for observation was developed based on the PBL alignment model and one group studying engineering and two groups studying medicine were observed and interviewed, as well as their supervisors/facilitators. Results have shown that these two models have some similarities and differences, which allowed comparisons to be made in order to design a strategy for implementation.

INTRODUCTION

Problem Based Learning (PBL) is defined as a learning philosophy and a set of learning principles (Graaff and Kolmos, 2007). These learning principles can be modelled into different types, such as the project approach and the case approach. PBL is characterised by an enquiry process where problems – mostly from real and complex situations – are formulated and drive the whole learning process. Learning through PBL promotes critical thinking, self-learning skills, lifelong learning, self-achievement, self-regulation, self-efficacy, communication skills and interpersonal skills for students. It also increases the students' interest in a course (Woods, 1994; Dochy *et al.,* 2003; Saven-Baden and Wilkie, 2004; Dolmans *et al*., 2005; Kolmos *et al*., 2009).

Several PBL models are being developed through experience and research and implemented around the world, but it is necessary to distinguished PBL as a learning philosophy or a learning strategy. According to Savin-Baden and Wilkie (2004), several variations (models) of PBL are used, however each model shares some basic learning principles: (i) cognitive (the learning process is started and organised around problems, which contextualise learning and are based on the students' experience); (ii) content nature (different types of knowledge are required, such as disciplinary and interdisciplinary knowledge; boundaries and methods are crosschecked and related allowing the transference of knowledge and skills) and (iii) social environment (students learn through collaboration, where dialogue and communication among peers takes place. Each student is not only responsible for his or her own learning and knowledge but also for the learning, knowledge and achievements of the group) (Savin-Baden and Wilkie, 2004; Kolmos *et al.*, 2009).

According to Barrows (1986), the combination of variables to design new PBL models, with educational objectives and purposes, is endless. However, all types of PBL must be evaluated in terms of: (i) type of problems, (ii) assessment methods, (iii) learners' autonomy, and (iv) in which way the teaching and learning occurs. Kolmos (1996) indicates that the original PBL model used at Aalborg University is widespread within engineering education and is based on the same learning principles described by Savin-Baden and Barrows, however there is an additional component in the submission of a common report. The project and the project report call for a closer collaboration and project management procedures.

PBL can be implemented at different levels, from just one course to the entire curriculum. To allow implementation several curriculum elements in the PBL environment and learning principles must be aligned. From this alignment several curriculum aspects emerge, which should be analysed in a particular learning environment in order to change and to develop a PBL model for future implementation (table 1) (Kolmos *et al.*, 2009).

Curriculum element	***Discipline and teacher-controlled approach***	***Innovative and learner-centred approach***
Objectives and knowledge	Traditional discipline knowledge Disciplinary knowledge	PBL and methodological objectives Interdisciplinary knowledge
Type of problems and projects	Narrow Well-defined problems Disciplined projects Study projects Lectures determine the project	Open Ill-defined problems Problem projects Innovation projects Lectures to support the project
Progression, size and duration	No visible progression Minor part of the curriculum	Visible and clear progression Major part of course/ curriculum
Student's learning	No supporting courses Acquisition of knowledge Collaboration for individual learning	Supporting courses Construction of knowledge Collaboration for innovation
Academic staff and facilitation	No training Teacher-controlled supervision	Training courses Facilitator/ process guide
Space and organisation	Administration from traditional course and lecture-based curriculum Traditional library structure Lecture rooms	Administration supports PBL curriculum Library to support PBL Physical space to facilitate teamwork
Assessment and evaluation	Individual assessment Summative course evaluation	Group assessment Formative evaluation

Table 1. Spectra of PBL curriculum elements (taken from Kolmos *et al*., 2009, p. 16)

PBL can be used at a curriculum, programme, course, discipline, or module level if attending to some specificities such as: professional area, nature of knowledge, organisation, etc. (Schmidt and Van der Molen, 2001; Saven-Baden and Wilkie, 2004; Kolmos *et al*., 2009). Studies from different professional areas and countries demonstrate reasons for the success of a PBL curriculum in higher education. For example, graduates who follow a PBL approach show greater learning satisfaction and motivation, self-confidence in their professional abilities, better preparation in the transition from school to work, and become more competent professionals compared with those that have traditional teacher-directed lectures (Prince *et al*., 2005; Whelan *et al*., 2007). Two PBL models commonly used in higher education are: project based learning and case based learning. Project based learning problems are defined from a badly structured situation and carried out as projects, which indicates that the problems are an integral part. Case based models are commonly used in medical education, psychology, social science or science education (Dochy *et al*., 2003; Kolmos *et al*., 2009).

At Aalborg University, all different types of PBL exist, ranging from very open problem based projects to more narrow case based learning. The PBL approach has been successfully used in Aalborg University, Denmark, since its foundation in 1974. The engineering and natural sciences education is problem based and project based during the entire curriculum, however, there are different learning goals and slightly different organisations for the learning processes. For instance, in the first year the main aim is to teach the students how to work in group, then in the following year the project work is mainly discipline-oriented (students deal with *know-how* problems as is mentioned in table 1). By the end of the graduation programme the work is project orientated, with students dealing with unsolved problems within science and their profession, using a *know-why* approach and supported by relevant lectures (Kjersdam and Enemark, 1994).

Methodology

The research questions are: (i) What are the main advantages and disadvantages of the two PBL models (case based and project based) used at Aalborg University?, and (ii) What can be learnt from the comparison of these models? The study aims to compare the two PBL models used at Aalborg University, to point out advantages and disadvantages and give some insights in order to design an implementation strategy in traditional educational institutions. This study called for a qualitative case study utilising both observations and interviews. In order to study the differences and similarities two types of programmes were selected: engineering and medicine.

The study had the following stages: (i) literature review regarding PBL models used at Aalborg University and its institutional organisation; (ii) observation of lectures and master classes; (iii) exploratory and non-participant observation of groups (first three weeks of September); (iv) development of an observation schedule; and (v) non-participant observation of groups (September and October). Some of the stages were carried out simultaneously.

The duration of the exploratory observations was three weeks and three engineering groups and three medicine groups, from undergraduate and masters levels, were observed during this period in order to develop an observation schedule (see table 2). The observation schedule (table 2) was developed based on PBL theory, namely on the spectra of PBL curriculum elements referred to in table 1, which were also defined as domains and categories of observation.

Domains	Observation categories	Examples of observation evidences
A. Objectives/ knowledge	**1.** Integration of new knowledge	Relate previous knowledge with new knowledge through new concepts, principles, theories, etc.
	2. Interdisciplinary knowledge	Use and establish links/ relations between the knowledge from different areas, etc.
	3. Relation between theoretical and practical knowledge	Apply theoretical knowledge into a new practical situation; develop new practices from theory; relate different practices to the same theoretical principles, etc.
	4. Collaborative knowledge (peer learning)	Share their own knowledge, notes, articles, books, etc., with peers, etc.
B. Type of problems, projects and lectures	**5.** Open and ill-defined problems	The solution is not known by students
	6. Supportive lectures	Students have timetabled lectures
	7. Problem projects	Solving process carried out as a project
	8. Innovative problems	New problems from a real and new social,

		economic and political situation, etc.
C. Progression, size and duration	**9.** Efficient learning progress	Time to accomplished a task; apply old strategies and develop new ones to accomplished tasks efficiently; improvement of the use and management of resources, types of knowledge, etc.
	10. Time allocated to solving process	Group meets once a week, twice a week every day alone/ with the facilitator, etc.
D. Students' learning	**11.** Team work	Share tasks, support each other, give ideas, participate in the braining storm, etc.
	12. Learning through collaboration	Students explain to each other concepts, theories, and principles; give suggestions to the solving process, etc.
	13. Individual learning	Search, learn and apply new knowledge by their own through books, articles, software, etc.
	14. Construction of their own knowledge	Plan the problem process, search and apply the necessary resources, etc.
E. Academic staff and facilitation	**15.** Facilitator role	Check the group learning progress; provide guidance in the solving process; suggest new resources; etc.
	16. Facilitator skills	Promote the development of new skills and supervise the learning progress through reflexive questions, get all students to participate in the solving progress, suggest resources and common goals
F. Space and organisation	**17.** Rooms for group work	Used only by the group
	18. Rooms for the facilitator and group meetings	For the meeting to take place
	19. Access to others resources	Field works, special equipment, software,

		library, etc.
G. Assessment and evaluation	**20.** Individual assessment	Admit error, reflect on what is not well explained, applied, etc.
	21. Group assessment	Point out errors, lack of commitment, accomplishment of tasks, attending lectures of group members; reflect on what needs to be done, to know or to improve in the solving process
	22. Facilitator assessment/ feedback	Have the proper resources, knowledge, strategies to solve the problem; what is needed to improve, etc.

Table 2. Observation schedule

The observation schedule (table 2) also included some examples that counted as evidence for the researcher. The observation schedule was used in one group studying engineering and in two groups studying medicine, chosen randomly and according to the timetables and availability of the students, facilitator and researcher. The groups were from undergraduate levels of the departments of civil engineering and health science and technology from the Faculty of Engineering, Science and Medicine. The groups were formed in the beginning of the semester (September) and each one was composed of eight to twelve students. The same observation scheme was used on all groups.

In the medicine groups, the group meetings were scheduled and took place two times a week for an open and closing session with the facilitator. In the open session, students: (i) read the case description, (ii) brainstormed the knowledge to know; (iii) stated the learning outcomes; (iv) divided tasks. In a close session, students presented and discussed with each other the learning outcomes achieved On the other hand, the engineering group established their own timetable for the group and meetings with the facilitator. The observation took place during the group meetings, and meetings with the facilitators. During the observation period some differences were observed in both groups, which were described. In order to complete the data gathering, some questions were put to students and facilitators: (i) What do you feel about PBL methodology? (ii) How do you perceive your learning progression? (iii) How do you use the university resources? (iv) How have facilitators influenced your learning progression? (v) How does the group divide tasks and share information before a case close session?

Both observation and categorisation processes were undertaken by the researcher with further validation by a trained researcher.

Results and discussion

The categories of analysis were built into the observation schedule itself, which allowed a rapid data analysis. The results are presented in table 3.

Domains	Observation categories	Case study	Project based
A. Objectives/ knowledge	**1.** Integration of new knowledge	X	X
	2. Interdisciplinary knowledge	X	X
	3. Relation between theoretical and practical knowledge	X	X
	4. Collaborative knowledge (peer learning)	X*	X*
B. Type of problems, projects and lectures	**5.** Open and ill-defined problems		X
	6. Lectures supporting (project and problem based)	X	X
	7. Problem projects		X
	8. Innovation problems		X
C. Progression, size and duration	**9.** Efficient learning progress	Not observed	
	10. Time allocated to PBL	X*	X*
D. Students' learning	**11.** Team work	X*	X*
	12. Learning through collaboration	X*	X*
	13. Individual learning	X	X
	14. Construction of their own knowledge	X	X
E. Academic staff and facilitation	**15.** Facilitator role	X	X
	16. Facilitator skills	X	X
F. Space and	**17.** Rooms for group work		X

organisation	**18.** Rooms for the facilitator and group meetings	X*	X*
	19. Access to others resources	X*	X*
G. Assessment and evaluation	**20.** Individual assessment	X	X
	21. Group assessment	X	X
	22. Facilitator assessment/ feedback	X	X

(*) present in both models but with differences

Table 3. **Results**

Analysis of the results highlighted differences and commonalities with both PBL models. According to table 3, there are more similarities than differences between the two models. However, three categories, marked with (*), presented some differences even when observed in both models. These categories are: (i) collaborative knowledge (peer learning) (number 4); (ii) time allocated to PBL (number 10); (iii) team work; (iv) learning through collaboration (number 12); (v) rooms for the facilitator and group meetings; and, (vi) access to others resources. With respect to collaborative knowledge, engineering students encountered situations such as: (i) sharing their individual learning; (ii) proposing and achieving learning outcomes with different methods; (iii) revising the week's schedule; (iv) proposing new ideas and more ideas for the solving process etc., which allowed them to learn collaboratively.

In the medicine groups, in the closing session, students only shared the learning outcomes and explained to each other, meaning the knowledge was more individual than collaborative. Therefore the students' learning presented some differences in both groups. For example, the medicine group students did not meet outside of the closing and opening sessions to share their individual learning achievements and products. On the other hand, the engineering group met every day to work on their project. During these meetings students brought, discussed and shared theoretical knowledge from different disciplines, and additional resources like software for simulations, new practices and ideas. The domain "type of problems, projects and lectures" (table 3 – domain B) demonstrated more differences between the PBL models used. In medicine, a virtual case description was the problem and it was from its analysis that students brainstormed and established the learning outcomes. The problem solution (theoretical and disciplinary knowledge to be learned by the student) was almost known, and students easily established links with lectures and the type of knowledge required to achieve the learning outcomes. The solving process was mechanical for students, similar to a procedure that they followed to reach the solutions. The solving process did not require new ideas, or innovative approaches to address social, economic or political needs, as with engineering, but was relevant for medical practices. In the engineering group, the problem was new and formulated from a real situation, where the group did not know the solving process, learning outcomes and possible solutions. The solving process started with the situation analysis where small questions were raised by students to develop a method to solve the problem. In the beginning, the problem was not clear and students brainstormed: what they knew and needed to know and used in the solving process. During the solving process, students used innovative approaches like software and computer programmes to predict results and to make simulations. Some indicators were only observed in the engineering group: (i) open and ill-defined problems; (ii) problem projects; (iii) innovative problems. They are specific to the project based learning model and used in engineering education. The medical groups only had rooms to meet with the supervisor for sessions, whereas the engineering groups had rooms to work on the project and met the supervisor.

Unfortunately, it was not possible to observe the efficiency of the learning progress with both groups because the evaluation (final exam in medicine and oral defence with more than one examiner in engineering) was only carried out in the term of the semester, in January. However, the researcher asked students how they perceived their learning process and its efficiency. Regarding the assessment and evaluation, students mentioned that there was a type of peer evaluation related to the commitment of a student within the group and the project. If a student did not do his tasks, or attend the classes, it would be difficult for him/her to be part of a group in the next semester. Once the entire course knows how he/she works, they will try to exclude him/her. This can be considered a kind of non-formal and social assessment. In all the observed groups, several aspects pointed out differences and similarities between the PBL models used at Aalborg University.

Conclusions and future studies

The combination of learning methodology, knowledge construction, and scientific approach is demonstrated through the alignment of the curriculum elements. PBL can be used at a curriculum, programme, course, discipline, or module level however some professional area, nature of knowledge, organisation requirements need to be addressed, etc. However, from the description and analysis of groups working under different PBL models it could be possible to understand in which ways PBL models can be implemented in a traditional educational system beyond the curriculum elements (figure 1).

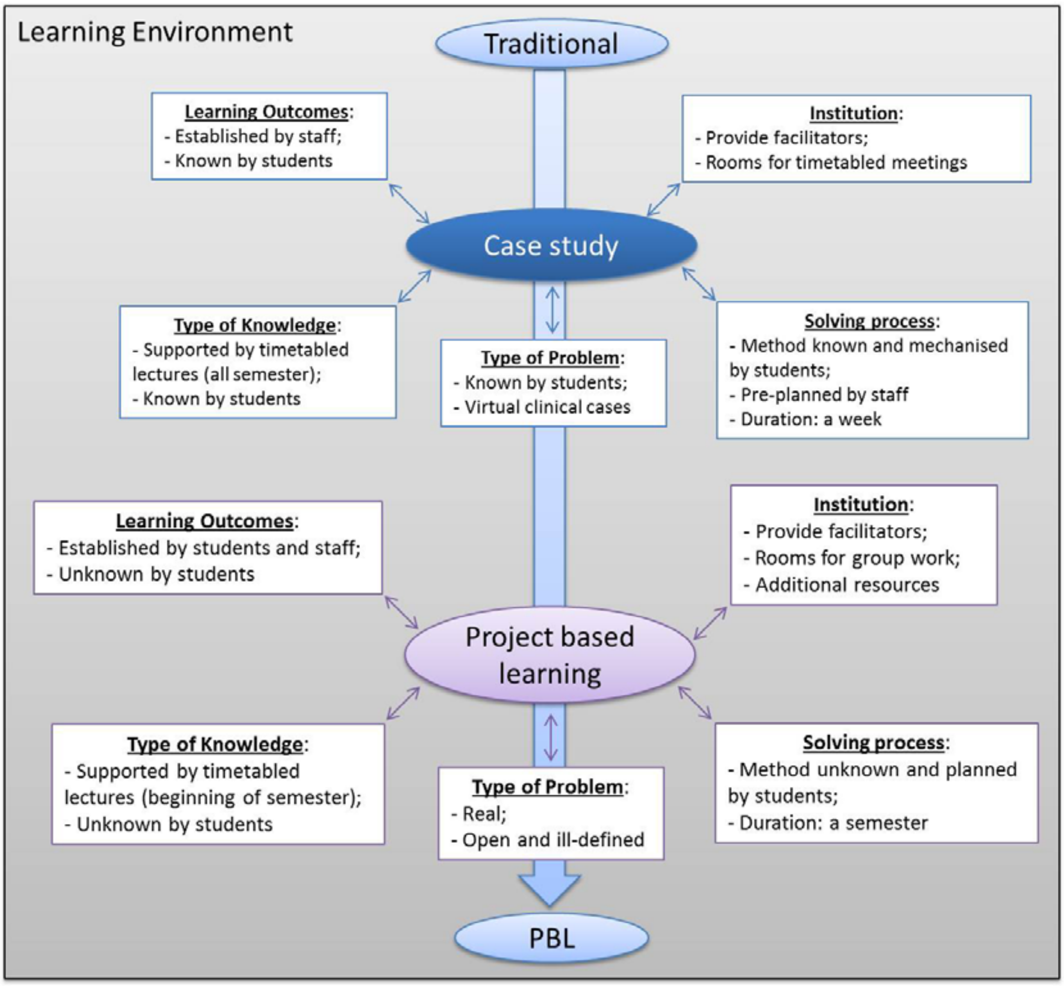

Figure 1. Progression from a traditional teaching environment to a pure problem-based learning environment

According to figure 1, the case based model can promote the transition from a traditional learning environment to a PBL environment and during the undergraduate period (for example, three years) addressing the learning principles that are presented (figure 1). In this PBL model, the learning and teaching process is centred both on students and staff living less autonomy and independence for students to establish their learning outcomes, for example. On the other hand, with a project based approach the solving process is unknown and has to be planned by the group, allowing students to develop several skills related to problem formulation and analysis. In this approach, the role of the student in the learning and teaching process is more central than the staff role, and in their first problem-solving process they should develop specific competencies focused on group work management. This study is a starting point for further studies providing an overview of the advantages and disadvantages of two PBL models and it presents some reflections regarding their implementation. Educational systems encounter barriers to changing their educational vision and approach, particularly from a traditional and teacher-centred learning approach to a student-centred one. The two learning environments (project based and case based) embrace the development of different cognitive and meta-cognitive structures in students, and therefore a progressive implementation guided by assessment involving students and staff is suggested (figure 2).

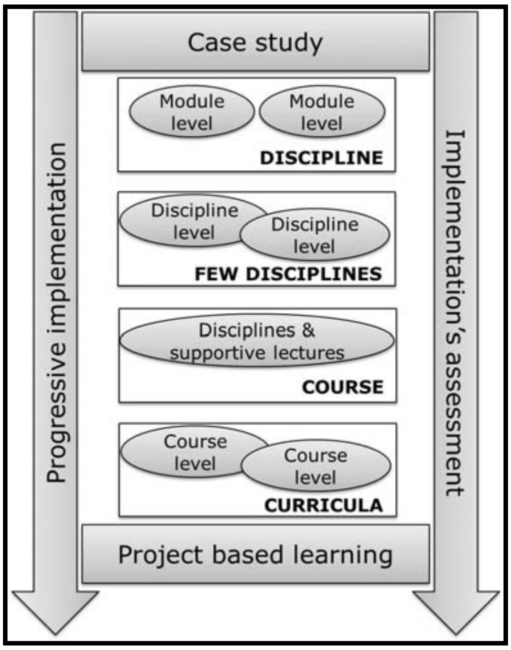

Figure 2. Suggestion to implement PBL in higher education

In a first phase, the case based model can be used at a disciplinary level, or module level. At a later stage, the project based model can be implemented at a curricular, or a course, level. However, the change of institutions' learning environments requires further studies such as (i) curriculum constructions; (ii) institutions resources (e.g. financial, human, infrastructure, academic, etc); (iii) methods for a progressive implementation of PBL; (iv) ways to promote the development of different types of competencies and at different levels of difficulty for students, (iv) the introduction of programmes for staff development, etc. The alignment of these aspects with the learning and teaching, social and professional objectives of an educational system that is to be changed also raises questions to be investigated.

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REFLECTIONS ON PROBLEM-BASED LEARNING PRACTICE AT AALBORG UNIVERSITY

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ABSTRACT

This study is conducted to develop an understanding of a range of differences in practising problem-based learning (PBL) at Aalborg University (AAU). In order to gain a deeper understanding of PBL practices at AAU, the study investigates academic perceptions and learning experiences of both students and supervisors from two faculties, 4 disciplines, where PBL is used as an educational strategy. The study is carried out as a case study supported by observations, interviews and questionnaires. Reflections on a variety of PBL practices and results from the case study will be an inspiration and a guideline for the researcher to further develop a framework for designing and implementing PBL with English as a foreign language (EFL) interdisciplinary program in a traditional education environment where English is used as the medium of instruction.

INTRODUCTION

Problem-Based Learning (PBL) has gained a reputation of producing students with comprehensive abilities which prepare students for the changing world in the globalization era. PBL has also been widely implemented in education systems worldwide because it is perceived as a pedagogical strategy which combines theoretical subject knowledge with practical skills (Amador et al, 2006; Poikela & Poikela, 2005; Schwartz et at, 2001). It can also be observed that the practices and implementations of PBL vary across groups, disciplines, and institutions. Despite these differences in practice, all PBL models and practices share the same theoretical principles of learning. All PBL models apply the principles and characteristics of student-centred pedagogy or systems using problems that are identified as the basis for learning process early on (Barrows, 1984) and consequently promotes active learning and lifelong learning. Furthermore, Savin-Baden (2000) points out that PBL should be seen as an approach to learning characterized by flexibility and diversity; therefore, PBL can be implemented in a variety of ways, in different disciplines and in diverse contexts, but these differences all share one common factor of having the focus of learning organizes around problem scenarios rather than subject matters. This case study intends to bring together the characteristics and the practices of PBL in the Aalborg University (AAU) context to inspire a new design of PBL curriculum for a more structured and traditional education environment. Based on the argument that PBL is an approach to learning with characteristics of flexibility and diversity which is supported by the practices at AAU, the study will foster a good refection for a curriculum developer to study the diversity and flexibility of PBL before integrating or implementing PBL with a new educational context.

Review of the literature

PBL curriculum

It is important for teachers who want to implement PBL to be aware of the differences between PBL used at course level and at system level. This literature review will focus on PBL at system level or what is called PBL curriculum. Savin-Badin and Major (2004) explain how problem-based learning curriculum can be put in practice and what elements are needed to be considered when designing a PBL curriculum. They point out that institutional, cultural, and disciplinary constraints can affect the design of PBL curricula. They further emphasize that all PBL curricula are designed on the basis of the learning theory of constructivism where students construct knowledge for themselves. Barrett (2005) points out that when viewing PBL as a total education strategy, the four components of PBL must be aligned: PBL curriculum design, PBL tutorials, PBL compatible assessments, and philosophical principles underpining PBL. Barrett further emphasizes that the focus of PBL curriculum should be on students' learning, not teachers' teaching; therefore, clarifying learning outcomes of the curriculum is a very essential stage of curriculum design. According to Kolmos et al. (2008), when designing a PBL curriculum in general, cohesion between all elements of curriculum is essential. Those elements are objectives, content, learning methods, assessment, teachers and students, and contextual factors. Inspired by Savin-Baden's PBL models, Kolmos et al. (2009) developed a new model for a more specific PBL curriculum alignment in a problem and project-based curriculum used at AAU. The seven elements that must be aligned are 1) objectives and knowledge 2) types of problems, projects and lectures 3) progression, size and duration 4) students' learning 5) academic staff and facilitation 6) space and organization, and lastly 7) assessment and evaluation. It is further emphasized that when changing one element in this model, the other elements will be influenced and changed as well.

The Aalborg PBL model and its practice variations

PBL has been practised in the Danish educational system by two new universities, Roskilde University and Aalborg University, since the 1970s. Precisely, in 1974 Aalborg University was founded, based on a new educational model—the problem-based and project organized model and also known as problem-based project work. The overview of the idea of how this AAU-PBL model works is that students work together in groups on their project, one project per semester, to analyse and define problems within the interdisciplinary or subject/ theme frame. Students furthermore are expected to submit a group project report and then participate in a joint examination, but obtaining individual marks. As for the core of learning principles for the Aalborg PBL model, the focus is upon the problem, the content, and the team (Graaff & Kolmos, 2003). In terms of time frame and learning management, in each semester students are expected to spend 50% of their time on the project (team dynamic) and spend another 50% on the traditional lectures. Each group has a group room as space for their study and has a supervisor to guide them through their project. In each semester, each program formulates a theme which covers a variation of problems and learning objectives; therefore, students' projects and courses (lecture based) must comply with or relate to the theme of that particular semester. Students are expected to apply knowledge from course lectures in working on their project work. In practice, depending on the programs, the Aalborg model varies in terms of themes and choices of project work, definition of a problem, relationship between courses and the project, methods of supervision, resources, and group size.

Cancino (2004) documents that every department in the Faculty of Humanities implements PBL through project work from the first semester, but still the practice of different departments are also in different forms. The project work at the Foreign Language Study Programs covers a wide range of topics or themes, such as linguistics, applied linguistics, sociolinguistics, intercultural communication, literary studies, social history and so forth. Cancino further explains that students' projects from the foreign studies programs are usually in a form of themes or topics relating to different foreign language countries. Students are expected to work with theoretical problems in a foreign language. In the first semester group formation is done for students through the administrative system, a group of 4-6 members. In this department, students are required to attend lectures which help them deal with project work and project methods. In one semester, students are expected to attend lectures from subject courses which run throughout the semester and to attend a project course which is about 8 weeks in duration. For the project courses at the Foreign Language Study Programs, students have choices to make on which course they want to work on in each particular semester; students choose one project course in each semester. The subject courses are evaluated by individual exams, but the project course is evaluated through the group project. Evaluations of subject courses can be in the form of open-book exam, essay, or portfolio. For the project itself, the actual operation on the project starts after the project course's lecture period ends, around week 8. For the project evaluation, students are required to submit a written report at a minimum of 20 pages per student (2800 key strokes per page) and also take an oral examination at the end of the semester.

As for the practice of PBL at the faculty of Engineering and Science, variety and differences are significant, as compared to the faculty of Humanities. As Rønsholdt (2004) states that the first year curriculum for engineering and science students has a flexible frame. The general semester curriculum structure of this faculty has two parts: 1) general courses to the entire program which each has individual assessment and, 2) the project unit consisting of the project itself and the project courses which are assessed simultaneously through the oral group examination. The Faculty also emphasizes coherence between study elements within the semester. These three elements are theme, projects, and courses which are raised by students. It is also important for curriculum developers or semester planners to be aware of the coherence between the three elements and to ensure that the theme and the project of each semester which ideally should be derived from real problems occurring in the society. As for the courses, they should be delivered to support the semester project and they should be flexible in contents and are subject to frequent changes depending on the type of projects. In the Engineering Programs, time spent on courses is 50% (for both courses related to the project and fundamental subjects), and another 50% is spent on the project work and preparation for examinations. The evaluation of the project is based on the group written report handed in prior to the oral examination and the oral presentation on the examination day (Knudstrup, 2004). It is further emphasized that the learning process of students in the

Engineering Programs involves external organizations or companies. These organizations are involved from the very beginning of the project description. Because these organizations often have a specific problem they would like to put in a new perspective; as a result, quite often further co-operation in research and development contracts between the departments and the companies continues (Søgaard, 2004).

Methodology

Conducting a case study over a one semester period with four groups of students from four different disciplines at AAU is used in order to describe and analyse the AAU-PBL model in practice. Throughout the process of data collection, observations on lectures and supervisions, interviews, and questionnaires are used to collect empirical data. Results from the empirical data reflect the actual practice of PBL at AAU and the perceptions from both students and supervisors on advantages and disadvantages in practising PBL at the institutional level. The four groups can be divided into: 2 groups from the Faculty of Humanities and the other 2 groups from the Faculty of Engineering and Science, details as shown in Table1. The methods used in this study began with observing lecture periods and then observing supervision periods. After that, around week 12 to 16 of the semester, interviews with students were conducted and questionnaires were completed. As for interviewing with students, it took a form of group interviews. There were 17 students participating in interviews and questionnaire administration. Lastly, interviews with 2 individual supervisors were conducted separately, one supervisor is from the Faculty of Humanities and another one is from the Faculty of Engineering and Science. An illustration of the research methods used with students is shown in Table1.

Faculty and groups	**Discipline**	**Lecture Observation**	**Supervision Observation**	**Interview**	**Questionnaire**
Engineering and Science		√	√	√	√
G1)Biotechnology (BIOT)	Science				
G2)Global Business Engineering (GBE)	Engineering				
Humanities	Language	√	√	√	√
G3)English and Internatioanl Studies					

G4) Information Technology (IT)	Art & technology				

Table 1: Matrix for research methods

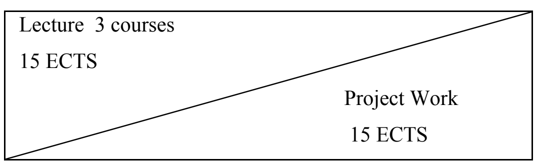
Results

Observation results

For both lecture sessions under the Faculty of Science and Engineering and the Faculty of Humanities, class size is between 30- 50 students. Both were conducted in a form of teacher-centred approach, most time was spent on delivering and explaining content knowledge through power point presentation and the blackboard. The lecture period lasted 2-3 hours with a 10-15 minute break. This format applies to both faculties. There was no checking on students' attendance. Students' participation rate was not high and it was observed that the very same 3-4 students participated in sharing opinions in class. The dynamic of the lecture session for both faculties appeared to be the same. The language of instruction is Danish, except the English group—using English language for instruction. As for supervision sessions, group size is varied. The range is from 3- 7 members, for the bachelor level. It appeared that students submitted the agenda and details of what needed to be discussed to the supervisor before coming to the meeting. For the two groups under the Faculty of Engineering and Science, supervisors came to the students' room for the supervisions. In contrast, for the two groups under the Faculty of Humanities, students came to see supervisors at their office for supervisions. Each supervision session lasted 1 hour for all groups. In every group, it appears that 1-2 students were passive and do not contribute in the group discussion. However, none of the supervisors raised the issue or asked questions about participation; the issue appeared to be ignored. Furthermore, in every group, it always appeared that there was one particular student who took a role of a leader and spoke up the most during the discussion and seemed to be in control of the project work the most.

Interview results

From interviews, it is found that time spent on the lecture periods and the project work periods of the PBL model in practice at AAU can be divided into two models, illustrated in the following two figures.



Model 1 is used by BIOT, GBE and IT groups

Week1 2 3………………………………….......................week18

Figure 1: Time spent on lecture and project [model 1]

Lecture 3 courses for 15 ECTS	
Lecture project courses	Project Work 15 ECTS

Week1 2 3……………….............8……………….............week18

Figure 2: Time spent on lecture and project [model 2]

Model 2 is used by English group

As for the exams, students reported that the 3 subject courses (5 ECTS each) have their own assessment and are in various forms such as open-book exam, portfolio, and essay. As for grading system, some courses use pass/fail scale and some courses use graded on 7 scales format. For the project work (PW), students reported that each group is expected to turn in one piece of final written report which must consist of a contribution of 15 pages per member. On the exam day, students are expected to present their project orally and after that each individual will be examined orally by oneself. Results on student interview, regarding students' perspectives on PBL practice at AAU can be summed up as shown in Table 2.

Interviewed Issues	Result Summary
1. Challenges/difficulties in studying through AAU-PBL Model.	- Self discipline in attending classes and working on the project. -Be focused when working as a team. - Self/group adjustment—'everyone is different and we have adjusted ourselves to one another'. - Time restriction – 'we need more time to complete all given tasks'. - Some members do not contribute to team work sufficiently and were late to the meetings.
2. Best experiences in studying through AAU-PBL Model.	- Working in groups allows students to learn from each other. - Students become independent/self-directed learners.
3. Group formation	- All groups reported that students form a group on their own regarding interest, attitude, and personality between the individuals.
4. Dynamics of meeting with supervisors.	- All groups reported that students are the ones who initiate each meeting. Numbers of meetings with supervisors vary group by group, but approximately between 5-10 times per semester.
5.Physical learning space	- Two groups from the Faculty of Engineering and Science have their private group room where they meet regularly to work on their project. The group from the IT discipline has a group room, but they have to share with other 4-5 groups, total 18 students. For the group from language discipline, they do not have a group room of their own, but they can book a room for a meeting when they need it.

6. Project descriptions and project phases.	- Every group reported that they are aware of the project theme from the very beginning of the semester. The themes posted allow open-ended type of project work. - At the beginning of the semester, students are presented with cases from a real world context. Then they choose the case they want to work on. In this way students indirectly from a group to work on the project of their interest. After that they meet with supervisor(s) and go through process of doing the project which has procedures the same as doing a research. After analysing and specifying criteria for solution(s) then students write up a group report, submitting the report, and then take an oral examination.

Table 2: Students' perspectives on PBL

Data from the supervisor interview was collected from two supervisors who supervise two out of four groups in this study. One supervisor is from the Faculty of Humanities and another one is from the Faculty of Engineering and Science. Supervisors' perspectives on PBL which emphasize in four major issues can be summed up as follows.

PBL issues interviewed	Results from supervisor 1	Results from supervisor 2
1. What are the essential characteristics of PBL?	- A practical problem which allows the actual potential usage in particular field, and not too wide in definition. - Working on a project that they initially define the problem by themselves. -Connect with research problem that cannot be only addressed by theories. - There should be some aspect of reflection on learning process.	- Be able to identify problem in a particular context. -Identify ways to frame and limit the problem of that particular context and can identify how knowledge can be utilized for this particular problem and context. -PBL matches theory learning with practicality. It helps students continue to be able to handle problems in a real working situation. - PBL is not class teaching. The problems must not have a predefined solution. Students must work through the process to solve the problem. There is no recipe on how to work on the problem
2. What are advantages of PBL?	- Motivation, students are motivated in both learning and employment because they chose their own problem. -Quality of teaching is high because teachers get to work in-depth with students.	- Ability to work in teams and work with real life problems. - Students are able to negotiate and interact with real life organizations. - be more humble in the theories and tools you have learned from the university, they don't always work. PBL allows a more

		pragmatic approach to learning
3. What are disadvantages of PBL?	- It is expensive to do PBL effectively.	- Wasting tremendous amount of time during the process because of being confused.
4. What make a good PBL supervisor?	- Listening skills -Use all the time allocated to students, don't cheat. -Having experience in the field can make the supervision be more effective because 'I will help students learn more'.	- At least have some time available for students and be engaged / committed to help students. - Having experience in the field is also important to make the supervision is more effective.

Table 3: Supervisors' perspectives on PBL

Questionnaire results

Questionnaire surveyed students' perception towards their capabilities and PBL methods used at AAU. The questions required students to evaluate 5 major aspects/values gained when implementing PBL: motivation, self-directed learning (SDL), collaborative skills, communication skills, and appreciation/satisfactory level toward learning and teaching process. A summary of details of the questionnaire and its results from 17 students are shown in Table 4.

1= Strongly disagree; 2= Disagree; 3= Neutral; 4= Agree; 5= Strongly agree

Values and statements	1	2	3	4	5
1. Motivation					
1.1 I am studying in the field that really interests me.	0	0	0	4	13
1.2 I enjoy learning at AAU because of the use of PBL approach.	0	0	2	9	6
1.3 AAU learning environment raise my interest and motivation in learning.	0	1	4	7	5
Average	0	0.33	2	6.67	8
Percentage	**0**	**1.94**	**11.76**	**39.24**	**47.06**

2. SDL and time management					
2.1 I learn a lot by reading books.	0	0	7	6	4
2.2. I am good at finding information in libraries.	0	2	6	9	1
2.3 I am good at finding information on the internet.	0	0	1	14	2
2.4 I manage my time effectively.	1	1	5	9	1
2.5 I can identify my learning goals without depending on my supervisor.	0	1	6	7	3
2.6 I am a self-directed learner and I take responsibility for my own learning.	0	0	0	8	9
Average	0.16	0.66	4.16	8.83	3.33
Percentage	**0.9**	**3.88**	**24.47**	**51.94**	**19.59**
3. Collaborative skills					
3.1 I am working well in a team with other people.	0	0	1	10	6
3.2 Working as a team has helped me in learning academic content of the program I chose for my study.	0	1	2	8	6
Average	0	0.5	1.5	9	6
Percentage	**0**	**2.94**	**5.97**	**52.94**	**35.29**
4. Communication skills					
4.1 I am good at writing reports/ essays.	0	0	4	10	3
4.2 I speak well in front of a group.	0	0	6	5	6
Average	0	0	5	7.5	4.5
Percentage	**0**	**0**	**29.41**	**44.12**	**26.47**
5. Appreciation and satisfactory level in PBL approach					
5.1. I like tackling unfamiliar problems.	0	0	4	8	5
5.2 In AAU learning environment, I have developed many useful strategies to help me in my learning.	0	2	3	8	4
5.3My supervisor gives me regular feedback on how I am doing with my project.	0	0	4	10	3
5.4I am able to get help from my supervisor whenever I need it.	0	1	2	8	6
5.5 AAU learning environment helps shaping me to be good at thinking things through.	0	0	3	9	5
5.6 I am satisfied with courses in this program and the supervisors I have for each project.	0	0	4	8	5
Average	0	0.5	3.33	8.5	4.67
Percentage	**0**	**2.94**	**19.59**	**50**	**27.47**

Table 4: Students' perceptions toward their learning through PBL-AAU model

Discussion

The results from both observations and interviews confirm that there is no difference in any aspect during the lecture sessions from the four disciplines. However, the results demonstrate that there are differences in the supervision sessions, types of projects, and the physical set up of working space for students at AAU. These differences depend more on the nature of study fields/disciplines. The fields that deal with more concrete elements in doing project work and depend on experiments and external organizations are treated differently than the fields that deal with more abstract elements. Despite differences in the practice, both students and supervisors expressed a strong appreciation towards PBL used at AAU. They further expressed that PBL also fostered many positive aspects of learning for both students and supervisors, especially on motivation to learn and work on their project because students feel the ownership of the project. A result from the questionnaire strongly supports the claim that PBL fosters motivation, self-directed learning (SDL), collaborative and communicative skills, as shown in Figure 3.

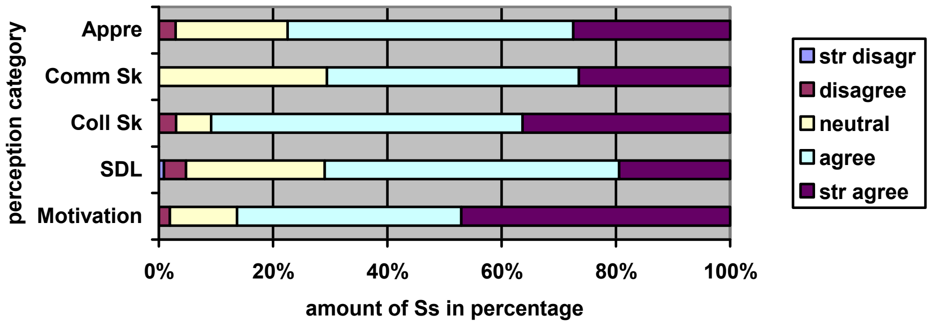


Figure 3: Students' perceptions

from Table 2 and Figure 3 (graph) indicate that students report on motivation is the most significant factor contributed by PBL used at AAU. 47.06 % of students (highest number) perceived that they were strongly motivated to study at AAU because of the field of study and the environments. As for other elements, students related positively toward their own learning in the environment of PBL system. The results from students' perception shown on SDL, collaborative skills, communication skills, and appreciation level indicated that most students agreed that they have obtained those mentioned values and competence. From the results, it can be concluded that AAU-PBL model has flexibility and diversity within its own model, but each practice shares and produces the same learning principles and outcomes. As it can be observed that both students and supervisors from different fields at AAU have practised PBL differently, nevertheless they perceive values gained from PBL practice in the same way.

Conclusion

At present PBL has expanded the horizon of its implementation throughout many educational fields at different levels throughout the world. Even though there is an on-going debate of the definition and practice of PBL, academicians and PBL practitioners worldwide respond to the concepts of flexibility and diversity of PBL which proposed by Savin-Baden (2000).The case study conducted at Aalborg University supports the concepts of flexibility and diversity of PBL practice, as the results showed that different disciplines practice PBL differently. Despite differences in practice, all disciplines have utilized common characteristics of PBL and also share common goals and objective in learning outcomes. The findings of the case study have given an inspiration to the researcher to take into consideration the differences in context of institutes, students. The nature of individual disciplines must also be given considerable weight when designing and implementing PBL under any circumstance. It is important for PBL curriculum developers to be critical with alignments between different curriculum elements and PBL components and principles. When PBL is intended to be implemented in different contexts, a redefinition of what PBL is for that particular context maybe necessary. Moreover, sensitivity to cultural and institutional needs must be included when designing a PBL curriculum for different contexts. Keeping in mind the principle of flexibility and diversity will help PBL curriculum developers and practitioners develop a more suitable PBL curriculum and practice for diverse educational contexts.

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EFFECT OF PROJECTS ON LERNING: AN INDIAN CASE STUDY

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ABSTRACT

In India education is instruction-based and focused on teaching rather than learning. Students here tend to concentrate on scoring marks rather than learning. The current education practices do not focus on skill development of students. To facilitate this, the Zensar and IBM Centre of Excellence (CoE) were established in Sinhgad Institute of Technology (SIT), Lonavala, India, in line with the Project Based Learning (PBL) model. In this paper, the effect of this PBL approach on students' learning is discussed. This paper encapsulates the feedback of 78 students working in the PBL scenario for the last two years. Employing PBL worked out well for students as well as industry, and learning achieved through these experiences made students feel more confident and prepared for real life work situations.

INTRODUCTION

Project-based learning (PBL) is a model that organizes learning around projects. What must a project have in order to be considered an instance of PBL? The five criteria are centrality, driving question, constructive investigations, autonomy, and realism (Thomas 2000). This case study attempts to review the implementation of the PBL model in the context of the Indian Education System and how it would be a exciting alternative form of learning in a structure which is desperately in need of an overhaul. The education reforms diaspora has been voicing the need for radical reform of the current instruction-based teaching methodologies. It has become necessary to supplement the current teaching paradigms with a much more knowledge-oriented approach. This paper analyses one such methodology known as PBL, and its implementation in the current Indian education scenario. The case study begins with a summary of the pedagogical theories behind project-based learning in relation to the conventional curriculum and makes an argument for adopting the PBL paradigm in the learning process. The case study then describes teaching and assessment methods adopted in a PBL model. It presents the outcome of a review of around 78 students, comparing their development of skills and knowledge depth in their conventional curriculum with the PBL model. The case study closes with benefits of the module as an implementation parallel with the students' course, aiming in the direction of overall development of the students.

Why PBL?

In PBL, the emphasis is on learning by *doing*. Rather than telling students *how to do* something, it stresses on *what to do* leaving the interpretations on the execution methods on to the students. Sinhgad Institute Of Technology, Lonavala, India(SITL) has reaped the benefits of the PBL model which was implemented for the faculty and students alike in association with the University of Aalborg. This served as a catalyst for promoting the PBL model.The PBL model may seem to solemnly put the Projects as a central concern but PBL has proven to be more than just that, with overall development of skills, both technical skills and people skills. PBL has proven to be a facilitator of development of the spirit of teamwork: a key concern of prospective employers.

An overview of the current state of the Indian education system

Learning in the Indian Education System has its roots in the traditional concept of *Gurukuls*. The *Gurukuls* were institutes devoted to churn out individuals who were competent enough to recognize real-life problems and with skills to overcome them. Over the centuries however, India's educational system has deteriorated.The fact that the current Indian education system is currently more result oriented than knowledge oriented cannot be denied. The process of learning by this approach may take months but the results obtained by the learner depend solely on the performance of the learner on the particular day of the test, which in the opinion of the writer is not the best way to evaluate a candidate's understanding of the topic. There exists a semantic gap between the classroom teachings and the implementation of these by the learners in their assignments. Educationalists have therefore put forward proposals for unconventional teaching models.

The PBL approach at Sit Lonavala

Enthused by the response by benefactors of the Mobility program from Aalborg University, SITL decided to implement a parallel PBL model in conjunction with its regular load of the University of Pune curriculum. This required learners to put in more efforts which were gladly accepted. The PBL approach was three pronged with focus on Industry Projects, lab innovations and Value Addition Programmes (VAPs). These efforts are elucidated in this paper.

Industry Projects

The concept of PBL in SITL was launched with the Industrial Projects, which were accomplished through the co-operation of large industrial entities such as IBM Corp., Zensar Technologies, Persistent Ltd, CAP-Gemini etc. The core aim of these industrial partnerships was to provide students with projects which conformed to industrial standards, and methods of developing projects. The second objective was to provide students with guidance by industry professionals and keep them at the forefront with the technology and tools used. The philosophy here was to help students use their classroom skills with the cutting-edge tools. The quality of the project along with the timely conformance with the deadlines is emphasized. The support of the faculty members and periodic guidance is of particular benefit to the students. Table 1 indicates the enrolment of students to Industry Projects.

Academic Year	No. Of Students Enrolled
Project with Industry in 2008-09	360 + Students participated in various industry Projects.
Project with Industry in 2009-10	450 + Students participated in various industry Projects.
Project with Industry in 2010-11	480 + Students participated in various industry Projects.

Table 1 Enrolment statistics of students for Industry Projects by Academic Year.

Zensar Projects: Zensar Technologies Pvt. Ltd., Pune, is a CMMI level 5 IT services company. The Zensar campus connect programme was initiated in the academic year 2006-07 and has so far seen the completion of seven projects by students in 5 years, all of which conformed to industrial standards and were developed with regular inputs from industry professionals (Table 2). The projects encouraged students to work after college hours, sometimes on weekends as well. The students were divided into groups of five to six with each group assigned a certain module of that project. Each team was allotted to a team leader from within the team. The responsibilities and roles of a team leader were to meet deadlines and ensure facilitation of ideas among the students. One of the important outcomes of this project was the introduction of software engineering concepts while working on live projects. Students were encouraged to implement what they learned in class through the use of the Software Engineering Process.

Year	Batch	Name of the Project	Students Involved
2006-07	I	Purchase Process of Retail	20
2007-08	II	QPS	60
2007-08	III	Intelligent Inventory Management System(Clothing)	40
2008-09	IV	Lead Management System	25
2008-09	V	Retail IT system	32
2009-10	VI	Health Insurance System	29
2010-11	VII	Inventory Management System (Manufacturing)	28

Table 2 Participation of students in the Zensar Centre of Excellence Initiative.

IBM centre of excellence: The IBM centre of excellence at SITL was established on the 4 August, 2009. The IBM software centre of excellence aims at increasing the skill sets of the faculty and students of the participating colleges, leading to improvement in the quality of technical education which lays emphasis on learning by doing. Since then the centre, in conjunction with IBM's The Great Mind Challenge (TGMC), has been providing students with project scenarios and tools for implementation of these projects. Students may also choose their own project ideas. The benefit of this method is that the problem statements are realistic and based on real world problems such as 'Employment for Rural Workers', 'Virtual Classroom Portal'. The advantage of having such scenarios is that it provides ample scope for students to research as well as survey the prospective and typical users of such systems. The company allocates a trainer for making the students familiar with the tools required to implement the project. The training session extends over a fixed duration of time parallel to the curriculum. The projects through this are then entered into a national level competition, The Great Mind Challenge, where the brightest young minds of India are on display. Thus the IBM centre of excellence serves as a great seat of learning at SITL.

Lab Innovations: An integral part of the PBL strategy is the concept of lab innovations. The planning commission of India observes that India needs innovation to accelerate its growth (Indian Planning Commission 2011). An innovation may be a product or idea which adds a new dimension to an old concept. In the views of many eminent scholars, India needs innovators not imitations to overcome the challenges of converting into a developed economy. Keeping this in mind, SITL has come up with the concept of Lab Innovations. Lab Innovations work in conjunction with the classroom teaching and the Value Addition Programmes discussed further in this paper. India is a country brimming with the young and restless, and staying fixed with traditional viewpoints is not the way of the current breed of Indian youth. Their restless minds seem to churn up various ideas but they lack the guidance and skills necessary to implement them. This was one of the concerns addressed by implementing Lab Innovations. Students are asked to choose project ideas which are innovative and appeal to the current set of problems faced in daily life. Then in order to learn the tools for implementing them, students are given the option of joining Value Addition Programmes (VAPs). The projects are deadline oriented and periodically reviewed with the activity concluding in a Project Presentation held at the end of each semester so as to provide encouragement to participants and to inspire others to understand the potential of innovation. The product of such initiatives can be seen from the student's projects such as "Snappy" *(*Bidkar 2011*)* and the Automated Survey Analysis System (ASAS) (Ranade 2011) projects which have drawn national attention.

These strategies were all implemented with the project-based model and their implementation was designed so as to complement the regular university syllabus of the students. For purposes of this paper the feedback of about 78 students participating in the industry projects, lab innovations and the Value Addition Programmes (VAPs) was garnered. The students were asked to compare their development of skills by the conventional curriculum and when working on the PBL model, and the results are depicted in the table below.

Sr.No	Skills Developed	Student's views on conventional curriculum. (Rating out of 10)	Student's views on PBL model. (Rating out of 10)
1	Teamwork	4/10	8/10
2	Understanding/ knowledge growth	5/10	9/10
3	Punctuality through deadlines.	6/10	7/10
4	Inculcating Research	7/10	9/10
5	Decisiveness	5/10	9/10

Tab 3.Results of the review taken from the students.

The results of the study suggest that the students favour the PBL model for their overall development. The skills like teamwork, knowledge growth, punctuality through deadlines, inculcating research and decisiveness are thought to be better developed through PBL than regular curriculum.

Value Addition Programmes (VAPs)

Value Addition Programmes were started in SITL with the intent of making the students develop out-of-box thinking and improve their technical skills. VAPs run parallel with the university curriculum and are carried out after college hours. These programmes provide the students with the additional inputs and training on technology. With SITL situated in a rural campus, students physically accessing such training is difficult, hence VAPs were started to upgrade students technical skills.

SR.NO	NAME OF PROGRAMME	NO. OF STUDENTS
01	CORE JAVA	97
02	ISM BY EMC2	81
03	SAP	55
04	ORACLE 9I	66
05	CCNA	35
06	EMBEDDED SYSTEMS	52
07	MATLAB	46
08	GERMAN LANGUAGE	50
09	ADV. CATIA	25
10	HYPERMESH	24
11	C	210
12	C++	17
13	C#	27
TOTAL STUDENTS		785

Table 4 Enrolment of students for Value Addition Programmes.

Conclusion

It has been observed that even though the students are already performing up to their peak on the University of Pune's (UoP) prescribed courses, they enthusiastically participated in the various programmes initiated with a view of developing their skill sets through the Project Based Learning Paradigm. It may also be noted that even though the PBL model is far from replacing the current academic curriculum, it is being used as a complementary tool for learning a subset of topics for a required course. The Institute, which is bound by the UoP's curricula, has tried to amalgamate various initiatives to implement the 'learning by doing' scheme and it has received encouraging response in its initial attempts.

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BRIDGING DISCIPLINES THROUGH PROBLEM BASED LEARNING

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ABSTRACT

This paper examines whether a problem based approach to students' learning may support interdisciplinary education at university level, where students are required to engage with the complexities inherent in constructing knowledge across disciplinary boundaries. These complexities include students engaging with multiple and conflicting epistemologies, identification and contextualisation of problems involving several disciplines in their solution etc. A practical example found in the case of newly developed BSc and MSc programs in Techno-Anthropology is provided. The paper includes some examples of how a problem based approach to learning will be implemented in the programs to support students in their engagement with the complexities of amalgamating and transgressing the disciplines of technology and anthropology. The paper is concluded by a brief discussion of problem based learning as an approach to operationalising interdisciplinary education, and some challenges are identified.

INTRODUCTION

Bauman (2004) is one of several prominent sociologists who in recent decades have suggested that the degree of complexity and contingencies of society are increasing. And from this observation follows some substantial implications and challenges to educational practices at all levels. A need has arisen to reconsider perspectives of learning as well as what constitute desirable learning outcomes matching the needs of society beyond the walls of higher education institutions. Deborah Britzman has noted about the education of teachers that:

"if teacher education is to matter, we are obligated to create conditions for learning to live in this time that is out of joint, in discontinuous time and the disjuncture of self/other relations. This means taking responsibility for the discomforting fact of our dependency on the unknown." (Britzman, 2007 p. 11).

In response to this it appears relevant to support education of students not simply to become experts within a particular discipline but also to be able to navigate within contingent scenarios and utilise the complexities of society, organisations and products to address and solve similarly intricate and pressing problems.

Ramsden has analysed the development of objectives of higher education and points to central objectives such as critical thinking, learning how to learn, integration of theory and practice and the capability to respond to changing contexts and new situations (Ramsden, 2003). We see these objectives and the complexities of education well reflected in the array of university educations on offer where disciplines and domains are merged into new constellations to better reflect trends and complexities of society. Examples found at Aalborg University alone include Health Technology, Innovation, Knowledge and Entrepreneurial Dynamics, Design Psychology to name but a few. One significant question arising out of this multitude of interdisciplinary and cross-disciplinary programs relates to the ensuring of approaches to learning which match educational complexities and societal requirements. With the ever increasing emphasis on interdisciplinary and transdisciplinary education naturally follows a growing realisation of the need to rethink both educational structures as well as developing approaches to students' learning which enables the intended outcome of such new structures.

One such learning approach to inter- and transdisciplinary education could be that of problem based learning (PBL). Rather than supporting content learning of a single discipline the problem based approach puts the problem to be solved before the 'tools to solve it' according to Sternberg (2008), and this in turn opens up to transgressing disciplinary boundaries in the search for a solution. The aim of the paper is to explore in greater detail whether a problem based approach to learning could serve as the operationalising mechanism in inter- and transdisciplinary education. To reach this aim the objective of the paper is to explore the level of resonance between a problem based approach to learning and an intention of learning to occur across and beyond disciplines.

Interdisciplinary learning in higher educations

In the twenty first century knowledge is available in abundance and the task of the learner has changed from that of acquiring knowledge to become an expert, to that of sourcing out knowledge and connect information (Fraser & Greenhalgh, 2001). In higher education the term Interdisciplinary is often associated with courses or programs in which students are presented with elements of several disciplines or with a challenge to construct knowledge based on a synthesis of perspectives derived from multiple disciplinary positions. It is relevant here to distinguish between concepts of multidisciplinary, interdisciplinary and transdisciplinary education.

Multidisciplinary education can be characterised as an arena where different disciplines are juxtaposed in order to analyse a theme or object. Interdisciplinary education seeks to integrate or mix knowledge derived from different disciplines and in this process participants may form new perspectives on the disciplines involved (Domik & Fischer, 2010; Ivanitskaya, Clark, Montgomery, & Primeau, 2002). Transdisciplinary education is characterised by the construction of new knowledge synthesised from differing disciplinary epistemologies into a whole. This implies a view of separate disciplines as fragmented or incomplete (Petrie, 1992). Palaiologou emphasises the transversal construction of knowledge transcending disciplines "*…through overarching synthesis, critique and sustainability"* (Palaiologou, 2010 p. 277). It should be noted that the distinction between inter- and transdisciplinary education and learning appears opaque and the term interdisciplinary is often used indiscriminately to signal both the integration of disciplines and the synthesis of knowledge across disciplinary boundaries. In the remaining part of the paper the term interdisciplinary will be used to mean both interdisciplinary and transdisciplinary which is interpreted as a natural progression based on an interdisciplinary outset and as the two conceptualisations appear to share underlying characteristics of learning.

Ivanitskaya and colleagues argue that when learners are exposed to interdisciplinary education they

> "*develop more advanced epistemological beliefs, enhanced critical thinking ability and metacognitive skills, and an understanding of the relations among perspectives derived from different discipline"* (Ivanitskaya, et al., 2002 p. 95).

Interdisciplinary learning finds its perspective on learning in the constructivist paradigm and is concerned with how concepts are interrelated how knowledge is constructed departing in complexities (Fraser & Greenhalgh, 2001). Interdisciplinary learning breaks with traditions of learning as memorising facts and instead emphasises higher order epistemologies and students' engagement with complex and unstructured knowledge domains (Ivanitskaya, et al., 2002). Although interdisciplinary learning cannot for obvious reasons depart in one specific discipline and its conceptions Petrie (1976) has noted the need to realise how the disciplines involved may use differing observational categories and how these categories may be expressed through similar terminology. This means that working in an interdisciplinary manner is not tantamount to disciplinary ignorance. On the contrary it is in existing disciplines knowledge, theories and methods can be found which integrated and combined in alternative ways may generate new perspectives. Interdisciplinary learning is an ambitious project from the outset focused on reaching the higher levels of learning as originating in Bloom's Taxonomy of Educational Objectives and further elaborated into Bigg's Solo Taxonomy (Biggs & Tang, 2009). This ambition places heavy demands on students, who will not learn in the comfort zone of disciplinary scaffolding, and consequently interdisciplinary learning cannot draw on traditional pedagogical and didactical tools and learning strategies. Ivanitskaya et al. (2002) points to some key pedagogical characteristics of interdisciplinary programs:

> *"More personal construction of knowledge, emphasis on coping with difficult tasks and the search for multiple solutions, focus on the evolving connections among ideas, and interpretation and application of knowledge across several contexts" (p. 98).*

As a result one of the key challenges in interdisciplinary education lies in the way the synthesising of elements of several disciplines is manifested in the curriculum design rather than being left entirely to students (Petrie, 1992).

Another key challenge is located in the didactical and pedagogical considerations, as interdisciplinary education requires not only students but also teachers to embrace a view on learning as construction and learning being embedded as much in reflection and synthesis of knowledge across and amalgamating disciplines as in disciplinary domains themselves. Moving beyond considerations of differing epistemologies and disciplinary boundaries it is clear that for interdisciplinary education to function and to deliver interdisciplinary learning it is necessary to consider how to 'operationalise' and establish conducive spaces for learning matching the ambitions laid out above. No place is this more evident than in higher education where educational programs are continuously developed and enhanced to meet the complexities of society and the requirements of consumers.

Interdisciplinary education and problem-based learning

Examining the literature on interdisciplinary learning in higher education one dominant characteristic recurs. It is the departure of learning, teaching and education in real life problems rather than within predefined disciplinary boundaries (e.g. Domik & Fischer, 2010; Fraser & Greenhalgh, 2001; Ivanitskaya, et al., 2002; Klein, 2006; Little & Hoel, 2011; Petrie, 1976, 1992). In support of putting problems at the centre of education Petrie (1992) points out that problems of society rarely follow or can be restricted within disciplinary boundaries. Following a constructivist epistemology it can further be argued that disciplinary boundaries are themselves constructed with little or no consideration of contingencies and unpredictability of emerging problems. Problem solving as an inherent constituent of interdisciplinary education invites for considering more specific approaches to learning also centred round the problem rather than the discipline.

Although a problem based approach to learning can be organised in diverse didactical and pedagogical strategies and be reflected in diverse curriculum structures (Barrett & Moore, 2011; Barrow, 1996; Savery, 2006; Savin-Baden & Major, 2004) there appears to be a general consensus that the learning approach:

- Has complex and societal problems at the centre of the learning process
- Represents a constructivist approach where knowledge is constructed by the learner through his/her engagement with a particular problem and its solution
- Is student centred – learning is self-directed
- Supports students in critical thinking
- Requires a shift in the role of the teacher towards that as supervisor and facilitator of the learning process
- Is based on students working and learning in teams which requires development of team and communication capabilities
- Assist learners in their developing of cognitive and metacognitive skills through an emphasis not simply on product but also on (learning) process.

Central to this approach to learning is a move away from what Freire labelled the 'banking' concept of education where students are passive recipients of knowledge poured into them by the expert teacher. Freire argues that the banking concept of education is ignorant to experiences and context of the learner (Freire, 1972). The components of a problem based approach to learning meet in the aspiration to reach higher levels of Biggs and Tang's Solo Taxonomy whereby the complexity of the structure of a learner's learning increases as he/her master academic elements. The SOLO Taxonomy of learning is organised around five levels of structural complexity. The unistructural and the multistructural levels are concerned with how much students know as a quantitative measure. The relational and the extended abstract levels see a move into the qualitative as these levels are concerned with students' restructuring what they know to rethink conceptions, establish relations and forming abstractions. It should be noted that each level is seen as constituting the foundation for the next (Biggs & Tang, 2009). The resemblances between an interdisciplinary approach to education and a problem based approach to learning are made visible through this shared objective for students' reaching levels of structural complexity where learning outcome is in the qualitative phase (Biggs & Tang, 2009; Ivanitskaya, et al., 2002) and as problem based learning is often considered an approach supportive of interdisciplinary learning (e.g. Savery, 2006; Sternberg, 2008). In the remaining part of the paper the interdisciplinary program of Technoanthropology which is taught from a problem based approach to learning will be presented and will serve as a point of reference for the subsequent discussion and concluding remarks. I

The case of techno-anthropology at Aalborg University, Denmark

Aalborg University is dedicated to a problem and project based approach to learning and all study programs are designed within this framework. The Aalborg University approach to problem and project based learning has been formulated into nine principles guiding anything from supervision, organisation of physical spaces to organizational and institutional premises (Barge, 2010). These principles guide the design and organisation of educations across the faculties, departments and disciplines however, the application of the PBL principles is diverse to meet the specific needs and resources of each study program (Kolmos, 2009; Kolmos, Fink, & Krogh, 2004). Students in the technical study programs engage in project work during 50 % of their study time and this work account for 50% of the ECTS points of the programs. The project work is problem based and characterized by:

- Students identifying and analysing a problem within the overall project theme e.g. humans and technology.
- Students formulating their own problem statement based on their problem analysis
- 1-2 supervisors assigned to each group
- Each group consists of 4 – 7 members depending on how advanced the student is in his/her studies
- Students are expected to identify and argue for the solution of a problem within the overall theme, and they must present and reflect on theories and methods suitable for addressing the problem. This scope of working forges a natural interplay between theory and practice and between problem and disciplines.
- Learning is student centred

The case of Techno-Anthropology

Since 2008 academic staff across departments and disciplines at Aalborg University, have worked intensively to create the framework for an interdisciplinary study program at undergraduate and graduate levels merging disciplines within technology with the discipline of anthropology. The B.sc. program will commence September 2011, and thus this presentation of the education is focussed on argumentations surrounding the curriculum and didactics of the program. The scope and aims of the program are:

> *Both programs aim at qualifying students with the academic skills that enable them to act and interact professionally in cross-disciplinary and inter-cultural positions combining and advancing insights in cutting edge technology with anthropological studies and individual plus collective responsible decision-making. Graduates will be equipped to navigate in specialist technology cultures, analyse these cultures, bridge cultural gaps between technology cultures to other cultural categories, as well as to be involved in socially, sustainably and ethically responsible technological innovations and policy advice on high-technology matters. (*English Summary of aims and scopes of the programs in Techno-Anthropology, 2011).

The study programs rest on three pillars. A technology pillar embedded into disciplines of technology. An anthropology pillar embedded into the discipline of anthropology and an interdisciplinary pillar where real life problems e.g. themed around ethics, user driven innovation, technological impact on society and culture are addressed from multiple and interdisciplinary perspectives. Enabling this transgressing of disciplines has posed a number of challenges to curriculum and didactical strategies:

- Students are right from the outset expected to handle and competently address complex real life problems from multiple perspectives. They are expected to handle conflicting epistemologies found in the complexities of technology and anthropological analysis. This requires scaffolding around their learning, which can support this complexity and insert the confidence to pursue alternatives even when these alternatives could not be considered disciplinarily sound from a traditional point of view or when disciplinary specific literature and research does not offer scaffolding support.
- Most components of the programs depart in complex real life problems which on the one hand ensures relevance into practice but which on the other hand challenges the pedagogical approach where relating theory and practice becomes central. Although originating in the specifics of real life problems, students' academic work must be exemplary and transferrable to other similar problems. This requires support of reflection and abstraction beyond the problem at hand
- Project work accounts for 50% of the curriculum which means that the lecturer is 'replaced' by a facilitator. Projects are student centred and in order to reach the learning objectives of the programs students must be able to reflect on their own learning and to make initiatives which may direct their learning and support their learning processes.

To meet these challenges and to ensure both a problem based and an interdisciplinary approach the curriculum, didactical and pedagogical elements of the programs have been implemented as suggested by Klein (2006).

- Disciplines will be taught mainly through courses. Projects are utilized as a catalyst for interdisciplinary and problem based work.
- Most single discipline courses draw on cases to enhance students' problem analysis and to facilitate problem solving through a multiple perspective approach. A case session consists of multiple learning possibilities of e.g. lectures, group discussions, seminars and workshops

and is concluded by student presentations. Many courses are evaluated through an assessment of students' continuous and active participation throughout the course period.

- Project themes are mainly interdisciplinary alternating between a predominant focus on technological or anthropological perspectives. To ensure discipline integration and transgression project groups are allocated facilitators from both the technical and the anthropological domains.
- Fundamental objectives of the programs are to equip students to think critically and to be able to reflect about their own learning process. Both elements are essential for graduates to become flexible and adaptable to changing tasks and circumstances. To meet these objectives the programs include compulsory courses in problem based learning highlighting strategies for engaging with learning and the learning process, team work as well as problem identification and project structuring. Moreover, courses on science studies and ethics elucidate working on themes from multiple and conflicting perspectives.

Above it is seen how didactical and pedagogical elements of problem based learning are integrated into the interdisciplinary programs in Techno-Anthropology. The final part of the paper contains a brief discussion of some possibilities and limitations emerging when adopting a problem based approach to learning as the pedagogical foundation of an interdisciplinary education.

Discussion

The study programs in Techno-Anthropology rest upon a well-established Danish secondary school structure, where interdisciplinary and project based activities are central to the pedagogical approach to learning. One of the key arguments for this structure is that students should be prepared for higher education. It is therefore necessary to educate for capabilities rather than simply competence when moving beyond disciplinary boundaries. Capabilities in this context refer to the extent to which an individual can construct new knowledge, cope with change and continuously improve their performance. Developing capabilities in students enhance their grappling with complex problems, uncertainties and constant change (Fraser & Greenhalgh, 2001). Fraser et al. further argue for the use of process techniques as that which distinguishes disorganised and unstructured teaching and learning from "learning which has a flexible and evolving content" (Fraser & Greenhalgh, 2001 p. 801). Educating for capabilities is visibly in line with general principles of problem based learning where self-directed learning, critical thinking and reflection are key constituents and seen as prerequisites for students' addressing complex problems. A view on interdisciplinary education as educating for capabilities in students rather than disciplines resonates well with a pedagogical and didactical approach rooted in problem based learning, however the approach does impose challenges as well.

Klein (2006) emphasises the need of integrating curriculum, didactical and pedagogical considerations into the structuring of interdisciplinary education thus approaching education from a holistic perspective. This places heavy demands on the institutional and organisational structures of interdisciplinary educations both in terms of resource allocation but also in terms of teachers' approach to their role, their knowledge and their disciplines. In rethinking curriculum and pedagogy in some programs and not all, some teachers may even experience a need to operate and navigate simultaneously in disciplinary and interdisciplinary contexts and thus facing conflicting approaches to learning.

The above presents several concrete challenges to higher education when interdisciplinary education is the objective and where problem based learning is selected as the strategy for operationalisation. The first is how to institutionalise interdisciplinary education and a problem based approach to learning. As pinpointed by Petrie (1992) the departmentalisation of higher education institutions according to discipline impedes interdisciplinary initiatives and preserve disciplinary boundaries. This challenges communication strategies within institutions and demands support for those individuals who will have to navigate within and around their disciplines in new ways. Disciplines are comfortable constructions as they serve as much as an excluding as an including framing of education and research. Transgressing boundaries may therefore be an uncertain endeavour which raises uncomfortable and chaotic scenarios. This challenge is double edged as it relates to both lecturers and students. Students are educated for capabilities, but which are the capabilities needed by the lecturers to tackle a move into interdisciplinary educations and support of interdisciplinary learning? So a key challenge is how teachers in higher education may make the transformation towards a role of facilitator of interdisciplinary learning and how he/she may still retain his identity and sense of authority as a teacher (Poikela & Moore, 2011).

The second challenge concerns the degree to which interdisciplinary education should and could constitute a definite break with existing disciplines through its transcendental perspectives. In addressing this challenge there are interrelated disciplinary and educational considerations to make. From the disciplinary perspective Petrie argues that disciplines are needed in order to constitute a framework for terminology and observational categories (Petrie, 1976). It is through the already established disciplines that structures can be found which enable negotiation and renegotiation of disciplinary boundaries eventually leading to the construction of new inter- and transdisciplinary alternatives. It can further be argued that it is in the possibilities of scaffolding learning by use of disciplines that both teachers and students may find a comfort zone or structures which assist in prioritising knowledge and directing studies. Implications of a clean break with existing disciplines can thus be severe and undesirable perhaps partly as the operationalising mechanisms found in a problem based approach to learning do not fully equip students or lecturers with the tools necessary to navigate comfortably in contingencies and complex scenarios. One possible way forward could be to tailor education much closer to the lives and complexities of students (Stentoft, 2009) or to the capabilities to which an education is directed. In a perspective of problem based learning the key to this could lie in the way problems are identified and made relevant and in the way construction of knowledge in a span of conflicting epistemologies is articulated e.g. by way of educating for capabilities as outlined above.

Concluding remarks

Interdisciplinary learning is characterised by its focus on solving real world problems through the integration and synthesis of knowledge springing from several disciplines. It rests on a constructivist paradigm through which it is possible to recognise the complexities and continuous change of the nature of the problems and to respond by constantly challenging existing disciplinary knowledge ultimately into new disciplines. It is the drive for solving problems that justifies interdisciplinary work and interdisciplinary education. However, as seen in this paper, a move towards interdisciplinary education presents a new set of challenges to learning and the learner. In interdisciplinary education the comfort of the disciplinary scaffolding is replaced by the daunting complexities of real life problems as the primary centre of the learning experience. Making the move from learning as memorising facts and reproducing knowledge towards learning as construction of new knowledge and explorations of new relations synthesised from several disciplines requires a rethinking of the pedagogical and didactical approach to teaching and learning in higher education. An approach of problem based learning resonates well with interdisciplinary education as it has at its core a focus on real life problems rather than disciplines and at its disposal an emphasis on the constructing process of knowledge. Interdisciplinary education places heavy demands on students' as well as lecturers'' engagement with complexities and uncertainties, and the question remains whether the pedagogical and didactical implications of a problem based approach to learning are sturdy enough to withstand both students' and lecturers' resistance towards uncertainties. How may a problem based approach be framed in the future to be an even stronger pedagogy in educational scenarios build upon the contingencies of society and the desire to move in-between and beyond disciplinary boundaries in our search for solutions?

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INTEGRATING THEORY AND PRACTICE ACCORDING TO PBL-BASED PROJECT DESIGNS IN SECONDARY VOCATIONAL EDUCATION OF ENGINEERING AND MUSIC

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ABSTRACT

Vocational education should prepare learners to meet the future challenges of change and renewal. Education is to help students master the skills needed and the theories connected to these skills. New applications of the PBL method were constructed for teaching and learning by Oulu University of Applied Sciences and piloted in two localities in northern Finland.

The first project (2009 – 2011) by M Pietilä was directed towards students of electricity and refrigeration technologies, and was carried out both in school and on-the-job learning. The findings show that by paying attention to a PBL based way of teaching, the students´ motivation and the mastering of course entities were increased. The second project by E. Virkkula in Oulu Conservatoire, the department of pop and jazz music in 2003-2007, experimented with a PBL method during on-the-job learning by planning and arranging instrumental "clinics" and master courses for students to collaborate with professionals.

INTRODUCTION

"A person´s knowing/knowledge and skills are like a hidden treasure." (Kojonkoski-Rännäli, 1996.) A person´s growth into a skilled and knowledgeable professional who is aware of his capacities, is not only a natural process, but needs an educator and is based on choices.

A skill can be understood to be a change from giftedness to skilful action in which a skill is the final outcome of learning and practicing. A vocational task can be made up of various sub-tasks and the daily routines connected to them. They can also be called skills.

Professional competence is central to solving open problems. In this process the aims must be defined and alternative ways of solving the problems must be found. A skilful performance is based on a system of inner patterns which directs the actions. Therefore obtaining a skill requires cognitive processes, motor skills, visual outlining, social competence and strategic ability as inner patterns.

Theoretical background and research methods

Skills can be simple or complex entities of learning. Simple skills are short-term and they are learnt quickly, for instance the lifting or moving of an arm. Complex skills are learnt through three phases which consist of cognitive, associative and autonomous phases. Learning a complex skill is the result of learning routines and sub-routines and develops slowly. After thousands of repetitions there is still something that can be learned. In performing arts, artistic personality is one of the targets of education. More is needed than just technical skills: these include thinking, feeling, understanding and expressing.

The PBL method in learning skills

PBL can be applied to learning both simple and complex skills. The 7 step PBL variation underpinning the present pilot projects was:

Step 1: Unknown wording, concepts and items to be learnt are explained;
Step 2: Problems or items to be learnt are defined;
Step 3: Brainstorming/ analyzing/ seeking for explanations to the problems are carried out;
Step 4: Systematic inventory of explanations is compiled, alternatives are compared and chosen;

Step 5: Self-study (team study) assignments are decided and formulated;
Step 6: Assignments are performed individually or in teams;
Step 7: Self-study or performance phases are reported, the outcomes are evaluated by the participants themselves, teachers and/ or learning-at-work supervisors.

The starting points and processes of teaching

The importance of following the basic tasks of vocational education should be understood by every teacher.

1. Teaching the basic skills. Theories and attitudes connected to the basic skills are learnt gradually, moving from small items towards greater entities by constructing schemes.
2. Confirming the knowledge and getting prepared for work life means internalizing models, speeds and routines.
3. Confirming vocational identity and the top level of knowledge includes automation of the learnt items, mental image exercises, connections with working life and meeting professionals.

Learning proceeds as a reflective action towards vocational skills and requires time to attain the goals. Vocational growth begins with being a novice and moves towards becoming an expert. Expertise is attained as the learning outcomes from knowledge and skills constructed in a person´s schemes (Eteläpelto 1997 et al). Kolb (1984) describes learning as a cyclic process which begins from a concrete experience and proceeds via reflective observation and abstract conceptualization to active action. Experiential learning is thought to be realized in learning-on-the-job. (Ruohotie 2000, 139.) It is direct, intuitive, open, emotional and creative action.

Knowledge of simple routine items allows the learning of principles and customs. The sub-areas of learning are simple routines, *what will be done, in what order, when and why.* Routines are learnt through modeling and repetition. (Steps 1 and 2.)

A single event involving learning and practicing does not assure the permanent mastery of the skill. For mastery to be deepened, it requires repetition which aims at involvement, integration and automation. Analyzing and constructing a new scheme includes the question: *why will this indeed be done in this way?* (Steps 3 and 4.)

After learning the skill, in order to act according to the model, a learner has to take a critical view of the sequence of actions in his work. It presupposes a longer period of practice which will result in emancipatory learning of professional knowledge and skills. (Steps 5 and 6.)

Learning the work means understanding. Learning is continued through training in real situations (on-the-job learning), through simulated situations and development projects. At work the learner has to test the practicability and adaptability of theory, as well as the changeable character of work and their suitability to further development. The richer the connections are created between theory and practice, the more flexible the competence will be. (Steps 6 and 7.) In other words, under the supervision of a teacher, a synthesis of theoretical knowledge and practical skill is created. Answering the questions *why does this happen, what phenomenon is behind this observation* leads to deeper understanding.

Carrying out the on-the-job learning in the field of music differs from that in engineering. While the latter takes place in normal work places, in pop & jazz music the work is freelance-based, without permanent jobs and professional music organizations. Classical musicians, instead, are mostly employed by orchestras and financed by the state and municipalities. Educational institutions are required to arrange on-the-job learning of pop and jazz music students in cooperation with, e.g., the professional musicians working in the field. (Musicians´ Union 2001.)

As project learning in general is connected to social constructivism and corresponding conceptions, it emphasizes functional and situational learning, learning environments and social interaction. (Kolb 1984.) Through action an individual gets information of one’s environment and of one’s relationship with it, while the logical chain of events - “what leads to what” - becomes evident. Active participation can be seen as a problem solving process in which an individual tries to analyze and construct a picture of his/ her environment and his/ her role in it. (ibid.)

Activating learning processes results in learning and using the contents in genuine environments. This is how learners can gain experiences in the general ways of acting in the fields in question as well as naturally facing the central problems of the field and learning to find proper alternative solutions to them. Attention should be given to authentic learning situations and environments seen from the viewpoint of the applicability of the intended knowledge and skills. It does not only mean the physical surroundings but also the emotional atmosphere of the teaching occasion. A teacher as its systematic creator has a decisive significance. A student´s ability to deal with the new information is greatly dependent on his/ her emotional state. The more excited or over-active the learner, the more limited are his/ her possibilities to act.

The learning environments should enhance risk taking and questioning one´s own and the others´ thinking and acting. (Kolb 1984, Rauste-von Wright et al. 2003.) In open communication the thinking and interpretation of a student will become explicit to him/ herself as well as to the others. It, again, will make it possible to exert collective reflection: each member creates the basis of both learning from others and of questioning one´s own preconceptions and "self-evidences" (Jarvis 2003). Consequently, one of the foremost challenges is to combine the above mentioned principles with formal educational practices. How can education include proper activities in authentic work life situations to enhance the students´ problem solving and constructive social interaction?

Levels of learning, reflection and socio-cognitive aspects

Vuorinen (1991) defines the comprehensive mastery of vocational skills as the mastery of thinking action and the ability of controlling action in the way which is optimal for the present task. He quotes Mickler et al. (1977) and introduces their idea of developing the mastery of the skills on the mental level. They are grouped as follows:

1. On the lowest, *senso-motoric level* non-autonomous sub-movements are automated and directed subconsciously "on the spinal level".
2. On the following level the entirety of the process is controlled *half-consciously* with the help of various observed signals and brief concrete thinking processes.
3. On the *level of adaptive thinking* the process can be adapted to new acute situational changes. This level presupposes, consequently, the ability to generalize.
4. The *level of systematic thinking* is present in the situations which demand the decision of action to be based on various learnt functions.

5.&6. The *levels of adjustment and strategic thinking* make it possible to apply the learnt material to new situations.

7. If the adjustment takes place on the level of strategic thinking, it is possible *to develop new models of problem solutions* and plan beforehand comprehensive events of action.

Research questions, contexts and methods

The central question in the engineering project was: *How can vocational studies be constructed to create a motivating experience for learners and inspire them to lifelong and life-wide learning as well as to make them success stories in their work?* The pilot project was supervised by the School of Vocational Teacher Education in Oulu and realized in a new kind of learning environment in Rovaniemi and Kuusamo Vocational Institutes in Northern Finland. It was started in 2009. The teachers (N= 12) adopted a new kind of approach to their classes and teaching according to the PBL design. The research data was collected from the group of 35 students aged 16 – 20 years representing the fields of electricity and refrigeration technologies. The methods of data collection were interviews, teachers´ observations and test results. Learning was analyzed and evaluated by mainly qualitative content analysis methods supplemented by some statistics. Evaluation concerned the mastery of skills observed through written tasks, workshop work, self-assessment, peer assessment and the evaluation by the teachers as well as the representatives of on-the-job learning. Some portfolios and learning protocols were also available.

The music education project in Oulu Conservatoire from 2003-2007 concentrated on developing work life cooperation in the field of music with the help of the so-called music workshop activities. A "musashop" means a functional model based on applied PBL learning with the idea of the music institution members carrying out a performance (a concert / a gig) together with students and music professionals. The starting point was the need to develop a model of teaching, based on musicians´ real work practices. The research question was: *What could a functional model be to realize work life cooperation in the field of music?* The data collection from the students (N=56), teachers and music professionals who participated in the musashops took place during the project. The research included a qualitative analysis of the observations and collected feedback as well as collected ideas for further development and carrying out the testing of competence based skills.

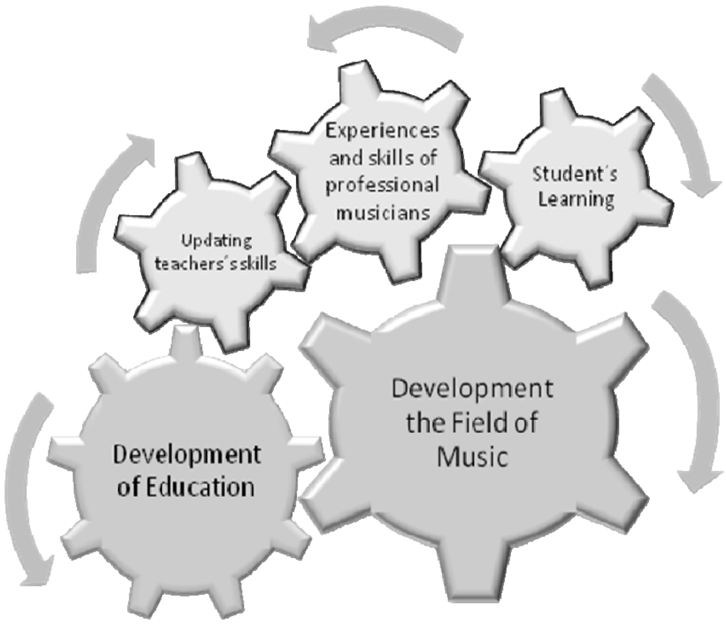

Figure 1. The framework of development in music education.

How should teachers apply the PBL in order to motivate students?

Step 1.The objectives of the lesson are first introduced and the importance of mastering a certain skill is justified. The outlines of the lessons' contents are explained as well as briefly explaining the methods and various phases. If the topic is broad and difficult to outline, it must be divided into parts and taught step by step. In the musashops, flexible action is connected to the levels of professional skills in authentic work tasks. Also the choice of the responsible teacher and the student group participating in the action is carried out in the beginning.

Step 2. Learning is an individual process. Thus in the learning of skills various guiding methods are often needed due to the individual ways of learning. Teaching starts from the learner´s situation. The event of teaching a skill is planned beforehand so that every student has a possibility to work. The necessary equipment and material should be ready at hand. Attention is paid to workplace safety and following the regulations. Choosing and using the right tools and protective equipment are taught before the actual training. The workshop is kept clean, and tools and apparatuses are cleaned according to the given advice.

Step 3. The teacher is to understand what is difficult and have an inquiring attitude towards problems. Often mastery will be attained after a number of repetitions. On no occasion should a teacher underrate a slow learner; he has to be given equal time to the others, but more time if needed. Brainstorming concerning choices of contents and methods can also be carried out in this phase.

Step 4. Obstacles to learning will often be smaller, when after some training the student has a sufficiently well established scheme or the principles of learning. The better the previously learned schemes can be availed, the faster the learning will become automatic. In teaching skills the direction should be towards deep learning and attaining a high level of know-how, as superficial knowledge does not develop proficiencies. In music education signing contracts (musician, place of performance, technique) will be dealt with here.

Step 5 is useful to be included in the form of combined self-study and tutorials/ seminars/ team sessions. Individual tasks and practices can be planned during this step. In music education planning, advertising, information procedures and organizing the implementation as well as the choice and preparation of the material for the practice period are carried out here.

Step 6 is mostly devoted to on-the-job learning. It can include also autonomous practicing depending on the profession. In musashops instrumental and ensemble practices and performing with the professionals are realized.

Step 7 includes written and skill-based tests and the overall evaluation and assessment of learning and practice. In this phase the representatives of work life usually cooperate with teachers and listen to the opinions of the students concerning on-the job learning periods. In short, reflection, feedback and evaluation belong to this phase.

The professional way of working, educational goals and the students´ professional growth are naturally connected together. Learning takes place in a cooperative way in authentic contexts, also including autonomous work. A project carried out together with a work place allows the essential ways and styles of acting at work to become a part of the education, when students acquire concrete experiences through the tasks and culture in the field. (Vuorivirta 2006.) “Musashop´s” themes can be connected to a style in general, the production of a certain artist or the most important material for some instrument, etc. They also include many other duties of a professional, e.g. responsibility for composing or arranging the music or marketing and selling the performance.

Findings

The teachers participating in the project were committed to following the principles and aims of teaching described in the above chapters. The process was more loosely applicable than the traditional PBL method.(cf Boud et al 1999; Nummenmaa et al 2001). Steps 1-3 are self-evident in principle to trained teachers, but even they considered it necessary to pay more attention to them.

On-the-job learning was either a hinder or blessing depending on what kind of work place the student went to. Models for collaboration between educational institutions and work life, especially in music education, were constructed so that the learning environments could correspond to the demands of work life. The work places were chosen and controlled whenever possible. The best thing was when the school and the work place acted according to similar principles at work and had the same kinds of aims and evaluation principles. Cooperation of the teachers and work place staff was necessary. The students assessed the outcomes of their on-the-job learning themselves and together with their supervisors. The following aspects were to guide their self-evaluation processes:

1. Specific vocational knowledge and skills, consisting of knowledge of work processes, expertise in routines, the qualifications of vocational technology or production techniques, facilities for planning and developing and specific skills of problem solving;

2. General competences and skills including adaptive expertise or ability to act in new situations, progressive problem solving, interpersonal skills, communicative skills, ability to use ICT and information services, critical thinking skills and innovative thinking;
3. Autonomy and self-initiative made use of planning one´s work and career, developing vocational/professional identity, autonomy, reflexivity and self-assessment as well as internal entrepreneurship. (cf. National board of education, 2006; Räkköläinen& Stenvall, 2008.)

The students were not very advanced in their skills after the first and not even after the second year of their education. Still, they were better than the students of the earlier cohorts. This is apparently due to a new kind of approach to learning the skills. During the first on-the-job learning period the progress of the skills was greatest in group 1 above and less developed in group 3. In group 2 the progress showed the greatest variety, obviously depending on the personality of the student. The previous year´s results were not available for this research.

Developing vocational identity is connected to the attitudes of the teachers and work place colleagues and leaders. It is something that is learnt non-verbally by observing people at work.

Their attitudes towards work and mastery of the skills had a great influence on developing self image and the conception of oneself as a representative of the trade.

Reflection was emphasized throughout the learning process, especially in the tutorials. In the beginning, the students found it difficult to verbalize their experiences. They became accustomed to it by dividing the reflection process into different phases according to Kolb´s model of experiential learning (1984). After the feeling phase, reflective observation was approached by simple questions: 1) How did you manage with the task? 2) What kind of result did you get? 3) What should be improved? 4) Could you do something in another way? 5) What did you learn from the experience? and 6) What should you know more about regarding the task or train more in? After answering the questions, first a few questions and gradually being able to answer more and more questions, the students were able to understand the work process as a whole. They were thus supported in the process in which understanding and skills became strengthened.

The research question in project 1 was: *How can vocational studies be constructed to be a motivating experience for learners and inspire them to lifelong and life-wide learning as well as to make them success stories in their work?* The outcome revealed that the PBL is a good way to construct motivating and meaningful learning experiences. According to it a teacher plans, prepares, organizes and starts the learning events systematically and pays attention to the diversity of learners. He/she also controls the situational factors of learning at school and on-the-job learning not forgetting to teach reflective practices and self-assessment to the students.

In project 2 the research question was: *What could a functional model be, to realize work life cooperation in the field of music?* The project was designed to correspond to the real work of a musician, and skills gained from it were adaptable in the work life. The students experienced that their professional identity was significantly strengthened when they were able to work together with the professionals. Accordingly, the educational institutions got possibilities to develop new work life- based teaching practices jointly with the professionals in the field of music.

A strong facilitator in the projects was observing experts and sharing their work. Beginning students were more concentrated on doing practical work, following the example of professionals, and their attitudes were observed unconsciously. The more the students gained skills, the more open they were to consciously learning non-verbal, verbal and attitudinal issues. They need practice and repetition, successes and failures, reflection and self-assessment as well as peer evaluation and guidance of experts to grow into real professionals.

The findings show that a new kind of approach, integrated experiential learning and PBL, increase theoretical understanding and practical skills as well as strengthen the mastery of the course entities. The best single observable feature was the increased motivation of all the students to study the course entities. It also means that it is also the teacher´s responsibility to develop his/ her practices.

Discussion

The demands concerning the know-how of vocational teachers will grow in the future. On-the-job learning has become a normal part of education. How and where can teachers, filling the requirements of the respective skills, both theoretical and practical, be recruited? Also the awareness and evaluation of the learning conceptions guiding the events of work-based practices must be emphasized. (Vertanen, 2002**.)**

A competent teacher is able to help the student study efficiently. For that reason it is important to train vocational teachers pedagogically both in pre-service and in-service programs. It is also important to acquaint the on-the-job learning staff with the aims, methods and evaluation of the educational institutions.

Conditions created in the environment which combines theory and practice are linked to subsequent retrieval and appropriate use of new information in the following way: 1) activation of prior knowledge, 2) encoding of knowledge in a specific context and 3) opportunity to elaborate on that information. Activating prior knowledge is a kind of cognitive structure that determines what is understood from a new experience and what is learned. New knowledge is encoded in a context modeled on practice. Knowledge is best remembered in the context it was originally learned. The possibility to elaborate on learned information provides redundancy in memory. It, again, reduces forgetting. (Bridges 1992.) Consequently, teaching theory and practice together, defining problems and taking efforts to gain systematic problem solving skills as well as controlling and guiding work experiences seem to be a motivating and meaningful way to acquiring the mastery of vocational skills.

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UTILISING ACTION RESEARCH AS AN APPROACH TO EVALUATING THE DESIGN OF A PROBLEM-BASED LEARNING PROGRAMME

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ABSTRACT

An essential element in the development of any new educational programme is the evaluation of its effectiveness; however, there is a lack of consensus on the process and focus when evaluating the design of a problem-based learning (PBL) programme. This paper will specifically detail the evaluation of the design of a new degree programme (the BSc in Small Enterprise Management), acknowledging that the design of continuing education for micro/small tourism enterprise owner/managers represents a particular challenge, however, by utilising an action research (AR) approach, which facilitates interaction with the major stakeholders, it is perceived that much of this challenge can be met. Further, this paper argues

that an AR ethos allows the evaluation of a programme's design to be "reflective, iterative and progressive" (Maudsley, 2001, p. 320).

INTRODUCTION

This paper originates in the context of growing recognition that the success of the global tourism industry will ultimately depend on the professionalism of its workforce (Edgell *et al.*, 2008). However, while a general consensus exists on the merits of higher levels of professionalism, and education's role as a key driver of the professionalisation process is undisputed, continuing education for owner/managers of micro/small businesses is problematic (Kelliher *et al.*, 2009). In light of the foregoing, Fáilte Ireland, the Irish national tourism development authority, began a tendering process for the delivery of a degree-level programme, specifically for owner/managers of micro/small business enterprises, and the authors' tertiary institute was successful in this process. A new three-year Bachelor of Science in Small Enterprise Management (BSc), based on an andragogical philosophy and problem-based learning approach (PBL), was developed during the 2008-2010 academic years.

As distinct from the traditional didactic transmission approach to education, PBL as an innovative teaching and learning approach has been utilised in medical education since the 1960s (first developed by McMasters University medical school in Canada); however, in the business discipline, especially in Ireland, it is in its infancy. PBL is based on an action learning ethos, with an emphasis on self-directed learning; it also utilises small student 'network' groups (of no more than five/six students) to develop responses to real-world 'messy' problems, thereby developing the students' generic skills through the experiential learning process. In this instance, the degree programme will be delivered through a blended learning approach, combining an online community aspect with the mainly face-to-face PBL element; inherent in this approach is the philosophy that the students themselves will take 'ownership' of the problem and, hence, their learning. However, PBL as a "complex mixture of a general teaching philosophy, learning objectives and goals, and faculty attitudes and values" (Vernon and Blake, 1993, p. 560), presents particular "unique challenges" for evaluation which must be considered. Evaluation has been defined as "a systematic process that judges the worth of an educational programme via quantitative and/or qualitative data analysis…and aims to improve students' experience and achievements" (Maudsley, 2001, p. 313); in this case the focus is at a programme-level as to whether or not the programme design will ultimately meet the needs of the stakeholders. This paper will argue that an action research (AR) approach to programme design evaluation is required to provide an evidence-base for design decision-making, especially as there is a lack of consensus regarding the "best" process to follow, as the literature tends to focus on what educational evaluation finds rather than the rationale for the approach taken. This paper seeks, in a major way, to address this deficit; hence, it begins by detailing what action research entails, and the evidence-base it provides in the emergent process of programme design, specifically by highlighting how feedback from programme stakeholders was incorporated into the PBL contribution and its associated evaluation.

Action research as an evaluation approach

Action research (AR) has previously been conceived as research *in* action and normally consists of a four step cyclical process of: (1) constructing (identifying the pressing issue and context), (2) planning for action (usually involving collaboration with stakeholders), (3) taking action, and finally, (4) evaluating the action. Each iteration of the cyclical process informs the next, as actions are taken to improve the practice, and evaluation results form the basis for further planning prior to the next cycle commencing. In the case of the new degree, the AR process has employed a range of different qualitative and quantitative data collection tools, adapted to suit the context, including focus groups, round-table discussions, surveys and telephone interviews; all focused on improving the future provision of the programme and the PBL content. Indeed, employing an AR approach prevents the methodology becoming "so disconnected from the reality it is designed to understand that it is no longer useful" (Argyris *et al.*, 1985, p. x). Further, AR is envisaged as a systematic research process that occurs in on-going, changing environments, with the change processes, interventions and products evaluated while the systems are in operation in the service of stakeholders (Bargal, 2008). Critically, by employing an AR approach, the programme design team were able to gather detailed and rich information concerning the degree's major design dimensions: content, context, process and outcomes through various formal and informal interactions with stakeholders. In many respects, each of these four dimensions of the BSc represented a 'blank sheet' and, as a consequence, the programme development began with a number of consultations with stakeholders in order to promote a culture both inclusive and responsive in terms of the BSc's design and future implementation. This paper presents the first cycle, which represents the BSc's design stage. There are other cycles involved in the BSc's implementation but these are beyond the scope of this paper. In order to demonstrate the value of the AR approach to programme design evaluation, the following section outlines this process and its evidence-based outputs under the four cycle headings: constructing, planning action, taking action and evaluating action.

Constructing

As previously indicated, AR focuses on problem-solving; the problem that was identified was quite a broad issue, the need for enhanced professionalism across the tourism industry, specifically involving micro and small tourism enterprises (MSE) (as identified by Fáilte Ireland). The national tourism body identified education as a means of enhancing tourism professionalism, and stressed that the degree programme should reflect the latest educational thinking on design and delivery with nationwide coverage. Secondary to enhancing professionalism, the agency also wanted to enhance the owner-managers of MSE's entrepreneurship and innovativeness. A further design complexity involved the nature of the targeted student – previous research in both Irish and international settings had identified a lack of engagement in higher education of micro and small enterprise (MSE) owner-managers (Lawless *et al.*, 2000; Storey, 2004; Devins *et al.*, 2005; Fuller-Love, 2006), with a growing body of research identifying that these MSE owner-managers had distinctive characteristics when it came to their educational needs and barriers to their learning (Kelliher *et al.*, 2009). These issues informed the programme development team's approach to the BSc, which, in turn, led to several discourses with major stakeholders. The programme development team also drew on their experience with the targeted cohort through their involvement in another Fáilte Ireland initiative, the Tourism Learning Networks (TLNs); indeed, feedback from both Fáilte Ireland and the TLN graduates (through a wide range of research activities with this cohort), revealed a high level of demand for a bespoke degree, crafted to meet their specific needs.

A particular feature of the AR approach is that it underscores the criticality of participation in the research for change, and specifically, the collaboration between educators and major stakeholders to ensure that higher education meets not only the knowledge needs of its targeted learners but also their generic skill needs. Not only does an AR ethos facilitate an environment where there can be an ongoing dialogue, but it also ensures that stakeholders are recognised for their contribution as co-researchers and the values that they bring to the process are made explicit.

Planning Action

Initial discourse with executives from Fáilte Ireland prior to the awarding of the tender for the BSc provided a 'working theme' (Coghlan and Brannick, 2010) to guide the planning action stage; it was evident from these discussions that an innovative programme design was required. Based on reflection, knowledge, experience, and a new PBL initiative in the authors' Institute, the programme development team crafted the tender, and ultimately the programme, around two major approaches: PBL and blended learning. An andragogical philosophy, which underlies PBL, was utilised due to its recognition of the value of the accumulated experience of the students – as recommended by Augier and March (2007). Indeed, a critical moment in the design stage was when the programme development team identified PBL as a possible solution to the problem of how to deliver a programme which would suit the needs of the MSE owner-managers, particularly their identified need for a sense of involvement, relevance and flexibility both in content and delivery (Storey and Westhead, 1997; Moon *et al.*, 2005). The literature indicates that PBL has been identified as conducive to achieving the high level skills, knowledge, and appropriate personal traits to grow and transform enterprises (cf. Duch *et al.*, 2001; Burns and Chisholm, 2005) (in line with both Fáilte Ireland as the funding body and the Institute's strategic aim to enhance tourism professionalism). PBL was combined with a blended learning approach, which combines face-to-face facilitation and support with distance learning (Sharpe *et al.*, 2006) (utilising the Institute's eLearning support website and Moodle). The blended learning approach that will be utilised will combine the best features of the interaction between student and instructor with the advantages of asynchronous learning. By its nature, asynchronous learning offers the student participant the advantage of choice in time and pace of study (Lawless *et al.*, 2000), thereby responding to the call for flexibility in programme delivery; this approach also meets the need for the programme to be available nationally.

Taking Action

In line with the AR approach adopted, and in order to maximise the contribution of the major stakeholders in the development of the programme, a number of interactions were organised (see Table 1). As outlined in Table 1, through interaction with key personnel from Fáilte Ireland, the programme team identified several content themes – these are detailed in Table 2 (themes were confirmed in the later evaluation stage by practitioners in the round-table discussions).

Stakeholders	Interaction Methodology	Key Outcomes/Implications
1. Programme design team	Review of the literature, reflection and ongoing team discussions.	PBL & blended learning approaches.
2. Fáilte Ireland & Institute	Various roundtable discussions.	Industry needs analysis – leading to programme themes and generic skills list.
3. Targeted student cohort (MSE practitioners)	Focus group	Confirmation of programme themes & further formulation of generic skills list.
4. All the major stakeholders	Pilot-study: observation	Confirmation of programme themes, PBL and blended learning.
5. Targeted student cohort (MSE practitioners)	Pilot-study: quantitative survey	Immediate feedback at the end of the pilot-study workshop – initial reactions of the participants to the group interaction, blended learning and PBL.
6. Fáilte Ireland, Institute & programme design team	Post-pilot: discussions	Confirmation of satisfaction with PBL and blended learning elements.
7. Targeted student cohort (MSE practitioners)	Post-pilot: interviews	Confirmation of key findings from observations and immediate feedback from the pilot, in addition to details regarding potential barriers to engagement (as detailed in a later section).

Table 1: Stakeholder interactions and outcomes

Programme Themes	
• Market Engagement & Web Technology	• Tourism Business Processes
• Network Development	• Entrepreneurial Development
• Sales & Strategic Market Development	• Tourism Competitiveness & Innovation
• Environmental & Energy Management	

Table 2: Programme Themes

Space issues do not allow the authors to discuss in detail each of the interactions with stakeholders in the design of the programme; however, these data gathering interactions culminated in the integration of the feedback into matching the targeted cohort's needs through a variety of approaches (such as the provision of recognition of prior learning (RPL) and a tailored induction programme). Ultimately, the programme team decided to develop a pilot-study employing one of the programme themes, PBL and blended learning, to evaluate the major design choices up to that point and determine if any further programme modifications were required.

The pilot-study was designed to mirror closely a real PBL situation, with 18 tourism owner–managers invited to participate in one full PBL cycle, that is, (1) Set the climate (roles & rules), (2) Introduction of a trigger/ problem, (3) Brainstorm, (4) Identify learning issues, (5) Independent study, and (6) Synthesis and discussion, culminating in the completion of a written assessment in the form of a group report to be uploaded onto Moodle. The pilot study and the follow-up interviews were crafted by the authors in order to gather information from potential participants of the BSc concerning: (1) their response to PBL, (2) perceived problems arising in connection with PBL, (3) particular challenges in connection with working in an online environment (e.g., distance learning and technology), (4) barriers to completing the assessment, and (5) any other issues/concerns arising. Although the programme design team made every attempt to make the pilot realistic, there were limitations to its 'reality.' However, despite the foregoing, it is perceived by the authors that the pilot study process accurately reflected that which occurs in an actual classroom context. In addition, the design team had their own PBL experience to draw on, this is all the more critical as "to create or improve PBL curricula, it is important to understand what kind of instructional conditions result in effective problem-based learning" (Gijselaers, 1996, p. 13).

Evaluating Action

One of the key features of AR is the immediacy of the feedback it offers. As indicated previously, AR involves an iterative process which generates knowledge that is both instantly accessible to stakeholders, and generates 'local theories' for application (Brulin, 1998); this allowed the programme team to reflect on progress and make adjustments to the proposed learning environment based on the growing evidence-base. As highlighted in Table 1, the emergent design process has involved multiple interactions with stakeholders, with evidence gathered to support each design choice. In particular, the evaluation of the major features of the BSc design involved: (1) Fáilte Ireland and design team observations of the pilot study, (2) pilot study participants' feedback on immediate reactions to the pilot, (3) post-pilot discussions between the authors, and (4) post-pilot interviews with pilot participants to add depth and detail to the statistical findings. As an example of the evaluation process undertaken by the authors, the results from point two above are presented here. In order to capture immediate feedback from the participants on the pilot-study, a short, highly structured questionnaire was prepared by the programme design team; the feedback form's design was based on PBL feedback forms which had been previously utilised by the authors. The quantitative survey findings indicated that all the mean scores were at the high end of the scale (where 1 represents 'Strongly Disagree' and 5 represents 'Strongly Agree') (see Table 3), with the participants' enjoyment of the workshop scoring a mean of 4.50.

Pilot-study Participant Feedback Results	**Mean**
• My first impressions of the BSc degree programme were positive.	4.22
• From what I have heard today, I believe the content of the BSc programme will suit my needs.	4.11
• I found the subject content of the BSc programme was relevant to me and my business.	4.22
• I believe the online forum provided (Moodle) will make it easier for me to communicate with others in my group.	4.35
• I enjoyed the chance to discuss the problem posed amongst our team.	4.50
• I understand the role each team-member plays in problem-based learning.	4.39
• The role of the facilitator in problem-based learning was made clear.	4.39
• The problem presented to us as a trigger was of relevance to me.	4.33
• I believe I have a fair understanding of what problem-based learning is all about.	4.28
• I have a good idea of the steps involved in the process of problem-based learning.	4.11
• I am interested in finding out about enrolling on the BSc degree programme.	4.39
n = 18 (Scale: 1=Strongly Disagree and 5 = Strongly Agree)	

Table 3: Pilot-study participant feedback results

In addition, major findings from post-pilot discussions between the authors were: (1) the practitioners quickly grasped the PBL process, (2) the participants saw the PBL process and trigger as engaging and very relevant to them, (3) the time that they would need to devote to their studies was a major concern (both in terms of time per week, as well as the degree's three year duration), (4) the financing of their fees was also a key concern, (5) the participants distinguished the online forum as generally supportive of the face-to-face aspects of the PBL process, and (6) obtaining exemptions for prior learning was another major issue for the cohort. Finally, key findings regarding the programme design from the post-pilot interviews completed with the pilot participants are listed below:

- ***Semester timing*** – some participants indicated that semester scheduling would need to take into account that they take their holidays in September-October and, furthermore, that there is a national movement to extend the tourism season, stating: "*The problem is we take our break in September-October and there's probably quite a few others in* *the same boat*" and another stating: "*I'm organizing a festival in late September, so I won't be available until October, really*."

- ***Length of degree*** - six participants indicated that the necessary three year commitment was daunting.
- ***Group work*** – some concern was expressed in connection with working with others to complete assignments such as an unequal burden of work. Five participants indicated that they were accustomed to being self-sufficient and were concerned over having to rely on the skills and abilities of others. For example, one interviewee commented: "*What we had to do was a very small thing…but some of the others took forever to do it*" while another participant stated: "*you always get studiers, then others not so into it*." However, others welcomed the added support from peers in completing assignments, stating: "*Gained a group with similar problems and needs*" and "*People were willing to help each other*".
- ***Distance learning*** – the issue of geographic spread of the group and the need for face-to-face interactions between residential workshops was raised by two and four interviewees, respectively.
- ***Technology*** – several interviewees indicated concern in connection with using the forum function in Moodle, their IT skills, and their lack of broadband (however, only two indicated they didn't have broadband) while others indicated technology "*Will make it a whole lot easier*" and "*Moodle side – a dream*."
- ***Relevancy*** – the BSc needed to be relevant for their business and for them personally; some indicated that they saw PBL as providing relevancy: "*Rather than having a lecture, everybody is involved in the problem…and rather than telling us the answer – our experience is brought into it,*" "*PBL is brilliant!...a workman's way of solving problems,*" and "*One really is getting to grips with the material – you are learning as you go along, going through the research*."

In particular, the pilot study evaluation confirmed that PBL offers the optimum balance in terms of meeting the needs of the stakeholders regarding relevance, practice and theory and also delivers a high level of participant engagement. The AR approach has brought to light some vital information with regards to the development and implementation stages of the BSc, and proved the value of employing this method of evaluation which provides formative feedback for the stakeholders involved. As indicated previously, the evidence from the literature suggests that in a PBL context an evaluation needs to be "reflective, iterative and progressive, highlighting the special features of the curriculum" (Maudsley, 2001, p. 320); these characteristics are certainly supported by employing an AR approach, as demonstrated in this paper. Specifically, AR allowed for multiple perspectives to be engaged within the development of new knowledge and sense-making, adding to our understanding of what works and why (James and Denyer, 2009). Indeed, the pragmatic AR format has allowed the authors to combine quantitative and qualitative findings in the evaluation of the design choices and, furthermore, the close collaboration with stakeholders has ensured that the design team has responded to the cohort's needs (in particular, the programme themes, content and expected generic skills) through adapting the programme design accordingly. For instance, the programme design team have undertaken a review of the timing, fees, RPL and induction required as a result of this evaluative feedback (see Hussey *et al.*, 2010).

Conclusion

The design and development of continuing education for micro/small tourism enterprise owner/managers represents a particular challenge, however, by utilising an AR approach, which facilitated interaction with the major stakeholders, it is perceived that this challenge has been met. The AR based evaluation of the design brought to light issues of stakeholders' concerns, which required adaptations to the design of the programme as it developed.

The programme design team concluded that PBL (as well as the blended learning approach) offered the optimum balance in terms of meeting the needs of the stakeholders in terms of relevance, practice and theory; this was concluded based on the evidence arising from the analysis of the interactions – results were overwhelmingly positive. The interactions confirmed the appropriateness of specific subject themes as well as relevant generic skills, which ultimately informed the crafting of the programme's modules, specifically, in the design of PBL triggers which replicate the real-life problems faced by the owner/managers.

The authors' ongoing longitudinal study seeks to evaluate whether or not the new degree programme enhances the tourism sector's professionalism. Hence, this paper represents a key stage in the development of an evaluation mechanism into this educational initiative. Although the AR approach to evaluating a programme's design as described here has been crafted for one particular programme, targeted at a particular sector, it is perceived that it should provide guidelines to other educators who are responsible for the evaluation of the design of higher education for adult learners who are owner/managers of micro/small enterprises. For instance, the paper highlights the centrality of the learner and the criticality of the interaction and collaboration between major stakeholders in programme design and how AR facilitates this process and its evaluation.

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A STUDY OF STUDENTS' PERCEPTIONS OF THE PBL ENVIRONMENT AND LEARNING MOTIVATION IN THE EFFECTIVE COMMUNICATION CLASS AMONG UNDERGRADUATES OF FACULTY OF TECHNOLOGY MANAGEMENT, BUSINESS AND ENTREPRENEURSHIP, UNIVERSITI TUN HUSSEIN ONN MALAYSIA (UTHM)

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ABSTRACT

Problem based learning is claimed to be one of the best methods for interactive learning, and more effective than traditional methods. However, there is still a limited empirical evidence of the effectiveness of PBL across various courses and learning disciplines. The aim of this study was to identify students' perceptions of learning environment and motivation in Effective Communication classes using a PBL approach.

Twenty five students participated in this single case study. Students were given four treatments and answered questionnaires in gauging their perception and motivation on the PBL approach to learning. Results indicated that these students who attended PBL classes have a positive perception of learning environment after attending the course. However, there is no significant difference on students' motivation at the begining and at the end of the course.

INTRODUCTION

The shift of paradigm from teacher-centered to student-centered is essential to make students become active and acquire additional skills which are valuable and cannot be gained through book learning. Currently, in Malaysia, there is a movement to shift the paradigm to student-centered in line with changes in industry and global trends (Ministry of Higher Education, 2005). Industry claimed that many graduates are lacking in many skills needed by industry such as planning and organizing, problem solving, decision making, communication, leadership, creativity, critical thinking, conceptual and networking skills (The Star, 21 August, 2005). Thus, a change of instructional approach is needed to overcome this problem.

Hill (2007) mentioned that there are advantages in the use of a student-centered approach; one of them is that students play an active role in the class. A student-centered approach encourages communication among the students. Students interact with peers and the facilitator in class. With this environment, where students are being active in class, it is seen that a student-centered approach is one of the ways to address students' problem such as being passive and less functional in the workplace when they graduate (Ministry of Higher Education, 2005).

One of the most popular student-centered approaches is Problem Based Learning (PBL). Previous studies have proved that PBL has a positive effect on higher education students in various disciplines (Chapman, 2002, Kim & Kwon, 2003, Goodnough & Woei, 2008, Selcuk & Caliskan, 2010) such as engineering, law, and even in high schools (Selcuk & Caliskan, 2010). Students not only acquire content knowledge but also develop their problem solving skills, critical and creative thinking skills, cooperative and communication skills, as well as learning how to adapt to changes (Albanese & Mitchell, 1993).

Although there are various ways of implementing PBL, they share the same goals such as having flexible knowledge, self-directed learning, effective problem-solving skills, and intrinsic motivation (Hmelo-Silver, 2004). Other than that, PBL offers students the opportunity to develop their life-long learning skills and flexible understanding. PBL requires the learners to be active and work in groups and changes the role of teachers (Hmelo-Silver, 2004).

Although PBL has generally been accepted as a valuable instructional option, there are several issues regarding the effectiveness of PBL. Among the issues are what do students learn and how they do it (Hmelo-Silver, 2004), students' perception towards PBL (Selcuk and Caliskan (2010), the issue of motivation - whether the students are motivated or not in PBL classes (Hmelo-Silver, 2004), the type of self-directed learners that students become (Hmelo-Silver, 2004; Berkson, 1993 in Gijbels et.al., 2005), the issue of collaboration among the students (Gijbels et.al., 2005; Hmelo-Silver), how do students construct an extensive and flexible knowledge based and have increased content knowlege (Gijbels et.al. 2005; Colliver, (2000) in Norman & Schmidt (2000), Hmelo-Silver, (2004), the cost, time and commitment of implementing PBL (Albanese & Mitchell, 1993), and the issue of whether the students are become better problem-solvers after attending PBL classes (Berkson, 1993 in Gijbels et.al. 2005; Hmelo-Silver, 2004).

Few studies have been conducted in Malaysia regarding the students' perception of PBL (Nur Izzati, 2010; and Neo & Neo, 2005). Both studies agree that various design variables of PBL are able to enhance students' learning as students enjoy the learning process, creating positive perceptions towards group work and the learning experience, and enhancing students' involvement in learning. However, Nur Izzati (2010) conducted the study among secondary school students, while Neo & Neo (2005) did the study among private university students.

Therefore, this study focuses on two significant issues: the perception of the learning environment and motivation of first degree students. Do first degree students have positive perceptions of this learning approach? The literature shows that many students prefer to have PBL as their learning approach rather than traditional methods (Albanese & Mitchell, 1993; Selcuk & Caliskan, 2010). Furthermore, PBL is designed to enhance students' motivation (Hmelo- Silver, 2004), thus, it is believed that there will be significant difference in the motivation of students after attending PBL classes.

The implementation of PBL in UTHM, Malaysia

In Universiti Tun Hussein Onn Malaysia (UTHM), PBL was introduced in 2005. At the beginning of its implementation, complaints were received from both the students and the lecturers. The lecturers complained that they have to prepare large amounts of work and spend much time in crafting the problems. For the students part, they have to put in extra time to get materials and prepare for presentations. Furthermore, they need to spend time meeting with group members as the tasks given should be completed or solved by groups.

In addition, management needs to allocate some funding to conduct training for lecturers, prepare the facilities to suit a PBL environment (such as new rooms in the new buildings which are designed to fulfill the needs of PBL), a new library with small rooms for PBL group discussions, campus television (the University Campus Interactive Television (UCiTV)), and Blackboard, the Learning Management System (Berhannudin, 2011).

The implementation of PBL is process oriented. Groups which consist of four to five members are formed and a leader is selected to manage the group. The leader's role may be passed amongst the group members based on the tasks given. Once the leader receives the problem/ task from the lecturer, he/she needs to conduct discussion to understand the problem, prepare FILA table and delegate the tasks. Discussions are conducted outside the classroom, since there is not enough time available in class. The students need to discuss problems which occur while completing the tasks. They also need to find ways to solve the problems, read materials on the tasks assigned, prepare presentations and produce the portfolio to be submitted at the end of the semester (Berhannudin, 2011) .

The course in Effective Communication is delivered in English. The syllabus covers three major topics: meetings, tools of advertisement and interviews. Each topic has several sub-topics. For example, for "meetings" the students need to know how to prepare memos, take minutes of meetings, conduct the meetings, and understand the roles of chairperson and members of meeting. Students were given a scenario of a meeting as a problem, and they needed to discuss in theri group, starting by identifying the problem and completing the FILA table. There were three formal meetings in class. The agenda of the meetings depended on the main objective of the course, that is, towards the end of the semester, students need to sell their products in order to gain profit. The best group with the highest profit wins the competition. All the activities conducted were inter-related; these were starting from the establishment of the company, products of the business, interviews to obtain information on running a business from those who involved in business, advertising the products and finally, selling the product. In addition, students need to prepare the presentations, reflective writings and a portfolio of the business, which had to be submitted during the last class of the semester.

Perceptions of the Learning Environment

Albanese and Mitchell (1993) claimed that students found PBL more nurturing and enjoyable, compared to conventional instruction. Furthermore, students in PBL settings performed as well and sometimes better on clinical examinations and faculty evaluations than those in conventional settings.

Ali, et al. (2005) conducted a study on the implementation of PBL in a local setting and point out several challenges to its implementation. The most challenging is the readiness of both lecturers and students to adapt these new formats of PBL in the process of teaching and learning. It is quite hard to convince them to shift the paradigm and this is common in the early stage of the implementation. Ahlfedlt & Overland (2002) share similar experience when they found that not all students and lecturers are in favour with the shift from teacher to student-centered.

Selcuk & Caliskan (2010) conducted a study of 25 first year students, where the students were divided into experimental and control groups. They were comparing the effects of problem based learning and traditional methods on students' and teachers' satisfaction with an introductory physics course. Results revealed that PBL students showed a more positive attitude towards the course in terms of quality of instruction and teaching methods/ activities. However, the traditional instruction group did not demonstrate any substantial progress in any of the satisfaction dimensions.

Motivation in Problem Based Learning

Motivation is associated with learning and performance. Motivation can influence what, when, and how we learn (Schunk et.al. 2008). Students are motivated to learn about a topic and to engage themselves with learning activities where they believe that, by involving themselves with these activities, these may help them with the learning process. Students focus on the instruction given, the preparation of materials, discussion with peers and lecturers and taking notes during lectures (Schunk et.al. 2008).

Song & Grabowski (2006) stated that intrinsic motivation is one important factor related to ill-structured problem solving success, where students are willing to engage in with goal-oriented and students work in groups in handling tasks given by the facilitator. It is believed that the design of the tasks and study activities can increase intrinsic motivation (Wijnia et.al. 2010).

One of the main goals of implementing problem-based learning is to enhance the intrinsic motivation of the students (Hmelo-Silver, 2004; Wijnia et.al. 2010). This is supported by a number of studies, for instance those conducted by Hmelo-Silver (2004), Norman & Schmidt (1992 in Wijnia et.al. 2010) and Berkson (1993 in Gijbels et.al.2005). Hmelo (2004) mentions that there are other studies which investigate directly intrinsic motivation. The findings from these studies show that PBL can influence intrinsic motivation.

Several quasi-experimental studies were conducted in comparing PBL and non-PBL approaches to learning. One example, a study by Sungur & Tekkaya (2006), found that the PBL group scored significantly higher on intrinsic goal orientation and task value compared to the control group.

Based on the literature on students' perception towards PBL and motivation to learn, it can be hypothesized that there is a significant change on perceptions of students of the learning environment with the application of PBL approach in their learning process. There is also a significant difference on students' motivation to learn in PBL and non PBL classes.

Methodology

This is a single case study using questionnaires to provide rich descriptions for measuring students' perception of the learning environment and their motivation towards the implementation of PBL. The participants of this study were twenty-five first year second semester students of the management program at Universiti Tun Hussein Onn Malaysia. After the briefing on PBL, the participants of the PBL group were given the questionnaire to obtain their view of the learning environment and motivation about the course. This was to get their views and motivation before experiencing the PBL approach.

The questionnaire was adapted from established questionnaires: Motivated Strategies for Learning Questionnaire by Pintrich, & DeGroot (1990) and PBL Learning Environment by Senocak (2009). The researchers adapted these questionnaires since the validity and reliability of these questionnaires had already been established. Four questions from the Motivated Strategies for Learning Questionnaire, specifically on the intrinsic motivation, were used. The researcher selected questions which were suitable for the objectives of the research. The Motivated Strategies for Learning Questionnaire (MSLQ) has been used widely in research to measure motivation in learning. As for the learning environment, although there are many inventories of the learning environment, such as the inventory by Fraser and Walberg (1991 in Senocak, 2009), there has been limited focus on PBL. Therefore, the Senocak inventory of the learning environment was chosen as this inventory claims to be one of the first inventories of the PBL learning environment (Senocak, 2009). The perception towards the PBL learning environment is measured on three aspects: teacher support, commitment towards learning, and perception of collaborative work.

The data were analysed using Wilcoxon tests. This test was selected to compare the two related samples in assessing whether there is any significant difference in perception of the learning environment and motivation to learn at the beginning and at the end of the course. Furthermore, the number of respondents is 25, thus it can be concluded that this test is the most appropriate test to be used.

Results

The first objective of this study is to determine the students' perception of the learning environment and the application of a PBL approach in their learning process. Elaboration on this subject is illustrated based on the analysis of the questions on the learning environment among students after attending the PBL class.

	z	p
Learning pre- Learning post	-3.517	0.001

Table 1: Wilcoxon Test of Students' Perception on Learning Environment – before and after Treatments (n=25)

Table 1 further shows the students' perception of the learning environment based on the questionnaire given to students at the beginning and at the end of semester. Results reveal that students showed a positive perception of the PBL learning environment since there was a significant difference between early in the semester and after attending PBL treatments (z= 3.517, p=0.001).

	z	p
Motivation pre-Motivation post	-0.652	0.515

Table 2: Wilcoxon Test of Students' Motivation – before and after Treatments (n=25)

The Wilcoxon test was used to measure the difference in students' motivation at the beginning and at the end of the semester. Based on the results, unfortunately, there was no difference in students' motivation as the z and p values were 0.652 and 0.515 respectively. Therefore, it can be concluded that PBL approach did not help students to boost their intrinsic motivation in class.

Discussion

PBL did give positive perceptions on its implementation. This is supported by responses given to the questionnaire. Other than that, the researcher conducted informal interviews to get the students' opinion of the implementation of PBL for "Effective Communication". Students also submitted reflective writing, telling the facilitator what they gained from two treatments of PBL.

Findings from this study showed positive perspectives of the implementation of PBL as students' learning approach. These findings are consistent with research done by Albanese and Mitchell (1993), where they proved that students found PBL to be an approach which is more nurturing and enjoyable, compared to conventional instruction. Selcuk and Caliskan (2010) found that students showed a more positive attitude towards the course in two dimensions: quality of instruction and teaching methods/ activities.

Students experienced PBL for the first time, and it was a good sign that students seemed to accept PBL as one way of learning. Students still experience the non-PBL approach in other subjects, and if they can get more benefit using PBL in class, this method can be applied to other subjects later. Other than getting students' perception towards the implementation of PBL, other aspects should be taken into consideration, such as motivation of students while going through the process of learning.

This study found that students had a positive perception towards the implementation of PBL. However, in terms of students' motivation to learn, findings showed that the motivation did not change after students attended the PBL class. From the trend of the tasks score, it is believed that the students felt overwhelmed with the tasks (treatments). The score on the task was slightly decreased on task 4. Furthermore, the questionnaire, which was given at the end of the course, was distributed after the completion of task 4. In addition, based on the informal interviews, the students responded that they faced difficulties in completing the task as attention was also needed in other subjects. Thus, it can be said that the task made the student less motivated at the end of the course.

Other than that, the students experienced PBL for only one semester; therefore, they might not be expert enough with the system. One semester is not enough for them to become accustomed to the new approach of learning (Hmelo-Silver, 2004). Zimmerman & Campillo (2003 in Loyens, Rikers and Schmidt, 2006) stated that although discovery learning such as PBL can lead to effective solutions, students may face failure in the process of solving the problem and this may affect their motivation.

It is seen that the implementation of PBL in one semester could be treated as a limitation in studying motivation as Effective Communication subject is only a part of degree course. In addition, the Effective Communication subject is regarded as a "service" subject or "university compulsory subjects", where students might not engage fully since this subject is not the main subject of their course. Students might be motivated to complete the course, whereas "Effective Communication" is only a part of course completion. Therefore, it could be said that motivation for one subject was not so obvious, since motivation needs to last for some time for degree completion purposes.

In summary, students showed positive perceptions of the PBL learning environment. Thus, it can be concluded that students preferred to have PBL as their learning approach. However, in taking the aspect of motivation to learn, students did not show improvement in their motivation, or it could be said that PBL did not help the students to boost their intrinsic motivation.

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STUDENT PERCEPTIONS AND EXPERIENCES OF PROBLEM-BASED LEARNING IN FIRST YEAR UNDERGRADUATE SPORTS THERAPY

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ABSTRACT

Problem based learning (PBL) has long been used as a means to foster critical thinking and student autonomy. However, few studies have investigated the effectiveness of PBL in Sports Therapy. The aim of this study was to examine first year Sports Therapy students' perceptions of PBL. Forty-five first year Sports Therapy students were randomly assigned into groups of five and case scenarios were presented where there was no specific right answer. The groups arranged their own meetings working towards a presentation demonstrating their solution to the scenario. Group tutorials were held during the module, one set of which was observed by a researcher who subsequently distributed questionnaires to each student. During the module, six students participated in a focus group interview which was analysed using thematic analysis. Results revealed that students perceived PBL as vocationally relevant, by enabling them to work in and across groups, whilst also engaging with a wider range and depth of information compared to more traditional methods of

curriculum delivery. A further account of how these results impact on the future of student learning in ST will be discussed.

INTRODUCTION

The UK National Student Survey revealed an area in Sports Therapy education which could be improved. This related to coursework not being stimulating, beside some general student comments that there was not enough specific Sports Therapy content in the course. The Sports Therapy programme is not up for review until next year so an alternative mode to assist student engagement in the course was considered. PBL is an approach to learning, rather than a teaching method, which is being increasingly promoted and utilised in higher education. Students are enabled to understand their own situations and frameworks enabling them to perceive how they learn, and how they see themselves as future professionals (Savin-Badin 2006). Problem-based learning is 'designed to help students develop competencies that will serve them throughout their professional lives' (Krishnan *et al* 2009:117) and have 'an apprenticeship for real-life problem-solving' (Dunlap 2005:1). Sports Therapy is an aspect of healthcare concerned with prevention and rehabilitation of clients to an optimal, functional and occupational fitness level. Sports Therapists are autonomous practitioners. But they can work in multi-disciplinary teams, where sharing ideas is an essential part of professional practice. Therefore, as PBL has been successfully employed in medical therapy education and is currently successfully utilised in Coventry University Sports Science department (where Sports Therapy is taught), but not specifically in the Sports Therapy course, it was considered to use PBL in one of the Sports Therapy modules.

By integrating PBL into the first year of a Sports Therapy course professional practice skills such as communication, team working, leadership and problem-solving could potentially be developed. We argue that these skills were not easily learnt in the traditional methods of teaching, for example through a curriculum that relies heavily on lecture-based delivery with a narrow set of defined competencies. Students might benefit considerably more with a PBL approach which supports independent enquiry and promotes real meaning and understanding into the case scenarios. In the context of Sports Therapy, there has been limited investigation on student perceptions and evaluation of PBL (O'Donoghue *et al* 2011). Therefore, the aim of this paper is to evaluate the PBL module in a first year Sports Therapy undergraduate degree course and to report and evaluate students' perceptions and experience of this module.

The development and use of problem-bases learning

The impact of PBL on students' learning experience was examined in the context of a single module approach (Savin-Baden, 2003) in a first year module titled 'Health and Fitness for Sport and Exercise" within the institution's BSc Sports Therapy Course. The module was designed using the McMaster model (Savin-Baden, 2003) where the students engage with one problem at a time and meet two or three times with the tutor over the course of each topic (Savin-Baden, 2003). Congruent with guidelines suggested by Savin-Baden (2003), the module was implemented to enhance understanding of the principles of the clinical practice of Sports Therapy. Tutorials were designed to support the groups at appropriate times. Practical skill sessions, subject-based knowledge, related to the problems presented had previously been taught in another module in the style of most traditional undergraduate modes of delivery. A wide variety of problems have been previously used within PBL delivery, although these have not tended to be based within the sports domain, and limited attention has been given to design of problems (Savin-Baden and Howell Major, 2004). This potentially made the development of problem scenarios for this module problematic. However, Schmidt and Moust (2002) outlined taxonomy of problems used within PBL which involve four types of knowledge: explanatory knowledge, descriptive knowledge, procedural knowledge and personal knowledge. The problem scenarios encouraged students to acquire these different categories of knowledge in order to answer the problems, which were centred around themes relevant to Sports Therapy: knowledge of the co-morbid condition, approaches to treatment of a presenting client, understanding the rationale behind the written requests from general practitioners for exercise therapy and direct client requests for massage/treatment. They were all based on real patients and clinical scenarios as experienced by Sports Therapy colleagues (Wood 2003).

In the first session, the students were introduced to the theory of learning styles and problem based learning, including the concept of collaborative learning groups. Concurrently, they were given the VARK questionnaires to evaluate their learning preference and an information sheet on PBL. Following this introduction, 45 students were randomly assigned into 9 groups of 5 (Krishnan *et al* 2009). The groups were given a different case study each, written in the format expected of a Sports Therapist. The remainder of this first session enabled the formulation of their group and planning their investigation into the problem. During this period, the tutor was available as a resource in accordance with suggestions made by Savin-Baden and Howell Major (2004). This initial period typically involved developing a number of skills including literature searching, computer/internet use, discussion among group members, and formulation of investigative strategies. Seminars and tutorial sessions followed depending on the lecturers' perceived requirement of the students, with the aim of encouraging students' development of a critical independent stance. In the final session each student group presented their solutions to the problem scenarios to the other groups, supported with an overview of relevant theory associated with the topic provided by the tutor.

The examination component of the module was designed with reference to examination procedures previously used successfully within PBL (see Macdonald and Savin-Baden (2003) for a review). However, this module was constrained by the module exam guide so as a result the assessment tasks developed for this module were unable to fully integrate these guidelines. A marked written exam was utilised to comply with module guidelines, plus an unmarked group presentation by each group who were subsequently provided with feedback. The written exam questions involved the series of problem-based scenarios that were anchored to the main themes of the module. It required students to reapply concepts, arguments and theory that had been previously used to solve the problems given to the groups. The answers required small word count reports as these promote succinct, critical pieces of work (Macdonald and Savin-Baden, 2003). Therefore, the assessment was based in a practice context i.e. what they would do to solve the problem, and assessed the process-based activity i.e. how they used particular protocols, treatments and the procedures they employed. However it did not consider the actual 'hands-on' working with clients or peers as this was assessed in another module. The exam did not simply assess the students' ability to provide knowledge, but rather assessed the students' understanding and application of practical skills previously learnt and their ability to evaluate their solution. It sought to examine the students' integration of their knowledge into practice by the application to authentic situations. Therefore, they needed to demonstrate competence in clinical reasoning behind their solution to each problem scenario question.

Methodology

Problem-based learning is an innovative approach to learning, and non-customary for the Sports Therapy course at Coventry University. So a pragmatic approach of action research was undertaken into students perception and experiences of PBL, in order to understand and improve educational practice for STs. Action research was chosen because PBL utilises this mode of approach, acknowledging that people learn in different ways which allows for students to make choices about the direction for their learning (McConnell 2002). This research is therefore a 'work in progress' (Brydon-Miller *et al* 2003:4) as knowledge of the students' attitude to PBL is developed through action and reflection. The tools used for this evaluation were: a focus group, observation and questionnaire.

Methods

The data collection involved observations of the 9 group tutorials. The evaluator was an independent researcher who notated the tutorials, appearing on the edge of the event, listening but not involved.

The questionnaires required 3 short answers to open questions asking the students what they felt they would be able to achieve after the PBL, what more did they require, and what they would like to do or change. These were handed out to each student at the end of their tutorials. On completion were returned on a pile at the end of the room.

The focus group was held midway through the module using 6 volunteers from different groups. The group comprised of 3 males and 3 females, age range 18-21 with no previous experience of PBL. The focus group interview was held at a mutually convenient, time being led by an independent lecturer on the Sports Science course. A focus group interview was chosen as it provides a more naturalistic data collection method compared to interviews (Wilkinson, 2004). Focus groups also allow respondents to build upon the responses of other group members and the relatively free flow of talk which can provide an excellent opportunity for hearing the language and experiences of the respondents (Wilkinson, 2004). The focus group was recorded on tape and the transcript was subsequently typed.

Findings

The results from the focus group interview were evaluated using thematic content analysis (Wilkinson, 2004). This revealed a number of themes within the student experience of PBL. These included the delivery of the module sessions, module content, skill development and module timing. It was quite clear that the students who had taken this module had not experienced the type of delivery involved with PBL previously but although many found this a challenge to begin with, the delivery of the module was perceived to be more enjoyable and effective.

Module Delivery

Students felt PBL was not delivered like other modules but related more to what they were ultimately wishing to become professionally and that they were encouraged more to engage in the learning process. For example, female students 3 and 2 reported:

> *"instead of just being told things, we were busy finding out different things, so we learnt a lot more I think, than say if we had just had lectures"*

> *"....... I put more effort into this than I did for other modules, it made me feel more involved … This was different, you really had to do it, not just know it"*

Module Content

Problem based scenarios: students reported they felt the scenarios were realistic and allowed them more autonomy to explore problems in the way they wanted to. It was clear from a number of student comments that simply presenting a problem and asking them to work through it can provide a stimulus for greater independent thought. For example, male student 2 noted:

> *"....everyone finds different ways of doing it, you know if someone comes and listens to a lecture they will just listen, but with the scenarios if someone comes in with a condition or co-morbidity people will do different things. So what I would do someone else would do something different so it makes everyone come at it from their own start point."*

Male student 1 agreed with this stating:

"I think it's good 'cos it causes you to set things out how we will in real life, you get a scenario that you don't know, like a new patient, you don't know all their contraindications so you have to look them up and then figure out what you would do about that person"

Likewise female student 1 added:

"yeah this gives us the skills we will need when we are out in clinic working with real people"

Similarly, male student 1 appeared to be relating his experiences to his future employability stating that:

"it's[employment] going to be more like this than what we have got in the other modules"

The experience of group work was discussed as facilitating communication skills and building confidence, although dependent on the contributions of the individual. Some students perceived this to be unfair.

Male student 1 and subsequently male student 2:

".....so pretty much it's resulted in all of us working together

"yeah so I know everyone enough to say hello and like know who they are but that wouldn't have happened if we hadn't have had to work with everyone on the different scenarios"

However, male student 1 said that:

"one bad part is though if you are in a group and you are quite happy to sit there and do nothing you won't get anything out of it for yourself but you can still pass"

With another problem highlighted from male student 3:

"it's very dependent on the group though, like last week one girl turned up from her group and the other people didn't turn up so she was the only one there and obviously you can't do group work without a group"

Presenting work, even though it can be difficult and challenging, was accepted as being important.

Female student 1:

"it's good too because as part of it we have to talk to each other and also present so if you don't like speaking you just have to learn to like it because you have to do it so it makes you more confident than lectures"

Male student 1:

" It's a good way to build self-confidence in yourself" and continued : ".....so pretty much it's resulted in all of us working together"

Organisation of the group work appeared to follow the process outlined in Williams (2004).

Female student 1 stated:

" well first we look at the information and then allocate jobs so someone would find out what the problem is and what the issues around it are"

Male student 1 added:

"and you know we would split it up and look at different bits, you wouldn't get it all done in time if we did the same thing so you have to coordinate and work with each other then you go away do your bit then come back to feed into the group and look at what they've done so you then build on each other's work"

However, there were some perceived difficulties. Although students were starting to make links with the learning outcomes of other modules enabling an understanding of how the degree could develop them into Sports therapist's, they acknowledged that they would not like every module taught as PBL as female student 2 stated:

"*I wouldn't want to do it every week though, or in every module"*

Overall, the student experience of this PBL module was positive although female student 2

> *"...wanted a final answer"*

This was in agreement with the commonly held belief expressed by female student 1:

> *"so you know what's right though".*

However this was quickly challenged by male student 2:

> *"but you know there probably isn't one so it's hard to know what to do".*

Male student 2 continued to perhaps express what a commonly held belief that in reality the students still want to know

> *" how to make sure you get a good mark".*

Acknowledgement followed from female student 1 that:

> *"you need the feedback from the teacher though"*

This perhaps validated the input from the lecturer!

Questionnaires from the observed session of the tutorial groups were designed for short answers to give insight into where the students were in their thinking about their experience. They were given to all students by the observer as an easy method to obtain student feedback for the session. Students were informed they were to help the observer understand what the students' perceptions of PBL are for this module. 40 questionnaires were returned to the observer, but group 9 did not return any questionnaires.

Question 1 asked the students what they felt they would be able to achieve after the session. The answers were all positive comments relating to the presentation the students were about to deliver on the problem scenario given to their group. Students reported they would be able to deliver an 'effective presentation', 'with confidence' and know what they were doing. Other students reported positive things they would know or understand better, for example to be able to research more effectively and understand what appropriate exercises to recommend. Two students commented on their being able to work in a group more effectively.

Question 2 related to what the students felt they needed more about. The majority of responses related to time: more time to research, to meet in with the group or time to prepare the presentation. One wanted 'more sessions like today'. Several reported the desire to improve their confidence. Several students wanted more specific knowledge and information to answer and solve the problem.

Question 3 asked the students what they would do if they could. Most comments had similar themes to the question 1 and 2, with requests for more time in the groups. Question 3 responses contained the only negative slants towards the experience of PBL. A few students did not want to do the presentation because they did not like 'talking in front of people' or they felt 'uncomfortable' working with a group they did not know.

In a feedback session with the tutor the observer commented that not all students were necessarily very familiar with group work and that learning to carry out group or team work was a learning outcome in itself. However she observed that every student got the opportunity to say something during the tutorial and that listening to each student appeared to be important to the tutor as she observed her body language demonstrating attentiveness and interest to students and their work. The observer also observed that after their tutorial the students did not leave, but voluntarily stayed with their groups to continue their discussions.

Discussion

Based on student responses from feedback of the focus group and questionnaires it would appear that the student expectations and responses were generally positive. The focus group of 6 volunteers may not be a true representative of the group; however it did enable students to develop their thinking by building on each other's responses. The questionnaires were anonymous, enabled everyone to respond and provided further understanding of student perceptions and experience of PBL. The negative comments possibly reflected students' lack of confidence in their ability or their personal stance towards group work or possibly indicating their preference to be a passive recipient in learning.

Assessment drives most students learning and influences our learning, our identity and assists us in construction of our society. To develop life-long learners Boud (2000) argues that we must integrate "sustainable assessment" into our lives focusing on learning rather than performance. This may be reflected in the exam results which demonstrated a bimodal curve with the majority of students appearing to engage in the process and have a deep understanding resulting in very good/excellent marks and the minority who possible did not connect with the process so easily, and failed. Those who failed were also the poor attendees for the group work, which contrasts with the belief of the student in the focus group that believed those who did not attend or engage in the group work could still pass.

Reflecting on the action research experience it would be helpful to identify those students who are less likely to engage in this form of leaning and therefore may initially require extra support. Some students commented on the difficulty of engaging in group activities, the time allotted for the process, and the desire to want to know 'what to do'. In PBL the responsibility for learning is on the student which might not be their preferred learning style, although it could be argued that the profession of Sports Therapy demands the qualities developed by PBL to be an effective practitioner. Only one module utilised PBL and although appeared to be valued by the majority as a positive experience, was not desired by students to be integrated across all modules. Students reported to the tutor that whilst PBL was enjoyable 'more effort' was required. On further discussion they were possibly being challenged into deeper engagement in their cognitive process being active learners.

Other problems were the complexity of the problems, as the students were asking for more information, knowledge and time. However, this could be lack of experience in group work or student confidence in their ability to explore the problem. The number in each group was chosen so that the group would not be too large for everyone to feel comfortable participating yet not too small to make it viable. Problems did occur with attendance which made some groups difficult to sustain. Personal communication with a student faced with this problem revealed a frustration and envy at those groups she perceived to be working. Perhaps more time to develop the group into a team before engaging in problem scenarios could be effective. Different modes of feedback could be considered, not just the presentations or exams, to more effectively illustrate how each student is relating and learning in the group.

Based on this study, the advantages of PBL for these first year sports therapists could be summarised by the following: fostering interactive learning, improved understanding and development of lifelong learning skills, allowing students to develop generic skills and attitudes relevant to their future practice. The style of PBL learning appears to have placed some students in a state of disjunction, as they were challenged to shift from a passive recipient role, with the didactic customary lectures into more active participatory learners. However, the negatives could be summarised: students may be unsure how much self directed study to do and what information to collect or use and that students may feel the process is unfair because of the grouping they are assigned to and the individuality of the students contributions.

Concluding thoughts

The spirit of PBL was well summed up by Savin-Baden (2000) who reported that: it is an approach to learning that is characterised by flexibility and diversity in the sense that it can be implemented in a variety of ways in and across different subjects and disciplines in diverse contexts. As such it can therefore look very different to different people at different times depending on the staff and students involved in the programmes utilising it. However, what will be similar will be the locus of learning around problem scenarios rather than discrete subjects.

In this specific instance, the use of a PBL approach appears to offer advantages in terms of student enjoyment, engagement and development of criticality compared to traditional lecture-led delivery in Sports Therapy. However, care is needed in terms of initial delivery, particularly with groups who have no experience of PBL and who are new to university education. Future work examining the lived experience of PBL within Sports Therapy and its integration into the whole year and course is needed to really identify key elements that could be used to structure future curricula including an appropriate assessment.

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APPROACHES AND CONCEPTIONS OF LEARNING IN PHYSIOTHERAPY
THE 3rd INTERNATIONAL RESEARCH SYMPOSIUM ON PBL 2011

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ABSTRACT

Aim: This study investigated the approaches and conceptions toward learning of undergraduate Physiotherapy students in a PBL module in order to inform curriculum development and enhance facilitation of learning at the Stellenbosch University Division of Physiotherapy in South Africa.

Methods: The mixed-method, descriptive study, utilised the R-SPQ-2F to determine the deep and surface approach toward learning of participants. Students also participated in focus group discussions to evaluate their conceptions of learning in the module.

Results: There was no significant shift from surface to deep approaches toward learning in the study population. Students conception of the module is that it has an effect on their approach toward learning as well as their personal and professional skills.

Conclusion: The Applied Physiotherapy module had no significant effect on students' approach toward learning. Further research is needed to determine the long-term changes in approach toward learning and the possible determinants of these changes.

INTRODUCTION

Problem Based Learning (PBL) lends itself to a self-directed, deep approach toward learning. This instructional approach requires a higher cognitive level of engagement by students such as is not required with lecture-based modules (Loyens, Magda and Rikers, 2008). Thus, knowledge of their conceptions of learning and the approaches they adopt could be of benefit to an educational institution as a means to inform curriculum innovation or evaluate a new curricular approach.

The use of PBL is a viable instructional approach in the training of physiotherapists. Research regarding approaches and conception of learning in PBL is however not as prevalent in physiotherapy as in medicine and nursing (MacKinnon, 1999; Prince and Felder, 2006; Kirschner, Sweller and Clark, 2006; Ellis, Goodyear, Brilliant and Prosser, 2007; Loyens *et.al,* 2008; Lewis, Menezes, McDermott, Hibbert, Brennan, Ross and Jones, 2009; Saalu, Abraham and Aina, 2010). In these medical fields students often change their approach toward learning depending on the environment in which they find themselves (Groves, 2005; Greasley and Ashworth, 2007; Kember, Biggs and Leung, 2004; Dolmans, Wolfhagen and Ginn, 2010). We conducted research into the influence of a PBL module on undergraduate physiotherapy students. Our research question was therefore, does a PBL module have an effect on undergraduate physiotherapy students approaches toward and conceptions of learning?

Context of the Study

The first and second year of the B.Sc. Physiotherapy degree at Stellenbosch University (SU) (South Africa) are comprised of a predominantly, though not exclusive, lecture-based pedagogy. One of the modules, namely, Physiotherapy Science (PTS), aims to equip students with the theoretical knowledge as well as technical skills which they are to use in their third and fourth year in the Clinical Physiotherapy module (CPT) and the Applied Physiotherapy (APT) module. In the CPT module, students are required to provide physiotherapeutic care to patients. The APT module was developed utilising a PBL approach in order to bridge the gap which is left between the basic module, that is PTS and the CPT module where these theories and techniques need to be applied. Students are thus exposed to entirely new forms of learning opportunities through this module. This could lead to frustration and dissatisfaction as they are required to make the transition from a traditional module based approach, where lecturing is the core mode of instruction, to a new approach half-way through their course (Choi, Lee and Kang, 2009). This blended curriculum is illustrated in the following table, identifying how the various modules overlap and in turn lead into each other.

	Phase 1 Scientific Basis		**Phase 2 Intermediary**		**Phase 3 Application**		**Phase 4 Professional Entry**	
Interdisciplinary Phase								
Psychology								
Anatomy								
Physiology								
Pathology								
Physiotherapy Science (PTS)								
Clinical Physiotherapy (CPT)								
Research Methodology (RM)								
Applied Physiotherapy (APT)								
Physiotherapy Practice (PTP)								

Table 1: Schematic representation of the 4 Phases of the Physiotherapy Curriculum at Stellenbosch University

In keeping with the SU teaching and learning policy which requires a student centered approach to teaching (SU Policy on Teaching and Learning, 2007), the Division of Physiotherapy adopts a hybrid-PBL approach. The hybrid approach used at SU refers to the fact that unlike pure PBL curricula, students in the APT are given guidance through practical classes and the provision of background learning resources by the academic staff (Savery and Duffy, 2001; Moust, Bouhuijs and Schmidt, 2007). This is preceded by a tutorial session in which students are presented with various cases/problems relative to clinical situations and building on subject matter learnt in their previous years. Students are required to submit and present their summarized information on the learning outcomes relevant to the case, as their learning material during a feedback session. Students also formulate multiple choice questions based on everything they have learnt.

The students enrolled in the APT module should benefit in their academic and clinical domains from adopting a deep approach toward learning. This study aimed to identify if this was the case, as it had not yet been determined in this environment.

Literature

Theories such as constructivism, in which students learn through creating meaning from things and/or situations which they have been exposed to previously, and social learning, which learners gather information for learning based on soical experiences, provide a stable basis for these types of learning environments (Schunk 2004; Torre, Daley, Sebastian and Elnicki, 2006). One of the main characteristics of PBL is that it emphasizes self-directed learning which "demands discipline on the part of the students" (Moust *et.al,* 2007). These environments allow students to construct an extensive and flexible knowledge base and, by becoming effective collaborative leaders, they are able to develop the afore-mentioned self-directed learning skills (Loyens, *et.al*, 2006). This quality of PBL can therefore be seen as a product of the APT module and yet, is not without its own advantages and disadvantages.

As an approach, PBL is said to have a positive effect on students (clinical) skills, learning styles, retention of knowledge, enhanced integration and application of basic science concepts into clinical contexts, to name a few (Vernon and Blake, 1993; Duke, *et.al*, 1998; Krueger, Neutens, Bienstock, Cox, Erickson, Goepfert, Hammoud, Hartmann, Puscheck and Metheny, 2004; Groves, 2005; Moust, Berkel, Schmidt, 2005; Loyens, *et.al*, 2006; Norman, 2008; Statham, Inglis-Jassiem and Hanekom, 2008). Conversely, disadvantages of PBL include the fact that students may be unaccustomed to the high levels of responsibility, the effect on transfer between problem situations in a course and similar ones in real life, the assessment methods and the lack of expert facilitators (Hoffman and Ritchie, 1997; Colliver, 2000; Gijbels, Dochy, Van den Bossche and Segers, 2005; Prince *et.al*, 2006).

Approaches and Conceptions toward learning

Students in any environment can and should have conceptions of their own learning. This differs from perception in that the perception of learning in the APT module refers to the students' awareness of various aspects of the module. Conception however, is the analysis by students of the subject matter, and their ability to challenge basic assumptions of how learning occurs in the module and question these ideas (Pawan, Paulus, Yalcin and Chang; 2003). Once they are able to have a conception of their environment, measures can be taken to ensure that they understand how this relates to their approach toward learning in that situation.

A deep approach toward learning is characterized by studying for meaning and aiming at understanding (Greasley *et.al*, 2007). Students adopting this approach toward learning are said to engage with subject matter in a way which promotes understanding (Ellis, *et.al*, 2008). This is contrasted by a surface approach toward learning in which students study by means of reading to remember disjointed facts (Greasley *et.al*, 2007). The students adopting this approach rely on external regulation and concentrate on the surface features of the work they are required to engage with within their learning environment (Papinczak, 2009).

Research regarding this subject matter ranges from attempting to establish a relationship between learning approaches and academic achievement (Groves, 2005), to trying to determine the conception of learning and learning approaches in relation to on-line activities (Ellis *et.al*, 2008). Duke *et.al* (1998) investigated the relationship between approaches to and conceptions of PBL and found that further research is needed into the relationship between conceptions of learning in PBL and approaches toward learning.

The premise on which previous research was based, on varying levels, was that the concept of studying approaches toward learning can guide the assessment and teaching styles in a direction to encourage students to adopt more effective approaches (Greasley *et.al*, 2007). The possible impact which research into learning approaches can have is necessary for curriculum development in a fairly new module such as APT.

Methods

Though primarily a descriptive qualitative study, the research lent itself to a phenomenographical and statistical approach in its analysis of the data. In this study, we attempted to describe the approach toward learning as experienced by the 3rd year students in the APT module and classify these experiences in a logical and hierarchical manner in order to illustrate their interrelation with each other (Greasley *et.al*, 2007). Previous studies using this methodology have also addressed students approaches toward learning with illuminating results (Ashworth and Lucas, 2000). The data collection period started at the beginning of the academic year in 2010 after the 3rd year students started with the APT module. The final data collection was conducted once the 3rd year students had completed their first semester in the APT module. The aim was to investigate their approach toward learning at the inception of their involvement in a PBL learning environment and then again at a later date once they had become accustomed to the instructional approach. Data regarding their conception of learning in the module was also gathered during this time period.

The students were invited to participate in the study by means of purposive sampling. The study population was the 3rd year class in 2010 at the Division of Physiotherapy. The participants completed the Revised Study Process Questionnaire (R-SPQ-2F) (Biggs, *et.al,* 2001) which is a validated tool for determining whether or not a student has a deep or surface approach toward learning. The outcome of the 20-item R-SPQ-2F allows the researcher to determine each students approach to learning and the motive and strategy for learning, with regard to that particular approach (Biggs *et.al*, 2001 and Groves, 2005).

Two randomly selected semi-structured focus group interviews were conducted by the researcher following the second adminstration of the R-SPQ-2F questionnaire and transcribed verbatim in order to categorize the students' conceptions of learning for the phenomenographical analysis. By conducting a second focus group with a different group of students, the statements made in the second interview served as a basis for further confirmation of findings from the first focus group interview. Focus group interviews as a data collection method is reported to have been used in other studies adopting a phenomenographical approach to the data collection, though the individual interview is the preferred method (Marton, 1994).

A portion of this study, not discussed here, focussed on the students perception of learning. This portion of the study addressed students perceptions of the advantages and disadvantages of learning in the APT module as well as identified the students preference for PBL versus lecture-based classes.

Results

This investigation sought to determine if the initial approach which students have toward learning in the APT PBL module will favour a deep approach toward learning, as is the intention of the Physiotherapy Division. Ultimately determining if students in the APT module learnt to apply themselves in such a way as to adopt a deep approach toward learning as a result of this instructional approach.

The responses of the R-SPQ-2F were scored as required by the questionnaire and identified those students who could be classified as having a deep or surface approach to learning. Table 2 identifies the percentage scores at the two time periods.

Approach to learning	R-SPQ-2F February		R-SPQ-2F July	
	Number	**Percent**	**Number**	**Percent**
Surface Approach	12	31.58	10	26.32
Deep Approach	26	68.42	27	71.05
Equal scores	0	0	1	2.63

Table 2: Approaches toward learning at the beginning (February) and middle of the year(July)

Equal scores indicate that one student did not show any change in scores at the two data collection time intervals. A response rate of 100% (n=38) was achieved for the R-SPQ-2F for both the beginning and end of the semester administration of the questionnaire. The Cronbach alpha for the deep and surface approach were 0.85 and 0.79 respectively, indicating an acceptable reliability for this instrument's ability to measure a student's overall approach toward learning with regard to deep or surface strategies and motives. This however was not the case for the individual sub-categories of the questionnaire, with regard to the inter-item reliability. It should be noted that this data instrument has been proven to be both reliable and valid in other studies (Biggs *et.al*, 2001; Leung and Chan, 2001; Kember, Biggs and Leung, 2004; Groves, 2005) and it could therefore be seen as specific to this group of study participants. Kember *et.al*, (2004) also highlights the fact that the arbitrary figure, or common agreement, that reliability is acceptable if the Cronbach alpha is 0.7 or above, can be questioned when analyzing questionnaires of this nature.

The learning environment is likely determine a student's approach toward learning more than the inherent traits of that student (Groves, 2005). Students completed the self-reporting likert-type R-SPQ-2F in February and July of the academic year in 2010. At the first administration of the questionnaire there was a statistically significant difference in the number of students scoring higher in favour of the deep approach toward learning (p-value:<0.0078). The results of the questionnaire in July continued to classify more students as having a deep approach toward learning than a surface approach (p-value: <0.01). However, the comparison of the participants' scores at these two time intervals reveal no significant change in overall approach toward learning by the students from the start of their PBL environment experience to mid-way through that year. Figure 1 illustrates the comparative analysis of deep versus surface approach toward learning over the time period described above, with a no shift over time (p-value: 0.75).

This confirms the findings of similar studies (Groves, 2005; Kember *et.al*, 2004; Dolmans, Wolfhagen and Ginns, 2010) in that students participating in PBL modules do not necessarily show a significant change in their approach toward learning, simply because that is the intention of the instructional approach. Rather, students are influenced by various factors, including the facilitators, learning outcomes, a student's willingness to accept responsibility for their learning, and possibly even assessment (Papinczak, 2008; Scouller, 1998), or their previous learning environment (PTS).

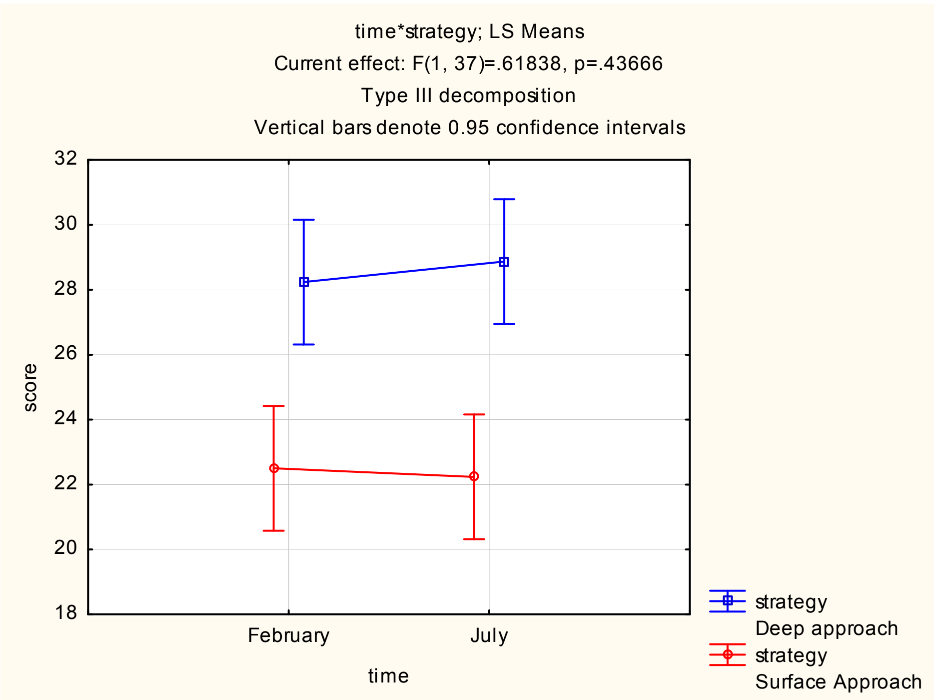

Figure 1: Deep versus Surface Approach over time

The R-SPQ-2F identifies motives behind students approaches to learning. A student who has an intrinsic interest in the learning environment and materials is said to have a deep motive. Those who have a surface motive influencing their approach to learning are said to have a fear of failure (Kember *et.al*, 2004). These motives cannot, however, be viewed on a solely independent basis as the specific structure of the R-SPQ-2F requires a concurrent analyses of the strategies employed by students along with their motives. The strategies either related to a student's tendency to have a narrow target approach to learning materials and rote learning, or those who tend to approach a learning environment with a need to maximize meaning in that environment (Kember *et.al*, 2004). The analyses of the results showed a trend toward a deep strategy being adopted by students participating in the study over the time period during which the study was conducted (Figure 2). This trend was, however, not significant, with a p-value of 0.05. This trend was not seen in the results pertaining to the Deep versus Surface motives, with no shift seen at either the first or second administration of the R-SPQ-2F for both deep and surface motives (Figure 3). Deep motive, however, measured significantly higher than surface motive, p-value <0.1.

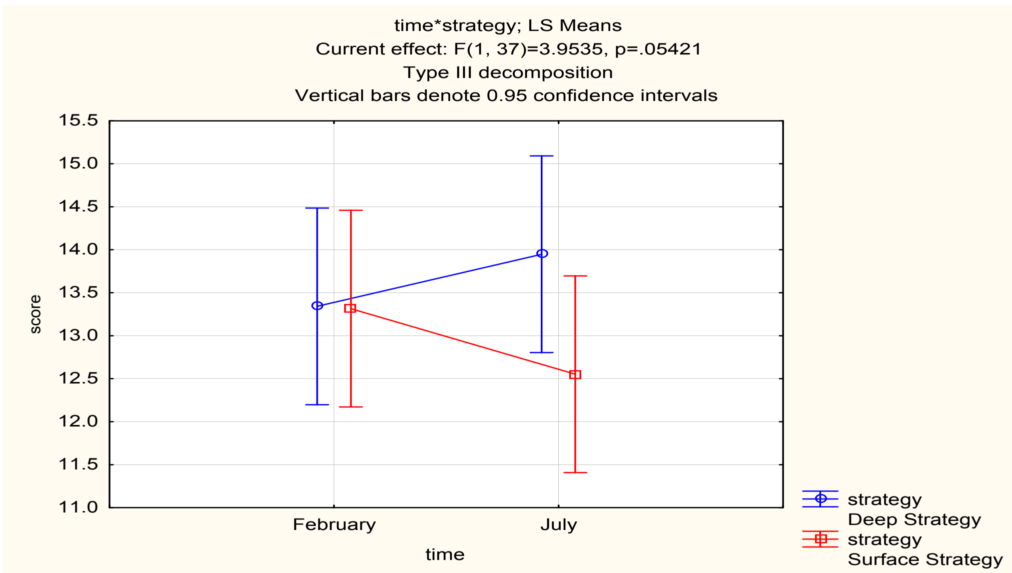

Figure 2 Deep versus Surface strategies over time

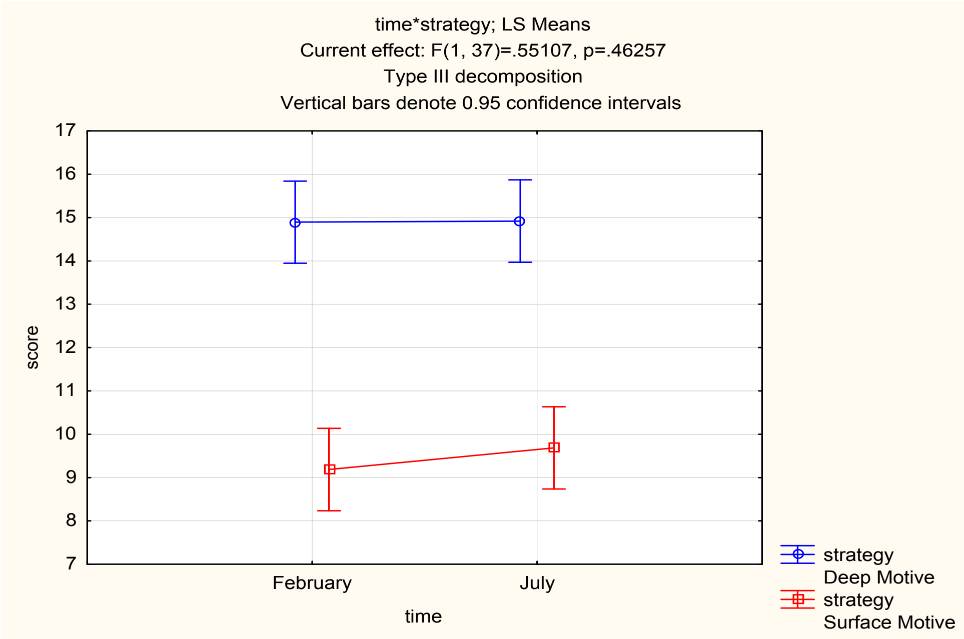

Figure 3 Deep versus Surface motives over time

Semi-structured focus group interviews sought to determine the students' conceptions of learning in the APT module. This was done because an understanding of the student conceptions of engaging with the APT module is necessary for understanding the process and outcomes of this PBL-based learning environment (Ellis *et.al*, 2008). The focus group interviews were transcribed and analyzed to determine common themes within the responses. There were ultimately five categories into which the responses could be organized. These categories, along with illuminating quotations by the students are illustrated below:

Conceptions of PBL - APT 373	Illuminating quotation
APT has an effect on approach toward learning	"I can put things into perspective now...I'm adapting what I know to specific cases"
Learning occurs in a variety of ways in APT	" I think…if you get in on the discussion in the feedback session it also helps, it helps to get other people's perspectives, an when you're in the hospital with a patient with that diagnosis, you can think, oh, but that one said this or that" (i.e. social learning)

	Translated
APT has an effect on personal & profesional skills	"You have already started to use clinical reasoning" *Translated*
APT has positive aspects for learning	"I think it's *(APT vs PTS)* actually better because you can't teach the base knowledge that we have in PBL, but the application thereof can be taught in PBL."
APT has negative aspects for learning	"That is, one is more unsure about quality than in PTS (lecture-based theory class)" *Translated*

Table 3: Student conceptions of PBL as presented in the APT 373 module

The effect of the APT module on approach toward learning specifically deals with situations in which the students are reportedly learning either in a manner in which they are able to gain a deeper understanding of the learning material by relating it to previous knowledge and personal experiences or to learn by simply identifying important facts and memorizing them, regardless of structure or principles embedded in the cases (Newble and Entwistle, 1986). The second category identifies specific studying or learning methods used as described by students in order to learn or apply the knowledge presented in APT. The last three categories deal with the conceptions of students regarding how the APT module has influenced their personal and professional (clinical) lives. It begins to identify their barriers to and advantages for learning. That is, the negative and positive effects of this module on the other aspects of their studies, such as social and clinical interaction.

The implication of this categorization of the conceptions of PBL is that in the APT module, physiotherapy students can expect to develop a deeper understanding of their previous knowledge and its application in clinical practice through modules such as APT. The necessary adaptation to the workload, time constraints and levels of confidence in researching skills can be made and with time, the transition to an alternative learning environment are likely to be accepted and understood through a concerted effort by staff in facilitating a smooth transition process to this module.

Discussion

The assumption that an instructional approach used in a module which incorporates and is built on the foundations of self-directed learning and constructivist theories, will automatically motivate students to adopt a deep, self-directed approach toward learning is one that should not be made (Duke *et.al*, 1998). This assumption was not necessarily made by this study. However it was the intention of the study to investigate the approaches toward learning of 3rd year students at a relatively early stage in their transition to a learning environment which forced them to take a greater responsibility for their own learning. This investigation would then allow academic staff to use the information for facilitation of learning.

The findings of this study indicate that students responded to the learning environment by starting to shift their focus from having a narrow target approach, or focusing on lists of facts, in an attempt to maximize meaning of their experiences and learning in the module. The inclination toward their motive being driven by a fear of failure as opposed to an intrinsic interest in the learning material at the middle of the year, is cause for concern. The inherent approach to learning that students have at the beginning of the module, should however encourage staff to ensure that these students are maintaining their deep approach throughout the module. It is necessary to remember that students easily change from deep to surface or surface to deep approach depending on the assessment, learning outcomes or facilitator, among others (Kember *et.al*, 2004;Groves, 2005; Greasley *et.al*, 2007; Dolmans *et.al*, 2010). The same can be said for students' conceptions of learning which develops over time (Duke *et.al*, 1998). The results of this study are in keeping with similar studies in other academic arenas (MacKinnon, 1999; Prince *et.al*, 2006; Kirschner *et.al*, 2006; Ellis *et.al*, 2007; Loyens *et.al*, 2008; Lewis, *et.al*, 2009; and Saalu *et.al*, 2010). These conceptions of learning by the students should stimulate discussions on possible changes to this specific module in the Physiotherapy course. The Physiotherapy Division aims to uphold student-centred learning, as outlined by the Stellenbosch University Policy on Teaching and Learning.

Using the results optimally for the facilitation of student learning, will require the academic staff to make changes to the curriculum. It will also be necessary to conduct further research to ensure that these results are not specific to this particular cohort of students, but rather, transferrable to other groups of students in PBL environments.

To ensure that students continue to internalize information they come into contact with through the PBL sessions, in-depth discussion during feedback sessions should be encouraged and facilitated by staff members involved in cases. A recommendation for improving the feedback sessions is to change the format in a way where videos can be used in combination with written descriptions allowing for role-playing with associated self-reflection on information formulated by students. This in turn could potentially facilitate a shift toward a deep approach to learning, as opposed to PBL cases in which students are simply reliant on group members to provide them with the information.

Understanding why and how students can have an inclination toward a deep approach toward learning and yet not significantly change their approach from surface to deep, could be clarified if a questionnaire such as the PBL-R-SPQ (a modified verson) could be used (Dolmans *et.al*. 2010) . This will be useful for module refinement and curriculum planning. An addition to the current study, for future research, could be to investigate the assessment outcomes with the approaches and conceptions of students in the APT module in order to identify any correlation between these factors and academic achievement. The results of which, over an extended period of time, would ensure enhanced facilitation of learning.

Conclusion

Within the profession of Physiotherapy, PBL remains a viable curricular option which needs to be further studied and debated (Solomon, 2005). As the Physiotherapy Division of SU decided on this approach for the APT module in 2007 as one which would help to develop the skills needed by students to be competent when working in the community (Statham *et.al,* 2008), the need to evaluate the module on various levels remains pertinent to the continued refinement of the module. The concept of studying approaches to learning can guide the assessment and teaching styles in a direction to encourage students to adopt more effective approaches (Greasley *et.al*, 2007).

Though there was no significant change in approach toward learning in these students, alignment of assessment, learning outcomes, and teaching and learning activities is important to positively influence approaches toward learning in a PBL environment (Dolmans *et.al,* 2010). Therefore, further research in this environment is needed to ensure this alignment. Approaches toward learning are not necessarily a static phenomenon; rather, it varies as the learner is faced with different situations and expectations in a module. With this in mind, the Physiotherapy Division at SU are now able to build on this research to inform further curriculum refinement and development.

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THE IRON RANGE ENGINEERING PBL CURRICULUM: HOW STUDENTS ADAPT TO AND FUNCTION WITHIN PBL

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ABSTRACT

Iron Range Engineering is a unique complete-PBL curriculum for upper division students. Rather than studying *about* engineering in traditional engineering courses, IRE students *solve complex and ill-structured industry problems*. To support students' transition to PBL and to facilitate deep approaches to learning technical and professional competencies required for the engineers of the future, faculty have created a variety of structures. Findings indicate that both students and faculty are continuing to adapt to the challenges of this non-traditional approach, and that students perceive they are developing engineering skills that will be directly transferable to their future employment.

INTRODUCTION

Engineering education in the United States is a domain where the application of PBL is gradually growing (Litzinger et al, 2011). Although many implementations are for single courses, or portions of a course, one program -- The Iron Range Engineering program -- has recently implemented an *entire* upper division engineering curriculum using semester-long industry-based PBL. Iron Range Engineering (IRE) represents a unique model for an undergraduate problem-based learning (PBL) engineering program. Rather than studying *about* engineering in traditional engineering courses, IRE students *solve complex and ill-structured industry problems* in mining, milling, and manufacturing industries. A majority of their learning activities are organized and indexed by these industry projects.

This paper describes IRE's PBL implementation and reports the results of a qualitative study of their students; we examine their perceptions of the pedagogical activities that aid in their adapting to and succeeding in the PBL curriculum as well as what they see as the primary barriers. We then analyze these data for the primary emergent themes and discuss how these relate to the literature to help inform future PBL implementations in engineering.

Background literature

PBL and Its Use in Engineering Education: PBL is an instructional methodology with the following characteristics (Hung, Jonassen, & Liu, 2008): *problem-focused*, where students learn by addressing authentic, ill-structured problems; content and skills are *indexed by the problems*, rather than as a list of topics; *reciprocal relationship* between knowledge and the problem; *student-centered*, where what is learned is determined by student intention rather than faculty objectives; *self-directed*, where students assume responsibility for generating learning issues and processes through self- and peer assessment; *self-reflective*, where learners monitor their understanding and learn to adjust strategies for learning.

According to the U.S. engineering degree accreditation organization, ABET, learning to identify, formulate, and solve engineering problems is an essential outcome for engineering graduates (ABET, 2010). Engineers are hired and succeed for their ability to solve problems. In addition, due to extensive globalization and rapid changes in engineering and technological know-how, engineering students must demonstrate life-long learning skills in applying new knowledge and continue to develop their problem solving skills. (Adams & Felder, 2008).

Several engineering degree programs have implemented PBL for all or part of their curricula. The first full implementation was the Chemical Engineering program at McMasters University in Canada, followed by Aalborg Linkiping, Rosilde and Maastricht Universities in Europe and numerous engineering programs in Australia (e.g. Monash University,). In the U.S., Worcester Polytechnic Institute requires all undergraduates including engineering majors to complete at least two synthesizing projects (Litzinger et al, 2010).

Student reactions to PBL: Although all learners new to PBL face challenges, there may be specific challenges for engineering students. When Nasr and Ramadan (2008) implemented PBL in an Engineering Thermodynamics course they noted that, ".. students are formulae-driven. Effective methods need to be employed to discourage students from reaching out for quick equations to plug and chug in" (p. 22). Engineering students may also have difficulty applying prior knowledge from earlier coursework to PBL problems. Students in an engineering communications course spent more time than instructors anticipated trying "to find new information to find a solution to a problem . . . and much less in contemplating how what they were being asked built on previous knowledge and experience" (Mitchell & Smith, 2008, p. 136). Johnson (1999) reported that students in a PBL hydraulic engineering course complained that the projects were vague, suggesting a discomfort with ill-structured problems. Engineering students develop learning strategies that help them to succeed in traditional courses. Those strategies often conflict with the intellectual requirements of PBL activities (Yadav, Lundeberg, Bunting,& Raj Subedi, 2011).

Engineering students are not alone in their resistance to PBL. Authors have noted that PBL experiences must be planned carefully if they are to avoid common learning pitfalls. Researchers have studied PBL group dynamics (Wilkerson, 1996), peer leadership in groups (Palmer & Major, 2004), and the role of tutors/instructors in facilitating PBL learning (Savin-Baden, 2000). In PBL settings, students may feel disempowered by assessment methods that do not match their PBL experiences (Savin-Baden, 2004). In addition, the PBL problems must be 1) intrinsically motivating, 2) provide adequate structure to match the level of student experience with ill-structured problem-solving, and 3) provide adequate challenge to encourage a deep approach to learning (Mauffette, Kandlbinder, & Soucisse, 2004).

Methods

Institutional Context: The IRE program resides in Virginia Minnesota and is a collaboration between the Itasca Community College (ICC) and Minnesota State University Mankato. IRE is an upper division, team oriented, PBL program organized by industry-mentored design projects, rather than topic-based courses. In a recent semester, an IRE student team designed and implemented a condenser performance test to be applied to a power plant's power generation condenser. To solve the problem, students learned cycle analysis, conduction heat transfer, convection heat transfer, heat exchanger design, engineering economics, and studied the environmental implications, all in the context of a real deliverable for a major client. The IRE program formally started its PBL program with a cohort of 14 students in January 2010.

Each problem is comprised of several stages: scoping the problem, selecting competencies appropriate to the project, (chosen from 16 core technical competencies in mechanical or electrical engineering or student-proposed advanced competencies that students must complete in order to matriculate), developing learning plans to acquire competencies, developing design plans to solve the problem, implementing and documenting both learning and design activities, completing oral exams to demonstrate competency attainment, and a series of design presentations throughout the cycle. As with all PBL programs, IRE students assume a large degree of responsibility for their own learning. At the beginning of each project cycle (Figure 1), students identify which learning outcomes or competencies will be addressed during the project. Each outcome is classified using the newer version of Bloom's taxonomy of cognitive outcomes (Anderson & Krathwohl, 2001). Working with faculty, students then determine what learning activities to employ and what types of evidence are needed to demonstrate outcome attainment. Learning activities include self- or peer-directed learning, one-on-one faculty directed learning, or industry engineer-mentored learning.

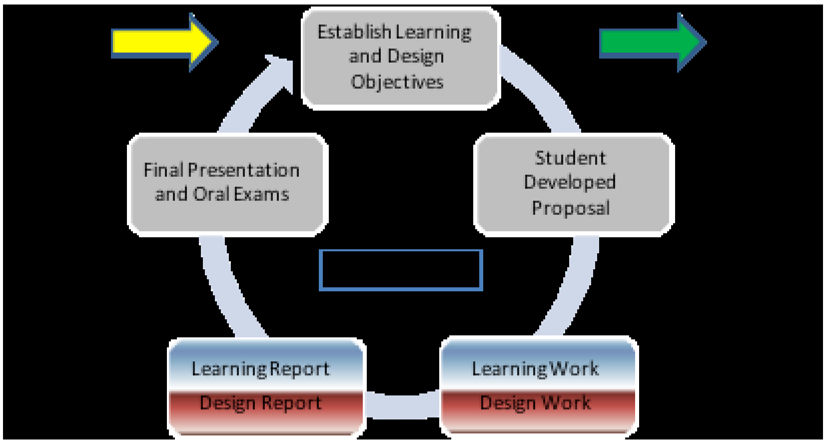

Figure 1. IRE Learning Cycle

Throughout the semester, students engage in a variety of assessment experiences including problem sets, laboratory experiments, written exams and oral exams in which they demonstrate their understanding of technical engineering knowledge on core and advanced competencies. The student also provides evidence, via independent or group projects of their ability to apply technical knowledge to a real problem. Problem solutions can also be used by students to demonstrate higher order analytic, evaluation and creative cognitive skills. Each problem cycle concludes with the presentation of two reports: a design report for the deliverable to the industry client, and a learning report that reflects on the learning process and provides evidence of outcome attainment. In addition to written reports, student teams present a final design review to their faculty and peers that is formally evaluated. They then present their final design to the external clients.

IRE Students: To date, students have been recruited predominantly from a nearby two-year college as well as from other two-year colleges in the Minneapolis – St. Paul, MN metropolitan area. The first cohort of 14 students will graduate in December 2011 with a B.S. in General Engineering with joint emphases in mechanical engineering and electrical engineering. A second cohort (10 students) began in September. Demographically, IRE students are 16% female, 4% non-Caucasian, 60% first generation college, and 72% qualified for U.S. federal aid. Students function as cohorts, going through the program together.

Data Collection and Analysis: Data for this analysis are from semi-structured interviews with thirteen IRE students. The majority of the sample (n = 10) were purposefully selected so as to ensure representation of both student cohorts, women and under-represented minority students, and students who completed their first two years at varying institutions. The remaining interviews (3) were with student volunteers.

Over a two day site visit, Authors Marra and Palmer conducted individual recorded interviews with students that lasted approximately 45 minutes each. We used a semi-structured interview protocol that probed student experiences on choosing IRE, their previous postsecondary educational experiences, their perceptions of the PBL curriculum and their plans for future work and education. We triangulated student interview data with: students comments from a publically available blog; observations of students working in their project teams and in faculty-led learning conversations; and interviews with faculty and one industry partner. We conducted the faculty interviews by telephone prior to and after the site visit and reviewed the student blog after coding interviews.

We analyzed these multiple sources of data in stages. First, the two primary researchers coded the 13 student interviews individually. We then consulted on our separate coding and created a collaborative coding structure. From the 13 interviews we developed the major themes outlined in our results section below. We clarified and further elaborated the themes by reviewing the student blog entries and by triangulating results with the faculty and industry partner interviews. At the last stage, we reconfirmed and documented the main themes by returning to the student interviews to find supportive quotations. Due to the small number of females and minorities in the program we use non-gendered labels for quotations.

Results

One of the struggles in implementing PBL curricula is helping students to transition from traditional pedagogies to this new way of learning. The IRE faculty recognize that this is a challenge students may face and have built in structures that may help students with this adjustment.

Industry Project Scaffolds: Students are initially assigned to industry project teams based upon their strengths and learning needs. Students found that peer teams functioned in both positive and negative ways. For instance, this student clearly reported learning from peers in the context of the teams. "Once that step was done, we went back and explained .. like I explained to the group how I did my portion then someone else would explain how they did their portion.. we kind of taught each other ...". But in other cases teams didn't function as effectively. Although teams create a contract that outlines expectations for participation, some students still experience being "stuck" in a particular role multiple times over several team experiences – and in some cases a gender bias emerged as female students took on the majority of report writing responsibilities. Others reported that the perceived intensity of the industry project led them to each do his or her own part and then combine the pieces to meet the deadline, limiting truly meaningful collaboration.

Teamwork is one component of the strong sense of community amongst IRE students. Another aspect is the community building activities -- such as group camping trips --- that are scheduled throughout the year to help students engage with each other in multiple roles and contexts. Although this is no longer the case, students in the first cohort were required to live on campus in close proximity of one another. Overall, students experience an intense and intimate relationship with one another and with faculty. As such they can be susceptible to some of the negative aspects of highly cohesive groups such as "group-think". The benefits, however, include a very open environment where students willingly give and accept constructive feedback without the barriers often seen in student interactions.

Learning Scaffolds: Student-developed learning plans help them to both take ownership of their learning and to realistically manage their time. For core competencies, an initial set of content areas provide students with an outline of learning expectations that match their outcomes to traditional engineering degree programs. This helps students to be confident that, in the end, their technical expertise will be competitive with student from other institutions. Learning plans for advanced competencies are negotiated over a period of time between the student and the faculty. These learning plans are often tailored very specifically to address a technical issue in their industry problem and are also used by students to develop expertise in an area of personal interest.

Students and faculty discuss and reflect upon the metacognitive aspects of learning primarily through examining Bloom's taxonomy. While students may initially only mimic the outlines of the taxonomy as they describe levels of learning, eventually students grow to appreciate the importance of reflecting on not only what they know, but how deeply they have learned it. As one student wrote in their student blog:

> *"To understand anything of course, begins with factual knowledge ... What is important though... is that we understand the concept of metacognitive learning and the role it plays in this program. ... only now am I starting to see how reflection on learning activities truly plays a key role in retaining learned material and dealing with the unknown through relation."*

Students are also able to tailor their learning activities to take advantage of a variety of resources. While some students still rely on traditional learning strategies such as textbook content, other students use peer discussions, internet resources, faculty learning conversations, workshop-style learning events, and industry expert mentors to actively engage with technical content. For example, students in one team we observed discussed their conceptual understanding of a technical equation with their faculty advisor prior to a scheduled meeting with an industry mentor to present their work in progress. The faculty member was able, in real-time, to help students develop alternative pathways for constructing a mathematical model of the real-world problem.

Assessments of Learning: Faculty generally require two or three assessment measures to triangulate the student's understanding of technical material. Some students found the oral examination assessment method to be helpful, noting that this type of assessment was in alignment with PBL pedagogical activities. This student describes how orals require you to more deeply understand the tested content.

> *"When you are talking about it, you have to know what's going on... it's not just memorization and learning most of what you need to learn right before a test and then probably forgetting it a week after..."*

These same oral exams, however, were described as an impediment by others. Several interviewees remarked that students "crammed" for orals – invoking memorization learning strategies to reach what the program describes as "level 2" (conceptual) learning. This level must be demonstrated in order to earn a minimal grade in the program – a "C".

Some said their strategy was to make sure to pass the oral exam for their competencies to guarantee that minimal grade, and then if time permitted move on to the more meaningful leering outcomes associated with levels 3 and 4. Students additionally remarked that this most commonly occurred for competencies not associated with industry projects, and that students' lack of time management skills may also play into this phenomenon.

Self-selection into PBL: Although pedagogical factors are clearly significant in terms of helping students to adapt and be successful in their PBL studies, the IRE students are somewhat unique as they have self-selected this non-traditional engineering program. Nine of interviewees had attended a two-year college at which one of the founding IRE faculty has taught pre-engineering courses using open-ended problems for many years. These students consistently mentioned positive prior experiences with these problems as a factor in their decision to attend IRE.

> *"There's the lecture learning and there's project-based learning and I'd put ICC somewhere in between... I've always been a fairly independent student....I learn at my own pace, so the opportunity to do that here was great..."*

These open-ended problems were clearly not as ill structured nor as extensive as the industry problems students encounter at IRE, however they did serve to provide students with a taste of doing "real engineering" and of learning in student-centered ways.

Student Predispositions: Our conversations with students revealed that student pre-dispositions combined with their past experiences with traditional educational activities may both help them to choose to attend and adapt and succeed in an PBL curriculum. For instance several students indicated their preference for "hands-on" learning and desire to avoid typical lecture-based classroom settings. At a surface level these comments may seem not terribly remarkable – after all, many students will express a dislike of lectures -- but they may also be an indication that they have some awareness of themselves as learners that accelerates their adjustment to IRE and makes the PBL method a good fit for them.

Students' previous educational and life experiences will color the way they react to PBL. For one IRE student, prior family and work experiences were an important part of his transitioning to and succeeding with PBL. This student described working in the family construction company and was coached by his dad to listen to more experienced co-workers and ask "a lot of questions". This student explained that those skills have serve IRE learners well where it is necessary for students to take charge of their own learning.

Access to Faculty: As our discussion of scaffolds illustrates, faculty interactions with students are a critical. We note that the IRE program does not employ "tutors" that are often used in PBL programs. Students rely on access to IRE faculty and project managers (adjunct faculty who have industry experiences) for the "tutoring", coaching and guidance that are critical for their success in a PBL curriculum. Students are on campus at a minimum five days a week for eight or more hours a day; they work individually and in teams to make progress on their learning competencies. When they get stuck, they turn to faculty for guidance.

> *"As far as individual learning goes [faculty] have been a great help. I like to do alot of individual work but I'll run into just bumps in the road that I can't quite make it past easily, so to have them to fill in those holes a little bit, make them a bit shallower makes it a bit easier to get over the top of them and move on..."*

However, because students' learning is not structured in "class time", students need for faculty time and attention are detached from a daily schedule and arise unpredictably, based on the pace of their learning and their individual problem-solving processes. Students commented consistently on their desire for more and more frequent faculty interaction. IRE faculty are aware of this issue and taking steps to address it. One strategy currently being employed is the use of Smartboard and Skype technologies to provide increased access.

Discussion and implications

After twelve or more years of practice at learning in traditional formats, tertiary-level students may have mixed reactions to a PBL pedagogical. Although there is certainly a strong potential connection between theory and practice in engineering, students may have even more difficulty with the transition than students in other disciplines because their foundational courses in math and science have rewarded them for rote memorization and focus on solving equations that lack connection to real world contexts. The IRE program successfully addresses many of the typical forms of student resistance through thoughtful curricular design and implementation.

As a complete implementation of PBL, students continuously engage in PBL rather than encountering it in a single course in the midst of traditional teaching methods. Students select the program because they are motivated to engage in PBL for the entirety of their upper division learning. Faculty have formulated multiple ways to scaffold students immersion in the semester problems while also supporting students to engage in deep approaches to learning the technical material that is the hallmark of quality engineering programs. Promotion of multiple modes of learning, encouragement to engage in metacognitive reflection, assessments that match their PBL experience, and a deliberate focus on building community were some of the many aspects of this program that facilitated student success.

Necessarily in a PBL curriculum, the industry problems are a major focus of students' learning, and as the literature suggests, the nature of that problem is significant both in terms of students' motivation and their success. Students affirmed the importance of the quality of their industry problems in their discussions of the IRE program. As might be expected, the degree to which problems were aligned with required technical competencies and student interest varied. When problem were strongly aligned, students found that they were more deeply engaged in learning and that their ability to manage their time was improved.

The IRE program continues to battle aspects of the traditional tertiary level education system that constrain how PBL is implemented. The architects of this program must still work within a curriculum approval system that favors pedagogies that align with traditional approaches. Additionally, students still predominantly focus on learning within a semester calendar that does not necessarily coincide with the realities of industry needs. Faculty are also limited by a reward system that places demands on their time that compete with full attention to the students' emerging problem-solving needs.

Conclusions

The IRE program is uniquely designed to immerse upper division engineering students in a completely problem-based curriculum. Although both students and faculty are continuing to adapt to the challenges inherent in this non-traditional approach, our study indicates that both are fully engaged in the process and – most importantly – students perceive they are developing engineering skills that will be directly transferable to their future employment.

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INTERNATIONAL INTELLECTUAL PROPERTY EDUCATION IN PROJECT-BASED LEARNING CLASSES

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ABSTRACT

The Kanazawa Institute of Technology (hereafter KIT) began incorporating intellectual property (hereafter IP) education into Project-Based Learning (hereafter PBL) engineering design courses in 2003. At the same time, KIT embarked on a joint international design project with institutions from Singapore and Taiwan. In 2009 KIT developed an internal IP digital library, named KIT-IPDL. The content for this system comes from completed student design projects. The KIT-IPDL system has now accumulated approximately 3750 design solutions developed by KIT, Asia University of Taiwan, and Singapore Polytechnic (hereafter SP) students. Students can log in and inspect the design solutions of previous students to help them develop better ideas. It was found that IP education using the KIT-

IPDL system enables students to acquire knowledge and skills necessary for IP asset management. This paper discusses details of the international IP education carried out with Asia University and SP.

INTRODUCTION

The increasing internationalisation of corporate activities and the borderlessness of trade and technology offer new challenges and new opportunities (Alikhan *et al.* 2004). Maskus laid stress on emerging needs for including intellectual property education and research in university curricula (Maskus 2005). In recent years, the engineering education community has shown increasing interest in PBL. With PBL, students are encouraged to assume responsibility for their learning experience and to shift from passive to more active learning patterns. The pedagogical methods and benefits of PBL are illustrated by considerable literature, e.g., (Boud 1985), (Boud *et al*. 1991), (Bouhuijs *et al*. 1993), (Chen *et al*. 1994), (Woods. 1994), (Dym *et al*. 2000), and (Prince *et al*. 2006).

KIT places strong emphasis on providing excellent education to develop self-directed, innovative, and productive engineers. In order to achieve its educational purposes, KIT began offering PBL engineering design courses for all freshmen, sophomores, and seniors, regardless of major (Matsuishi *et al.* 2002) and established an innovative facility "Yumekobo" or "The Factory for Dreams & Ideas" (Hattori, 2003).

KIT incorporated IP education into the PBL courses in 2003 (Matsuishi *et al.* 2010). The IP education content includes lectures and exercises. In 2009 KIT decided to develop an internal online digital IP library, KIT-IPDL, that would be easier for students to use as they encounter technical problems during the patent survey exercises using the onlone IP Library of the Japan Patent Office.

KIT, Asia University, and SP incorporated IP education into their international design project using the KIT-IPDL (Matsuishi *et al.* 2006). The content for the KIT-IPDL is provided by uploading completed student design projects. Students can log in and survey the design solutions of other students to help them develop better ideas. By the end of each PBL engineering design course all student teams have acted as inventors and produced innovative design solutions, which they then upload to the KIT-IPDL. The KIT-IDPL system has now accumulated approximately 3750 design solutions, all developed by students of KIT, Asia University and SP, since the database was created.

Project-based learning engineering design courses

Outline of Engineering Design Courses

KIT developed three compulsory PBL engineering design courses: namely ED I, ED II, and ED III. The three courses are offered to all freshman, sophomore, and senior engineering students, respectively. ED I and ED II are PBL courses. ED III is a capstone design project or a research project as shown in Table 1.

Course Name	Students	Period (Credits)	Type
Engineering Design I	Freshman	One semester (2)	Project-Based Learning
Engineering Design II	Sophomore	One semester (2)	Project-Based Learning
Engineering Design III	Senior	One year (8)	Research Project Capstone Design

Table 1. Engineering Design Courses

Procedures covered in the PBL courses are:

- To identify design opportunities
- To characterize the design project
- To generate design concepts
- To evaluate the design concepts and to select the most promising one
- To design in detail
- To presents results

Mechanism to Help Students Learn Autonomously

The educational goals of KIT are to develop self-directed, productive, and innovative engineers. Therefore, KIT developed the following three mechanisms to be used in engineering design courses to achieve the educational goals.

(1) Learning style

Students tackle problems independently, not by directions given by an instructor. An instructor is a facilitator who advises, identifies technical resources, and gives tutorials as needed.

(2) Self-evaluation of the course objectives

Engineering design course objectives are classified into 28 elements and shown to students. Eighteen objectives are related to the ability to be a professional engineer. The remaining 10 are related to understanding and following the engineering design process. Students are advised to evaluate their performance and progress three times during the term: at the beginning, the middle, and the end of the course. Students are able to recognize the current level of their achievements and try to attain the higher levels. This process is referred to as the PDCA cycle of self-learning.

(3) Facilities for extracurricular activities

KIT established an innovative factory "Yumekobo" in 1993. The mission of Yumekobo is to enhance students' motivation and creativity through extracurricular activities. Yumekobo is staffed with highly skilled full-time technicians to support students' extracurricular activities. Students are able to learn the skills needed to build models and prototypes to test and improve their design solutions. Students are encouraged to build models and prototypes at Yumekobo to see if their designs, which are generated in engineering design courses, are feasible and useful, or find out what needs to be improved.

International Collaborative Design Project

International collaborative design projects are carried out between KIT, Asia University, and SP. Before starting the collaboration, discussions were held to determine the optimal method for carrying out the project. Due to the differences in time, academic calendar and grading system among participating institutions, the following program was selected:

Students from each institution, who stay in their own institution, form one independent team, select one project theme which is related to the main theme, and practise design activities separately. Each team independently works on their project theme focusing on their themes of interest. Progress reports and final achievements are exchanged among participating institutions through e-mail, website and/or video conference, and are exhibited in each class. Students of each institution developed their design solutions, while exchanging their progress reports by using ITC technologies.

International IP education in PBL courses

Outline of IP Education

KIT's PBL engineering design courses were selected to host IP education efforts because it was believed that PBL classes would help students better understand and employ IP strategies and capabilities in a manner similar to the increases in learning of idea generation techniques, e.g., Brainstorming, TRIZ, Osborn's Checklist, etc. The IP education content in the PBL courses includes lectures and exercises. Students are given an overview of basic IP concepts as shown below:

- Intellectual property rights (hereafter IPR)
- The outlines of patent law, copyright law, trademark law, and trade secret law
- The patent application process
- Licensing intellectual property rights
- Infringement of intellectual property rights

Students are also given an overview of the practice of surveying patents through the online IP library of each country. They are required to search for relevant patents and use information they find to improve their designs while also avoiding infringement of IP rights. An IP search is composed of the following steps: developing a search strategy, conducting a patent search, understanding search results, and utilizing the search results into improvement of design solutions. Figure 1 shows the process of developing creative and original design solutions based upon patent surveys. Problems encountered by students during the patent survey exercises are as follows:

- Primary technologies of most patents are advanced and surpass students' technological levels.
- Patent papers are too sophisticated for easy understanding by students.

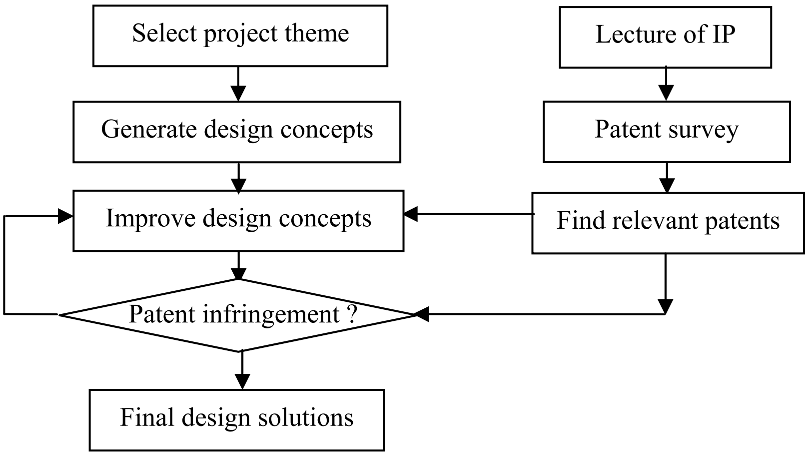

Figure 1. Developing Creative and Original Design Solutions Using Patent Searches

Therefore, KIT decided to develop an internal online IP digital library, named KIT-IPDL, which will be discussed in the subsequent section.

Outline of the Digital Library

The online KIT-IPDL is composed of a search engine, an indexer, an index database, and an IPR database as shown in Figure 2. The content for this system is provided by uploading completed student design projects. The indexer periodically searches the IPR database, finds indexes of the uploaded design solutions, and stores them into the index database. Therefore, the index database is periodically updated.

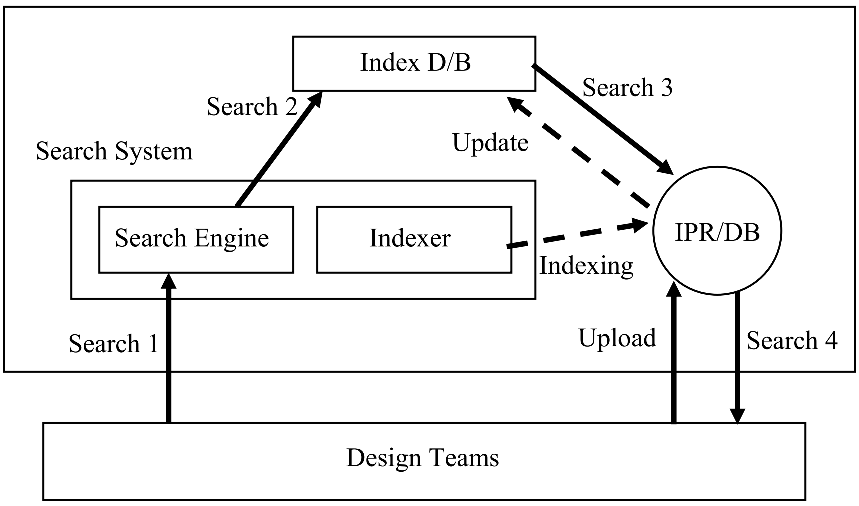

Figure 2. Configuration of KIT Digital IP Library

International IP Education in PBL Classes

Students of the three institutions are required to develop their original and innovative design solutions and condense them into Idea Summary Sheets as shown in Figure 3. Instructors of the engineering design courses examine the design solutions. If the design solutions pass the examination, students are allowed to upload Idea Summary Sheets, design reports, final presentation slides, and posters to the KIT-IPDL.

Design Solution Name:
Problems To Be Solved:
Expected Effect of the Design Solution:
Details of the Design Solution:
Scientific Principle Employed by the Design Solution: if any
Did you confirm if the design solution works?
Name of existing product(s) and the difference: if any
Is the design solution feasible?
Advantages and Disadvantages of the Design Solution: Advantage: Disadvantage:
Is the design solution ethical?

Sketch of Design Solutions
Draw illustrations below to show the whole structure and details of a design solution

Figure 3. Idea Summary Sheet

Students' Achievement

First they log in to the KIT-IPDL and search for relevant design solutions. If they find design solutions similar to their own, they develop new solutions. If they find their design solutions are inferior to those in the database they improve their design solutions (refer to Figure 1). Thus they develop original and innovative design solutions. Some of the typical design solutions are shown below.

(a) Design team of KIT

One civil engineering EDII design team selected a project theme "Design of Drought-Resistant Green Roof". Their design goal was to develop a green roof which can prevent an urban heat island from forming and protect plant life in a roof-top garden from dying due to lack of water. They found nine relevant design solutions in the KIT-IPDL. Their design solution was quite similar to one in the database. Therefore, they tried to develop a new design solution. Their final design solution is composed of plant life on a roof, a water-absorbing substance, and photovoltaic modules. The water-absorbing substance in the ground prevents the plant life from drying out. The photovoltaic modules cast shadow over plant life and may block out excessive sunlight. Their idea summary sheet is shown in Figure 4

Design Solution Name: Green roof with solar panel and high water-holding ground
Problems to be Solved: 1. Preventing an urban heat island 2. Protecting plant life in a roof-top garden from dying due to lack of water
Expected Effect of the Design Solution: 1. Preventing an urban heat island 2. Protecting vegetation in a roof-top garden from dying due to lack of water 3. Generating photovoltaic power
Details of the Design Solution: Green roof preventing an urban heat island Inserting water-absorbing substance in ground to prevent dying of plant life Photovoltaic modules installed on a roof cast shadow over plat life and may block out excessive sunlight
Scientific Principle Employed by the Design Solution: *if any* Photovoltaic power generation
Did you confirm if the design solution works? No.
Name of existing product(s) and the difference: *if any* Green roof Photovoltaic power generation system
Is the design solution feasible? Yes, our design solution is feasible
Advantages and Disadvantages of the Design Solution: Advantages: Preventing an urban heat island, Protecting plant life in a roof-top garden from dying due to lack of water, Generating electric power Disadvantages: No serious disadvantages
Is the design solution ethical? Yes, it is. The design solution may contribute to prevent an urban heat island

Figure 4. Example Idea Summary Sheet from KIT Student Team

(b) Design team of Asia University

(a) Plant Information Learning System (b) Description of Leaves

Figure 5. Ubiquitous Campus Plant Information Learning System Images (Asia University)

One computer science design team of Asia University selected a project theme “Building a Ubiquitous Learning System for the Instruction of Natural and Life Sciences”. Their design goal was to design a simple ubiquitous campus plant information learning system “SUCPLS” to let the students access adaptive learning materials and obtain appropriate learning sheets at specific locations. The SUCPLS can provide adaptive learning materials and learning sheets to the students. The students can obtain better understanding and learning performance relating to knowledge of plant life. They did not find any relevant design solutions in the KIT-IPDL. Some of the pages of the website are shown in Figure 5.

(c) Design team of SP

One civil engineering design team of SP selected a project theme “Rainwater Generator”.

Rain is very common in Singapore, and the basis of the idea is to obtain kinetic energy from rain. Presently in Singapore, there are two funnel shaped rainwater catchments at Sungei Tampines. The rainwater collected is currently only stored and treated to supply water to nearby estates such as Tampines and Pasir Ris. The students suggested that before it is treated, the rainwater should turn a turbine and generate electricity. They did not find any relevant design solutions in the KIT-IPDL. Their idea summary sheet is shown in Figure 6.

Figure 6. Idea Summary Sheet from SP Students

Design Solution Name: Develop a rainwater generator
Problems To Be Solved: To harness the rainwater to convert into electricity
Expected Effect of the Design Solution: The new idea in this project is to make good use of rainwater to turn the turbine. Thus, kinetic energy is produced to generate the electricity.
Details of the Design Solution: In this rainwater generator, rainwater is being used to generate electricity. During heavy rain, rainwater is collected. The collected rainwater will be controlled by a valve. The water pressure increases as the rainwater flows through the valve. The flow of water turns the turbine as it enters the turbine box. The kinetic energy is then generated by the flowing water and this energy is transferred to the generator through the gears and belts. In the generator, the kinetic energy is then being converted into the electrical energy.
Scientific Principle Employed by the Design Solution: Physics concepts on kinetic energy, heat and electricity.
Did you confirm if the design solution works? No, we did not.
Name of existing product(s) and the difference: Turbine of a generator
Is the design solution feasible? Yes, it is feasible. It uses kinetic energy to run the generator which does not produce any harmful gases to the environment. Hence it will be a more environmental friendly choice.
Advantages and Disadvantages of the Design Solution: Advantage: • Energy saving. • Rainwater that could be collected and stored Disadvantage: • Slow process • The velocity in the pipe is not fast enough to turn a turbine of a generator
Is the design solution ethical? Ethical because it can save energy and it is also an environmental friend product.

Evaluation of Students' Performance and Progress regarding IP

KIT has been interested in developing an instrument to assess the learning and skills growth in PBL courses on a university-wide basis in order to understand the impact of our educational efforts in the engineering, personal, and interpersonal skills and improve upon them. During the 2011 academic year, preliminary administration of a series of surveys featuring new methods and materials were undertaken (Rynearson et al. 2011). The classes selected to host the surveys were ED I and ED II. The question format is behaviourally anchored multiple choice. The survey contains 10 inquiry areas and 56 questions. One of the inquiry areas is Engineering Ethics. The survey is administered at the beginning and end of the first semester of 2011.

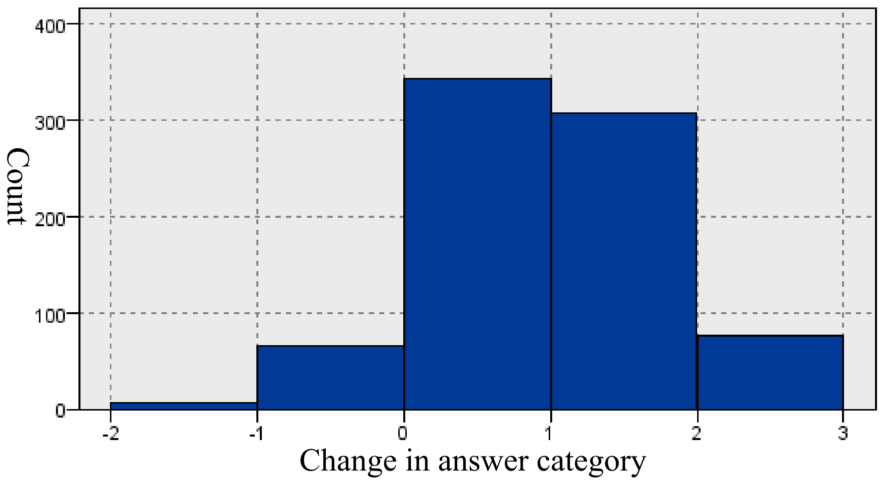

Figure 7. Change in Students' Engineering Ethics Abilities

Our IPR education is a subset of our broader engineering ethics education, and a rise in reported engineering ethics skill and knowledge would be a strong indicator of a rise in skills and abilities relating more specifically to IP education. Students were asked "How would you evaluate your understanding of engineering ethics and your skill in its use?" Note that the text here has been translated from the Japanese of the survey materials.

Figure 7 shows a change in students' ability to use engineering ethics during ED I, including IPR. The mean reported rise in engineering ethics ability was 0.48 behaviourally anchored levels of ability. This change was found to be statistically significant. Therefore, there are strong indications that the ethics and IP education of KIT is effective in improving students' skills and abilities. The data for ED II have not yet been collected, and it is expected that the upward trend in students' skills and abilities will continue with the further ethics and IP education offered in that class in the second semester of 2011.

Conclusion

The following important information was obtained as shown below:

(1) KIT has developed an internal online IP digital library (KIT-IPDL), which has now accumulated approximately 3750 design solutions. KIT-IPDL enables students to improve design activities and to prevent duplicate design activity by referencing design solutions stored there.

(2) Students of the PBL engineering design courses search for relevant design solutions in the KIT-IDPL and use information they find to improve their designs while also avoiding infringement of IP rights of other students. If they find that their design solutions are similar, they develop new solutions. If they find that their design solutions are inferior, they improve their design solutions. Therefore, they can develop original and innovative design solutions.

(3) A survey using behaviourally anchored multiple choice questions was employed to study if the incorporation of IP education into PBL engineering design courses is effective in increasing the IPR ability of students. It was found that the mean level of the IP skills and abilities rises in this case.

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IMPLEMENTING PROBLEM BASED LEARNING IN MATERIALS SCIENCE

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ABSTRACT

Problem solving is the primary intellectual activity of mechanical engineers. Enhancing problem-solving skills is essential for preparing mechanical engineering students for the workplace. A potentially effective approach to preparing students to solve authentic problems is problem-based learning (PBL), an instructional methodology that focuses student learning on relevant problems. This paper presents an initial implementation of a PBL-based course in materials science in the third year of a mechanical engineering program as a case study. Implementing PBL into engineering courses has been shown to be problematic. The challenges we faced are considered, including self-regulation skills, study strategies, and examinations for students and assessment and facilitation issues for the faculty members.

INTRODUCTION

Practicing engineers are hired, retained, and rewarded for solving problems (Jonassen, Strobel, & Lee, 2006). Therefore, enhancing problem-solving skills is essential for preparing mechanical engineering students for the workplace. Workplace engineering problems are substantively different from the kinds of problems that engineering students most often solve in the classroom. Workplace problems are ill structured and complex. They possess conflicting goals, multiple solution methods, non-engineering success standards, non-engineering constraints, unanticipated problems, distributed knowledge, collaborative activity systems, the importance of experience, and multiple forms of problem representation. Although many forms of PBL have been reported, most engage students in solving authentic problems rather than memorizing content. This paper reports on the initial implementation of a PBL version of a materials science course in the mechanical engineering curriculum at a U.S. university.

How to Implement PBL

One of the major differences in PBL implementations is the extent of the problem-based program, which is a measure of an institution's commitment to problem-based learning. At one end of the implementation continuum, several researchers have described the development and implementation of course modules (a portion of a single course) in numerous engineering programs. A number of PBL implementations, including the one described here, have sought to convert entire semester-long courses into PBL. Final year, capstone engineering courses are often implemented as a form of PBL. They typically require students to solve a single, complex and ill-structured design problem, such as the 16-week capstone course in software engineering (Dunlap, 2005). Such course-level implementations present multiple challenges for both students and faculty members, including expectations, study strategies, and work effort. Changing expectations of students who have rehearsed strategies for studying for and succeeding in traditional courses is very demanding of them.

The most effective implementations of PBL are at the curriculum level. For example, medical education programs, such as the University of Missouri (Blake, Hosokawa, & Riley, 2000), replace the entire basic sciences curriculum with week-long diagnostic problems that address all of the content formerly addressed in stand-alone courses in anatomy, physiology, immunology, and so on. Students solve diagnostic problems while teaching each other the basic science content necessary for understanding what they are doing.

Very few such curricular level implementations have been attempted in engineering. PBL has been implemented as a partial strategy for Mechanical Engineering and Biomedical Engineering at Technische Universiteit Eindhoven (Perrenet, Bouhuijs, & Smits 2000). The oldest curricular implementation of PBL in engineering is offered by Aalborg University in Denmark (Mills & Tregust, 2003). Faculty members meet with industry partners to solicit everyday problems, which they redact for the students. Based on those problems, the students determine the project's content and structure with approval of the faculty supervisors. A significant benefit of this method is the very high retention rates among students.

Another significant challenge for students is learning to solve authentic problems that do not necessarily have correct answers. Well-structured problems, such as those commonly solved in science and engineering classes, have accepted solutions, solution criteria, solution methods, and a constrained set of concepts and principles included in the chapter prior to the problem. Workplace engineering problems, on the other hand, are ill-structured. They have conflicting goals, multiple solution methods, non-engineering success standards, unanticipated constraints and problems, distributed knowledge, and collaborative activity systems (Jonassen, Strobel, & Lee, 2006). Because of the uncertainty in outcomes, ill-structured problems tend to be more difficult to solve, especially for students who have learned in school that problems have correct answers. Problem difficulty is a function of problem complexity, the skill and knowledge levels required to solve the problem, and the degree of nonlinearity of the relations among the variables within the problem space (Jonassen & Hung, 2009).

In addition to the challenges faced by new problem-based learners in general, there may be specific challenges for engineering students when adapting to a PBL approach. For example, Nasr and Ramadan (2008) list a variety of challenges they faced when implementing PBL in an Engineering Thermodynamics course. They noted that, "The majority of students are formulae-driven. Effective methods need to be employed to discourage students from reaching out for quick equations to plug and chug in" (p. 22). Johnson (1999) reported that students in a PBL version of a hydraulic engineering course complained that the projects were "too vague and needed additional clarification" (p. 11), suggesting a discomfort with ill-structured problems. Mitchell and Smith (2008) noted that engineering students had difficulty relating prior knowledge from earlier coursework to the problems provided in a third year PBL course in communications systems. Students spent more time than instructors anticipated trying "to find new information to find a solution to a problem, as if it were just one discrete task, and much less in contemplating how what they were being asked built on previous knowledge and experience" (p. 136). This study clarifies one of the significant advantages of PBL, that ideas that are learned in the context of solving problems is better retained and more transferable. Students also found difficulty in the practical nature of the assignments as compared with the more academic assignments they had done in the past; their written reports showed a tendency toward "replicating rather than applying theory" (p. 138). Engineering students develop learning strategies that afford them success in traditional engineering courses. Those strategies often conflict with the intellectual requirements of PBL courses and curricula. PBL represents an instructional paradigm shift for students, who have developed effective scripts for traditional learning.

This study reports on the challenges occurring during the initial implementation of a materials science course in the mechanical engineering curriculum. In this first PBL implementation of this course, we sought to identify student and faculty difficulties that may compromise the effectiveness of the course. These finding would help us to determine improvements in the course. Our research questions included:

- How well will students adapt to a PBL curriculum? What problems will they experience?
- What changes in teaching must engineering faculty accommodate in order to help students achieve?

In order to answer these questions, three data sources were collected. The engineering faculty members were interviewed weekly throughout the semester. During classes, students and faculty members were observed as they worked on solving the problem modules. At the conclusion of the semester, research staff conducted extensive, semi-structured interviews with 15 students.

Method

Students were randomly assigned to ten groups initially consisting of six students each. With the exception of moving one student to another group to address shortages due to students who had dropped the course, students remained in their assigned groups throughout the course. An initial lecture introduced students to the structure of the course, the principles and methods of PBL, and the supporting materials available to them for solving the problems. Students then worked in their teams to solve a series of seven problem modules and collaboratively produce a written technical report detailing their group's solution to each. Each module was allocated two weeks (6 contact hours) over a 15-week semester. The whole course consisted of seven problem modules (see list below). In order to ensure that important content elements are not missed, we list the subject categories normally covered in the traditional version of the course in Table 1 that each problem addresses.

Module 1. *Improved Design of Cassette Plates* – You have been asked to redesign x-ray film cassettes so that they are lighter but retain the same stiffness to bending loads. Compare various materials that are compatible with the application to produce an improved cassette. Addresses: (d, j, k, l).

Module 2. *Silicon Wafer Orientation* – Write a letter to a confused customer explaining the difference between 100, 111, and 110 silicon wafers and the orientation of the flats on the sides of the wafers. Provide a drawing illustrating the orientation of the crystal in the wafer. Addresses: (a).

Module 3. *Variation of Single Crystal Strength* – A bulk single crystal of aluminum is provided to students. Each student cuts a prescribed rectangular cross section sample from any portion of the bulk material, for tensile testing up to failure. However, on testing they find that each student obtains a different value for the elastic modulus and the yield stress. Explain the possible reasons for the apparent discrepancy. Addresses: (d, e).

Module 4. *Failing Brackets* – In an attempt to improve the strength of mounting brackets, 2024-T3 aluminum is replaced with 7075-T6 aluminum, which is stronger. It is then found that the brackets fail at a higher rate. Determine the reason for this and find another suitable metal alloy that will fix the problem. Addresses: (d1, f1, g, i1).

Module 5. *Design Improved Automotive Springs* – A hypoeutectoid alloy steel wire containing Cr and V is used for manufacturing coil springs for automobiles suspension systems. These steel springs can be heat treated to obtain excellent toughness and also have high UTS and hardness. This spring wire, purchased from a wire manufacturer, is coiled into springs and heat treated by appropriate quenching and tempering before installation. However, the springs begin to fail prematurely by fatigue failure. What could be the causes for such failures and how could it be remedied? Addresses: (c, d, d1, d2, f, f1, f2, i2).

Module 6. *Creating Copper Contacts* – Select a beryllium-copper alloy for cell phone battery contacts. They need good conductivity and high strength. If applicable, design a heat treatment for the contacts. Discuss any safety aspects of beryllium. Addresses: (d2, g, i1).

Module 7. *Design Dies for Forging Ti-6Al-4V Alloy Connecting Rods* – You want to make forged automotive connecting rods from Ti-6Al-4V titanium alloy. Select a tool steel from which to construct the dies and design the proper heat treatment for the dies. Addresses: (d, d2, e, g, i2, i3).

For each problem module, students were provided with a contextualized case scenario introducing them to the details of the problem and their role in solving it, a guide to the module listing the learning objectives, related reading material, and, for the early problems, suggested strategies for approaching the problem; and a variety of supplemental reading materials affording more detailed information from research and practice related to the engineering materials concepts involved in the problem. Because students had no prior exposure to PBL, the module guides were used as a form of scaffolding or epistemic scripts ((Weinberger, Ertl, Fischer, & Mandl, 2005) to help them understand both what was expected of them and how to meet those expectations. Instructors provided a detailed task list that modeled how they would approach solving the problem along with conceptual diagrams illustrating the relationships of various material properties to the expected performance of the materials in the implementation. Flowcharts were also provided illustrating the decision-making processes for materials selection and processing. Further, early on in the semester the students were instructed on the way a team in practice might approach the problem and collaborate on its solution. In subsequent problem modules, these supports were gradually reduced so that, by the end of the course, problem scenarios stopped short of describing team problem-solving approaches and problem guides listed only the objectives and requirements for their respective modules.

(a)	Crystal structures, naming planes and directions
(b)	Imperfections in solids
(c)	Diffusion
(d)	Mechanical properties
(d1)	Tensile Testing
(d2)	Hardness
(e)	Dislocations and strengthening
(e1)	Grain size and strength
(e2)	Solid solution hardening
(e3)	Cold work and annealing
(f)	Failure
(f1)	Fracture
(f2)	Fatigue
(f3)	Creep
(g)	Phase Diagrams
(h)	Phase Transformations
(i)	Heat treatment of alloys
(i1)	Precipitation hardening
(i2)	Quenching and tempering of steels
(i3)	Hardenability of steels
(j)	Ceramics
(k)	Polymers
(l)	Composites

Table 1. Materials related topics to be covered in MAE3200 Engineering Materials course. Topics are listed in the order that they are currently covered in the existing course.

Materials Science is designated as a writing-intensive course in the Mechanical Engineering program, which requires that student assignments take the form of written artifacts similar to the types of writing they might be expected to produce as practicing engineers. Thus, each team was required to produce a written report for each problem module detailing the group's solution to the problem and providing justification for that solution as well as explicating their understanding of the engineering materials concepts related to that problem module. For the first problem module, extra writing support was provided by returning the reports with detailed feedback. Students were provided with the opportunity to revise their reports based upon the feedback.

Results and discussion

The following section describes the challenges encountered in this initial implementation and suggested design changes to improve upon both student and instructor experiences for a subsequent implementation planned for the spring semester of the 2010-2011 academic year.

Challenges for Students

It is expected that learners experiencing PBL for the first time will find it challenging, not only because it represents a shift from their prior classroom experiences, but also because much of the benefit from learning how to solve problems within a discipline comes from mistakes made along the path toward mastery (Barrows & Tamblyn, 1980). Participants in this study expressed difficulty with the overall structure of the course, and, to a lesser degree, with working in teams. Additionally, the course instructors identified performance challenges for students that should be addressed in the subsequent design.

Course Structure. Participants expressed considerable confusion about the way the course was structured around problems rather than topics. Students perceived the course as effectively lacking structure, describing it as "jumping around on different subjects," "going backwards," and "having the test first [before learning the material]." Participants also had difficulty relating their work on the problem modules to the types of questions asked on the course exams.

Students most commonly suggested that more lectures would best address these challenges. Organizing the course around problems rather than topics, however, is a central characteristic of PBL (Barrows, 1996), and students' desired solution of incorporating more lectures is not desirable. In fact, their impression of "test first, lecture after" based on a lecture that was given during the first problem module suggests that fewer lectures may actually improve the design! However, providing supplemental information to help frame particularly challenging topics for students, such as brief, single-topic recorded lectures or other multimedia materials, that students may access on a just-in-time, as-needed basis may help them better appreciate the structure of the course content as it applies to the problem and to the exams. Exams should be rewritten to more clearly assess the skills and knowledge that students would be expected to obtain from their work on the problem modules. Module guides should explicitly state learning objectives and required reading from the textbook related to the problems so that students can more readily make the connection between the problem modules and the key concepts that those problems are intended to cover. Debriefing sessions after each problem could also help reinforce the relationship between key course concepts and their application in solving the problems, however this strategy would require careful planning so as not to significantly increase instructor workload (discussed further in the instructor challenges section below).

Working in Teams. Most of the students interviewed described their interpersonal experiences with team members as positive and their team roles and structure as informative. Only two of the groups reported particular problems with group dynamics, and the instructors reported that only one student came to them with a request to address interpersonal issues within his group. A brief presentation on working in teams was provided during their work on the first module, but it did not help the two teams experiencing problems with their group functioning to improve their group processes during the module. Given that most participants had little experience working in teams before the course and minimal guidance was provided to students about teamwork strategies, there may be a need for facilitators to be more attentive to group dynamics early in the semester and to provide more direct mentoring to underperforming teams proactively.

Performance Issues. Instructors were generally dissatisfied with the quality of the group collaboration as demonstrated by the submitted reports. Instructors perceived that very little collaborative writing was occurring. Instead, they observed that students would tend to divide the report into sections and write those sections individually, then simply combine those sections with little or no attention to how well the sections fit together. While this improved to some degree over the course of the semester based on feedback from the instructors, students interviewed at the end of the semester expressed that they rarely read their respective teams' full reports prior to turning them in, though a few mentioned that they used the reports to help them study for exams. One possible remedy for this challenge might be to require each student to individually prepare and submit an abstract for the "executive summary" section of the paper rather than including it in the group report and modeling that task as the last step to be completed prior to turning in the report. Since individual students would have direct impact on their own grades with such an assignment, such a strategy could provide greater incentive for each team member to understand the report holistically and thus to contribute to ensuring that the overall report is appropriately edited to reflect that holistic understanding.

Instructors also perceived exam performance to be lower for the PBL students than students who had participated in prior traditional, lecture-based versions of the course, though the data analysis comparing the PBL and non-PBL versions of the course has not yet been completed. Given that participants themselves identified a lack of understanding how the exams related to their work on the problem modules, however, refinement of the exams is warranted as noted above.

Instructors were also concerned that students were often not making productive use of class time allocated to working together in teams on the problem modules. The PBL model intends for team members to bring their individual research together for discussion so as to teach each other and construct a shared understanding of the meaning of the concepts they are learning (Hmelo-Silver, 2004). While it may not be desirable for the instructors-as-facilitators to police the students during class time (i.e. penalize them for off-task behavior), the initial introductory lecture could be enhanced to recommend how to make effective use of class time and facilitators could reinforce these ideas by guiding students back on task when off-task behaviors are observed. However, specific strategies for providing this guidance should also take into account the facilitation issues discussed in the instructor challenges section below.

Instructor Challenges

Students face many challenges when making the transition from lecture-based courses to PBL, but the transition is also challenging for instructors. There are two main areas of difficulty for instructors transforming their traditional lecture-based courses to PBL: the transition to the role of facilitator and assessment workload.

Facilitation Issues. In PBL, it is no longer the role of the instructor to provide didactic instruction on key concepts. The PBL model makes use of facilitators rather than instructors to guide student work on problems, provides a single facilitator for each student team, and often employs facilitators who do not have prior experience as instructors in the discipline. In situations where this is not possible, instructors and teaching assistants must adjust to guiding the students to find their own answers rather than providing direct answers to student questions and resist the temptation to resort to lectures when students are struggling to understand new material.

In the first implementation, the two instructors alone served as facilitators for all ten groups. They were not provided with significant training in how to facilitate PBL groups prior to the implementation, though as primary members of the research and design teams, they were introduced to the concept of facilitation in this context. Instructors were, as previously mentioned, not readily able to identify issues in group dynamics, primarily because they were spread too thin trying to facilitate all ten groups.

There are two opportunities for design improvements to address the facilitation challenges identified in the first implementation of PBL in MAE 3200. The two teaching assistants, who were used solely to provide outside demonstration labs for this implementation, could be employed as additional facilitators to reduce the facilitation load of the instructors. A graduate student from the College of Education can also be trained to serve as a fifth facilitator. While this would not provide the optimum solution of one facilitator per group, it would come considerably closer to that ideal. In addition, all facilitators should be provided with more formal training prior to the start of the course so that everyone would be better prepared for the facilitation role and the instructors could more effectively address the transition issues inherent in their shifting roles.

Assessment Workload. The two instructors performed all of the grading work associated with the course. In the traditional version of the course, students were responsible for individually submitting three written reports as well as taking the two exams. While there were fewer reports at each submission for the PBL students because they were submitted by team rather than individually, there were reports due for all seven problem modules and they were more incoherent, representing an increase in workload for the faculty. The increased workload made it difficult to return student reports in a timely fashion, which in turn affected students' ability to adjust their strategies and improve their performance on subsequent problems.

Because timely feedback is important to promote continued improvement in student performance, some way to alleviate the workload is perhaps the most critical concern for subsequent implementations. It is possible that the additional facilitators could be trained to give general feedback on report structure and cohesiveness, but they will not be qualified to fully assess the student reports. One possible remedy is to have fewer full solution reports due. Instead, early problem modules could focus on shorter assignments that represent portions of what would be a full report and only require full reports for 2-3 of the problem modules. Such a strategy could also provide the opportunity to get students to learn specific strategies for addressing particular aspects of the overall report, such as the science section, that instructors identify as being particularly important to the success of the report. Students could also be asked to give presentations rather than full reports for some of the problem modules. However, this could increase the time they will need to spend outside of class to work on the problem modules since in-class time would need to be allocated for the presentations.

Changes for the Second Implementation

In order to facilitate collaboration, students in the second implementation will be required to construct wikis that that are organized by both epistemic and social scripts (Weinberger et al, 2005). Students will collaboratively address and comment on conceptual as well as procedural issues that arise in each problem by answering questions. During the first three problems, student groups will construct wikis based on the scripts. For the remaining problems, question prompts will be faded and students allowed to organize their wikis in order to assess transfer effects from the scripts. Students will be pretested and post-tested with an engineering adaptation of the Problem-Solving Inventory (Heppner & Peterson, 1982) and the Materials Concept Inventory (Krause, Decker, & Griffin, 2003) n order to determine conceptual gains and self-perceptions of themselves as problem solvers. At the end of the semester, instructors and students in the PBL treatment will be interviewed.

Conclusion

As the Accreditation Board for Engineering Technology (ABET, 2008) has stated, graduates of engineering programs must demonstrate an ability to identify, formulate, and solve engineering problems and to function on multi-disciplinary teams. PBL represents a challenging transition for both instructors and students. However, problem-based approaches to engineering courses may better prepare engineers for the types of work they will actually perform upon graduation and entry into professional practice making the work of implementation worthwhile. Curriculum-wide PBL is more likely to be successful than implementation of PBL into individual semester-long courses.

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INTEGRATION OF ACTIVITY LED LEARNING IN ELECTRONIC ENGINEERING AND RELATED DISCIPLINES

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ABSTRACT

A series of interventions to the style of teaching on the first year curriculum of courses in the broad area of electronic engineering in an attempt to activate the experience of students are described. These include induction group projects, an integrated approach to delivery of professional skills and personal tutor work, more computer simulation and laboratory work, audience response systems, and a combined experience across related technical modules. The interventions have been evaluated through a combination of staff and student feedback and the monitoring of statistical data. Results show a significant improvement in student satisfaction but there remains room for improvement in achievement on formal examination assessments.

INTRODUCTION

Project, group and design based learning have featured in the delivery of the electronic engineering curriculum at Coventry for at least 25 years (Griffiths et al 1993, Jinks 1996, Poole 1994). Over that time their delivery has changed from projects which ran predominantly at the end of the academic year when traditional module delivery had finished, through core design modules running through the academic year, to the current scheme (Medhurst-Wilson et al 2008) entitled Activity Led Learning (ALL).

In 2009, in-line with the introduction of activity led learning across the first year of all undergraduate programmes, students experienced a 6-week practical challenge designed to introduce them to their chosen field of study and prepare them for life at the university. This proved valuable in demonstrating the potential of the approach but also high-lighted a number of issues that needed to be addressed. Subsequently, the 2010 academic year introduced a series of refinements to the approach addressing better integration of the projects with the academic content of the curriculum, delivery of transferrable skills, and relationships between students and their personal tutors. The effectiveness of the developments was evaluated through the existing mechanisms of satisfaction, completion and progression statistics combined with purpose designed student evaluation questionnaires and staff focus groups. The main interventions applied to activate the first year curriculum are described below.

An activity led approach to delivery

Group Projects

Adopting a very practical approach, the 'Group Project' module aims to provide transferable and technical skills associated with group project execution and management. To facilitate learning the student groups are mentored by academic staff and supported by teaching assistants and technical staff. It was decided to tap into creativity and to accentuate fun with team work using a theme that is universally popular: music. Why choose music as a platform for ALL in the areas of electronics and communications? Quite simply massive synergies and motivators exist in the teaching and delivery of engineering (Lehrman and Ryan 2005). Music ranks highly on the list of what students like to do (van Kollenberg and van Schenk Brill 2009); it was perceived that the project would appeal to students in terms of making music (the creative element). Synergies - plenty in the world of communications and electronics, for instance tuning and resonant circuits, notes and frequencies, distortion linked to harmonics plus a whole host of others such as attenuation and noise. The challenge: 'Select a small piece of music and convert its notes to frequencies. Develop a suitable electronic instrument to produce these frequencies, build and test.'

Initially most student groups got into the 'ask more and/or then deliberate or defer mode'. With the structure of the project lasting over a six week period it was imperative to monitor and assist groups and if necessary give a large nudge if initial inertia looked to be a problem. Once work began the phases of the project were in logical order with the music segment being looked at first. Some groups choose a popular ring tone whilst others went for a basic melody such as 'Three Blind Mice'. In some cases the musical segment was made simpler, whilst in a few cases groups went for more complex arrangements. A set of oscillator types where simultaneously evaluated for feasibility. Of these the front runner in the student choice was a 555 based astable oscillator. Clearly the disadvantage of the 555 astable was the non sinusoidal nature, but the tones generated gave a distorted sound and this usefully prompted discussion on harmonics and harmonic content. From the point at which the 555 timer approach was established many groups refined and developed the design to produce a keyboard using push button switches. This induced some thought on the layout of the switches and progressed into the area of the ergonomics. All groups produced a design which gave some form of electronic sound and 20% achieved good fidelity. Group dynamics and sociability was evident in the enjoyment in which the tasks where reported at the presentation. Did the module enhance the student experience? Yes, part of the assessment involved writing a report which was marked as the first coursework in the module. Feedback relating to accomplishment was given which strongly influenced the scope of the 2010-11 activity. The experience suggested the plan had to change to distribute work amongst more academic staff. Additionally, the 'go out and do it approach' had to be toned down, the model needed to be more supported and structured.

Professional Skills and Personal Tutorial

The 'Professional Skills' half-module was introduced to provide a regular opportunity for students to meet with their personal tutor as a group while addressing transferable skills content. In the first term, students work in groups to produce a technical report. In the second term, they begin to reflect on the capabilities that they will need in their intended career by way of producing a personal development portfolio. This paper focuses on the activity carried out in the first term in order to produce a technical report. During the academic year 2009-10, students met their personal tutor every week for an hour. Students were grouped according to the ‘theme’ being studied.

The six-week group project exercise was used as the basis of a presentation and a technical report. As shown in Table 1 (weeks 6 and 7), students were required to present details of their practical work at the end of the six weeks. This was assessed as ‘Assignment 1’. A ‘presentation skills’ lecture was given in week 4 and there was an opportunity to develop and practice presentations during the weekly sessions before the presentation weeks. The second assignment, submitted in week 10, was the technical report. Students were required to write this review of the practical work as a group.

<table>
<tr><th>Week</th><th>w/c</th><th>Tutor session</th><th>Lecture</th><th>work</th></tr>
<tr><td>1</td><td>5 Oct</td><td rowspan="5">To be covered during weeks 1 - 6.
The role of the personal tutor
Studying in HE
Group work
Time mgt & prioritisation
Learning styles
Presentation practice</td><td>Module organisation</td><td rowspan="5">ALL period ass1&2 out</td></tr>
<tr><td>2</td><td>12 Oct</td><td></td></tr>
<tr><td>3</td><td>19 Oct</td><td></td></tr>
<tr><td>4</td><td>26 Oct</td><td>Presentation skills</td></tr>
<tr><td>5</td><td>2 Nov</td><td></td></tr>
<tr><td>6</td><td>9 Nov</td><td rowspan="2">Group Presentations</td><td rowspan="2">Info retrieval (week 7, or 6)</td><td>ass 1 in</td></tr>
<tr><td>7</td><td>16 Nov</td><td></td></tr>
<tr><td>8</td><td>23 Nov</td><td>Academic writing and research.</td><td></td><td>exercises</td></tr>
<tr><td>9</td><td>30 Nov</td><td>Report writing & referencing</td><td></td><td>exercises</td></tr>
<tr><td>10</td><td>7 Dec</td><td>Developing a reflective approach.</td><td></td><td>ass 2 in</td></tr>
</table>

Table 1. Content of the first ten weeks in 2009-10

The six-week group project activity and the Professional Skills module were reviewed before the 2010-11 academic year. It was felt that the assessment could be simplified by requiring only a technical report. Also, more integration was needed between the group project work and the writing of the report. As personal tutors were meeting weekly with their groups, this integration would be clearer to students if personal tutors were directly involved with the practical exercise. Also, this would provide a more natural environment in which students could become acquainted with their personal tutor. It was therefore decided to arrange that the first six weeks of ‘Professional Skills’ be incorporated into the group project activity – personal tutors being the main point of contact for advice throughout the six weeks (Table 2).

<table>
<tr><th>Week</th><th>w/c</th><th>Tutor session</th><th>Lecture</th><th>work</th></tr>
<tr><td>1</td><td>4 Oct</td><td rowspan="6">To be covered during weeks 1-6:
(suggested content)
The role of the personal tutor
Studying in HE
Group work
Time management & prioritisation</td><td></td><td rowspan="6">ALL period
Ass 1 out</td></tr>
<tr><td>2</td><td>11 Oct</td><td></td></tr>
<tr><td>3</td><td>18 Oct</td><td></td></tr>
<tr><td>4</td><td>25 Oct</td><td></td></tr>
<tr><td>5</td><td>1 Nov</td><td></td></tr>
<tr><td>6</td><td>8 Nov</td><td></td></tr>
<tr><td>7</td><td>15 Nov</td><td>No session, but tutor available</td><td>Info retrieval / library</td><td></td></tr>
<tr><td>8</td><td>22 Nov</td><td>Academic writing and research.</td><td></td><td>exercises</td></tr>
<tr><td>9</td><td>29 Nov</td><td>Report writing & referencing</td><td></td><td>exercises</td></tr>
<tr><td>10</td><td>6 Dec</td><td>Developing a reflective approach</td><td></td><td>Ass 1 in 10 Dec in</td></tr>
</table>

Table 2. Content of the first ten weeks in 2010-11

The ALL period was staffed by personal tutors for a two-hour session every week. The personal tutors introduced the practical exercise and were available to advise students during each session. A detail that is not apparent from the timetable is that personal tutors met their tutees during the induction week. In the previous year, students had been allocated to personal tutors after the induction week. It was intended that, from 2010-11, students would meet their personal tutor as early as possible during the induction week.

Integration of Electronics Teaching

One of the key modules in the first year curriculum was 101CDE covering analogue and digital electronics. This module includes an introduction to diodes, transistors, operational amplifiers, logic gates, Boolean algebra, combinational design and sequential storage elements. With the advent of activity led learning through the course it was necessary to rethink the delivery of this module (Poole et al 2010). The first pre-requisite was a decision on the theme of the 6-week activity led group project. This was a difficult decision and a number of options were considered: musical instruments, microprocessors, audio amplifiers, burglar alarms and computer interfaces included. Eventually it was decided that an electronic musical instrument provided the best opportunity to enthuse students and communicate the essence of their courses during the first few weeks of their higher education experience. The main opportunity for integration with 101CDE would be in the design of signal processing circuits employing operational amplifiers so these were scheduled to be the first topic delivered on the module in parallel with the project work.

The plan for activating the 101CDE module after the 6-week activity led projects completed was to make extensive use of the National Instruments™ Multisim circuit simulator. Consequently, these were introduced during induction week as a topic that could be readily tackled by new student groups with very little introduction on a self-paced basis. The subsequent delivery of the operational amplifier topic emphasised the use of the simulation software through tutorial exercises requiring students to design and evaluate operational amplifier applications on the computer simulator. To maintain enthusiasm after the 6-week projects drew to a close the first module coursework was also centred on the design of an operational amplifier application circuit. Each student received a unique specification for an amplifier where the configuration, input impedance, and gain were derived from their student identification number. The three parts of the assignment required:

- The design of an amplifier stage compliant with the unique specification.
- Simulation of the resultant circuit to confirm that the specification was met.
- Research into the practical issues associated with physical implementation.

It was also decided to make extensive use of the University's virtual learning environment. In addition to providing a repository for all the learning materials of the module, the environment was used for distribution of the coursework, on-line submission of the student work, electronic marking by annotating the student's work in Adobe Acrobat™ and return of grades and feedback in response files. A particularly useful feature was the use of a discussion forum related to the assignment. Students were encouraged to use this if they had any queries or problems on the task. Initially the forum was a little slow to gain momentum but, as the submission deadline drew close, it was good to see students directly responding to queries from their peers.

Activating Electrical Circuits Teaching

The first year electrical engineering module is a mandatory module for many programmes. The total number of students in the module is generally between 140 and 200. However during the academic year, 2010-11, the total number of students increased to 270. The main challenge associated with the teaching and learning process is to deliver the material for the large, mixed cohort. The large number of students come with a range of different experience and abilities. Prior to the 2008-09 academic year the module was delivered using a traditional lecture, one-to-many, approach. The course team felt that the formal lecture method for a large mixed cohort was not effective in improving students' engagement, satisfaction and pass rate. The team decided to exploit the drive by the Faculty to develop ALL strategies, to provide a better learning experience for the students and improve engagement and participation. The new method of delivery involved three types of session: namely a formal lecture, a tutorial session with use of an Audience Response System (ARS) and a laboratory session, see Table 3. The same pattern was repeated for each run of the module through the academic year.

Session	Teaching Methods
First session	Formal Lecture to present key definitions, concepts and applications (2 Hours)
Second Session	Tutorials to develop analytical and numeracy skills associated with circuit theory and electronic circuit analysis (second hour with Audience Response System (ARS))
Third Session	Laboratory sessions using Multisim software, based on the topics that students learned in the previous two sessions

Table 3. First year electric circuits module delivery pattern

Every third teaching week a laboratory session was planned. These laboratory sessions were based on simulating electrical circuits using National Instruments™ Multisim software. Multisim enables the students to simulate electrical circuits and analyse or investigate the behaviour of electrical circuits. The laboratory sessions enable the student to carry out both simulation work as well as theoretical calculation. The pedagogy involved in this approach is that laboratory sessions will help students to relate the materials that have been covered in the lecture and tutorials. They offer a good opportunity for students to identify and then find the information they need within their lecture notes to apply to the laboratory work.

To increase the students' engagement and participation in the tutorial sessions an Audience Response System (ARS) has been introduced (Nicol and Boyle 2003). Students were divided into small groups of three each with one clicker (hardware through which students can provide their response). When a concept question was asked, students were asked to discuss among other members in the group and provide their answers through the clickers. Once all the groups submitted their answers (or time elapsed), ARS will provide immediate feedback to the students. The Interwrite® Personal Response System (PRS), a type of ARS, was used for this activity.

Because of the changes in the approach, the method of assessment has also been modified to fit the method of delivery. Different assessment methods were adopted: laboratory based work including on-line assessment and assignment, in-class test and final examination. All these assessment methods were designed to meet the intended learning outcomes of the module. Most of the laboratory sessions were designed to be part of the coursework assessment. There were in total 6 such small laboratory sessions and 4 laboratory sessions which contributed to the coursework mark. The large number of scripts to be corrected and moderated in a very short period (the University allows 4 working weeks for large modules) meant that it was difficult to provide effective feedback for the laboratory work. To overcome these issues the use of on-line assessment was adopted. Another main concern in setting up the coursework, in a large group, is to avoid the chance of plagiarism. For this purpose also an on-line assessment method was designed to produce a unique coursework task for each student.

The pedagogy approach in using alaboratory session as a part of the course work was to provide feedback to students before the next laboratory session. Hence, students are made aware of the areas where they need to improve. On-line assessment based on Respondus (2010) was therefore introduced as it enables immediate or timed feedback. Another significant advantage of using Respondus is the ability to create unique questions for each student reducing the likelihood of plagiarism.

Evaluation and discussion

Tutors were asked for their views on their direct involvement with students during the group project exercise. Three questions were posed:

- Did the students benefit from your direct involvement with them? If so, how?
- Were there any other positive or negative aspects with your tutor groups?
- Is there anything you would do differently? If so, what?

Tutors who gave a view were generally positive about the experience of being involved with the group project work. They all felt that students had benefitted from this. The students were more confident in communicating with their personal tutor and felt more secure in voicing any concerns that they had. Students continued to keep in contact with the personal tutor, seeking guidance on academic matters. It was felt that this allowed a better relationship to develop than that of the traditional personal tutor role. Opportunities were available to ask ‘How is it going?’ etc during the practical sessions.

Sadly some students did not take the activity as seriously as they could and did not attend fully. Those who did attend regularly benefited from the interaction with their tutor and their marks reflected this. One tutor felt that the laboratory was not the best environment for a discussion and found it sometimes difficult to move from being a lecturer to being a facilitator of a discussion. There may be a case for additional break out rooms for discussions and further training for tutors. A tutor who taught the electronics module was able to relate the lectures to the practical work that was taking place.

There are various improvements that are being considered in the light of comments from personal tutors and students. Students could be shown a good example of a previous project before they begin. Measurements on this project circuit could introduce them to items of test equipment. One tutor felt that some kind of ‘ice breaker’ activity would be helpful before launching into group work. Timing was another issue, with large student numbers resulting in some enthusiastic students running over into the next session. A more radical proposal is that the personal tutor’s role is placed entirely within the group project module. This would allow contact throughout the year with the ‘Professional Skills’ content delivered throughout the year in small groups at the most appropriate time.

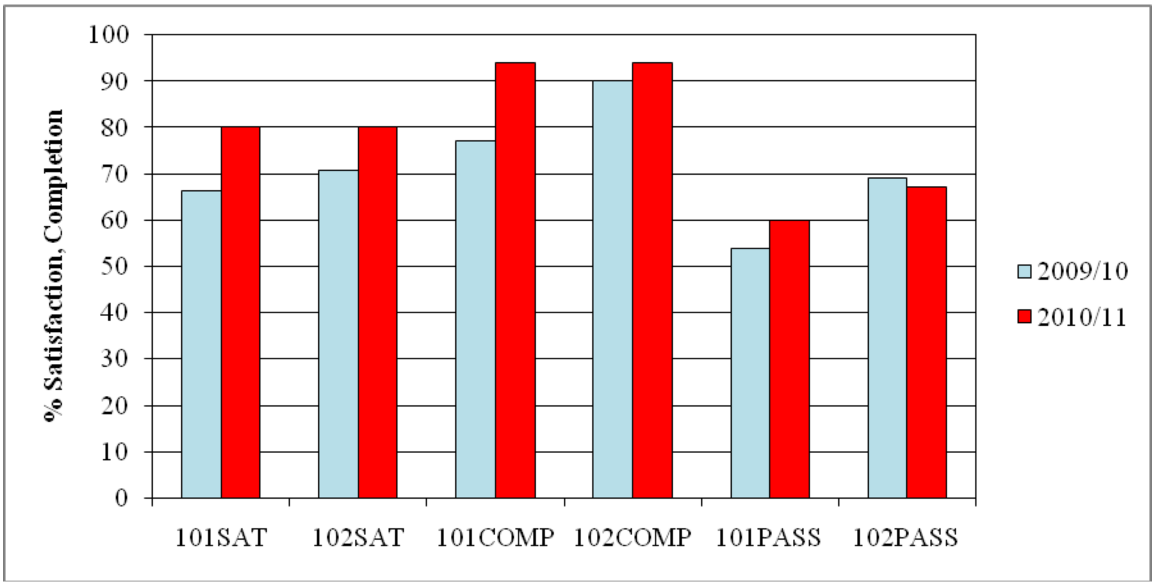

Figure 1. Selected module statistics

Figure 1 shows some selected operational statistics on two of the key technical modules involved with the intervention: 101CDE Analogue and Digital Electronics and 102CDE Electrical Engineering. Only two years of data are shown as there was a significant change in course structure before the 2009-10 period. They show a significant improvement in overall satisfaction (SAT) for both modules. This is thought to be due to improvements in using the virtual learning environment in addition to the integrated group projects. Completion (COMP), the number of students submitting assignments on time has also increased although this is likely due to removal of a late submission facility in the University regulations. Raw pass rate (PASS), before resit attempts, has improved slightly on 101CDE but dropped by 2% on 102CDE. The individual coursework assignments were generally well done but formal examinations have proven more challenging. There is clearly more to be done here. A more detailed analysis of the 102CDE module follows.

In order to evaluate the effectiveness of the new method of delivery in the electrical engineering module direct feedback was obtained from students (Ramachandran and Haas 2010). From the students' feedback it is evident that ARS sessions provided a positive impact on students' learning experience. ARS sessions improved the students' participation in discussions and encouraged team work. Students also mentioned that ARS provided immediate feedback and hence they were able to identify the subjects that they need to revise. The immediate feedback provided by the ARS system is very helpful for staff as well. It helps the course team to adopt the changes required in delivering materials. However, the main challenge with ARS sessions is that the time required for both preparation and delivery is significant. Due to the significant increase in the student numbers and also due to limited resources, ARS sessions have not been used for this academic year.

For the 2008-09 academic year module evaluation survey, most of the elements scored 'satisfactory' to 'very satisfactory' except the on-line assessments that scored 'adequate'. The introduction of on-line assessment initially raised a number of issues, such as software crashes, material availability and the formatting of answers - number of decimal points and units for electrical quantities. These issues had a negative impact on the students learning experience. The course team addressed these issues by introducing strict and consistent formatting and allowing several attempts to avoid issues with software crashing.

In the 2010-11 academic year module evaluation survey, students were asked to rate the overall module satisfaction with scores from 1 to 5, from 'very dissatisfied' to 'very satisfied'. The average score for the academic year 2009-10 was 3.53, rating 'satisfactory'. In 2010-11 the module overall satisfaction increased to 4, rating at 'very satisfactory', an increase of 13.3%. This is the first time this module achieved an overall result of 'very satisfactory'. The improvements in the delivery of laboratory sessions and on-line quizzes were the main contributors for the increase in the module satisfaction. This factor is reflected in the module survey results that the average score for the effectiveness of the virtual learning environment scored 4.2, compared with 3.25 for the previous academic year. Some of the feedback comments from students are:

- Mix of laboratory session and lecture is good
- Laboratory sessions help you learn what was covered in the lecture
- Regular online tests are useful

Once again there is very positive feedback on the assessment method, the different types of assessments and their regular pattern. This academic year, 94.59% of students completed all elements of the coursework, indicating that this approach increased the students' participation in the module. The average coursework mark achieved was 71%, a 3% increase compared with the previous year's result.

Conclusions

A series of interventions has been introduced to the first year programme over the last two academic years that have significantly improved the experience for students. This is most clearly evidenced through improved scores in student satisfaction surveys. However, improved satisfaction has not automatically led to significantly better academic performance and there are still challenges in improving the pass rate in formal examinations.

The involvement of personal tutors with the operation of the activity led learning projects has been most beneficial and is an approach that may well have potential for wider application. The more thoughtful selection of technical material and a low intensity approach to assessment has also brought improvements. Further integration is planned between the first year group project module and the professional skills – personal tutorial activity. This should see personal tutors involved with group practical work through the full academic year and the creation of a new 30 credit module. Transferable skills topics like ethics will be introduced at the most opportune time in conjunction with project work. This will assist the programme to transit from a discrete set of study modules towards a more holistic course experience.

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PROBLEM-BASED LEARNING – A WAY TO INCREASE ATTRACTIVENESS OF ENGINEERING STUDIES

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ABSTRACT

This paper will introduce two different case studies showing how Helsinki Metropolia University of Applied Sciences has tried to increase the attractiveness of engineering studies and thus diminish the drop-out rate during undergraduate studies. The motivation for the studies arises from an interest in the education, learning methods, expectations of professional life and appreciation of the meaning and status of being an engineer. As tuition fees are not collected from students they do not self-evidently feel, nor are they treated, like customers. These two examples show how the first year students and the 3rd year students are using problem based learning as a part of their education.

INTRODUCTION

The dropout rate of the students at Metropolia University of Applied Sciences is unnecessarily large and is influenced by many factors. One of the attempts to lower the dropout rate is to try to establish a stronger connection between theory and practice. In this way students may be more motivated even to study the necessary natural science and mathematics, as they understand its importance. Additionally they become 'charmed' by the engineering profession as they notice how exiting challenges can be solved and how important engineering solutions are for the sustainable development of both industry and society. Helsinki Metropolia University of Applied Sciences joined the CDIO (Conceive – Design – Implement – Operate), (Crawley *et al.,* 2007), consortium a couple of years ago. Our adaptation is covering all of our engineering degree programs, (Schrey-Niemenmaa *et al.,* 2010). In implementing this initiative the curricula will include PBL, (Kolmos *et al.,* 2010), learning that is organised around problems, which will be undertaken though projects, at least during the first and third years. The teaching methods of other than project courses should also be active ones and provide students readiness to be actors instead of consumers (Eugéne 2006). Use of integrative and innovative teaching methods is well in line with the global trends of engineering education (Sunthonkanokpong 2011).

The two cases were very different both in their contents and the number of participants. In the first case the PBL methodology was applied to the first year introduction course, which also includes project methodology and in the second case the PBL method was used to replace a traditional lecture course. The planning of the courses was thus done separately. Although in this paper two very different ways of using PBL are introduced, the different theories of PBL are not deeply analysed or considered, as this article is concentrating on the practical experiences and outcomes of these case studies towards the attractiveness of engineering education.

In our experiment the drop our rate of these courses was very low, but only later will it be seen whether this leads to higher number of graduates.

Case 1: Introductory project course the bachelor programme for electrical engineering in the 1ST year

This was an introductory course for 1st year students of electrical engineering. The course was held first time during the spring 2011.There were 94 students' registered on the course. The students were divided into 3 groups according to their background and main subject (electronics or power engineering). The aim of the course was to give students an understanding of the basic elements of electrical engineering, hands on experience of how to get something done and learn how to report the whole process; progress as well as results. The course, which had 72 contact hours per group, was assessed as being of 6 ECTS. In each contact hour at least two teachers were available. All the groups were divided in teams of 3 to 4 students.

The background of the students was varied; some of them had graduated from the secondary high with long courses of mathematics, whereas others had taken only shorter courses in mathematics. Additionally there were students who had entered university via the professional route, i.e. through the school for technicians. That last group had studied previously very little mathematics, but had quite a good understanding about the work of an engineer.

The structure of the course

In the beginning of the course there was a lecture concerning engineering as a profession (what kind of jobs are typical and what kind of skills and competences should be mastered by the time of graduation), sustainable development, ethics and responsibility for continuous self-improvement.

From the very beginning of the course each team started to create a 'learning diary' - and they were taught how that should be developed into the project report during the course. Each week teams were able to submit a new version of their diary, although the diaries were evaluated for the first time only two weeks prior to the end of the course. In that evaluation teams were told what they should do to reach the grade for which they aimed in the final report.

At the beginning of the course teams went through 10 laboratory exercises just to get used to the technologies used in the project work. Different teams used very different amounts of time for these exercises, according to their pre-knowledge. Some used only 4 hours, whereas others used up to 25 hours.

After the laboratory exercises teams had to define their own problem for a project – there was a list of possible subjects, but suggestions for their own topics were strongly supported. The idea of the projects was that they should include both the building of a simple electrical structure and the accompanying program to control it. In this way the students were encouraged to understand a basic electrical engineering system.

The course evaluation was completed in three different sections:

1. How challenging was the project work that the team had undertaken, how well had they succeeded in their own aims – how well had they explained the changes to plans as the realities became understood.
2. How good and well-structured was the final report, had the team shown evidence of understanding the meaning of the engineering profession, had they been able to explain clearly the steps they had taken and how constructively critical had they been while evaluating the outcomes of the course. (Also the expectations of their own studies during the coming 3 years had to be included in the report.)
3. How actively had they participated in the different actions of the course, how had the team worked, how capable and active they were they in asking for help when needed? Was the team proactive or just doing what it was told?

The results were surprisingly encouraging – in the beginning the students did not really know each other, and they were confused by the tasks – but in the end they were happy to have done together “the impossible” – solved problems and had “something working”. Good teams and teamwork with different roles were created.

The drop out rate from the course is shown in table 1. In each subgroup there were 2 students who never came to the lecture. When asking them why that was, all of them reported that they had registered by mistake, so this cannot be counted as drop out.

group	registered	did not start	drop out in the middle	passed on time
A electronics mixed	23	2	0	21
B power eng, high school	35	2	5	28
C power eng mixed	29	2	1	26

Table 1 Course drop-out rate by different subgroups.

Interesting is that the group that had the most theoretical background, had the most drop outs – two teams failed. The only one from other groups had personal excuses why he stopped although the team continued and got the highest score as the outcome. The two teams that dropped out had joined the course until they were in the phase of really starting their own project – one explanation could be that in high school they had very little experience on self-regulated teams.

There was only one student who failed although the rest of his team continued. In one other a student case left his team and passed the course by doing his own project

Conclusions

It was found that guided, clearly structured and controlled, but, from the content perspective, a freely chosen problem based learning course, works well for these first year students. The evaluation criteria should be clear and guidance continuously available. This kind of course helped the students to strengthen their weak areas and showed the benefits of those with prior learning. All the students seemed to have understood that there are several parts to engineering systems: for example the mechanical structure, the power supply for it, the information supply for it and the programming to make the system work; An individual engineer might need to master just one part of this as her/his job, but learnt to understand that all the parts needed to be there.

By asking about the development of motivation during the course the students that had passed it unanimously reported that it really opened-up their thoughts and improved their motivation towards engineering education and profession. The ones who dropped out were very mixed on their motivation, wondering why should a power engineer need electronics and control system knowledge.

Case 2: Planning of coatings for constructions, a 3RD year course

An application of PBL was planned for third year students to develop their problem solving skills. The students will have a CDIO project during this following period. Another aim is to develop the teaching methods of materials and coating technology in the engineering programme.

A course that deals with building site practices of coating work was chosen as a pilot. Ten students were participating in this course. The five credit course addressed site practices from work safety issues to engineering methods, scheduling and calculation of costs. The first half of the course was carried out with traditional methods, i.e. lectures and an exam. The

PBL method was applied to the second half of the course, which deals with technical plans of interior and exterior coatings for buildings and responses to the call for tenders, by planning resources, calculating costs and making schedules.

Method

The introduction of the objectives, contents, methods, and evaluation was presented for the students using a mind-map, see Fig. 1. Also a brief description of the PBL method was presented as it was new for the students. The application was done using three different problems areas i.e. building projects. The principal variation factor between the different problems was the size of a building project. The instructor's intention was to make tasks from the easy to more difficult ones by adopting small projects that would be easier than larger ones.

The first project was to plan and calculate the interior coatings for a small school building. A layout of the school was given to students as initial data. The school was an existing one and some additional information could also be found through internet. The task included all different areas of the latter part of the course i.e. making a request to bid and answering it by resource planning, cost calculation, scheduling and finally making a formal tender.

The second project was to undertake similar work for the exterior coatings of the same building. Students were given the façade drawings as a starting point.

The third project was to prepare a tender according to a real request to bid for interior coatings for a four floor block of flats. The starting information package included drawings, coatings plans made by an architect's office and an invitation to tender.

The course arrangements included seven meetings. During these meetings students were introduced to the problems, and then used PBL methods to solve them. Between the meetings students continued to prepare the work, which they then presented during the following meeting.

Learning diaries, group discussion and a course feedback questionnaire were used to make an evaluation of the results.

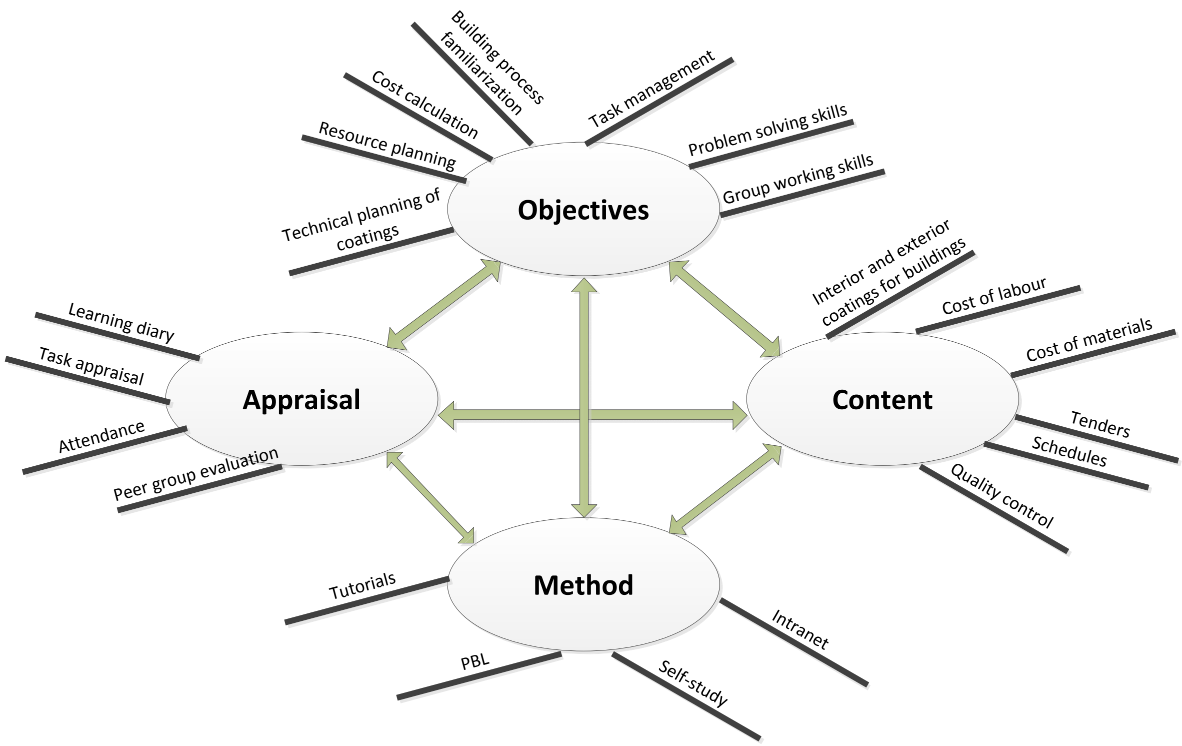

Fig. 1. The introduction to the course

Results and discussion

The two groups selected a different approach to work between meetings: one group selected to have face-to-face meetings in the premises of the school and another to keep contact through Google Docs. Both groups made progress quite well, although the latter group suffered a little bit more from absences. However, they reported that without network surroundings they wouldn't have made any progress.

Both groups appeared to have been confused about the method at the start of the first task. It was recognized that the groups did not follow the methodology to solve the problem, but jumped directly to sketch their solution for the problem. The reason may be that the students already had good background information on the theme, based on the lecture section. The problems were also more or less straightforward. During the course the use of the method was enhanced by writing the steps on blackboard and indicating when each step should have been applied. Even that didn't help greatly, with the conclusion that the PBL method in this context was not the best problem solving tool.

However, the method helped with the discovery of practical tools i.e. work and cost calculation tables and information about material and labour input amount and costs. The information about sources was effectively spread among students thanks to the method.

Learning diaries revealed that the size of the building project was not actually the determining factor in the level of difficulty, but rather the number of tasks to be done. When a construction process was simulated and students were asked to form a bid, which they found difficult, although the project was small-sized. One possible reason may be that there were too many degrees of freedom at that point. However, this is where the problem solving method was required most.

According to the learning diaries and the course feedback questionnaire the students were very satisfied with the method and course arrangements. Although no statistical relevant result of measurements can be presented, due to the small number of answers (<10), the mean overall satisfaction number was 4.7 out of maximum five, these results being in line with some other case studies (Harris et. al 2008). Every student was very satisfied with the PBL method. They felt that the method was excellent to support their learning and wished to have it applied on other courses as well.

The first task took about two meetings before it was completely solved. The second, with comparable contents, took only one PBL cycle to be finished, as well as did the last, a more arduous task. Clear development was noticeable as students became more experienced with the working method. From previous experience it can be said that tasks this large would not have been ready at the end of the course with conventional teaching methods. Some of this can be explained by the time that the method allowed the students to use during the course, but it seems that it is more efficient than the traditional lecture course. The result is consistent with the work of Eugéne (Eugéne 2006). Another notable matter is that much less absence was recorded, compared to a traditional lecture course. The pass rate will be also higher, which is consistent with the results of Ruiz-Gallardo et. al. (Ruiz-Gallardo et. al. 2011). Thus it can be stated that the PBL method proved more effective at delivering learning results than a traditional lecture method would have done.

Conclusions

According to their learning diaries every student was very satisfied with the PBL method. As one student stated, “learning happened as if by itself.” They were at first a little confused about what to do, but after a while they found out that they learnt by solving tasks and also learnt from processing problems as a group. Compared to the traditional way where students would have solved problems on their own, the work as a group proved to be more effective. Thus the students were able to undertake larger tasks at the given time and in this way were able to have a better picture of the overall planning process.

Based on these experiences the method could be applied to the whole course at the next iteration. The problem setting could be a slightly different one, for example using trigger stories to start the subject matter. The order of tasks could also be a different one, not considering the size of the project as a level of difficulty. Regrouping the curriculum of interior and exterior coating courses should also be considered.

Reflections

These two cases were very different from each other, but were aiming at the same result, keeping the students involved and avoiding drop outs. In the first year mass-course the drop out was about 7% and the small 3^{rd} year course 0%. In the 3^{rd} year course the teacher could know and follow each of the students, and also the students knew already more about problem solving, knowledge searching and doing projects. Nobody registered to the course just by mistake. From both of these cases the clear outcome was that doing by themselves is motivating, encouraging and fun. The joy of learning seems to be a key element in the continuous development for both the students and the teachers. Still within Finnish culture there remains a residual emphasise encapsulated in the saying “life is hard and then you die”. How can we change that? How can the learning experiences become so full of fun that people want to learn more and more all the time? How can we develop our own university so that all students and staff feel like staying in a learning society, a learning organisation?

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A COMPARISON STUDY OF PROJECT-BASED-LEARING IN UPPER-DIVISION ENGINEERING EDUCATION

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ABSTRACT

A new model for engineering education was launched in January 2010 in northeastern Minnesota. The Iron Range Engineering (IRE) model is a project-based-learning (PBL) methodology that focuses on producing graduates with integrated technical and professional knowledge and competencies. A unique and important element of the IRE model has 100% of IRE student learning taking place in the context of industry projects. Students at IRE are upper-division engineering students who transferred from Minnesota community college lower-division engineering programs. To understand the impact that IRE methodology may have on preparing engineers with the competencies needed for the future workplace, a comparison study has been developed to investigate the extent to which students in integrated applied models are affected. The curriculum model and comparison study are described within this paper, along with preliminary results on student development and engagement.

INTRODUCTION

The Iron Range Engineering (IRE) program and this project are a collaborative effort between Itasca Community College and Minnesota State University, Mankato (MSU). The investigators are evaluating the effects of project-based-learning (PBL) in engineering education. The evaluation is approached from four different perspectives: the cognitive development of the student, the technical competency of the student, the professional competency of the student, and the motivation of students to learn.

The study focuses on the IRE students enrolled in the newly established Iron Range Engineering program in northeastern Minnesota. This program is a project-based-learning model in which students work with industry on design projects while developing integrated technical and professional knowledge and competencies. Students typically begin their education at one of Minnesota's community colleges for introductory engineering, math, and science courses and then continue their studies at IRE for the final four semesters of the students' upper-division engineering education. In the IRE program, students do not take classes. Instead, they spend their upper-division years working on industry-driven projects and obtaining core engineering knowledge through a guided independent study model. Graduates earn a bachelors degree in general engineering with an emphasis in mechanical, electrical, chemical, or biomedical engineering based on their project focuses and interests. The first cohort of 13 IRE students will graduate in December 2011, 9 more will graduate in Spring 2012, and the third cohort of 23 students began the curriculum in August 2011. Given the preliminary success of the first students, the developers, industry partners, faculty, students, and academic advisory board of the IRE program believe this new teaching and learning design is revolutionary for engineering education in the United States.

This paper describes the background information supporting the model, the IRE approach, the assessment strategy, and preliminary results addressing cognitive development and student engagement. The investigators on this project have developed a strategy that uses a wide variety of proven tools to gauge the extent of student development of knowledge and competencies. The results of this study will provide useful evidence to engineering programs wishing to establish project-based-learning cohorts and to engineering programs that have strong industry-based contextual co-op or internship emphases. In addition, the study will lend information regarding "best practices" to academia in general, supporting the notion of learning engineering design and practice in a contextual environment.

Supporting background

The calls for a new model of engineering education and the evidence for its need are extensive. These calls for a new engineer have come from a wide variety of sources, such as: The National Academies of Engineering (NAE) in "The Engineer of 2020":

> *'It is our aspiration that engineering educators and practicing engineers together undertake a proactive effort to prepare engineering education to address the technology and societal challenges and opportunities of the future. With appropriate thought and consideration, and using new strategic planning tools, we should reconstitute engineering curricula and related educational programs to prepare today's engineers for the careers of the future, with due recognition of the rapid pace of change in the world and its intrinsic lack of predictability'* (NAE, 2004, p. 51).

Leaders in engineering education through American Society for Engineering Education (ASEE) Journal of Engineering Education (JEE) articles, for example:

> *'In view of the broadening and rapidly shifting scope of the engineering profession, it is imperative to shift the focus of engineering curricula from transmission of content to development of skills that support engineering thinking and professional judgment. Future engineers will need to adapt to rapidly changing work environments and technology, direct their own learning, broaden an understanding of impact, work across different perspectives, and continually revisit what it means to be an engineer. Traditional approaches to engineering education (chalk-and-talk lectures, individual homework, three years of "fundamentals" before an introduction to engineering practice) is incompatible with what we know from decades of cognitive and classroom research*' (Adams and Felder, 2008).

The need for change is not new and should be considered part of the continuum of change our society is going through. The same need existed in the middle of the 20th century in the United States as summarized in "Educating the Engineer of 2020" (NAE, 2005):

> *'Some 50 years ago, such debate led to the introduction of the engineering science model of engineering education. It produced engineers who "practiced" differently, and that led to many new products and technologies that were developed more*

rapidly and were of higher quality than those developed by the semi-empirical methods that were then the norm for engineering practice. Today, the practice of engineering needs to change further because of demands for technologies and products that exceed existing knowledge bases and because of the changing professional environment in which engineers need to operate' (NAE, 2005, p. 13).

The same sources that have called for a change in engineering education have also given directions for this change. The student-driven IRE model focusing on the development of technical and professional knowledge and competencies in the context of industry sponsored project-based learning is one response. The call for engineering education to be driven by empowered students in their development of competencies is summarized in the National Science Board's report "Moving Forward to Improve Engineering Education". This report suggests that the best approaches to engineering education are "Using student involvement in the design of the curriculum" (NSB, 2007, p. 15). In addition, "Educating the Engineer of 2020" focuses on the need for a focus on students in curriculum development:

'Pursue student-centered education - One should address how students learn as well as what they learn in order to ensure that student learning outcomes focus on the performance characteristics needed in future engineers. Two major tasks define this focus: (1) better alignment of engineering curricula and the nature of academic experiences with the challenges and opportunities graduates will face in the workplace and (2) better alignment of faculty skill sets with those needed to deliver the desired curriculum in light of the different learning styles of students.' (NAE, 2005, p. 24)

The iron range engineering education model

The IRE model in the United States addresses the calls for change in engineering education. The primary emphasis is on the development of learning outcomes, contrasted with primary emphasis on coverage of topical material that characterizes many of the engineering programs throughout the world.The learning in the IRE model is 100% project based and is targeted at the development of a technically sound, highly professional graduate who possesses high levels of problem solving ability and has experience in engineering design. In an adaptation of the Aalborg Model of PBL (Figure 1), IRE students combine learning of technical information and professional development with the execution of engineering design projects.A guiding principle for the IRE model is that, throughout the projects, students own the responsibility for their learning through the projects while obtaining the technical and professional knowledge and competencies which have been defined for the program.

Project Cycle

The core of the IRE model is the learning that takes place around engineering design projects. At the beginning or "proposal stage" of each project cycle, students, in collaboration with faculty and clients, develop two plans: a design "work plan" which details the entire execution of the deliverable to the client; and a "learning plan" which addresses professional learning objectives, technical learning objectives, and the learning modes that will be employed to meet the objectives (self-directed learning, peer-directed learning, faculty-directed learning, and external expert-directed learning as well as methods for formative assessment and reflection). Students execute one to two project cycles per semester.

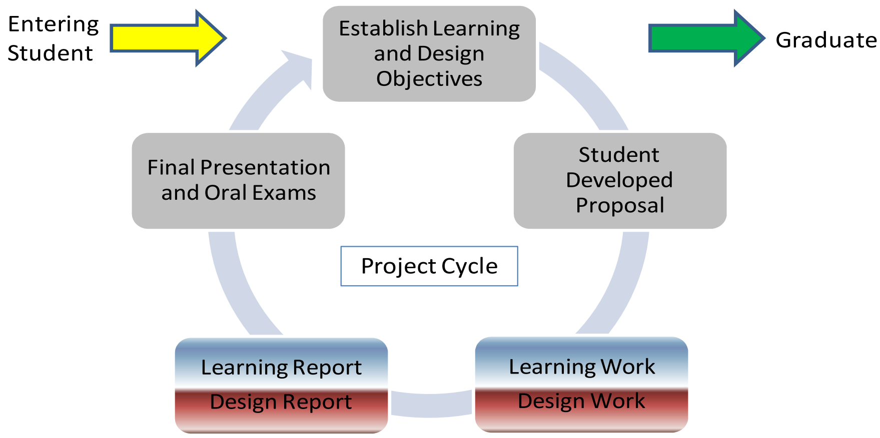

Figure 1. Iron Range Engineering Program Model of PBL: Adapted from the Aalborg Model of PBL (Kolmos, 2004).

Each cycle concludes with the presentation of two reports: a design report for the deliverable and a learning report that reflects the learning process and provides evidence of outcome attainment. In addition to written reports, a student presentation is made to faculty and external clients. The final presentation includes an extensive oral exam in which students show their understanding of technical engineering knowledge and the competencies acquired. At the conclusion of each project cycle, students have a new view of their levels of knowledge and competencies.

Technical Competencies

For each technical competency, assessment is done on a continuum, from novice to expert, using Bloom's modified taxonomy (Krathwohl, 2002). During the student's first semester, her individual starting point is established through working with faculty. In this way, the IRE model recognizes each student's different starting points and empowers all students to build on their strengths and overcome their weaknesses as they navigate their education. Each semester students achieve eight technical competencies. For core competencies (eightmechanical and eight electrical), there is a fixed syllabus. For advanced competencies, students work with faculty to develop a personalized syllabus. In all cases, a technical competency consists of the development of knowledge through deep learning activities (Litzinger, 2011). Upon starting a project and meeting with industry clients, students identify which core and elective competencies best meet their individual and project needs. Some technical competencies are learned early in the semester as necessary background knowledge. Others naturally develop during project execution and are learned later in the semester.To graduate, studentsmust attain "work ready" competency in core and advanced competencies.

Throughout the learning process, students have multiple interactions with faculty, learn through self-study and in peer groups, and tie their learning to their projects. Students regulate their learning through organization of new knowledge, evaluation of quality of learning, and making in-progress changes to learning based on those evaluations. Each week, students meet with faculty in a "Learning Review" to discuss progress, impediments and plans for learning in the upcoming week. Students take oral and written exams, and provide evidence of deep learning for each competency. Students complete course and graduation requirements by exceeding or meeting levels of competencies based on clearly articulated outcomes.

Professional Competencies

At the beginning of the IRE experience, students also identify all of the professional competencies or attributes that are expected of them by graduation. Working with faculty, they gauge their baseline in each attribute. Each semester, faculty provide learning activities in leadership, learning about learning, team work, communication, personal responsibility, professional responsibility and the entire spectrum of executing the design process. Through reflection, personnel evaluation by project mentors, client feedback, peer feedback, and faculty evaluation, students track their advancement towards their graduation goals. At the end of each semester, students write improvement plans for the next semester including specific activities aimed at enhancing their performance.

Through PBL, industry interactions, and significant metacognitive activity, students develop advanced problem solving skills, deep technical knowledge in the fundamentals of engineering, advanced knowledge in selected disciplines, and a well developed set of professional skills such as writing, speaking, project management, leadership, conflict management, and ethical decision making. The expectation is that these experiences will lead IRE graduates to meet the ABET a-k student outcomes (ABET, 2009) at levels much higher than in traditional US programs.

Comparison study

The purpose of the evaluation is to determine how effective the project-based IRE learning model is at meeting the call to develop a technically competent, professionally competent, and learned engineer in comparison to a traditional engineering education model. If successful, a cohort-based approach to the IRE model could be readily incorporated into other university departments and/or co-op and internship programs in the United States. The IRE faculty recognizes that curriculum-wide PBL is more common in Europe and other parts of the world.

Study Goals and Expected Outcomes

Several goals and outcomes have been established to evaluate the effectiveness of the IRE model as compared to traditional engineering education:

Goal 1: Evaluate cognitive development of students in:

a) evaluate changes in learners' perceptions of their skills and attitudes with respect to self-directedness in their learning.

b) determine changes in the relationships between learners' study processes and the structural complexity of their learning.

c) assess changes in learners' motivational orientations and use of different learning strategies.

d) track changes in learners' cognitive and affective perspectives.

Goal 2: Evaluate ability of engineering learners to acquire technical knowledge through PBL:

a) evaluate changes in learners' abilities to develop conceptual knowledge using concept inventories.

b) investigate changes in learners' abilities to acquire technical knowledge using oral examinations and Bloom's 2-D taxonomy.

c) apply portfolio assessment to qualify student acquisition of technical knowledge as they learn.

d) assess student achievement and learning in areas of design processes, and solution assets (intermediate and final design products) to quantify knowledge acquisition.

Goal 3: Evaluate ability of engineering learners to acquire professional competencies:

a) assess student achievement and learning in areas that include teamwork and professional development to quantify professional competency acquisition.

b) qualify satisfaction of industry with respect to abilities of students' and graduates' to demonstrate desired professional attributes.

c) apply portfolio assessment to qualify student acquisition of professional competencies.

Goal 4: Study impact of PBL environment on student interest-level and motivation to learn:

a) quantify changes in student engagement as they learn.

b) assess changes in learners' motivational orientations.

c) track student interest level and attitudes through learning sequence.

Study Approach

A combined case and comparison study approach is being used toinvestigatethe cognitive development of the student, the technical competency of the student, the professional competency of the student, and the motivation of students to learn. The study will involve three groups, each with cohorts for the next three years as shown in Table 1. The project began in full in Fall 2011 with Cohort B being the students who entered in August 2011. Cohort A is composed of students who began before August 2011. Limited research is being done with Cohort A. The preliminary results described in this paper are for Cohort A.

	Brief Description	Year 0	Year 1	Year 2	Year 3
Iron Range Engineering PBL group (IRE group)	Juniors and Seniors at IRE who have transferred from	Cohort A	Cohort B	Cohort C	Cohort D

	other institutions; majority from ICC				
Minnesota State University, Mankato comparison group (MSU group)	Juniors and Seniors at MSU; majority started at MSU as Freshmen		Cohort B	Cohort C	Cohort D
Itasca Community College (ICC) graduate/transfer student comparison group (ICC group)	Juniors and Seniors at various regional institutions who completed first two years at ICC		Cohort B	Cohort C	Cohort D

Table 1. Group and Cohort Descriptions.

The IRE group will be the focus of the case study while the MSU group and ICC group will be used for the comparison study. Each cohort is a class of students who will begin their program with the same expected time to graduation.In years 1-3, each cohort will be assessed pre-intervention, during intervention and post intervention.

Data collection will begin with a baseline study of each of the groups at the beginning of their junior year (pre-intervention) and then continue with multiple day workshops held each spring at the end of the academic year. The tools being used bridge the spectrum of the goals of the project and are described next. In order to establish rigor and credibility for the study, parameters such as triangulation of data sources and multiple researcher analysis will be employed as described by Darke, et al. (1998).

Research Instruments:

Self Directed Learning Readiness Scale (SDLRS) is a method for evaluating an individual's perception of their skills and attitudes that are associated with self-directedness in learning (Guglielmino, 1977).

Study Process Questionnaire (SPQ) determines the relationship between students' study processes and the structural complexity of their learning (Biggs, 1978, 1987).

Motivated Strategies for Learning Questionnaire (MSLQ)assesses college students' motivational orientations and their use of different learning strategies (Pintrich, 1991).

Transferable Integrated Design Engineering Education (TIDEE) consortium developed an integrated system (IDEALS) for assessing outcomes related to students' personal capacity, teamwork, design processes, and solution assets (Davis, 1999).

ABET Outcome Portfolio Analysis (PORT)was developed by faculty at Itasca Community College for a structured review of student attainment of ABET criteria based on articles of evidence for demonstrating competency in each criterion.

Concept Inventories (CI) are multiple choice instruments narrowly focused on learner understanding of essential conceptual knowledge (Reed-Rhoads &Imbrie, 2008).

Full Length Practice Fundamentals of Engineering Exam (FE): Practice exams from Professional Publication Inc. (PPI) will be used as part of a mock FE exam to assess student attainment of technical knowledge.

Preliminary results

Preliminary evaluation of the model using Cohort A has focused on goals 1 & 4 for the IRE group using the SDLRS, MSLQ, and SPQ evaluation tools.Results are shown in Table 2.

		SDLRS		MSLQ		RSPQ			
						Year 1		Year 2	
Cohort	Cohort Starting Date:	1st Year Data	2nd Year Data	Motivational Beliefs	Self-Regulated Learning	Deep Approach	Surface Approach	Deep Approach	Surface Approach
Generation 1	Fall 2009	206	218	4.8	4.4	29	23	34	28
Generation 2	Fall 2010	222	N/A	4.7	4.3	38	22		
Generation 3	Fall 2011	244	N/A						

Table 2. Preliminary Data for Cohorts A and B

The *SDLRS* is a self-report questionnaire with Likert-type items designed to measure the complexity of attitudes, skills, and characteristics that comprise an individual's current level of readiness to manage his or her own learning. The adult average is 214 with 202-226 for an average range and 227-290 for an above average range. IRE students in generation one started with a below average mean of 206 and have shown an increase in their skills and attitudes that are associated with self-directedness in learning to 218 in year two.Generation one is still in the average range, but as a group is above the adult average. Interestingly, as the IRE learning model, student learning goals, and outcome expectations have become more clearly defined through program assessment and modification, each of the following generations of students show an increase in their skills and attitudes associated with self-directedness in learning.

The generation three group (Cohort B), which is starting this fall, has self-identified in the “above average” range.

The Motivated Strategies and Learning Questionnaire assesses college students’ motivational orientations and their use of different learning strategies. There is no significant difference between generation 1 & 2 students of cohort A in both sections of the questionnaire in their first year in the program. In addition, generation one students had no significant difference in both sections of the questionnaire when reevaluated in their second year. It appears the IRE program has no measurable impact on student motivation orientations or learning strategies.

The Study Process Questionnaire (SPQ) evaluation of the IRE student complexity of learning structure shows similar results to the SDLRS evaluation. As the IRE learning model has developed, it appears that the generation 1 cohort has increased the complexity of its learning structure from year one to two. In addition, the generation 2 cohort has benefited by starting out with a higher level of complexity in the learning structure.

As the IRE model matures, initial results show that students within each generation and from one generation to the next are increasing in their a) identification with self-directed learning and b) motivation towards using deep learning strategies. However, the IRE model does not currently appear to impact students’ motivational orientations and their use of different learning strategies.It will be important to evaluate generation 1 students’ motivational orientations and their use of different learning strategies as they graduate and start their careers.

Future work

Ongoing evaluation of goals 1 & 4 will need to continue in order to monitor the progress of each generation as they move through the program and enter the profession. Further work is needed to collect and compile the data for evaluating goals 2 and 3 and to develop the comparison groups at MSU and ICC. The collection of this data in combination with interviewing program graduates and their employers will provide evidence for the success of the IRE model of engineering education.

Conclusion

According to the literature, there is a need in the United States to change engineering education to meet the changing needs of society and the ever increasing amount of knowledge and technology related to the field. Preliminary findings indicate that the new IRE program may provide insights on best practices in the use of PBL in the United States engineering education system. Initial student results and feedback from program partners and sponsors indicate the potential for this program to serve as an example of how to successfully develop the engineers needed to meet the needs of the 21st century.

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GAMA-PGA: THE BASELINE TO ASSESS PBL PROJEKTS IN BIG GROUPS

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ABSTRACT

Engineering students at North-west University start their training programme with a helicopter view approach of engineering practice. *Professional Practice 1* (PP1) was developed to expose the students to realistic engineering practice parallel to the training in theoretical modules. This 24-credit module affords the students the opportunity to practise the engineering process, already in their first year of study, with a real project developed for a real client with real needs.

This module of training is based on Project-Based Learning (PBL), implemented by several universities around the world as an active learning style of teaching. There are different approaches to PBL globally, and we tried to implement a PBL style to best suit our needs in South African context, and with more than 400 students in the class. Since we only implemented the training programme in its current form in 2010, there is no scientific proof yet what the impact will be on the quality of training in the engineering program, but we hope to equip students to 'take greater responsibility for their own learning, with the benefit that they develop a wider range of transferable skills such as communication skills, teamwork and problem-solving' and to 'develop better reasoning ability and have consistently higher levels of satisfaction (Savin-Baden & Wilkie 2004) (p11).

With this new style of teaching at NWU, we also try to have real projects from industry and the community to find useful applications for the funds and energy spent on the projects. It seems that ECSA also realized the value of this programme, and referred to this new training style as follows:

"The faculty has embraced project-based-learning, and implemented it in a number of places. In particular the first-year course Professional Practice I (FIAP172) and second-year course Professional Practice II (FIAP271) apply the concept in a way previously not thought possible at first-year level." (ECSA visit Leaders Report, May 2011.)

With no exam or tests for PP1, assessment is focussed on progress of the projects in small groups, supervised by tutors, with the application of the engineering process. This ensures that the groups are not assessed on the difficulty of the project, but on the method they followed to solve the problem.

A lot was learnt from international visits, literature and personal experience before this module was designed and implemented in its current form. It is only a starting point for research and change for the future; therefore this paper is only a descriptive approach to initiate debate on this topic. The module is still far from perfect but at least it is the first step to assist students used to surface learning *'to engage in the sort of learning deep learners do spontaneously'* (Biggs and Tang 2007)(p13).

Why this new approach

In our own exposure to active learning we decided to start small, but to have first-hand international experience. After a very small fun project on the North-West University (NWU) campus, we decided to take the winning team to the Netherlands to experience active learning styles at the Technical Universities of Eindhoven (TU/e) and Twente (UT). With collaboration between the NWU, TU/e and UT we draw from the experience from our colleagues in Europe. The following quotation inspired me to design and implement the South African version of PBL as described in this presentation:

In our experience young engineering students fresh from school are curious to solve real problems......... The engineering student wants to learn to think like a professional engineer and behave like an Engineer. Project-Led engineering education brings in an element of realism from the beginning....even on the first day of the engineering degree programme. (Powel & Weenk, 2003)

Other advantages to convert to PBL in certain modules of the programme are the different dimensions of learning as described by Kolmos et al (2008):

Cognitive learning – learning is organized around problems and will be carried out in projects (problem solving strategies)
Contents learning – interdisciplinary learning across traditional subject-related boundaries and methods. Analytical approach as theory is used in the analysis of real life problems.
Collaborative learning – where learning takes place through dialogue and communication. Students are not only learning from each other, but they also learn to share knowledge and organize the process

From many publications on PBL it was clear that the advantages claimed are worth trying out with the new generation. The new generation are equipped with different skills compared so students from the past and if their energy could be directed towards self-directed learning skills, they may surprise the educators.

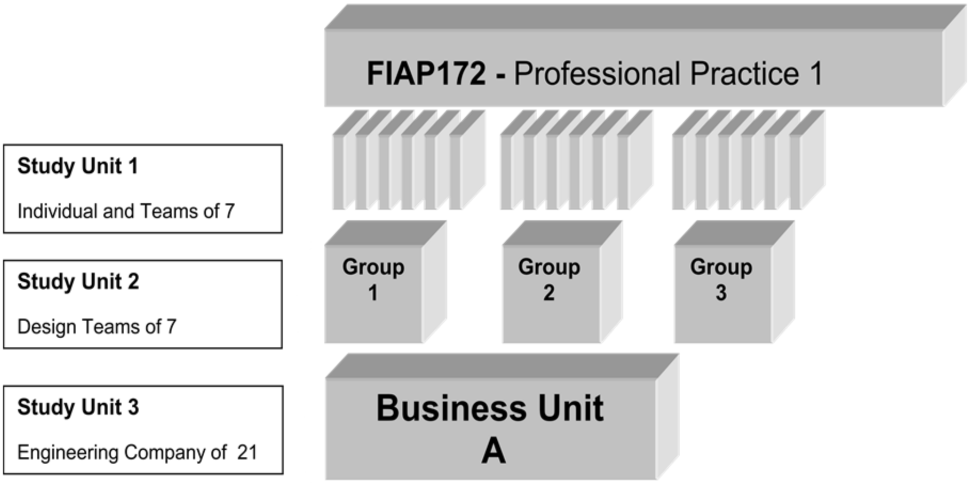
The Professional Practice 1 module, in its current form, was implemented in 2010. A combination of literature reviews, international exposure and teaching experience of more than a decade led to the design of this programme. It was accepted by ECSA (Engineering Council of South Africa) at their accreditation visit earlier this year with great enthusiasm.

Some innovative approaches in developing relevant competencies and skills by the introduction of the Professional Practice Modules by the Faculty have had a positive impact on the students. (ECSA Team Leader – Dr Raymond Els)

Some other comments from the report also indicated that this teaching programme is on the right track.

The team was impressed with the very positive feedback from students, particularly relating to Professional Practice I and II. The format of these courses appears to stimulate enthusiasm for engineering work and inter-active project management.

The Faculty is to be congratulated on the success of the Professional Practice modules (FIAP172 and FIAP271). The teams are multidisciplinary, but their training has not been specialised at this stage of their training. Progress in the assignments is assessed by a combination of reports and interviews.



Structure of Professional Practice 1

Professional Practice 1 (PP1) is the first real engineering contents module for students. They are used to school style teaching and to start the module with an active learning approach will be too much for them to digest.

Figure 1: Group development of Professional Practice 1

The module is divided into three study units, each with a very clear teaching goal:

- **Study Unit 1** meets the learners where they were left by the South African school system. The unit starts with an almost school style teaching method. They start with lectures on the basics of the engineering process and with individual class activities, and class tests. Then they progress towards group activities in class and towards practising the basic skills needed for the rest of the module
- With **Study Unit 2**, groups develop in teams, and with a real community project with a real client they continue with the assistance of tutors, whilst applying what they had learnt in Study Unit 1. The role of the lecturer has changed from teaching to facilitation, and no more formal lectures are presented. With communication on eFundi and regular feedback on "Forums" the learners are informed about their progress, and an

environmental friendly, paperless assignment and assessment system opens the opportunity to run this Study Unit with distant learning clusters.

- With a detail design in hand, **Study Unit 3** has changed to intergroup communication and the practical implementation of the design. Three teams have merged to form an engineering company with Marketing, Configuration control, Manufacturing and Assemble and Test departments. This “company” will independently manage the company towards a final product. The lecturer and tutors continuously observe the progress, assess it and give feedback on it.

Selecting groups and Group dynamics

The students need to experience group dynamics with diversity. With a dominant Afrikaans-speaking student population, it was decided to do a MBTI (Myers-Briggs Type Indicator) on them and to compile groups as diverse as possible from the results. To prevent majority domination in the groups, the English students were put in groups in such a way, that they have a 40% presence in their groups. A limited number of groups had non-Afrikaans presence but all the groups have to do all their documentation in English. Field of study plays no role in the selecting process for setting up the groups. The groups are exposed to group diversity and the challenge is to convert the group to act as a team with common goals.

Documentation and Communication

As prescribed in all PBL training programmes, official meetings take place with an Agenda, Minutes and Action List. Each student gets the opportunity to act as Chairperson, Secretary and Board Writer. These procedures are practised in class first before they start their own meetings under supervision of a tutor. The tutor’s role is to ensure that every meeting is held in a specific manner to embed professional meeting procedures. All meetings are scheduled on GroupWise and the facilitator is also invited.

The facilitator does not have to be at all the meetings, because of the tutor’s presence. The tutors report any difficulties with the group and the facilitator can visit unannounced to observe the quality, or to address problem areas.

Adding to the scheduling are reminders and the Agenda for the next meeting to ensure that the Agenda is available to all who could be present. Agenda, Minutes and Action Lists are also published on e-Fundi to have all progress available on one electronic platform.

Figure 2: Regular small group meetings

Meeting the client

Visits to the client help the student to have a better understanding of the problem. Most students have not had any exposure to a technical environment before. The trip to the client's world gives them that real-life experience they need to focus on the problem. Three teams work in parallel on the same topic before merging to form a business unit to solve the problem.

Figure 3: Determine the client's needs

After the visit to the client, each individual prepares a concept design and does a PowerPoint presentation to the rest of the team. The team ranks the individual ideas and with a brain storm session from there develops a team concept design. A follow-up meeting with the client, together with the other two teams working on the same topic, sets a single possible solution to the problem. The merging of the teams and their ideas ends in a Requirement Specification and all parties – the team, client and facilitator – agree on the end product and the budget available to the business unit.

Operating as a business unit

Once the merged team has decided on a business structure to fit the specific project, they appoint a CEO and HOD’s for all departments. The business unit has the freedom to set its own work schedule, meeting frequency, and deadlines (as agreed with the client and facilitator). They have to do a Work Breakdown Structure and set a Gantt chart to guide them through the project. All meetings have Agendas, Minutes, Action Lists and individual Journals as a documented trace of their progress. All these documents are published on an electronic platform (e-Fundi) and are visible to the tutors and facilitators. Regular peer group assessments reflect individual participation.

The business unit has to do the detail design and the development of a prototype as stated in the Requirement Specification. They have to manage the workload and ensure that each team member is doing his/her part, guided by the Action List. They manage the project as prescribed with a Gantt Chart and official progress meetings. Funds for the project were transferred to the student’s personal bank account that was selected by the group as head of finance. They do their own procurement and organize the manufacturing activities.

Figure 7: Manufacturing and assembling of projects

Parallel to the manufacturing, configuration control ensures that the latest version of design is used for manufacturing and updates the data pack if any changes in the design occur. The Marketing department starts with a marketing campaign for the exhibition day to invite the public to the event. Radio interviews, magazine and newspaper reports, websites and Facebook sites ensure that visitors know what to expect on this day.

The advantage of having different projects is that students can learn from each other. They also make use of the exhibition to visit the other projects to find out what they did and how they solved their problems. On this day they are also exposed to different technical fields to add to their field of experience needed for the modules to come in their senior years.

Figure 9: Project evaluation and exhibition day

Assessment

There are no assessments in the form of traditional exams or tests for this module. We start Study Unit 1 with individual exercises in class immediately after a lecture/DVD/guest speaker from industry to apply what was learnt. This process develops towards group activities; first in class and later in group meetings after class. Group activities are supervised by the lecturer in class, and meetings after class are supervised by undergraduate tutors. In the group meetings the students are afforded the opportunity of becoming familiar with meeting procedures and documentation. Peer Group Assessments are also practised during this study unit.

From the second study unit a double track of assessments are implemented. The first track is called the GAMA-PGA system, where the qualities of the meetings are assessed as well as the quality of the individual inputs to the team's goals. The G represents the Gantt Chart to be used weekly to clarify the strategic goals of the team. The first A represents the Agenda to be prepared for each meeting and the M reminds them of the Minutes of the previous meeting to be available and approved. The Action List spells out in detail what was expected from each team member for this meeting. A Peer Group Assessment confirms the quality of work done by each individual comparing the results with the assignment on the Action List. These results are updated weekly on eFundi and the students can track their results, by comparing with the other group members.

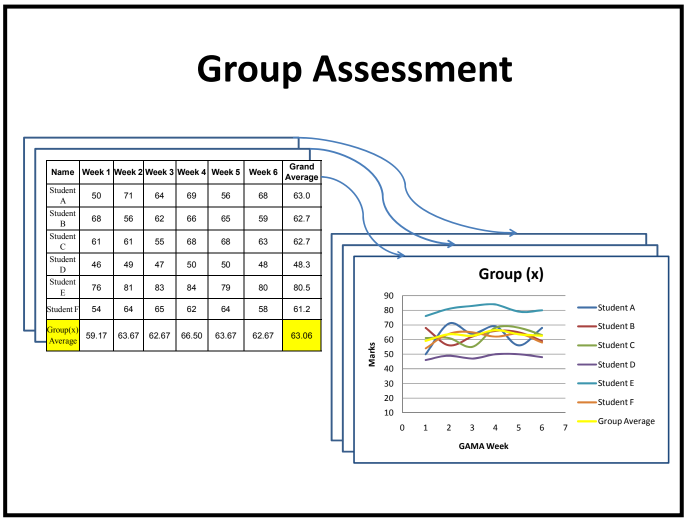


Figure 8: Individual progress with GAMA-PGA

The second track of assessments is the more traditional way. The group's documents are assessed for technical quality and a group mark will be awarded for each document (Requirement Specification, Work Breakdown Structure, Detail Design, Detail Budget, Marketing Plan, etc.)

The final marks are calculated for each student as follows:

(Average of group assignments) X (Relative proportion of GAMA-PGA) = Final mark

The focus of the assessment process is clearly on the student's ability to be constantly working through the engineering process to reach the goals of the project. The difficulty of the project does not influence the assessment process. A student can even pass or fail independently of the successful delivery of a working prototype.

In Study Unit 3 the complexity of the roll of each student in the group increases in such a way that you need to have all activities on one page, showing each individual's role in the group, and the PGA grading for each activity involved.

Names of Team Members	Activity 1: Documentation	Activity 2: Detail Design	Activity 3: Finding a work site	Activity 4: CEO report Preparation	Activity 5: Finding Sponsorships	Activity 6: Manufacturing of frame	Activity 7: e-Fundi site Maintenance	Calculated Average	Comments	Correction	Final PGA
Alberts, Johan	80			80		20	90	67.5	Johan did extremely well with the documentation control and e-Fundi site is perfect thanks to him, although he did not spend much time at manufacturing comparing	22.50	**90**
Botha, Tertius		70		80				75	Tertius was assigned by the team to take control of Detail Design, and was released from all other duties to focus on that. At the end George had to save the process, taking charge. Then Tertius worked under guidence of George, but still did not join other activities in the group	-15.00	**60**
Combrinck, Lida				80		80		80	Lida did well with the assigned tasks in the team. Calculated mark reflects her contribution to the team's effort	0.00	**80**
Dumini, George		95		80		80		85	George did more than expected from him because he saved the project, taking charge when Tertius did not perform as expected. He show care to ensure the project is successful. He deserve a bonus for this Milestone.	15.00	**100**
Everson, Letitia			30	80	20	90		55	Letitia did more than her part with manufacturing, but let the team down finding sponsors and a worksite, as aggreed with the team. She spend her energy on things that the team could do, but the more important tasks, with more effect on the team's performance was not done. Her Calculated average reflects het total contribution to the team.	0.00	**55**
Fourie, Duwan				80		0		40	Helping the CEO with his report was expected from everyone, and was not a time consuming task. Duwan did not turn up at all for the manufacturing and let the team down with this important, time consuming, activity. His calculated mark does not reflect his contribution to the team, and a penalty is	-20.00	**20**
Gouws, Johan		80		80		20		60	The aggreement with the team was that Johan must be part of the manufacturing, but he helped George fixing the damage created by Tertius, and spend at the end more hours on Design, that was expected from him in manufacturing. He also tried to be also at manufacturing, but could not proceed with both efforts. He deserves a bonus for care for	20.00	**80**

Figure 9: Individual progress in multi-task projects

For activities not involved, the student gets no mark, but when he did not show up for an activity where he was supposed to be involved, he gets 0. Averages are calculated for all his activities. A higher level of assessment is needed to adjust this mark to a sensible PGA-value. Comments are added to the table to put each student's contribution into perspective and a correction factor is added to the mark to ensure that the PGA-value is a real reflection of that individual's contribution to the activity.

In Study Unit 3 progress reports for each milestone generates a GAMA mark for the group. The PGA as discussed above ensures that each student gets the portion of the group mark they deserve.

From interviews with students it was clear that there is another action needed to adjust the final mark with a reflection on performance exercise. An overall performance assessment sheet was completed by each individual in the group.

Group O Performance assessment

Perception of: Madelein Grobler (22824995)

Student No	Small Group	Project Team	Name	Ranking	Comment
22754466	44	O	BECKER JJ MNR	?	Have met him but he is not on my marketing team
22700897	16	O	BEZUIDENHOUT J MNR	?	Have met him but he is not on my marketing team
22744169	16	O	BOTES WJ MNR	+	I am not sure of his contributions but he is willing to work
22747400	18	O	ENGELBRECHT A MEJ	?	I do not know of any of her contributions
22822135	16	O	FUCHS E MNR	??	Don't know this person
22856897	16	O	GOUWS AB MNR	?	This person is not on my marketing team
22106715	18	O	GOUWS LA MNR	?	He is not on my team but I know he can work hard
22743324	16	O	GREYLING WV MNR	+	In meetings he seems to know what he is doing but I don't know him personally
22824995	18	O	GROBLER M MEJ		That's me
22838929	16	O	JANSE VAN RENSBURG J MNR	+	
22772154	18	O	LIEBENBERG FJ MNR	--	He does not show any interest in the group, he never attends meetings
22952799	44	O	PEENS GJJ MNR	-	He can do more for the group
22155066	18	O	POTGIETER M MNR	?	I am not sure of his contributions but he is always willing to work
22116192	44	O	RIEKERT AH MNR	0	His attitude is a bother
22225374	44	O	SMIT NJ MNR	??	Don't know this person
22794905	16	O	SMITH A MEJ	-	Refer to atteached progress report
22654542	44	O	SMITH A MNR	??	Don't know this person
22687505	18	O	SWART DD MNR	--	He does not show any interest in the group, he never attends meetings
22805516	44	O	VAN DER MERWE SAP MNR	??	Don't know this person
22223037	44	O	VAN NIEKERK CGJ MNR	??	Don't know this person
22771948	18	O	ZAAYMAN M MEJ	-	She has not shown any progress

Figure 9: Performance assessment in groups

With the results from reflections of the students on the performance of their group members, it was possible to compile a very clear profile of the performance of each. These results were compared with the Milestone PGA's and a correction factor is added to the final marks to ensure each student gets the mark they deserve.

The results are not available yet with the writing of this paper, but it will be available on the conference and will be added to the presentation.

Conclusion

The aim of teaching Professional Practice 1 is to give the students real practice experience, even before they start with the basic principles of their engineering modules. With this helicopter view on the engineering process; with their experience in documentation quality and control; their exposure to group dynamics and conflict management; and their ability to plan ahead, we believe students are now equipped to cope better with the rest of the engineering programme.

The first students who did this new style of training are now only in their second year of study. The programme is still far from perfect and research to come will clarify the advantage of practice training for students at entry level. An interesting observation in the senior groups, but not scientifically confirmed yet, already shows that students who act as tutors for PP1 clearly stand out in the class. Quality of meetings, quality of documentation and posters, level of group meetings and project planning, peer assessments and conflict management, are clearly on a higher level. If the indirect effects in the faculty are already clearly visible, I can imagine what we will find in two years' time, when the first group of students reach their final year of study.

I hope that my contribution can help other facilitators with large number of students. To assess 30 or less students are well documented. To ensure that each student are assessed in class sizes of 400 students and more in a PBL training system is a real challenge.

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REVIEWING AND EVALUATIN CDIO [CONCEIVE, DESIGN, IMPLEMENT, OPERATE]: AN EMPIRICAL APPROACH TO ENGINEERING EDUCATION CURRICULUM DEVELOPMENT

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ABSTRACT

This paper draws upon research conducted at Aston University which critically evaluated the issues surrounding the introduction of CDIO across the first year undergraduate curriculum in Mechanical Engineering and Design. From the induction of the programme, engineering education researchers 'shadowed' the staff responsible for developing and introducing the new curriculum. Utilising an Action Research Design, and adopting mixed methodological research techniques, the researchers worked closely with the teaching team, critically reflecting upon the issues arising in introducing CDIO into the curriculum. Drawing upon the emergent findings of the study, the paper discusses how Problem-Based Learning, in the shape of CDIO, can offer a viable alternative to traditional engineering education. In doing it adds to current debates in this area by showing how an approach based upon PBL not only enriches students' learning experiences, but also challenges those responsible for programme planning and delivery.

INTRODUCTION

Engineering has recently received much public attention with events such as the Mexican Gulf Oil Spillage and the Japanese Earthquake receiving worldwide press coverage, whilst other more longstanding problems associated with sustainability, pollution and global warming have long been on the public agenda. Based on the premise that by acting to shape the world in a manner that benefits humanity (RA.Eng, 2010), engineering provides an integral link between society and science. Key to this link is engineering education, which in providing the vehicle that society uses to attract, recruit, train and professionally develop engineers at all levels, has a vital role to play. This role is both in the future sustainability of the profession and also in the future prosperity of our society. Yet, whilst engineers are increasingly called upon to solve some of the world's most complex problems, it is ironic that in the UK in particular, the profession is experiencing significant difficulties in attract new recruits. Although there can be no doubt that engineering offers an exciting and viable career, the question of how to convince young people of this, and in doing so increase the numbers of future engineers enrolling on university programmes, is something that both engineering education and the profession have yet to address (IMechE, 2009; Spinks et. al, 2006).

The need to equip students with a broad range of technical skills, competencies and abilities, whilst providing them with a broad theoretical grounding, and preparing them for the workplace, means that university level engineering education is in facing something of a trichotomous split (Lucena et al, 2008). To make matters worse, in the complex learning environment that is today's Higher Education Sector, many engineering programmes find themselves having to deal with high levels of student attrition (DIUS, 2008; NSF, 2009). Furthermore, complicated by difficulties in recruiting new students onto programmes, problems indicative of high student 'drop-out' rates are augmented by public perceptions of the profession as being one in which inequalities in gender, social class, and ethnicity are the norm (Gill et al, 2008; NSF, 2009). Indeed, it may be argued that commonly held stereotypes of what 'an engineer' is [a white, middle-class, middle aged, male] do little to help recruitment into the profession. This means that many 'potential future engineers' do not even begin to consider engineering as a career choice. Added to this is the fact the traditional pre-requisite subjects of physics, maths and chemistry are generally not favoured by today's generation of 16-18 year olds (Jones et al, 2000; Dickens & Arlett, 2009) who find them overly demanding and difficult.

If current trends of low recruitment into the profession, and high attrition rates on engineering education programmes, continue then the outlook for engineering and engineering education over the next two to three decades appears to be increasingly bleak. It is clear therefore, that as a discipline, engineering and engineering education need to work together to redress the balance. Failure to do could mean that in the relatively near future, the UK will face unprecedented shortages of engineers (IMechE, 2009; Spinks et. el, 2006) and engineering education in the UK could find itself struggling to survive. This could have devastating effects for UK society as a whole.

CDIO: A solution to issues in engineering education?

Like the rest of the UK Higher Education Sector, engineering education is facing unprecedented changes to the way it is financed with the coalition government drastically cutting funding to all universities and colleges. Furthermore, government and industry expectations that Higher Education will 'produce' large numbers of work-ready, flexible and highly qualified graduates means that all educators are increasingly finding themselves having to 'produce more with less'. Contextualised by this highly pressured financial environment, Aston University School of Engineering and Applied Science decided to radically change its pedagogical approach to engineering education – introducing CDIO (Crawley, 2002), across the first year curriculum for all Mechanical Engineering and Design students in 2010-2011.

Identified as '*an innovative framework for producing the next generation of engineers'* the founding principles of CDIO are such that it encapsulates '... *a commonly shared premise that engineering graduates should be able to: Conceive – Design – Implement – Operate complex value-added engineering systems in a modern team based engineering environment to create systems and products'* (CDIO, 2011). With regards to Aston University, CDIO enables the teaching staff to engage the students through providing a practically relevant and academically grounded learning experience. The University website provides students with the rationale for teaching with the CDIO approach ... *"... the essence of you becoming an engineer or designer is not only dependent on you developing technical knowledge but also being able to combine this with practical engineering skills, social awareness, team and* *project management abilities, and competencies in many other fields to solve engineering problems"* (Aston University, SEAS, 2011).

The Aston University approach to CDIO was purposefully developed to take account of students' learning needs in a manner that both meets industrial expectations whilst capturing the high levels of theoretical and practical knowledge expected of a contemporary university level engineering programme. Additionally, the curriculum was designed to provide economically viable and practically relevant active learning experiences that would both engage and challenge students whilst enthusing them about engineering. The module, which is taught in a bespoke CDIO laboratory, is taught over a 9 hour period one day each week. In addition to this students are required to dedicate a further 14 hours per week on CDIO related activities (both practical and theoretical learning). More traditional lectures and tutorials supplement the curriculum as appropriate to the discipline. The module is taught by 4 engineering lecturers, all of whom are highly committed and enthusiastic about the approach. They, in turn, are supported by 'guest' lecturers and technical-support staff.

In order to evaluate the pedagogical effectiveness of the CDIO approach, two independent researchers were employed to critically analyse the overall educational and practical value that CDIO adds to the student learning experience. It is this research that forms the basis of this paper.

Methodology

Utilising mixed methodological research approaches, and following an Action Research Design, the researchers followed the programme development and delivery right from its onset – making a contemporaneous record of events, experiences and issues as they arose. This paper captures the first phase [Year 1] of a longitudinal study which is aimed at critically evaluating the CDIO approach as it is rolled out across all 4 years of the Undergraduate Programme in Mechanical Engineering & Design. By undertaking a 'real-time' analysis, the study will provide a unique record and analysis of the students' and faculty's pedagogical experiences as they occur.

The first stage of the research involved non-participant observations. An observational framework was drawn up and observations scheduled during 12 different CDIO sessions occurring over the first two terms of 2010 / 2011. It was decided that the lead researcher should undertake these observations as he was familiar with the engineering context and content of the programme – and so could focus on the pedagogy and research without being distracted.

During the middle of Term 1 a quantitative survey was administered to all students. The response rate was 65%. The data was analysed and the findings reported directly to the teaching team – thereby providing them with an early indication of students' perceptions of the approach. This meant that they were able to identify potential difficulties and deal with them in a timely manner. Building on the findings of the observations and survey, a qualitative questionnaire was administered at the end of the second term in April 2011. Comprising ten 'open' questions, all of the students were surveyed. The response rate was 73%.

Observational findings

The observations provided the ideal means by which the researchers were able to gain first-hand insight into the issues and experiences of students and staff as the CDIO approach unfolded. The observational framework was grounded in pedagogical research and utilised an ethnographic approach. The observational data was analysed utilising a grounded theory approach (Strauss & Corbin, 1990). Four distinctive concepts were identified in the analysis of the observational data: people: pedagogy: process: and product.

The first concept 'people' captured staff anxieties with regards to the practicalities of offering such an intense learning and teaching experience. These concerns were not unfounded. Once the programme began, high levels of physical, mental and practical stress were observed amongst the staff. The nature of the CDIO approach means that it is not an easy option for staff. Its student focus requires those responsible for teaching to be continually mentally astute, able to deal with students' constant questioning and high expectations.

One of the major issues identified during the observations related to the difficulties of 'large group' teaching. Although the university provided a bespoke CDIO laboratory, which was ideally suited to the practical activities, the 'instructional' part of the sessions provided difficult as the acoustics in the room were not ideal. This was observed to be equally frustrating for students and teaching staff.

The second concept 'pedagogy' captures the challenges of balancing the requirements of an active learning approach with an engineering content and context. During the observations it was noted that towards the end of Term 2 some of the staff appeared to find the need to be constantly innovative more than a little challenging. Whilst this was overcome by the staff working together to develop new, academically grounded and practically relevant projects, the fact that they had to work with limited financial resources proved more than a little frustrating at times.

A second pedagogical issue reflected difficulties with assessment and feedback. A range of formative and summative assessment techniques were used during the module including instant electronic feedback systems, and the keeping of individual logs. The use of electronic feedback systems was observed to be highly successful in keeping students (and staff) engaged. Other methods of assessment proved to be less successful. Most notably, difficulties were observed in the provision of individual feedback. The large group size meant that much of the feedback tended to 'generic' in nature identifying commonly experienced problems and issues. Whilst this worked for most of the students, it was evident that a minority were not able to contextualise and apply 'group' feedback to their own work.

A third pedagogical issue reflected students' experiences of group work. Whilst the majority of the groups 'bonded' and were observed to be cohesive and supportive in nature, a few students failed to 'pull their weight' causing friction and tension within in their group.

Although group work caused some predictable difficulties, the 'process' of CDIO, breaking the sessions into the four distinctive stages of *Conceive, Develop, Implement* and *Operate* proved highly successful. The students were observed to quickly adopt, and adapt to, the active style of learning engendered by CDIO. From an engineering perspective, each stage was clearly distinctive, comprising separate but integrated theoretical content and practical activities.

The final concept 'product' captured three separate strands linked with the development and delivery of CDIO: resources; technology; and production. The Aston approach has been developed at a time when the need to be 'financially astute' was of paramount importance. Resources for the activities were, on the whole, locally acquired from recycled materials. This enabled students to learn about the basics of engineering in a practical, problem-solving yet financially shrewd way.

The second strand within the ‘product’ concept was ‘technology’. This related to the electronic feedback system. That this was not always totally reliable caused frustration for staff and students alike. This meant that on more than one occasion staff were required to ‘think on their feet’ and improvise. Whilst this was undoubtedly more than a little exasperating, that students were able to witness their lecturers finding practical solutions when the technology failed to work was an important lesson in engineering practice.

The final strand forming part of the ‘product’ concept related to ‘production’. In each session the students were required to make something ‘real’ and then test it. This was observed to be a successful and engaging way of learning. It enabled the students to actively test theoretical and practical perspectives and in doing so link the two. They were observed in their groups discussing the various options around each project – relating their choices to a range of theories and concepts. However, on the negative side, varying levels of commitment were observed with some students notably contributing more than others.

Survey findings

In administering the survey during the first term, the researchers aimed to gain insight into the students’ previous learning experiences. In addition to providing ‘benchmarking’ data, this meant that the programme leaders were subsequently able to adapt their approach accordingly.

Likert Scales were used to gain a breadth of opinion and insight. Questions were focused into 4 distinctive categories: Previous learning experiences: Expectations of the University learning environment: Expectations of the ‘added value’ of University: Perceptions of the first few weeks of participating in CDIO.

The survey was developed in such a way so as to deliberately reflect the fact that around 80% of the students had entered university straight from school. It captured students’ perceptions of how useful they found previous learning approaches in preparing them university and revealed that ‘problem-solving’ was their previous preferred learning approach, with ‘designing things’ and ‘making things’ also popular. This finding was not entirely unexpected given the discipline choice of the sample group. ‘Formal lessons with 21 or more students’ proved to be the least favoured approach.

Students were asked to indicate their level of agreement in respect of the types of learning approaches they expected to experience at university. The study revealed that the students' least expected 'essay type' assignments. This finding possibly reflects typical pre-university education where 'long' essays are not generally part of the curriculum (particularly in the sciences). The vast majority of students in the sample were, more or less, completely new to engineering, with their previous exposure being limited to participation in competitions, or to familial linkages (usually fathers, grandfathers, brothers or uncles who are engineers).

Students were then asked about their expectations of how university would prepare them for employment. Not surprisingly given the high costs of higher education, the study revealed that the students had high expectations that the programme would prepare them for the 'world of work'. In many respects, this in itself highlights the importance of CDIO in that it promotes employability by giving students 'real-life' skills and experiences.

The final part of the survey looked specifically at the students' perceptions of participating in CDIO. The value of CDIO in helping students' link engineering practice to theory, and theory to practice was evident in the study findings. Likewise, its value in promoting team-working, independent thinking and problem solving were all indicated in the findings.

The questions in the qualitative questionnaire provided the students with the opportunity to give their views in a more open manner than afforded by the earlier quantitative survey. The questions focused on the students' perceptions of CDIO as a learning approach and covered all aspects of the learning experience. Typically, most of the responses took the format of a single sentence.

Discussion and concluding remarks

The emergent findings from this study suggest that the engineering students entering undergraduate programmes prefer 'hands on / problem-based' approaches to learning. It also reinforces previous study findings which argue that on the whole, students prefer working in small groups rather attended large lectures. The CDIO approach allows teaching staff to capitalize on such preferences, and in doing so make the most of students' natural predispositions towards 'practical' learning. By providing an active, problem-based, learning environment in which theory can linked to practice in a realistic and understandable manner, CDIO enables students to experience a range of engineering problems in a 'safe' and 'controlled' environment. Indeed, there can be little argument that CDIO provides students with the opportunity to develop high level engineering specific skills and also offer them the means by which they are able to acquire 'softer' transferable competencies such as team-working. In this manner the PBL nature of CDIO is crucial to promoting the students employability and employment prospects.

From an educational management perspective, it would appear that the problem-based nature of the CDIO approach has provided the means by which the university has begun to address issues of retention in engineering education. By providing a positive and exciting learning environment the 'drop out' rate has decreased from an average of 10% of the cohort for each of the preceding three years (from the academic year 2006/ 07 through to 2009/ 10), to 2% of the cohort so far this year.

In conclusion, it should be noted that CDIO does not provide an easy option. For the staff, the academic and theoretical practicalities associated with offering such an intense learning experience can prove demanding. Whilst for students, CDIO provides an innovative way of learning that does much to prepare them for their future careers. What is clear is that the next four years will be both exciting and challenging for both staff and students alike.

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LARGE-SCALE INTEGRATED PROJECT FOR BUILT ENVIRONMENT UNDERGRADUATE STUDENTS: A CASE STUDY

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ABSTRACT

This case study describes how the Department of The Built Environment at Coventry University set up and managed a large-scale Integrated Project (IP) for final-year undergraduate students on a variety of different courses within the context of an increasing adoption of activity led learning (ALL) methods. Some challenges for the students in completing the project and for the staff in managing it are described, together with the solutions found. This multi-disciplinary module began evolving whilst in its first year of presentation due to a policy of collecting and acting upon student evaluation responses in a short feedback loop. The case study is informed by these questionnaire responses, by direct observation of teaching sessions and by interviews with students and teaching staff.

INTRODUCTION

This case study describes how the Department of The Built Environment at Coventry University set up and managed a large-scale Integrated Project (IP) for final-year undergraduate students on a variety of different courses. The aim is to compare the **intent**, in terms of learning outcomes, teaching methods and assessment, with the **experience** of the project in its first year of operation in this form. Information on the experience was gathered through direct observation of teaching sessions, a study of student and staff perceptions of the project, and formalised student feedback.

Research methods

To produce some of the findings for this case study, a researcher who was external to the module observed most of the 18 weekly sessions during which students were required to hold group meetings and presentations were made. The researcher moved between the six classrooms, frequently shadowing one of the module leaders. In the sixth month of the module, 22 students were interviewed to discover their experience of the IP. These formal semi-structured individual interviews covered their personal background, what they learnt during the project, how their group worked together, self and peer assessment, problems encountered and overcome, and their understanding of the approach to learning. All eight staff were also interviewed in a similar manner.

The IP module for 2010-11 was, in effect, a new module as it combined two previous modules. Use of peer assessment as a development tool for the students was also a new feature. Taking these changes into consideration, it was vital to evaluate the module at an early stage in order to ascertain any issues and facilitate any necessary changes. This was planned for the fifth week with an additional evaluation towards the end of the module. Both evaluations took the form of a universal University satisfaction questionnaire completed anonymously by individual students. To eliminate bias as far as possible, the questionnaire process from start to finish was undertaken by people external to the module.

Background

This project is set within the context of an increasing adoption of activity-led learning (ALL) in the Faculty of Engineering and Computing, where it is regarded as an effective teaching strategy to enable students to gain knowledge, experience and skills in their chosen professions, together with additional life-long learning skills which equip them to understand the requirements and constraints of working in the industry.

A description of ALL which staff and students agreed, when interviewed, is a close fit to the IP experience is provided by Wilson-Medhurst and Glendinning (2009): 'Engaging students through challenges requiring them to develop and apply their technical and scientific knowledge, whilst simultaneously developing their team working, leadership, problem solving and life-long learning skills.' The IP can 'provide students with multiple opportunities to practice and hone (with feedback) these critical professional/interpersonal skills' (Sheppard *et al*. 2010). The design of the IP is aligned to two key features of ALL, 'that the activity is the starting point for engagement in learning and that the tutor acts as facilitator' (Wilson-Medhurst 2010). As suited to a learner-centred and innovative approach, group assessment and formative evaluation (Du *et al*. 2009) are fundamental aspects of the IP.

The practice of forming multi-disciplinary groups to carry out integrated project work covering design, construction and building use is well-established in the Department for architectural technology, building surveying and construction management students. Over several years, students on civil engineering courses leading to Incorporated Engineer status were included, and then quantity surveying and building services engineering students. There was a separate group project module for students on civil and structural engineering courses leading to Chartered Engineer status. For the academic year 2010-11, these two modules were amalgamated into the first presentation of the IP with a cohort of 210 students. As the 'Guide to Learning Engineering Through Projects' (PBLE Project 2003) confirms, 'Integrative group projects may require students to work in teams from different disciplines. This reflects the real world more closely and, although projects of this nature are more difficult to plan and implement for the lecturer(s), the learning experience for the students can be significantly enhanced.'

Staff involved in the delivery of the IP have a range of professional backgrounds with at least two years construction industry experience after graduation. Both module leaders have previously managed final year group projects on a smaller scale. Most of the six teaching assistants remember being involved in group projects when they were themselves engineering students, though not in such a multi-disciplinary environment. All staff have been involved in providing ALL previously and are enthusiastic about it. One module leader identifies 100% of his teaching load as ALL. Graham and Crawley (2010) find it a particular characteristic of engineering project-based learning in the UK that development 'is being driven by academic champions'. They identify benefits of this in terms of quality of leadership and also autonomy in project design, but also potential drawbacks in terms of vulnerability to staff changes.

The department has a large minority, 30%, of part-time students who mostly have full-time jobs in the industry. They bring a distinctive set of qualities to the cohort, as explored by Davies (2008), particularly attitudes and motivation developed in the workplace. Some full-time students have industry experience from a placement or a year out; others are mature students with prior employment, not necessarily in the contruction industry. There is a strong contingent, approximately 17%, of overseas students for whom English is a second language, including some European exchange students. In the 2010-11 academic year, most final-year students had not previously encountered ALL as an explicit teaching style.

The authors' contributions are made from complementary perspectives. One is a module leader on the IP, another is researching ways of evaluating ALL and a third is undertaking research on engaging part-time learners in the professional skills development of full-time students.

Intent

Learning outcomes

The IP was carefully constructed to achieve particular learning outcomes by means of ALL teaching methods. The aim of the IP was that students should develop group integration, across various construction professions, of knowledge and skills (including environmental sustainability and health, safety and welfare) for a major scenario-based project within a design and construction environment.

Students were expected to synthesise the knowledge gained in the other taught modules in their respective undergraduate degrees and to apply these skills and abilities to the development of a project from inception through to tender. Through this process the students gained an appreciation of the iterative nature of the project development cycle and the importance of teamwork to successfully meet complex client needs.

Of equal importance to these technical skills were the personal and professional skills that the students were expected to further develop through participation in the IP, including those necessary to participate effectively in group work. These included the development of critical, analytical and transferable study skills, which are of practical benefit in the workplace and are key to continued professional development. These skills are specified in Table 1.

Technical	Personal and Professional
• Diagnose client requirements • Produce a detailed design solution which meets client and project needs • Undertake technical design as specified in the design brief	• Further develop their range of visual and verbal communication skills with a range of professionals • Develop further a critical approach to study skills through team work and continuous personal improvement • Demonstrate the ability to manage and control personal

• Formulate appropriate project management strategies for meeting specific client needs • Monitor costs from project inception through to tender • Produce relevant tender documentation for the project	and professional development, and the responsibilities and duties required, through reflective evaluation and to review this development for future uses • Demonstrate good professional practice as a reflective and conscientious student

Table 1. Skills identified as learning outcomes of the IP

These technical, personal and professional skills were developed in the IP solely through group work. Careful consideration was given to the formation of the groups with the intention of trying to replicate real-life scenarios so far as possible. The module leaders selected the students to form each group, as in real life where a choice of who one works with is not always possible. Again simulating real life, each group included a range of construction professions such as architectural design, building surveying, construction management, civil and structural engineering and building services engineering. In addition to this mix of professions, the module leaders also looked closely at the experience of each student to ensure that groups were made up of students with a range of industrial experience. Students engaging in the programme on a part-time basis and students who had undertaken a sandwich year industrial placement were spread through the groups.

Teaching methods

The IP relies on the synthesis of technical knowledge and skills taught through other technical modules. The module began with a lecture delivered to the entire cohort to provide key information. This included an outline of the building project itself, its three phases and the tasks associated with each phase, together with the assessment methods to be used and how the groups had been formed. The students were advised later, via the VLE, of the other members of their group and its designated meeting room. Throughout the module, any information needed by all students was given to them in the form of a printed handout and also made available on the VLE.

In the second week, the groups of 10 or 11 students met together for their first two hour session. This initial meeting of the 20 groups gave them time to decide upon the task allocation for each student for the first phase of the project. The tasks were explained in more detail in a written handout provided at the meeting and, subsequently, at the beginning of each new project phase. During this task-allocation meeting, a rota was drawn up to outline who was to be responsible for leading the group and who for producing meeting minutes; each student had to undertake each role during the project. After the meeting, each group submitted a written report outlining the group members responsible for each task and how this was to be coordinated within the group. This task-allocation and report submission process was repeated at the beginning of each project phase.

The groups met weekly to discuss the technical tasks, make group decisions, ensure synchronisation of closely intertwined technical tasks and review the progress of group members. Minutes had to be taken and submitted at the end of each phase. Based upon decisions made during each meeting, and recorded in the minutes, individual group members were expected to continue working on their identified task and discuss progress at the next meeting. These processes, which continued throughout the module, were overseen by two module leaders and six teaching assistants who were available to give advice on both technical and group issues. The module leaders sought to ensure that each group had the opportunity to discuss any issues with the module leaders on a weekly basis.

Assessment Methods

The IP was assessed in three ways –the submission of technical tasks, visual and spoken presentations, and peer- and self-assessment. At the end of each of the three project phases, each group submitted their completed technical tasks. Although these tasks may have been completed by individual group members, the submission had to be presented in the form of an amalgamated group report rather than a series of individual pieces of work. This involved each group deciding upon, and using, a company name and logo and their work being formatted in a coherent professional manner such as would be expected in the workplace. The module leaders marked all the submissions. This marking took the form of awarding an overall grade for each task and providing detailed written feedback to each group upon which the students could reflect and build.

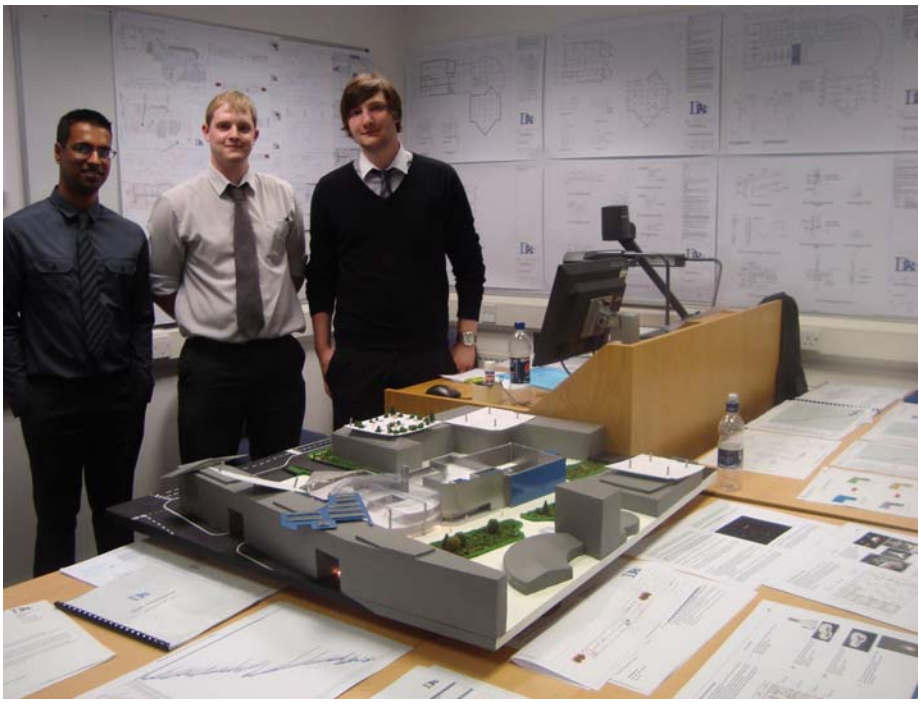

Figure 1. At the student exhibition

At the end of phase one and phase two of the IP, each group gave a visual and verbal presentation to the module leaders and teaching assistants, outlining the key aspects of the technical work undertaken during that phase.. At the end of the IP students exhibited a selection of group work spanning the entire module. This exhibition was open to members of University staff, other students, and to members of the public including invited guests from the construction industry. Students were expected to answer questions during the exhibition (shown in Figure 1). Assessment for the presentations and for the final exhibition was as for the written submissions outlined above, taking the form of an overall group mark and written feedback.

To enable each student to be assessed individually for their own unique contribution to the overall project, the students each undertook peer-and self-assessment. This was done via a computer process known as WEB-PA. The assessment criteria were decided by the students themselves, being the top seven suggestions from the cohort at the beginning of the project: Communication within meetings and externally; Attendance/reliability/punctuality at company meetings; Effort and enthusiasm during the project relating to set tasks, presentations and meetings; Quality and presentation of work; Teamwork; Knowledge and technical ability demonstrated; Leadership skills when managing the company team.

The WEB-PA process was undertaken by each student at the end of each phase. At the end of phase one, the peer- and self-assessment was only worth 10% of the group phase mark. This low percentage was to encourage and allow students to reflect and act upon their contribution. In order to facilitate this, each team member received a report outlining their key strengths and weaknesses and their relative position within the group. At the end of phase two, the peer- and self-assessment was worth 25% of the group phase mark. At the end of the module, it rose to 50%. Peer- and self-assessment therefore had an ever-increasing effect upon the individual student's grade to differentiate between individuals in the group.

Experience

The department had not run a project on this scale before so the module leaders were prepared to be receptive to the possibility of discovering problems in the methods of delivery and assessment and were keen to be agile enough to make changes where feasible.

Challenges for students

Final-year students have many demands upon their time, particularly if they also have full-time jobs. Many students reported they were spending too much time on the IP to the detriment of their other responsibilities to studies, work and family. Some students learnt to manage their expectations and workload but a few felt compelled to take the heroic stance of rescuing their whole group by reworking the offerings of other members because they were worried the grade of their own degree was threatened by a standard of work which they did not find acceptable. Understandably, they felt stressed and overworked. The driver to perform at this level was the assessment scheme which allocated marks to groups rather than to individuals. Many students felt this was unfair. Some students complained that the tasks required of them were not comprehensively described so they needed to make their own decisions or ask the module leaders about scope and level of detail. In interview, these students agreed staff were available and always prepared to answer these questions but unfortunately no student acknowledged this process of confirming the brief to be either authentic to the construction industry or a learning experience.

Although the students all had some prior experience of groupwork (albeit in much smaller groups), the multidisciplinary aspect was new to them and provided fresh challenges of communication, leadership and reliance upon others. Most of the groups reported experiencing a variety of management issues (for individuals, the group and the project) and some problems they had successfully overcome. These included non-contributing and late-contributing individuals, lack of the requisite knowledge, poor standards of spoken and written English, domineering leaders, insufficient collaboration, unequal workloads, misunderstandings and personality clashes. Peer- and self-assessment required reflection at three points during the IP - for the development of the interpersonal and professional skills required, it was important that 'students would begin to see failure as an important part of the developmental process of learning rather than as a differentiation between those who *can* and those who *cannot*' (Savin-Baden 2004).

Challenges for staff

The nature of the IP meant staff were required to have a large technical knowledge base upon which to draw when assisting and giving advice to group members. In the academic year 2010-11, this was achieved by dividing the knowledge base between the two module leaders with one focusing on aspects related to undergraduate building degrees and the other focussing on aspects related to civil and structural engineering. This necessitated each module leader speaking to each group every week so any guidance given was consistent and advice was given by the one with the relevant knowledge base.

Initially, the six teaching assistants rotated between the rooms on a weekly basis so they worked with different student groups. The philosophy was that the students would receive a rich range of advice from different members of staff. However, the rotation prohibited the establishment of good working relationships between the teaching assistants and the students and so the students preferred to ask the module leaders for advice. This problem of reliance on the module leaders was further compounded by issues surrounding the marking of submissions and presentations, which was exclusively the responsibility of the module leaders. Students believed that advice from the module leaders rather than the teaching assistants would lead, in theory at least, to more favourable grades. A separate issue is the huge burden this marking placed on the module leaders. To mark the work with sufficient useful feedback took many working hours; consequently, students did not always receive feedback in time for them to act upon it quickly.

Response to student feedback

The results of the first evaluation, conducted during week five of the IP, were below average for the department; the overall student satisfaction rate for the module was only 64%.

Some of the lowest levels of satisfaction surrounded *materials used by the staff as an enhancement to learning* and *teaching by staff making the module interesting*, which received satisfaction rates of 47% and 53% respectively. Several strategies were applied to try to improve student satisfaction.

A major change, probably the one with the greatest impact, related to the use of teaching assistants within the IP. Throughout phase one of the IP teaching assistants rotated around meeting rooms on a weekly basis which, upon reflection, prohibited the establishment of effective student-staff relationships. This was confirmed by several teaching assistants when the matter was discussed following student feedback. As a direct result, teaching assistants no longer rotated but remained in one room with a static set of student groups. Additionally, handouts which had previously been made available to both students and staff at the same time were now delivered earlier to teaching assistants so they had time to read them and pose questions to the module leaders before discussing issues with the students.

Another change concerned staff availability. Initially, the module leaders sought to see every group within a 2-hour time slot. As there were twenty groups, this meant that the amount of time that could be allocated to each group was minimal. From the end of phase one, students were informed that all members of staff, module leaders and teaching assistants would be available, by prior appointment or by email, to discuss any issues external to the 2-hour project session. Furthermore, students were offered the opportunity to have their work skim-read prior to the formal submission of work, so that improvements could be made.

The second evaluation, conducted towards the end of the project, demonstrated much higher satisfaction rates with the rates surrounding *materials used by the staff as an enhancement to learning* rising by 20% and the rates for *teaching by staff making the module interesting* increasing by 16%. In addition, the response regarding staff availability rose by 19% to 87%. The satisfaction rate for the module overall rose by 16% to 80%, a figure in line with the departmental average. Alongside these improvements, satisfaction rates for other aspects also rose. The complete results for the two questionnaires are outlined in Figure 2.

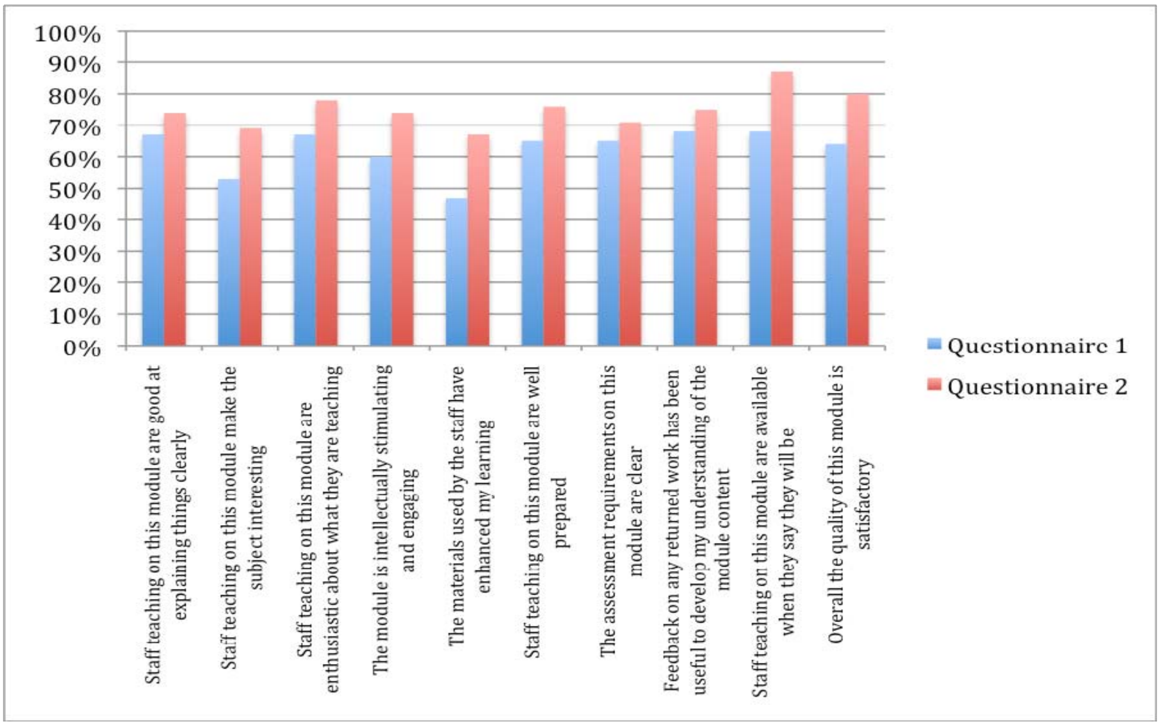

Figure 2. Percentage responses from both questionnaires

Conclusions

This paper has described the arrangements for a large-scale integrated project involving year 3 undergraduate students within the disciplines of architectural technology, building surveying, construction management, quantity surveying, civil engineering and building services engineering. The students work in large multi-disciplinary teams with representation across these discipline areas and across the modes under which they study: part-time, full-time and sandwich. The project aims to develop technical, personal and professional skills in the students, consistent with the framework for activity-led learning promoted within the Faculty.

The challenges for students and staff have been investigated through the work of a researcher external to the project. Particular challenges for students have been identified as relating to the complexity of the groups and the approaches to assessment of groups. Challenges for staff relate particularly to providing the appropriate continuity of support for the groups. A policy of rapid response to student feedback has been introduced and has been demonstrated to have had some success.

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CAN PROBLEM BASED LEARNING BE USED TO TEACH INTERNATIONAL STUDENTS PROJECT PROPOSAL WRITING SKILLS?

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ABSTRACT

Problem Based Learning (PBL) and Activity Led Learning (ALL) at Coventry University have mainly been focused on courses able to provide 'concrete' problems for the students to solve, such as aerospace- or motorsport-centric courses. This paper presents the results of an ALL pilot at Masters level to support students in the development of the generic skills required to select their dissertation subject area and write the supporting project proposal. What has been developed is a PBL/ALL approach using a 'logbook' which incorporates recognised PBL/ALL tools and techniques to encourage and support the students in the development and documentation of their thought processes surrounding the production of a Masters level project proposal. It has been designed so that, by the time the student gets to the end of the logbook, they are armed with the knowledge and understanding that the processes of developing aims, objectives, deliverables and a solid research methodology are the means to success.

INTRODUCTION

This pilot was set in the Department of Engineering and Knowledge Management within the Faculty of Engineering at Coventry University, England. The module that was at the centre of the pilot was a 10 credit Masters module entitled 'Study Skills and Research Methods' which was a compulsory module taken by all Masters students within the department. The module splits into two halves, the first focuses on the generic study skills required to complete a Masters programme at Coventry University and details the types of assignments that students may come across during their studies at the University and how to tackle them. The second half of the module (and the subject of the pilot), is the research skills required to successfully complete the 50 credit dissertation required by all Masters Students. In previous years, engagement of students on this 10 credit module has proved difficult to achieve which has often seen a higher than average failure rate (20-25% compared to the institutional average rate of 5%). Through informal focus groups with past students the anecdotal feedback as to the reason for this high failure rate appeared to be that whilst the students understood the basic concepts, a lack of opportunity to apply these concepts and appreciate their complexity was missing. This coupled with the inability of the student to apply what they had learned to problems outside those presented in the lectures themselves led the authors to investigate the possibilities of developing a Problem Based approach to teaching this subject. It should also be noted that a further facet of complexity for this particular module is that it is a compulsory module for all Masters Students in the Faculty leading to a total annual cohort of between 300 and 450 students; the majority of whom are international students.

Relevant background to problem based learning and activity LED learning

It is not the purpose of this paper to provide lengthy detailed literature reviews around PBL and ALL as these have been well documented over the last decade (For example, Barrows and Tamblyn (1980), Barrett (2005), Savin-Baden (2006), Dunn et al (2009), and Wilson-Medhurst *et al* (2008)). But a brief summary of the pertinent points and relevant definitions that provide the foundations to this pilot are provided in the following section of the paper.

Problem Based Learning (PBL)

Barrows and Tamblyn (1980) indicated that the defining characteristic of PBL is the fact that the problem is presented to the students first, at the start of the learning process before any other curriculum content. This was the underlying principle adopted by this pilot study. It should also be noted that Barrows and Tamblyn promoted what is known as the McMaster version or pure model of PBL; that is, that the whole curriculum is problem-based and the students do not receive any tutorials or lectures. This is in contrast to the hybrid model which is usually defined by the inclusion of fixed resource sessions such as lecture or tutorials to support the students. Savin-Badin (2000) suggests that given the number of forms of PBL in existence, most models would be classed as 'hybrid' as oppose to the pure 'McMaster's' model and this pilot therefore goes with the definition of PBL as follows;

> *'Problem-based learning is an approach to learning that is characterised by flexibility and diversity in the sense that is can be implemented in a variety of ways in and across different subjects and disciplines in diverse contexts. As such it can therefore look very different to different people at different moments in time depending on the staff and students involved in the programmes utilising it. However what will be similar will be the focus of learning around the problem scenarios rather than the discrete subjects'* (Savin-Baden (2000))

The operational scaffolding used for the pilot was based around a six point model proposed by Barrett in 2005 that being;

1) At the onset, students are presented with a problem.

2) Students discuss the problem in a small group PBL tutorial. They clarify the facts of the case. They define what the problem is. They brainstorm ideas based on the prior knowledge. They identify what they need to learn to work on the problem, what they do not know (learning issues). They reason through the problem. They specify an action plan for working on the problem.

3) Students engage in independent study on their learning issues outside the tutorial. This can include: library, databases, the web, resource people and observations.

4) They come back to the PBL tutorial(s) sharing information, peer teaching and working together on the problem.

5) They present their solution to the problem.
6) They review what they have learned from working on the problem. All who participated in the process engage in self, peer and tutor review of the PBL process and reflections on each person's contribution to that process.

Activity Led Learning (ALL)

ALL is an umbrella term that has been chosen to represent the learning 'philosophy' adopted by the Faculty of Engineering and Computing at Coventry University (Dunn *et al*). The formal definition of ALL by Wilson-Medhurst *et al* is;

> *'Activity Led Learning is a pedagogy in which the activity is the focal point of the learning experience and the tutor acts as a facilitator. An activity is a problem, project, scenario, case-study, enquiry, research question (or similar) in a class-room, work-based, laboratory-based or other educational context and for which there a range of possible solutions or responses. Activities may cross subject boundaries, as activities within professional practice often do.*
>
> *Activity Led Learning requires a self-directed process in which the individual learner, or team of learners, seek and apply knowledge, skilful practices, resources (personal and physical) relevant to the activity being undertaken.'* (Wilson-Medhurst *et al*, 2008).

Whilst it is accepted that ALL adopts many of the defining characteristics of PBL, it also leans heavily on industrial support and one of the key outputs is that activities cross subject boundaries. So whilst this pilot study relies heavily on PBL models (both of pedagogy and operation) it does address industry requirements such as critical analysis, reflection and evaluation highlighted in reports such as that commissioned by the Royal Academy of Engineering (Spinks (2006)).

Research methodology

The research methodology used was one of 'methodological triangulation' (Denzin (2006)),; this uses three methods of data gathering in an effort to ensure a detailed but balanced view of the situation (Altrichter *et al*. (2008)). The three methods chosen in this instance were; questionnaires, observations of the students and documentation in the format of the relationship between the students engagement in the PBL and their final mark on the project proposal. The questionnaires were administered to the students after completion of the module and were used to gauge students understanding of the PBL process and to monitor if they would further engage in this as a method to develop their final dissertation proposal. Observations were carried out on all the students during the module to monitor their engagement in the PBL process. This was achieved through weekly reviews of their 'logbooks' (see later section in the paper for more detail) to observe how much of the activities allocated the students had completed. The final method of documentation data assessed the relationship between their final mark and the amount they had engaged with the PBL process. This was compared with general statistics available for the module over the last two years.

The questionnaire itself was broken down into 4 sections, summarised in the table below, only the results from sections 2, 3 and 4 are discussed in this paper.

Section	
1	Review of the first five sessions of the module (not relevant to PBL)
2	Review of the second five sessions of the module (PBL based)
3	General use of the logbook
4	General comments

Table 1 – Questionnaire Sections

Logbook development

The main objective of the logbook was to work in harmony with the materials presented by the lecturer and to stimulate a realisation that merely understanding the theories of research methods and project preparation did not in itself mean that the students were able to apply these methods effectively. There were a number of PBL methods that could be applied to demonstrate the topic areas for the students, but in this case it was important that the students grasped the link between the different topics and appreciated the gradual build up of knowledge and with this in mind the logbook was developed. For these Masters students neither PBL nor ALL were common approaches to teaching and learning in their curriculum, (although the rational behind developing the approach is that over the next few semesters ALL will be being introduced into the Masters teaching at Coventry University) so it was decided to take a funnelled curriculum mode approach. Students are taken from their more familiar lecture based approach and funnelled through to problem-solving learning and finally through to problem-based learning. (Savin-Baden, Major (2004)) As it is a mode that is usually applied gradually from first year undergraduate through to final year undergraduate, it required careful consideration (which was made) to adapt it to these students over such a short time scale. The model of PBL that was undertaken in the pilot was one that aimed not only to support the academic learning of 'Study Skills and Research Methods' but also to support the more generic skill of 'critical analysis' and that was the PBL model for 'critical contestability' (Savin-Baden (2000)). This model encourages reasoning and reflection by encouraging students to challenge and evaluate what they and others have achieved.

The methods used to employ these techniques was limited by the prescribed delivery style of the module, that was one 2-hour slot per week for 10 weeks (only 5 weeks were used on PBL activities and will be discussed in this paper) staffed by one academic supported by one teaching assistant with a class size of between 20-60. It was decided to split the two hour slot in the following manner; the first section of the slot to be used on the PBL activities, allowing the students to examine and critique example proposal titles, aims, objectives and deliverables etc totally unguided in small groups of approximately 5-8 students (as per operations 1-2 in Barrett's model), a small section of time (approx 15 minutes) in the middle of the 2-hour session to be used as fixed resource session (operation 3 as per Barrett's model), the remaining time being used to readdress the problems once the subject knowledge has been discussed (operations 4-6 in Barrett's model).

The following table shows the lecture title and activities;

Subject Topic	PBL activity
Choosing a Research Topic	Reviewing topic ideas Analysis of your strengths/weaknesses Mind Map Topic Analysis Expanding your ideas Satisfying Masters Level Criteria Final Research Idea
Writing a Research Proposal	Refining your Research Idea Developing an Aim for Your Project Objectives for your Research

	Research Deliverables Your Research Deliverables
Planning a Masters Project	What is a Project Plan Turning Activities into Tasks Activity List Project Risks
Research Methodologies	Collecting Data Ethics
Presentation of Results	Data Analysis

Table 2 – Logbook Sections

Results and discussion of pilot

Questionnaires

Upon analysis of the questionnaire it could be seen that all aspects of the logbook were well received with over 80% of the students indicating that they found the activities supported their final dissertation proposal. The only PBL activities (refer to Table 1) with less than 80% indication of support were 'Refining your research idea' with 77% and 'Analysing your strengths and weaknesses' with 71%. 96% of the students indicated that they found the PBL logbook useful and that they intended to continue using these techniques throughout their remaining Masters modules. An interesting result was that, when asked to identify where they felt they developed their research skills, over 60% of the students identified this as the fixed resource sessions of the two hours with only 40% of the students acknowledging the logbook as a means of developing these skills.

In the general comments section of the questionnaire students were asked about the use of the logbook and their feelings about it, on average the comments were quite positive including statements such as;

'I would say that the logbook is an excellent initiative as it helped a lot for developing the proposal on a periodic basis.'

'Thank you so much, really this module was very useful and helped me so much in project proposal. Many thanks for your help to me, all lectures were very useful (logbook good idea).Thanks.'

Although there were also students who did not feel engaged with this type of learning; this was reflected in comments such as;

> *'Even though it did help me eventually, I wont be using it to do my project proposal. This is because the module makes me have to use a technique that I do not usually prefer. To be able to choose my project proposal, I should be given the freedom of selecting it my way. The logbook, although it covers various areas, doesn't really help me do it the way I like to do it.'*

> *'It didn't help me because, before I attended MO4 I knew all about what I wanted to write my dissertation. In my opinion idea of MO4 lecture is good, but filing logbook is waste of time attending on lecturers are more helpful than logbook.'*

Documentation data analysis and general module statistics

Figure 1 shows a graph of the breakdown of results across the four runnings of the module over the two years. What can clearly be-seen is that there is a gradual increase in the mean value over the four runnings, the spread of the data is similar for runnings one, two and three and it can be seen that there is a wide distribution i.e. students were achieving highly in the module or clearly demonstrating that they had an inability to work with the ideas and concepts of the module, (this result was almost identical to that shown by Montgomery *et al* in 2008 on a module with similar student profiles). However, in running four after the introduction of the PBL activities, the spread narrowed significantly with far fewer students scoring low marks, although it must also be noted that few students in running 4 obtained a mark of 80+%. This is discussed in a later section of the paper. The over all pass rates of the module changed significantly with a pass rate of 74% in running one, increasing to a pass rate of 85% for runnings two and three with the pass rate rising to 90% during the use of the logbooks.

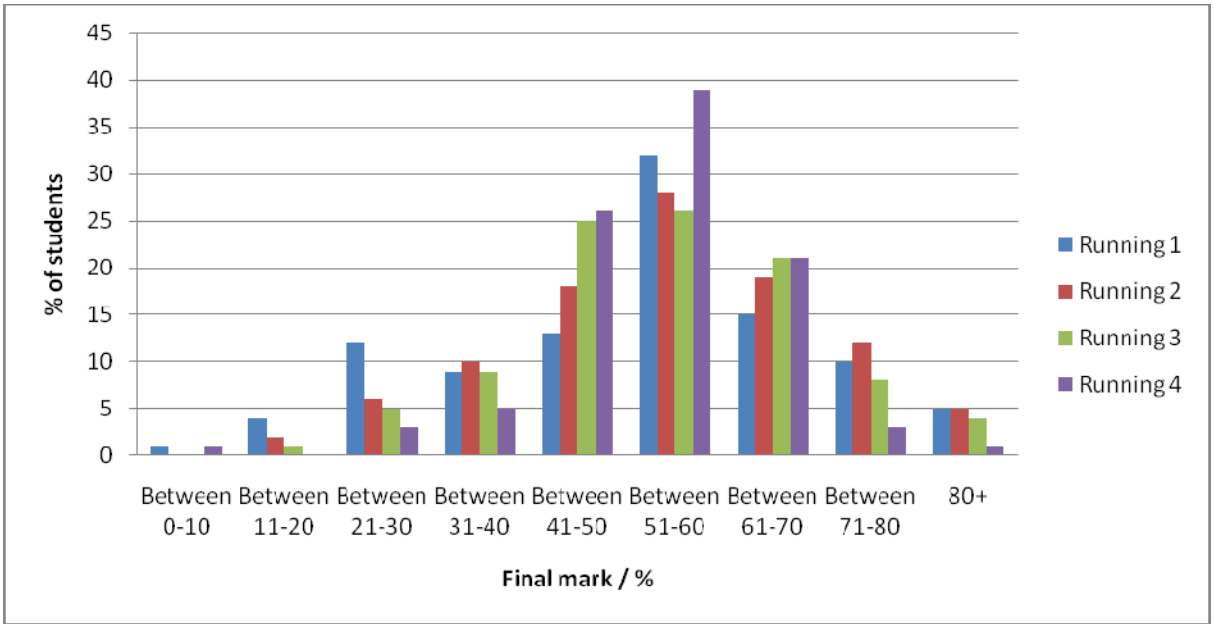

Figure 1 – A histogram showing the spread of results for the four runnings of the module

Figure 2 shows the relationship between the students' engagement with the PBL activity in class and their final mark for the project proposal. What can clearly be seen is the increase in attainment in the final proposal when the students have engaged in the PBL activities. Around the 50%-60% mark the graph appears to indicate that there are an equal number of students who attained their marks whilst not engaging in the PBL activities as there are students who attained these marks with engagement. What this graph also shows is that just over 25% of the students gained a mark greater than 60% but only a small proportion of students (5%) managed to do this with less than 50% engagement in the PBL activity.

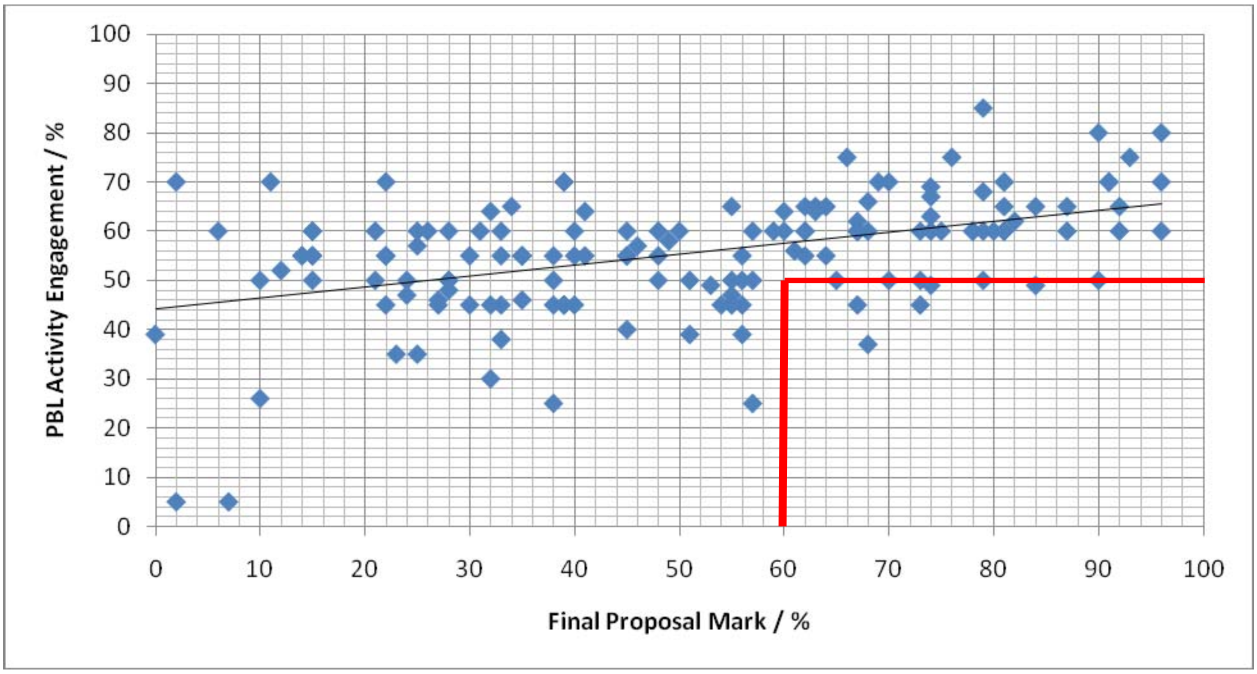

Figure 2 – A graph showing the relationship between the final marks and the PBL engagement of the students

Conclusions

This work clearly shows that the addition of the PBL logbook to the module has made an impact on the module results of the students. The key conclusions are as follows;

- The number of students who failed the module decreased significantly throughout the fourth running of the module, with the only alteration to the module being the introduction of the PBL logbooks.
- There were an almost equal number of students not engaging with the PBL activities and still gaining a mark in the region of 50% - 60% as there were students who engaged with the activities and achieved such marks.
- There were very few students who obtained the marks of 60+% with little or no PBL engagement.
- One worrying result is that there was a significant drop in the percentage of students obtaining marks in the 80+% region with the use of the logbook compared to the previous runnings with no PBL activities. It is suggested that the reason behind this is that the logbooks gave some form of 'false' security to the students. Hence, once they had completed a section in their logbooks satisfactorily, they did no further refining of this for the final proposal.

- A further concern is that the students appeared not to acknowledge that they had developed their skills through the use of the logbooks preferring still to cite the fixed resource session as the point at which they expanded their knowledge. It could be suggested that this was due to a lack of exposure to PBL by these students earlier in their education and as such indicating that the 'funnelled' approach adopted was the best method of introduction to the concept of PBL.

Further work

It is the intention of the authors to further refine the logbook based on feedback obtained from the students in the questionnaire. In conjunction to this it is the intention to develop a fixed resource session about PBL itself to enable and assist the students in their understanding of why the PBL sessions sit in the module and how they support the learning process. There is also a need to review the students individual learning styles and relate these to the success of the logbook with the students.

Furthermore, this is a pilot study and further development of a robust method for measuring the effectiveness of the logbook must also be investigated and developed. There is also a need to review the students performance over all modules to confirm that a better overall cohort performance is not a significant factor in the improved module performance.

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WHAT IS THE EFFECT OF PROBLEM-BASED LEARNING ON STUDENTS' APPROACH TO LEARNING IN AN MSC ULTRASOUND PROGRAMME?

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ABSTRACT

In 2007 a fully problem-based learning Masters in Ultrasound commenced in University College Dublin. It aimed to provide a student centred learning environment to radiographers and midwives undertaking postgraduate studies in ultrasound. Problem-based learning was selected due to its ability to motivate learning of ultrasound knowledge, and its claims to develop a range of generic skills including critical thinking abilities. This ongoing PhD research aims to evaluate critical thinking skills in the second cohort of students undertaking the problem-based learning Masters Programme in Ultrasound. A mixed methods approach was selected using a sequential explanatory design. An element of the quantitative data employing the Approaches and Study Skills Inventory for Students (ASSIST) will be presented in this paper. Paired t-tests of pre and post programme scores showed a significant increase in deep approach scores and a significant decrease in surface approach scores. There was no significant change in strategic approach scores.

BACKGROUND

Healthcare professionals who provide ultrasound imaging services need to be highly educated in a wide variety of skills in order to practice, manage and direct this rapidly evolving field. The problem-based learning MSc Ultrasound programme was developed due to a recognition by the programme team that a student centred approach would develop more of the attributes required of radiographers and midwives in this rapidly changing arena. Problem-based learning offered a curriculum model which claimed to develop a range of relevant attributes such as the means to learn content knowledge while simultaneously developing a range of generic skills.

> *"At its most fundamental level, PBL is characterised by the use of real world problems as a context for students to learn critical thinking skills and problem solving skills and to acquire knowledge of the essential concepts of the course"* (Watson, 2004, p188)

Edwards (2006) discusses the intellectual skills required of ultrasonographers. These skills in the cognitive domain are divided into two categories. The first of these incorporates the skills of acquiring knowledge, comprehending it and applying it appropriately. These are considered lower order thought processes, which are nonetheless necessary in the development of competent ultrasonographers. The higher cognitive abilities such as analysis, synthesis and evaluation are required for critical thinking (Edwards 2006). The College of Radiographers (COR) (1998) provide a large number of occupational standards for diagnostic ultrasound practitioners. They use many of the verbs that are incorporated into definitions of critical thinking, including evaluate, discuss, analyse, reflect, synthesise and interpret. The PBL process provides students with opportunities to develop both lower and higher order thinking skills. Descriptions of the skills and attributes required of ultrasonographers have similarities with the deep approach described by Entwistle (1997) hence the selection of the Approaches and Study Skills Inventory for Students (ASSIST) as one method of evaluating the effect of problem-based learning on this cohort of MSc Ultrasound students. This instrument contains 52 items, and uses a likert technique on a five point scale designed to measure students' attitudes. The items are constructed to identify students' inclinations to follow deep, strategic and surface approaches to learning and studying. Summing the items associated with each approach gives a score for each construct. The deep, strategic and surface approaches have each been found to have distinct sub-scales, which can also be summed to produce scores for each of the sub-scales (Entwistle, McClune & Tait 2006). The three approaches are summarised as follows:

Deep Approach

Intention – to understand ideas for yourself
Relating ideas to previous knowledge and experience
Looking for patterns and underlying principles
Checking evidence and relating it to conclusions
Examining logic and argument cautiously and critically
Becoming actively interested in the course content

Surface Approach

Intention – to cope with course requirements
Studying without reflecting on either purpose or strategy
Treating the course as unrelated bits of knowledge
Memorising facts and procedures routinely
Finding difficulty in making sense of new ideas presented
Feeling undue pressure and worry about work

Strategic Approach

Intention – to achieve the highest possible grades
Putting consistent effort into studying
Finding the right conditions and materials for studying
Managing time and effort effectively
Being alert to assessment requirements and criteria
Gearing work to the perceived preferences of lecturers (Entwistle, 1997, p.19)

Course structure

The MSc Ultrasound programme is a one and a half year full time masters level course, which includes both taught and professional practice elements. The participants in this research commenced their programme in September 2009 and finished in December 2010. Each student registers for eight PBL modules which they complete over a sixteen month period. Central to the aims of the programme is that graduates are both clinically competent at the time of graduation, and that they can continue to develop their skills and knowledge throughout their professional life. Facione (2011) claims that third level technical and professional programs have a half life of about four years, and therefore four years after graduation professional training would need to be significantly updated. Strategies to develop generic skills aimed at life-long learning are built into this problem-based learning curriculum. The teaching and learning activities are centred around carefully designed multidisciplinary problems which reflect clinical practice in ultrasonography (Stanton & McCaffrey 2011). Students work in small groups with facilitators who are University lecturers with clinical ultrasound qualifications. Resource sessions are provided when students have completed a particular problem. These generally consist of an ultrasound lecturer or a clinical expert providing students with an opportunity to discuss outstanding issues and related case studies. Students attendance at the University is interspersed with experiential learning in a clinical ultrasound department. The programme is assessed by a wide variety of continuous assessments including: individual and group assignments, posters, clinical assessments, presentations, and reflective writing. The structure of the MSc Ultrasound programme fits the fully integrated mode described by Savin-Baden (2003), and matches the closed-loop problem-based learning described by Barrows (1986) in his taxonomy of PBL based on: the type of problem used; teaching-learning sequences; responsibility given to students for learning and student assessment methods.

Methods

The PhD research is being conducted using a mixed methods approach. The specific design is a sequential explanatory design which uses qualitative and quantitative data in a planned sequence (Creswell & Plano Clark, 2007). In this paper a section of the quantitative data regarding students approaches to study will be presented.

Following ethical approval all students registered for the University College Dublin (UCD) Masters in Ultrasound programme in September 2009 were invited to contribute to the research. All 19 students returned written consent forms however, one was absent on the first data collection day resulting in 18 participants. An electronic copy of the inventory was obtained from Noel Entwistle with his permission to use it for this study (Entwistle, 2009).

Cronbach alpha coefficients for the ASSIST instrument are reported by its authors as follows Deep 0.82, Strategic 0.83 and Surface 0.65 (Entwistle, McClune & Tait 2006). In the current study Cronbach alpha coefficients were calculated as 0.88 Deep; 0.82 Strategic and 0.79 Surface. Analysis of the data was performed with the dependent t-test.

Results

Following ethical approval the 19 students registered for the MSc Ultrasound programme in September 2009 were recruited to the study. One student was absent on the first data collection day therefore there were 18 participants in the study. During the induction programme and again towards the end of the programme 18 students completed the Approaches and Study Skills Inventory for Students to identify superficial, deep or strategic approaches to learning.

The participants included ten Radiographers and eight Midwives, they were all female. The mean age was 31.83 (7.20 SD). They were already in clinical practice for a minimum of one year, and they had begun to train clinically as ultrasonographers for at least 3 months.

		Mean	SD	p
Overall Deep	Pre-programme	80.39	7.06	.013*
	Post-programme	88.11	12.07	
Seeking Meaning	Pre-programme	16.78	2.82	.045*
	Post-programme	18.39	1.46	
Relating Ideas	Pre-programme	14.56	2.99	.008*
	Post-programme	16.11	2.11	
Use of Evidence	Pre-programme	15.94	3.35	.031*
	Post-programme	17.94	1.70	
Interest in Ideas	Pre-programme	15.56	3.20	.112
	Post-programme	16.78	2.07	
Monitoring Effectivenes	Pre-programme	17.56	2.28	.058
	Post-programme	18.89	1.45	

A significant difference in pre-programme and post-programme scores is denoted by an * when $p < 0.05$.

Table 1: Deep Approach and Study Skills

The deep scale increased significantly between the beginning and end of the programme (see Table 1). The deep sub-scales for seeking meaning, relating ideas and use of evidence increased significantly over the period of the MSc Ultrasound programme. The remaining deep scales interest in ideas and monitoring effectiveness did increase but did not reach significance. However the monitoring effectiveness sub-scale was high in its pre-programme score at 17.56, it increased to 18.89 at the post- programme time point, this is close to the maximum score, so the potential to reach significance is reduced.

		Mean	SD	p
Overall Strategic	Pre-programme	63.00	10.52	.121
	Post-programme	66.56	8.13	
Organised Studying	Pre-programme	15.44	3.42	.155
	Post-programme	16.61	2.57	
Time Management	Pre-programme	15.28	4.21	.032*
	Post-programme	17.22	2.82	
Achieving	Pre-programme	16.33	2.87	.098
	Post-programme	17.28	1.96	
Alertness to Assessment Demands	Pre-programme	15.94	2.29	.580
	Post-programme	15.44	3.71	

A significant difference in pre-programme and post-programme scores is denoted by an * when $p < 0.05$.

Table 2: Strategic Approach and Study Skills

The only strategic sub-scale to change significantly was time management the level of significance was 0.032.

		Mean	SD	p
Overall Surface	Pre-programme	42.94	9.61	.016*
	Post-programme	34.78	9.19	
Lack of Purpose	Pre-programme	6.50	2.12	1.00
	Post-programme	6.50	1.69	
Unrelated Memorising	Pre-programme	10.33	3.61	.007*
	Post-programme	7.56	2.57	
Fear of Failure	Pre-programme	14.22	3.25	.021*
	Post-programme	11.50	4.55	
Syllabus-boundness	Pre-programme	11.89	3.10	.021*
	Post-programme	9.22	2.80	

A significant difference in pre-programme and post-programme scores is denoted by an * when $p < 0.05$.

Table 3: Surface Approach and Study Skills

The overall Surface scale decreased significantly. The surface sub-scales unrelated memorising, fear of failure and syllabus-boundness all decreased significantly. The lack of purpose sub-scale stayed the same at both time points. However, this was already at a low score of 6.5 so there was limited potential for it to reduce to a significant level.

Discussion

The improvements in deep scores together with reductions in surface approaches suggest that students' response to PBL was to focus on trying to understand ideas for themselves rather than just coping with the course requirements. The lack of significant change in the strategic score supports a lack of focus on just trying to satisfy the lecturers to maximise their grades.

Deep sub-scales

The deep subscales provide more detail on the approaches adopted by the students to learning through the PBL method. Significant changes in relating ideas can be linked to a number of PBL strategies including: the use of complex multidisciplinary problems (Abrandt et al 2001); the opportunity for students to discuss their prior learning and subsequent independent learning with a peer group facilitated by a tutor; and feedback from peers and tutors on their ideas (Engle, 1998). The following features of the MSc Ultrasound programme provide students with opportunities to relate their ideas. Firstly, the MSc Ultrasound programme is fully PBL providing students with lots of practice of working on a wide range of multifaceted problems. Secondly, students return to clinical practice during their independent learning phase, which gives them the opportunity to discuss their learning issues with clinical experts thus helping to integrate their theoretical and practical learning. Significant improvements in the use of evidence sub-scale can be linked to the inherent design of PBL programmes which require students to find information related to their learning issues themselves, and to justify it to their group and facilitator. Dodd, Eskola & Silen (2011) identify important stages in information literacy as including: identifying the need for information; identifying the most appropriate sources; and accessing, evaluating and using the information effectively. In the MSc Ultrasound context librarians are involved in the curriculum design and problem design phases of the programme.

Students are introduced to information literacy during the induction programme. Students work on a practice problem and bring the learning issues to an information literacy session with the librarian in a library skills classroom. The librarian is already familiar with the problem and is provided with the tutors guide well in advance of the session. During independent study students practice the skills of finding and evaluating information. During group work students are challenged regarding the sources and interpretation of the information they contribute to the group discussion. Follow-up information literacy sessions are provided during the programme after students have worked on some problems. Specific grading criteria related to information literacy are included on all assignments, students are provided with written feedback on their information literacy skills following each assignment. PBL has been classified as a constructivist approach to education, seeking meaning is at the core of constructivism (Savin-Baden & Howell Major, 2004). Work on PBL problems starts with activation of prior learning on which students build a knowledge base (Biggs, 2003, p233). According to Savin-Baden and Howell Major (2004, p25) the focus in PBL is to help

> *"students to utilize their previous knowledge and ways of thinking, and constructing it into a new form that is understandable and meaningful to them."*

The design of the MSc Ultrasound programme matches the fully integrated mode defined by Savin-Baden (2003) and closed-loop PBL as defined by Barrows (1986). In a well-designed PBL programme students are encouraged to seek meaning rather than rote learn information.

Strategic sub-scales

There was only one strategic subscale which changed significantly, time-management increased with a significance level of 0.032. The participants are all in clinical practice while they are registered for the MSc Ultrasound programme, work on problems starts from their first day on the course and continues throughout the programme. It is unsurprising that students' time management skills develop during this programme.

Surface sub-scales

Decreases in the surface subscales shed some light on the PBL features which may be contributing to this group of students reducing surface approaches following a PBL programme. A significant reduction in unrelated memorising could be linked to the contextual problems constructed in PBL. The MSc Ultrasound included problems developed with the cooperation of clinical ultrasonographers and lecturers in ultrasound, such problems integrate learning from theoretical and clinical perspectives (Stanton & McCaffrey, 2011). The use of continuous assessments and the lack of an end of semester exam reduces the incentives for students to rote learn factual knowledge. Independent study requires students to investigate the learning issues with the aim of bringing integrated knowledge back to their group which can be discussed rather than regurgitated. Reductions in the fear of failure subscale could be explained by the focus on developing meaning and the alignment between aims, PBL teaching and learning activities and assessment. Problems are designed to reflect professional practice and for students to be successful (Biggs, 2003). In the MSc Ultrasound programme alignment between the aims, teaching and learning activities and assessment are likely to reduce students fear of failure. Continuous assessments are issued with written guidance including marking criteria, students have opportunities to ask module leaders questions regarding assignments and following grading, written feedback is provided on each continuous assignment. Reductions in syllabus-boundness reflects the divergent approach of PBL (Biggs, 2003) problems can be designed to trigger students to cross multiple disciplines and to investigate topics which are of relevance to them beyond the constraints of a curriculum divided into individual subjects or disciplines. The MSc Ultrasound problems are multidisciplinary e.g. they can include triggers related to anatomy, physiology, pathology, patient history, ultrasound images, protocols, physics, management, psychology, infection control; and medico-legal issues among others. The students are from two different professional backgrounds radiography and midwifery which provides opportunitiues to share knowledge from both professional disciplines and experience. The groupwork provides students with opportunities to move outside of a narrow conception of ultrasound due to their exposure to other students' interpretations of ultrasound issues. The lack of change in the lack of purpose subscale may be explained by its already low score at the beginning of the programme, which limited the potential to reduce this score further.

Limitations

It could be claimed that the positive findings in this research are due to the maturation of the participants over the 16 month period of the MSc Ultrasound programme. However the participants already had professional qualifications in midwifery or radiography and a minimum of one year's clinical experience. The mean age of participants at 31.83 years (7.20 SD) also argues against this explanation of the improvements.

The lack of a control group and the small sample size limit the potential to generalise the findings to other contexts. However, the findings could be used to suggest curriculum design features in the MSc Ultrasound programme, which may explain improvements in deep learning and reductions in surface learning.

Conclusions

Improvements in deep approaches to learning and decreases in surface approaches to study were found in this study. Changes in these scales and in their sub-scales can be linked to inherent features of a well-designed PBL programme. However, the number of participants is small and therefore care needs to be taken in trying to generalise these findings. These findings will be used in the next phase of this mixed methods study. This data will contribute to the design of an interview schedule for semi-structured interviews with the graduates of the programme and topics for a focus group discussion with staff who designed and implemented the programme.

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REFLECTION AND REFLEXIVITY IN CONTINUING PROFESSIONAL DEVELOPMENT IN ENGINEERING: A CROSS-DISCIPLINARY APPROACH

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ABSTRACT

This paper argues that in order to promote professionalism in distance learning graduate level engineering programmes, engineering educators need to introduce students to the concepts of reflection and reflexivity right from the very beginning of the course. Focusing on the delivery of a new *Distance-Learning Work Based* Master's in Professional Engineering, the findings of an exploratory study in which a Narrative Analysis, aimed at analyzing the value of reflection and reflexivity in graduate level engineering education was

undertaken, the paper critically discusses the issues encountered in delivering the first part of the programme. It concludes by arguing that in encouraging professional graduate level engineering students to use reflection and reflexivity, both in their approach to learning and as a management tool, the learning and teaching techniques used on the programme are beginning to provide the students with the high level skills necessary required to meet the ever changing and increasingly complex requirements of the Profession.

INTRODUCTION: REFLECTION AND REFLEXIVITY

The link between professionalism and reflection in practice can be linked back to Dewey (1934) who argued that experience is generally qualitative in nature and, as such, is what makes life unique. By reflecting upon their lived experiences, individuals begin to consider what happens beyond the 'here and now' in such a way so as to begin to understand how past experiences can be used to guide and inform future action (Dewey, 1934). Put simply, the act of reflection entails *looking back* on individual experiences and practice, reflecting on decisions made and activities undertaken (Brewer, 2000, 2004; Bryman, 1989, 2001). Reflexivity, on the other hand, takes the process of reflection one stage further; it involves *critically reflecting* on past activities, analyzed one's actions and decisions, and using that analysis to advance and improve individual decision making thereby enhancing future practice (Giddens, 1991; Alvesson & Skoldberg, 2000; Doane, 2003).

Reflection and reflexivity are particularly important in professional engineering where it is imperative that past mistakes are not repeated but are instead used as a learning opportunity. Indeed, in applying Dewey's perspective to professional engineering education it may be contested that although a professional engineer may correctly perform a task using appropriate and accepted norms and practices, a lack of insight and understanding into the underpinning theoretical and experiential drivers impacting those practices may negatively impact the decisions made. This could have dire consequences in the wider environment in which the individual engineer is working.

Nightingale and Cromby, (1999) argue that from an epistemological perspective, reflexivity necessitates engagement with current and future professional practice through a process of reflecting upon individual assumptions of knowledge. Critical reflexivity requires the individual to consider how the theoretical and conceptual underpinning of their past experiences may potentially influence future practice. Likewise, ontological reflexivity involves thinking about one's personal outlook on life and attitudes, and considering the impact that past events could have on future experiences.

The value of reflection and reflexivity in engineering education is briefly raised in the literature (Socha at el, 2003; Feest & Iwugo, 2006). Similarly, the requirement that professional engineers use reflection in their practice has also been previously discussed (Robins, 2007). However, there is a clear gap in current knowledge about the pedagogical issues faced by engineering educators in promoting reflective and reflexive practice within the curriculum. It is these issues that this paper begins to address.

The Msc professional engineeringby work-based learning

The MSc Professional Engineering by *Work Based* Learning was developed as part of a Government funded Gateways initiative led by the UK's Engineering Council (EC). It is a collaborative venture with other universities, and a number of Professional Engineering Institutions (PEIs), under the direction of a National Steering Committee. The programme at Aston University was introduced in April 2010.

Within the University the programme is delivered and managed by the School of Engineering and Applied Science. Designed to be sufficiently flexible so as to meet the unique needs and requirements of professional engineers from all types of industry and backgrounds, the programme is not attached to any particular department or engineering discipline. As such, collaboration across disciplines is key to the programme success. Likewise, quality assurance is also fundamental, and so the programme adheres to the usual University standards, requirements and practices.

Upon enrolling, students are required to take 5 core modules, and 4 optional ones. The programme itself is distinctive in that it is entirely underpinned by the principles of Problem and Project-Based Learning [PBL / PjBL]. In acknowledging that professional engineers are increasingly called upon to solve an array of complicated local, national and international problems, including those related to global warming, sustainability and pollution (IMechE, 2009; RAEng, 2008), the programme aims to equip students with the high level knowledge and skills necessary to work in an increasingly demanding environment. The fact that such problems, whilst usually grounded in engineering or science, tend to be complex and multifaceted in nature, means that more than ever professional engineers are required to be able to 'think out of the box' (Lucena et al, 2008; RAEng, 2007). Indeed, it is the need to produce engineers who will become the 'flexible and globally astute' critical problem-solvers of the future that the MSc Professional Engineering aims to fill.

Reflections and reflexivity ine the Msc

The first part of the programme is a core module that requires students to undertake a Personal Development Audit (PDA). Comprising three distinctive components: The Evaluative Review; Competency Mapping Report, and; Learning Agreement, this module underpins the rest of the programme. The Evaluative Review (ER) is credit-bearing whilst the other two components are subject to approval by the relevant Professional Body (as well as by the University). In developing the learning and teaching tools for the ER, the programme lecturers have adopted an approach that incorporates reflective and reflexive practice right from the onset. This approach encapsulates a unique cross-disciplinary pedagogy that meets the diverse needs of the individual engineers enrolled on the programme. The programme is delivered by means of five interlinked, but separate, Work Packages. Each of these was developed specifically for the programme in a manner suitable for distance learning. By making sure the principles of reflection and reflexivity are built into the PDA right from the beginning – it is designed in such a way so as to encourage students to apply similar principles both to their professional practice and to the remaining modules. In adopting such an approach, the PDA lecturers and Programme Director aim to equip individual students with the high level skills and competencies required for success in modern-day professional engineering.

Study methodology

Utilising an Action Research approach (Norton, 2009) exploratory research was conducted aimed at analyzing student and staff perceptions of the role of reflection and reflexivity in engineering education and professional practice. The first stage of this process comprised a 'Narrative Analysis' of students' Evaluative Reviews [ERs]. It is this analysis that forms the basis of this paper. In total, 10 ERs were analyzed comprising a total of just over 30,000 words. The reflective and reflexive component required within the ERs make them the ideal medium with which to conduct a Narrative Analysis. In discussing the methodological rationale for such an approach, Coffey & Atkinson explain that a Narrative Analysis provides researchers with the opportunity to determine ...“*How actors retell their life experiences as stories..* [this]… *can provide insight into the characters, events and happenings central to those experiences”* (1996, p 69).

In order to deal with issues of validity and reliability in the process of analyzing the students’ ERs, the documents were first anonymised. Following this, an ‘analytical framework’ was developed enabling the researchers to analyze the data through systematic coding and categorizing (Cousin, 2009). The data was broken down into ‘manageable’ units of analysis (Cohen et al, 2007) and comparative themes and sub-themes identified. The findings were then collated and summarized for the purposes of curriculum development. This summary is given below.

Findings

Three main themes were identified during the course of the analysis. The first of these pertained to the students’ propensity to focus on epistemology and technical description when discussing the practical aspects of past engineering experiences. The second theme centred upon students’ experiences of management, and the third on students’ perceptions of their own learning approach / style. Each of these is now discussed.

Theme 1: Epistemological and Technical Description

In undertaking the analysis, the most notable similarity across all of the ERs was that the students all appeared to have some difficulty with the act of ‘reflecting’, and experienced even more difficulty being ‘reflexive’. As a distance programme, the MSc is designed in such a way so as to provide a supportive pedagogical learning environment. Students are encouraged to seek formative feedback prior to submitting their final work. As a consequence of this, each ER included within the analysis had been through 1 or 2 iterations. Despite this, there was a tendency for the students to focus very much on the technical aspects of their past experiences. One the whole students’ written reflections were very much grounded in the epistemology of their past experiences. They all described in great detail the ‘engineering and scientific' underpinnings of their actions and decisions, whilst collectively failing to critique such experiences ontologically and subjectively. Furthermore, there was a notable lack of reflexivity in all of the students accounts – each failing to conceptually link past decisions to future experiences.

Theme 2: Reflections of Management

One of the 'non-technical' issues discussed in all of the ERs related to the students' past experiences of management. These reflections related to their experiences of either dealing with their line managers or supervisors, or of line managing or supervising others. In all cases, it was evident that the students' found the task of reflecting upon the relational (ontological) aspects of their experiences extremely difficult. Whilst some cited examples of management practice (good and bad), little or no attempt was made to explain or analyze such experiences by referring to the academic - theoretical literature pertaining to organizational or strategic management. Furthermore, the majority of students did not discuss how, or what, they had learnt from their past managerial relationships, although two did briefly discuss how they might do things differently in the future as a result of past experiences. In short, similar to the students reflections about the practical aspects of engineering, the majority of the reflection pertaining to management was overwhelmingly descriptive – with students struggling to move beyond descriptive reflection to achieve reflexivity and critique.

Theme 3: Reflections on Approaches to Learning.

The Work Packages have been purposefully developed so as to encourage the students to reflect upon their past learning experiences and to consider how such experiences might impact their future approach to education (both on the programme and beyond). Unlike the discussions pertaining to management and the practical aspects of engineering, a certain amount of 'reflection' about how they learned was evident in all of the ERs; with all of the students using Kolb's (1984) work as the basis of their reflection (this is included in the Work Packages). However, as with the other reflective discussions, none of the students contemplated discussed how they could use their past learning to inform, shape and guide their future approach.

Discussion: The omplications of the study for future learning and teaching

Arguments that in order to achieve high quality scholarly outcomes, university teachers need to adopt an approach to teaching similar to that of research (founded upon academic rigour and evidence), have long been discussed in the literature (Elton, 2005 & Healey, 2000). Such arguments suggest that in order for academic staff to improve their practice, they should receive formal training in how to become critically reflective and reflexive teachers and researchers (Giddens: 1991, Alvesson & Skoldberg: 2000, Doane: 2003, Finlay & Gough: 2003). Applying this argument to engineering, it may be contested that learning from past experiences, both positive and negative, is essential when considering how to improve and enhance future professional practice.

It is acknowledged that this study is in its very early stages, however, the Action Research nature of the research design is such that by identifying the difficulties experienced by students in developing as reflective and reflexive professional engineers, the lecturers responsible for the ER have been able to put into place a number of support mechanisms to help students develop in this area. It is clear that the engineering students enrolled on the programme have a long way to go before they achieve reflection *and* reflexivity both in their learning and in their professional practice. That all of them are struggling to grasp the concepts may be indicative of the fact that they are all engineers – and as such are used to thinking in a more practical and applied manner. Yet despite this, the findings of this short study, when contextualized with the literature, begin to provide evidence to suggest that in order to promote professionalism amongst professional engineering students, the concepts of reflection and reflexivity need to be embedded into the curriculum.

As a consequence of this study the Work-Packages have been refined and input made into the manner in which the remaining modules are delivered. The module lecturers make a point of working with each individual student – offering advice and guidance about how they can improve their learning approach and their practice through reflection and reflexivity. This is not an easy process, but taking into account that the fact that it is a *distance* programme, with little face-to-face contact, some success is beginning to show as students start assembling their competency mapping and personal development audit.

Concluding remarks

The students whose work was analyzed as part of this research were all enrolled as distance learners, and were based in Africa and Asia. All had studied engineering to Bachelors Level in the 'traditional' manner. In addition to identifying issues pertaining to reflection and reflexivity, the in-depth Narrative Analysis undertaken during the exploratory study has enabled the researchers to identify key pedagogical issues arising in the early stages of the programme. Such issues vary in nature from the need to make sure the students are all fully prepared to study at graduate level (in terms of academic skills and competencies), to the need to make sure that the remaining programme modules are delivered in a cohesive and professionally relevant manner. As such, the ER has become an essential component of the whole programme. It allows students the time and space to consider how to compose their 'Competency Mapping Report' and provides them with the means by which they can identify the areas they need to work on from both professional and educational perspectives. The individually 'tailored' nature of the programme means that the remaining 'technical' modules are delivered in such a way so as to benefit both the learner and the organization in which they are employed. In this way reflection and reflexivity become key to student success.

In conclusion, by encouraging graduate level professional engineering students to use reflection and reflexivity both during their learning and as a management tool, the learning and teaching approaches used on the programme are beginning to provide them with the high level skills necessary required to meet the ever changing and increasingly complex requirements of the profession.

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ACT-UK SIMULATION CENTRE: USE WITHIN THE DEPARTMENT OF CIVIL ENGINEERING, ARCHITECTURE AND BUILDING

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ABSTRACT

The Advanced Construction Technology Simulation Centre (ACT-UK) is an innovative facility for training future construction managers, enabled by a semi-immersive virtual reality model of construction sites. As part of the degrees at Coventry University, four 2-day training sessions were conducted and attended by nearly 80 students. A reflective account of the process of formulating the training programme is reported in this paper. It highlights the process of running two pilot courses to help formulate the proposed training sessions. In addition, questionnaires were taken to identify the necessary 'soft' skills that the training process delivered. Comments on how the courses altered during their delivery are also described. As such the case study offers a lesson on the adoption of an innovative new problem based learning process to enhance the student learning experience within a higher education context.

INTRODUCTION

ACT-UK is a national centre of virtual reality simulation located at Coventry University Technology Park. ACT-UK uses the latest technology to train construction trainees through the pedagogy of problem-based learning (PBL). The centre delivers scenarios with all the pressures, issues and interruptions that are experienced on a real building site and incorporates a philosophy that the students will first need to identify and define problems and develop a thorough understanding of their nature in order to formulate a response. The response is then analysed and presented. As part of its training process, the centre uses a form of semi-immersive virtual reality simulation (VRS) where the users feel as if they are in a real situation and interact with actors as necessary (Horne and Hamza, 2006). The centre is unique in the UK and is based on the VR technology used at the Building Management Simulation Centre (BMSC) in Leeuwarden in the Netherlands (Vries et al., 2004). It offers learners a simulated learning environment based on the complexities of operating within a construction site. Within their "site huts", learners complete specific construction related tasks whilst actors play a variety of roles that a construction manager might encounter during a typical day (Stewart, 2007). As suggested by Macdonald and Savin-Baden (2004), the students are not expected to produce "right" answers, but to engage with the complex situation presented to them. At the end of the training session, the learners review the process and discuss the consequences of the decisions that they took - therefore the actions that the learner undertakes can be shown in direct relation to the building construction. This approach tends to be stronger than the traditional approach of verbal or written descriptions of the possible consequences.

The simulation centre offers training which complements existing education and training programmes and therefore its use was considered appropriate for the existing undergraduate Building degree programme at Coventry University. However, the centre does **not** offer full education but focuses on problems that require 'soft' skills that can be developed through the experience (Taylor, 2008). The simulation centre has undertaken a full review of the Chartered Institute of Builders (CIOB) educational framework (CIOB, 2009). In addition, a development team from the centre, in conjunction with members of the construction industry, identified competency and skills categories which were deemed the most important for a UK site manager (Stothers, 2007), these being, leadership; planning and organisation; monitoring and controlling performance; problem solving and risk management; team and people management; and communication.

Previous research (Austin and Soetanto, 2010) has been undertaken regarding the use of the centre to enhance the learning experience of undergraduate students within the

Department of Civil Engineering, Architecture and Building at Coventry University. The findings suggested that ACT-UK training should not be offered to all students at all levels within the undergraduate Building degrees. However, that is not to say that the use of the simulation centre was not deemed worthwhile. The case study data collected showed that the use of the construction simulator was seen as a positive step forward in construction teaching. Issues regarding cost, available curriculum time and appropriate modules in which the simulation centre could be embedded meant that it was not possible for all students to use the centre at all degree levels. In direct response to this conflict, a proposal was established to develop a programme that would be offered to Construction Management students at level 2 and 3. This case study explains the development and implementaion of this programme.

Programme development

Having established which course would be using the centre the first stage in the development was to establish which constituent modules within the Construction Management degree would have the most synergy with ACT-UK. This process was simplified by there only being one module at level 2 and 3 that was undertaken solely by undergraduate Construction Management students: -

- Level 2 – Management Principles and Statistics
- Level 3 – Construction Management Studies

As both modules have strong management content, a key focus of the simulation centre, the choice of these two modules was deemed appropriate. The next stage in the process was to ensure that the use of the centre would be suitable within these two chosen modules. To facilitate this process a review of the learning outcomes and there suitability for use in the centre was undertaken, in conjunction with the skills identified above, that the centre delivers. The process of matching the module learning outcomes and centre's competency skills was undertaken during a meeting with the centres manager and a designated ACT-UK co-ordinator from the department. The co-ordinator had previously helped to develop the training activities and scenarios used within the centre and therefore had prior knowledge of possible training activities. For the level 2 module the following learning outcome matched closely with the centres competency skills. "Identify and appraise factors affecting relationships between individuals in organisations". At level 3 the learning outcome that most closely matched was “Articulate solutions in addressing common construction problems”. These two learning outcomes were chosen as they closely match with the centers competency skills of leadership, team and people management and communication. Having decided on a focus for the training programmes the next stage, during the meeting, was to decide which of the centres training scenarios could best deliver these learning outcomes. A review of the 100 possible training scenarios that the centre has available was undertaken to ensure that those chosen focussed on the three competency skills of leadership, team and people management and communication.

The centre operates its training programmes on a maximum of 2 simulation sessions a day. During each simulation session there is 1 main training scenario and usually 2 smaller scenarios. These scenarios are snap-shots of real-life construction site situations, and require the trainee to interact with various actors who introduce the site problems. By referring to information presented to them and interacting with the actors, the trainees need to make decisions, and will also receive feedback once the session ends. The interaction with the actors represents the most important phenomenon in the process as it can unfold the trainees' ‘soft’ people management and communication skills and demonstrates their inherent personal attributes such as empathy, confidence, decisiveness and assertiveness. Based on the feedback, the trainees can reflect on their behaviour during the sessions and learn from the reasons why they have behaved in a certain way when faced with a specific construction site scenario. Such a cognitive process will enhance their people management skills and promote deep learning due to their engagement with the scenarios. The following training scenarios were chosen.

Level 2	Level 3
Simulation 1 *Main* – Damaged vapour barrier. • Details – the breather membrane has been damaged on a plot. The site manager has to organise the repair and to ensure the correct laps. *Secondary* – Carpenter walking off the street looking for work, ground operative complaining about their goggles	**Simulation 1** *Main* – Foundation problem. • Details – ground worker comes to the site office because foundations to a certain plot have encountered loose made-up ground and a solution is needed *Secondary* – site worker late for induction, visit from the quantity surveyor.
Simulation 2 *Main* – Clients kitchen. • Details – purchaser has visited his kitchen and notices it is incorrectly installed. He refuses to complete until the layouts is as per his drawing *Secondary* – Project manager asking for completion dates, site foreman asking to work on a Sunday	**Simulation 2** *Main* – Unsafe use of scaffolding. • Details – bricklayer foreman called to the office to see who changed the scaffold and then used. *Secondary* – Plasters plasterboard has been damaged, an angry neighbour.

Table 1. Scenarios identified for each level

All the scenarios chosen for level 2 have a strong focus on team and people management to meet the specific learning outcomes identified. The level 3 outcomes have a strong focus on leadership to again meet the specific learning outcome. Both levels have strong communication focus need for working within construction.

Pilot

Prior to the courses being undertaken it was felt necessary to undertake a series of pilot sessions to see if the scenarios chosen were appropriate. These pilot sessions were limited in spaces, and were open to all final year building degree students, but excluded Construction Management students. The pilot courses were for half a day and therefore only had 1 simulation. The simulation piloted was level 3, simulation 2, unsafe use of scaffolding, plus the angry neighbour. After each pilot course a review was undertaken and discussion was undertaken with the delegates to gauge their experience and try and make sure the scenarios were correct. An area of clear consensus was that the proposed use of the centre was a rewarding and valuable experience for the students within the construction industry.

> *"..the experience is enormous... a lot more was learnt"*
> *"…used good real life examples…definitely do it again!"*

However, there was one area that the students felt could be improved and this was the ability to review the process and discuss the consequences of the decisions that they took.

In addition to the verbal feedback obtained, a questionnaire was issued. The aim of the questionnaire was to ascertain the student's views on the skills being developed in the centre and how they rated their own performance in these skills.

Skill descriptor	Level of importance							
	Very		Fairly		Low		None	
Communication skills	90%	45%	10%	50%	0%	5%	0%	0%
Leadership	85%	40%	15%	45%	0%	15%	0%	0%
Team working & team building	70%	70%	25%	25%	5%	5%	0%	0%
Problem solving	90%	50%	10%	25%	5%	5%	0%	0%
Planning and organisation	70%	25%	30%	55%	0%	20%	0%	0%
Monitoring and controlling performance	60%	25%	35%	55%	5%	20%	0%	0%
	Importance with career	Own rating ability	Importance with career	Own rating ability	Importance with career	Own rating ability	Importance with career	Own rating ability

Table 2. Skills analysis

Out of the 6 competency skills a high majority of all the students rated each one as being a very important skill in helping them prepare for careers in the construction industry. In relation to their own ability the majority of the students rated themselves as only having a fair ability in the skill. However, there was one exception to this, teamwork. This could be somewhat explained by the nature of the degree programmes the level 3 pilot students were undertaking. Their courses contain an integrated project module, which they were currently undertaking and which heavily focuses on team work and team building.

What was drawn from the pilot feedback and questionnaire is that the students were extremely positive about the training within the simulation centre and identified that the skills the centre focuses on are very important in the construction industry. In addition, they also showed that they felt there was a clear area of developmental opportunity that undertaking training in the centre could start to address.

Following the two pilot courses a decision was taken to run the proposed courses, for level 2 & 3, using the scenarios previously outlined, but to also address the issue of being able to review the process and discuss the consequences of the decisions taken.

Course delivery

The first issue to decide upon was the number of courses to run. The ACT-UK centre works best when around 5 or 6 site huts are being used at the same time. The reason for this is that if there are more site huts being simultaneously used, the ability of training supervisors to give effective feedback is reduced, as there is too much to observe. In addition, as the training is a new facility that the students hadn't experienced before, the decision was taken to allow the students to initially work in pairs for the first day and work independently on the second day. This decision also replicated 'real-life' site management where individual and team work ability is vital. As the training is a semi immersive process it can be very tiring mentally, the centre recommends that no simulation session last longer than 90 minutes. This allows for 2 simulations to be run in the morning and two in the afternoon, resulting in more students being trained. As a consequence of this information it was decided that there would be one level 2 course of 14 students and three level 3 courses, with each occurrence having 22 or 23 students. The level 3 course structure is shown below.

<table>
<tr><td colspan="2">Day 1 – ACT-UK
9.00 – 9.30 – Arrival, introduction to course
9.30 – Briefing of the project and Familiarisation of simulation hall and site huts</td></tr>
<tr><td colspan="2">Simulation 1</td></tr>
<tr><td>Group A (10 students in pairs)
10.00 – Briefing of simulation session
10.15 – Simulation exercise in pairs
11.15 – Feedback from actors
11.30 – Lecture & Coursework introduction</td><td>Group B (12 students in pairs)
10.00 – Lecture & Coursework introduction
11.30 - Briefing of simulation session
11.45 – Simulation exercise in pairs
12.45 – Feedback from actors</td></tr>
<tr><td colspan="2">Simulation 2</td></tr>
<tr><td>Group A (10 students in pairs)
2.00 – Briefing of simulation session
2.15 – Simulation exercise in pairs
3.15 – Feedback from actors
3.30 – Observation</td><td>Group B (12 students in pairs)
10.00 – Observation
3.30 - Briefing of simulation session
3.45 – Simulation exercise in pairs
4.45 – Feedback from actors</td></tr>
<tr><td colspan="2">Day 2 - ACT-UK & Coventry University
11.00 – 1.00 – Feedback and discussion – review of previous days simulation and preparation of final simulation process
2.00 – Simulation exercise individually and observation
4.00 - Feedback</td></tr>
</table>

Table 3. Course structure

The briefing outlines the specific exercise that the students have to undertake in the simulation session. These are related to the specific construction site, but were also related to prior learning that the students had undertaken within the module and included relevant site management issues (e.g. checking Health and Safety paperwork). However, the exercise does not provide any detail regarding the simulation scenario that will also be undertaken. This is to ensure that the simulation process remains as realistic as possible. During the simulation session the learner undertakes the outlined exercise. Whilst undertaking the exercise the simulation scenario will also be started (e.g. to find out how the student reacts to a leadership, team and people management and communication issues). The beginning of the scenario could be that the site manager's foreman (played by an actor) comes into the site office and explains to the student (in the role of the site manager) that there is a problem excavating the ground for a certain plots foundations (Level 3 – Simulation 1). To make the simulation effective a number of parties would be involved in the scenario, including a foreman and subcontractor (played by actors) and structural engineering representatives who could be contacted via the telephone. Expected outcomes as a result of the simulation scenario could be that the student stops the work immediately, contacts the company's structural engineer representative, discusses the situation with the site foreman or makes an uninformed decision. The main aim of the simulation session is to see how the student reacts to and manages this news and not the exercise scenario that was outlined in the briefing session. Such a simulation scenario would allow the student to show competency in team and people management along with leadership and necessary on-site communication. During the rest of the training session the students would encounter two smaller site scenarios from the actors, linked to leadership, team and people management and communication issues, which also require action. Following the simulation there is a short feedback session by the actors, to the students in groups, focusing the students on their strengths and how they might have undertaken the scenario differently by using knowledge gained from the skills session.

The afternoon simulation sessions were devised as consequence of the feedback provided from the pilot courses. The students had commented that they wanted the ability to review the process. This was not fully achievable, however, a compromise was devised. When one group was being simulated, the students from the other group were given the opportunity to watch the first group of students going through the simulation process. They got to see the interaction between the students and the actors and therefore see and understand the consequences of the decisions that the students made. This process was then reversed. However, on the first course when group A were being simulated it soon became apparent that the students in group B, who were observing, thought that they had an advantage because they knew the scenarios and problems that they were about to encounter. Therefore, a decision had to be quickly made regarding the second group and their afternoon simulation to ensure that it was still a valid learning experience. In consultation with the manager for the ACT-UK centre, the decision was taken that, though the second group would encounter the same scenario, it was possible through the actors to considerably alter the experience and therefore make the students react to the new experience and not the one they were expecting. The alterations were instead of the bricklayer foreman arguing that his workers hadn't altered the scaffolding (level 3 – simulation 2) to being totally agreeable but not really suggesting ways to help improve the problem. This difference, that is achievable through the actors, ensured that the students received the same scenario but had to react to different experiences.

The structure to the second day was also developed from the feedback where the students commented that they wanted to discuss the consequences of any decisions that they took. Therefore, the start of the second day was an open review of the previous day, undertaken as a group experience. The students, in their pairs, received feedback from the three supervisors who had monitored their performance from the control room. The feedback very much focussed on positive reinforcement. The students were advised on the consequences of the actions they had taken. It wasn't stated that it was wrong, just that different people had reacted in different ways and as a result had different outcomes. The students were asked to listen to other group's feedback and see whether they could learn from how other people had undertaken the process. Discussing the possible use of more imagination and passion to respond to the situation, rather than just relying on pure technical knowledge or authority/ power further developed this. All six scenarios were reviewed over an approximate 2-hour period. Students made notes of the feedback to help with a coursework that had been set on their experience of using the simulation centre in relation to the module learning outcomes. At the end of the feedback process the students were introduced to the format of the remainder of the second day. Whereas the first day was undertaken in pairs, the second day was an individual experience. To help the students learn by reviewing their actions, the second day simulation was a repeat of the one of the first day scenarios (simulation 2). However, rather than one actor being involved the students had to deal with two actors. Whilst five students were being simulated all of the other students were in the control room observing. Once the first five had been simulated the next five undertook the scenario. The original plan was that they would all receive the same process, but after the changes need in the first day it was decided that each group of five would receive a slightly different experience by altering the actions that the actors undertook. It ranged from a foreman refusing to get off his mobile phone whilst in the meeting, to disengagement and finally near physical confrontation between the two actors. Another change that was made was that when the first five students had undertaken the scenario instead of sending the next five straight in the first five were bought up to the control room so that all students were together. The observing students, along with the observing supervisors, then gave verbal feedback to the first five students, in a similar process to what had been undertaken in the morning.

Evaluation

To ascertain the effectiveness of the training the students undertook two questionnaires. The first questionnaire was undertaken before the start of the training, during the introduction, the second after the training. Both used the same questions to evaluate the student's response to the training that had just been undertaken.

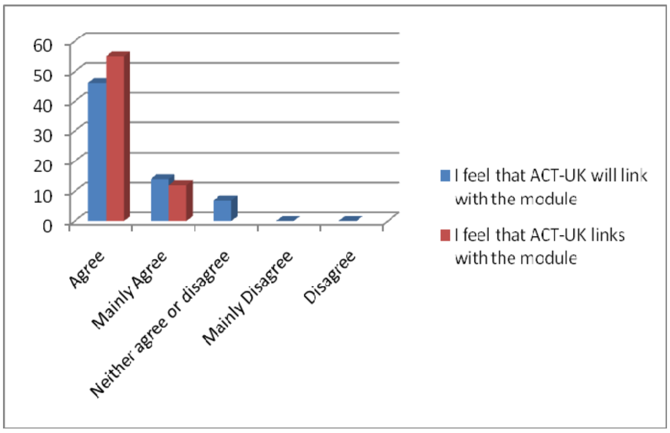

Figure 1 – Linkage to Level 2 & 3 modules (Number of responses)

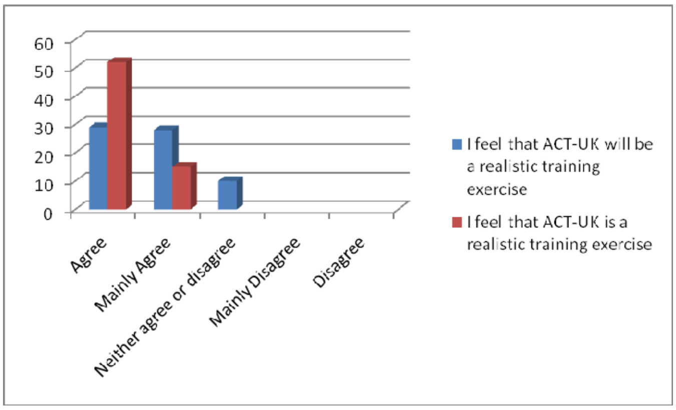

Figure 2 – Realism of the ACT-UK training (Number of responses)

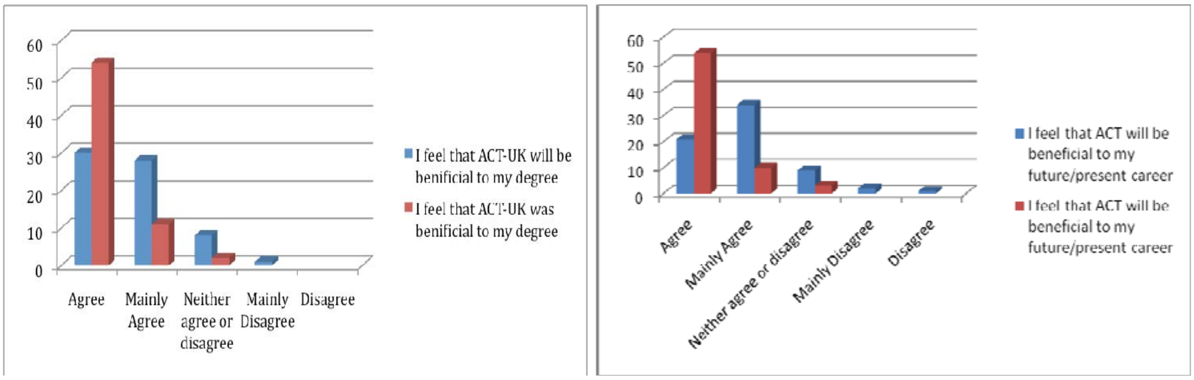

Figure 3 – Benefits of the ACT-UK Training (Number of responses)

Students thought that the centre was going to link well with their respective construction management modules. After the training this rose to 80% of the students agreeing and no student disagreeing. The realism of the training also rose after the students had experienced it, to 77% with again no students disagreeing. Regarding the benefits of the training this rose to 81% for both questions. In addition to the questionnaire, as part of the modules assessment the students were asked to write a report on their ACT-UK experience. Three questions were asked. How did the training go?; What was positive and what was negative about the experience?; How useful was the training in terms of both your current BSc. course and current and/or future development. The first question relates the ACT-UK expereince to the module learning outcomes and especially the centres comptencies of leadership, team and people management and communication. Below are a sample of responses the students produced in relation to these comptencies.

> *"I got to learn what leadership is with respect to the organizational aspects of managing human tendencies..."*

"This training improved our thinking as a person, making me aware of how to deal with things when they arrive unexpectedly on site. Handling pressure and solving issues at the same time boosted my confidence".

"I then realised that communication was the key to learning in the simulated environment...".

"The feedback given by the actors on the concepts of communication skills, teamwork and leadership skills, individually were very informative".

The second and third questions asked reinforced the data from the questionnaire. All the data collected showed that the students saw the training undertaken in the simulation centre as a valuable, relevant and beneficial experience. In addition to the questions students were able to provide summary comments on the training. These were extremely positive.

"Overall I thought this was a good course and gives students a heads up when starting a job in the real world"

" I feel as if a learnt more about my own strengths and weaknesses than any other University event"

The results of these comments, and the data received from the questionnaires, has meant that the use of the ACT-UK centre is planned to be used next academic year, and, as a consequence, module descriptors have been amended to reflect this integration.

Conclusion

To conclude, the use of the ACT-UK centre within the construction management modules in the Department of Civil Engineering, Architecture and Building has been received extremely positively. The development of the course provided has been closely linked with the relevant module learning outcomes and centre competencies. A pilot process has been undertaken to ensure the training scenarios chosen are effective and relevant. After the pilot courses the new training courses were implemented across the two modules. As part of the review, data and views were collected from the students that showed an extremely positive and valuable problem based learning experience that met the learning outcomes selected from the specific modules.

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GETTING OUT THERE
PBL AND THE CASE OF COMPULSORY PRACTICUM IN ENGINEERING EDUCATION

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ABSTRACT

The universities are asked to get out of the ivory tower, secure the employability of the candidates and in all get closer to the society that is paying for the research and the educations. At Aalborg University the connection to and cooperation with organisations and institutions outside the university has been a focal point right from the university's inauguration in 1974. Because of the PBL structure of most of the study programs students get used to work on problems and projects in organisations outside the university. Practicum, as these internships are called, are a success – students, university supervisors and company representatives all like the cooperation between student and companies. But it seems that the administration of the programmes causes some problems. In this article the experience with the introduction of practicum in the bachelor programmes in engineering at Aalborg University is analysed.

INTRODUCTION – PRACTIUM IN ENGINEERING EDUCATION

In recent years the on-campus PBL model at Aalborg University has been developed further so practicum arrangements have been written into still more study programs and curricula and in some cases they are even made compulsory. This article is describing and analysing some of the experiences with the practicum gained at Aalborg University (Kolmos, Krogh & Fink, 2004; Kolmos & De Graaff, 2007; Barge et.al. 2010).

The term practicum is chosen very deliberately here instead of praxis, internship or traineeship, as these terms carry certain connotations and do not necessarily cover the same as practicum. Practicum is inspired by the German “Praktikum”, and describes the situation where a university student is spending some time, typically one semester, in a company outside the university. Here the student performs certain tasks that are related to the field of study that the student is part of. The idea is to get as close as possible to future job situations and make use of what is learned at the university in a real life situation.

This article describes the results of an investigation of the compulsory practicum in the study programme in the bachelor engineering education. The data for the article was gathered through 2010 via interviews with students, faculty at both bachelor and master programmes and administrators from local and central management bodies at Aalborg University. Representatives from companies hosting practicum students were also interviewed.

One of the main findings of the project is that the practicum arrangements at Aalborg University are very different, but always successful. That is, the students are very enthusiastic about the practicum and they learn a lot. The companies also like the practicum while the university faculty has a more mixed conception of this type of cooperation with the outside world. Some of the reasons for this difference in the attitudes towards practicum are analysed in this article.

Compulsory practicum

In Denmark several educational institutions offer programs in engineering educations – at both bachelor and master level. In 1993 the different programs from the different engineering education institutions were streamlined, so all programs at the bachelor level should incorporate a compulsory practicum element. At Aalborg University this caused problems, as the university’s bachelors programs do normally not include any practicum. When the change also caused economic problems for the study boards, it was foreseeable that the changes were met with some suspicion and only implemented reluctantly.

In this paper the changes and their consequences for the educations are described with the emphasis on the bachelor program in industrial engineering.

Changing the curriculum – reform of 1993

In 1993 the Ministry of Education decided to change the curriculum for the bachelor education in engineering. Before 1993 there were three kinds of engineering educations in Denmark: First, civil engineers (M.Sc.'s, not to be mistaken for the construction engineers called civil engineers in the English speaking countries. In Denmark all engineers with a masters degree are civil engineers), a five years master programme at Aalborg University or DTU (Technical University of Denmark). Second, academy engineers, they were educated at Aalborg University and the Engineering Academy in Copenhagen. Third, teknikum engineers were educated at Technical colleges.

The two educations, academy engineer and teknikum engineer, were both regarded bachelor programs and they had each their own professional profile. The academy engineering education was a shorter theoretical education (3 ½ years) and the training was primarily aimed at students (students have a degree from high school). Teknikum engineering education was also a 3½-year program, but was primarily targeting young people with a technical background (craftsmen, who were educated through an apprenticeship programme). With the reform of 1993 the two educations were merged into what was called a diploma engineer.

The latest change of the bachelor programs in engineering came in 2002 when all university educations in Denmark were changed to the Anglo-Saxon 3 plus 2 system with bachelor and master programs in all educations. All these changes meant nothing to the bachelor programs at Aalborg University, except from the change of the name from academy engineer to diploma engineer. Because of protests from the Danish Industrial Association the new diploma engineering education had to encompass a 6 months practicum. But because of the PBL (problem based learning) structure of the Aalborg University educations, the diploma engineers from Aalborg were excepted from the practicum. The argument was that in the PBL education there was plenty of cooperation with external partners during the problem-based projects that the students would take on during their education.

This was all changed in 2006, when the Ministry of Education decided to change the Aalborg model. Now the study boards at Aalborg University were told to integrate a practicum placement into their study programmes.

There is some doubt why the exception from the practicum was withdrawn. Some say it was because of intense lobbying from the other engineering schools that found it unfair that Aalborg University was exempted from the compulsory practicum. This was due to the fact that the Ministry of Education did not pay the engineering schools any school fees for the time the students spent in the practicum placement. This meant that Aalborg University would be paid for 7 semesters for a full diploma engineering education, while the other engineering schools would only receive school fees for 6 semesters. Therefore there would also be an economic incentive for the ministry to withdraw the exception. Therefore the whole affair, from an Aalborg perspective, looked like a budget cutting exercise – of course much to the annoyance of the managers of the study boards in Aalborg which now were supposed deliver a full seven semester education for the payment of six semesters.

The compulsory practicum

The compulsory practicum has been in effect since 2007. For the study boards at Aalborg University this meant that they had to change the curricula so they would fit the new circumstances. New study programs were made so they would fit the demands of the Ministry of Education. In a note dated 27 October 2006 Aalborg University was handed a set of "recommendations" on how to handle the practicum. The recommendations were made by EVA, the national evaluation institute, an independent evaluation body, working closely together with the Ministry of Education. The recommendations were as follows:

1. Seminar after the practicum to share the experience to secure that the students and the supervisors would reflect upon the practicum experience.
2. The practicum should be grated a minimum 30 ECTS.
3. The practicum placement should be within the professional domain and secure relevant professional competencies.
4. The practicum should be placed in the last part of the education.
5. The practicum should secure the exchange of experience and theory between the education and the practicum company.
6. Goals and purposes should be planned and described.
7. Evaluation of the practicum should be done through known and appropriate methods.

At first glance these recommendations seem quite reasonable for any kind of practicum, but still they caused the study boards a lot of problems as well as cost of money when the study boards tried to implement them. During the next two years the study boards tried to implement the recommendations and a lot of e-mails and other correspondence went back and forth between Aalborg University and the Ministry of Education. This was often held in a very harsh language, as the study board managers thought this was unfair to their study programmes. In the process the recommendations from EVA changes status from

recommendations to demands, and the study boards had to comply if they wanted their educations accreditated by the national accreditation committee.
This process has found its final conclusion – at least so far. In a letter dated 29th May 2009 from the central administration of the INS-faculty (INS – Engineering, Science and Medicine faculty at Aalborg University) which responds to the recommendations. The letter is a response to a letter from the Ministry of Education dated 7th February 2007 where the ministry is asking for a plan to fulfil the recommendations and get a final accreditation for the diploma engineers in Aalborg. The letter lists the activities and changes made in order to fulfil the demands. That is, the change in the study programmes, the curricula and the concrete actions taken by the study boards. According to the letter of 29th May 2009 this is done in the following way:

1. Secure that the students and the supervisors would reflect upon the practicum experience. This is fulfilled by using the practicum as a point of departure for the bachelor thesis made in the final seventh semester.
2. The practicum should be grated a minimum 30 ECTS. This is written into all study programs.
3. The practicum should be within the professional domain and secure relevant professional competencies. The study boards secure this by confirming the company's ability to provide a sufficient professional content of the assignment, and thereby give the student the opportunity to experience and develop professional competences in accordance with the theoretical part of the education. The study board will also secure that the possible exchange of knowledge, skills, competencies and values between theoretical education and the professional skills and competence in relation to this. The study board will appoint a university supervisor to each student, and this supervisor will secure that the plans and goals are reached.
4. The practicum should be placed in last part of the education. According to all programs the practicum is places in sixth semester (Second half of the third year).
5. The practicum should secure the exchange of experience and theory between the education and the practicum company. Each student will be granted a university supervisor and besides this, the students will also be granted a supervisor from the practicum company. This ensures a continuous exchange of knowledge, skills and values between university and company - between the student, university supervisor and company supervisor. Before the students begin their practicum there is arranged, in addition to an introductory course to the practicum, a course with a focus on exchange of knowledge, skills and values between university and

business.
6. Goals and purposes should be planned and described. For each practicum placement there is specified purpose, expected content and outcome. For each practicum agreement a written agreement is prepared. This agreement states the content, goals and duration of the practicum.
7. Evaluation of the practicum should be done through known and appropriate methods. In connection to the practicum placement, the student will prepare a written report of between 50 - 80 pages. This report will form the basis for an oral evaluation of 50 minutes. The criteria are described in the curricula. The evaluation is conducted by university supervisor and the participants are the student, of cause, the supervisor, a company representative and an external examiner. In addition to this, there is a half way meeting between university supervisor, student and company representative/company supervisor to evaluate the progress of the practicum.

The bachelor programme and practicum

The implementation of the demands from the ministry caused a lot of problems for the study boards and the study board managers. These problems will be described below with the bachelor programme in industrial engineering as an example.

The bachelor programme in industrial engineering is a seven-semester programme (3 ½ years) qualifying for the title diploma engineer. The programme is part of the Department of Production's portfolio of educations consisting of educations in global production management, business systems management and technological systems management. Each of the programmes is offered as master programmes and as bachelor programmes. The programmes are part of the PBL structure of Aalborg University. This implies that all students are enrolled in the basic year, a one-year course followed jointly by all students of production management. After the basic year the students must choose one of the three programmes. The third to sixth semester is then a joint course for all students in the chosen program in global production management and business systems and after the fifth semester the students must choose either the two year masters programme or the six month bachelor programme, both starting after the sixth semester.

During the sixth semester of the bachelor programme the students are expected to spend five months in a manufacturing company as the compulsory practicum part of the programme.

The bachelor programme in business systems management focuses on production and quality management, supply chain management and information technology. The program aims at providing theoretical and practical learning about management and strategy of production companies operating globally. Projects with industry are an essential part of the training, and many tasks are carried out in co-operation with businesses.

The content of each semester is: First semester: Operations Management. Second semester: Supply Chain Management. Third semester: Global Manufacturing Management. Fourth semester: Thesis.
The task of the fourth semester is to solve an industrial problem through independent work. The groups are small (1-3 students) and the situation is very similar to the one existing in industry. The final project may take the form of a industrial development project and it may comprise entirely new subjects or be an extension of the project at 3rd semester. Fifth semester: Design of control systems.
6 – 7 semester – Practicum and thesis. Choosing the bachelor program means taking part in the compulsory practicum program in the sixth semester. The purpose of the 6th semester is to complete the Bachelor education through a combination of courses, practicum and final dissertation. The purpose of the practicum is, according to the study program, to give the students practical experience in working with the planning and implementation of engineering solutions by applying technical knowledge, management, operation and maintenance of technical installations.
The purpose of the dissertation project is that the student demonstrates that he is able to plan and implement a project.

Case – Student M in the real world - Shop floor lay-out in a machine factory

Student M is part of the bachelor programme in Industrial Engineering. It is up to the students to find a practicum company, and it is up to the students to make the contacts and the arrangements necessary. Normally, this poses no problems. In the practicum semester the students are offered training courses before entering the practicum – courses preparing them for the practicum. The courses included valuable experiences from older students, who had already finished their practicum.

Student M is twenty-nine years old and has a background a banker and he had studied to become a pre-school teacher for some years before beginning his engineering studies. Student M was eager to get in contact with a manufacturing company and he started in late 2009 to send applications to various manufacturing companies, but this was unsuccessful. Through the fifth semester project he got in contact with The Company D. Company D is a medium sized manufacturer of standard and specialised pumping solutions for marine and food industry use amongst others mainly employing highly specialised, skilled metal workers and engineers. As part of a ”lean project” where the factory layout is changed to a more rational layout, the company’s stock and warehouse facilities are changed as well, so they are able to respond rapidly to the needs of the manufacturing facilities. The project was initiated in order to enhance productivity and improve the workflow. Student M knew about company D, because he had visited the company in the second semester of his education, but he knew nothing about the lean project before entering the practicum. It was agreed, though, that Student M should prepare, organise and implement the proposed changes in the stock and warehouse facilities throughout the entire layout, connected to the ”lean” project, supervised and supported by the warehouse manager AJ.

The task was easily defined, as the agreement was focused on the new layout of the stock and warehouse facilities and their ability to support the workflow in the factory. The task for Student M was to assist warehouse manager AJ and participate in the planning and implementation of the changes in the warehouse. In addition to this Student M was also assigned to some jobs of his own, e.g. the planning and implementation of the new cleaning and degreasing facilities and plans for the best use of a heated and an unheated warehouse. The task was defined by Student M and warehouse manager AJ jointly.

The project is to be documented in a 20 page report which also will form part of the basis for the 6th semester exam. The report is supposed to include three parts; 1. A description of the company (as production engineer would do – with an emphasis of the manufacturing process). 2. The task of the student (an analysis of the problems that the student is assigned to help solving) and 3. The student’s reflections on the assignment in general and the practicum experience particularly. To assist all this, Student M is keeping a diary/log book, as he supposes – very rightly – this will help him in the writing of the final report and it could form the basis for a future bachelor thesis (in the 7th semester). During the 20 weeks Student M meet with his university supervisor once a month and every Friday with warehouse manager AJ, in order to discuss the progress of the project. These meetings are planned to last one hour, but normally exceed this.

Even if Student M is still in the middle of his practicum he has already learned a lot; especially the very difficult task of implementing changes in a real life setting. Even if the changes are well planned, negotiated and discussed with the parties involved, unforeseen problems will eventually occur. The university was not able to prepare the students for this – this has to be tested and tried in the real world, in a practicum placement. This has very much to do with communication and communication skills, which are not part of the engineering curricula. In addition to this Student M finds it very rewarding that the work he is doing is actually used by the company and is actually implemented in the real world. So far student M finds his practicum very interesting and very rewarding. He also finds that the support from the company is very good and the support from the university is satisfactory, but there is room for improvement. E.g. would a database of potential practicum companies have been helpful in the initial search for a practicum placement. The meeting with older students was very helpful though.

Warehouse manager AJ is also very satisfied with the arrangement. He likes the work that Student M has been doing and he is also very supportive of the idea of practicum in general. He found, though, that he could have been informed better about the content of the practicum arrangement, his obligations and the whole idea behind the arrangement. The university could have informed better, as the only information he got was through Student M.

Findings

Students, supervisors and the practicum companies all like the practicum. The students like it because they get some real life experience into their education. The boosting of self esteem through success in the real world can hardly be overestimated.

The supervisors like the practicum because the project reports are in most cases much more interesting than normal theoretical projects. Some supervisors have raised some concern as they think that not all students get enough theory into their practicum projects, but most are positive towards the practicum.

The companies like the practicum. They say they get some new inspiration and new ideas to solve problems. The only ones not liking the practicum is the study board managers – for obvious reasons. First because of a very long and cumbersome process of negotiation with EVA, the ministry and with the local administration at the university. But mainly because of the economic consequences; changing curricula and study programs, providing supervision and developing new courses are costly. And when practicum equals cutting budgets, no wonder the study board managers are complaining and only implementing the changes reluctantly.

As noted above there is a general positive attitude towards the different practicum arrangements whether on-campus, bachelor, or master programs. But despite this general positive attitude there are some differences in the perceptions of the practicum.

The students like the practicum even if they find it laborious, challenging and sometimes frustrating, but also very rewarding.

The students in the on-campus PBL arrangements do not have many thoughts about this. The on-campus PBL is seen as the norm, the way things are done at Aalborg University and definitely much more interesting than the classroom teaching they know from their high school days (Mainly because they escape the widespread use of "The Banking Model", Freire 1996). PBL is challenging, sometimes frustrating like when they have to meet a deadline. But first and foremost the learning process is seen as very rewarding and the social life in the group room is much more attractive than being left alone in a corner of the library and only visiting the university when there is a lecture to be attended.

This enthusiasm for project work is seen in both the bachelor and master programs. There are some challenges and there are a lot of frustrations, but this is by far overshadowed by the joy of having achieved something and to have learned something important. Getting in contact with the real life of companies and getting a glimpse of what the working life is all about is worth all the frustrations, and trying out what is learned at the university is rewarding.

In most programs the students are responsible for finding the company as well as formulating the assignment together with the company. The students finds this very difficult and they often express some frustration about what they see as lack of support from the university. They feel more or less left alone in this, because it is the first time they get in contact with the companies in this way. In the on-campus projects they had the rest of the group to support them.

Should anything be changed in this, the students would like to see an organised way of searching for the practicum companies and assignments. That could be some kind of database or some kind of "office" that should be able to act as a broker that should be able to advertise companies and assignments to the students. Such offices already exists – the international office, the project office, the career office – but according to the students this does not work at all. In addition to this, the students in the master program in learning and change would like the university to support them when contacting the companies, as it is seen as difficult to explain what their abilities really were. Analyse the problems of change processes seems not to be a very easy selling point for the students and the university was not very helpful in presenting this to the companies. The engineering students did not have that problem as engineering is a very well-defined field.

The faculty, on the other hand, have more reservations when it comes to the practicum arrangements. Concerning the on-campus PBL model the supervisors are very much in line with the students; this is the way we have always done our teaching and it is much more interesting to do that, than giving lectures. No problems here. The scepticism towards practicum is first and foremost found in the bachelor program with its compulsory practicum. The financial problems are evident and the study program managers are particularly dissatisfied with the present financial model. They are supposed to deliver supervision for free and find the money somewhere else, e.g. from other programs, which they then have to cannibalise. The supervisors do not like the practicum either. They know about the cannibalisation of the other study programs and they oppose it. They also have reservations on the academic level of the reports the students are writing. “They solve problems but do not know the theory behind the problem solving” say the supervisors. It would be much more beneficial for the students to stay at the university and finish as master candidates – then they would learn more. The supervisors also question the value of the practicum as a kind of training ground for future jobs. “They do not learn more than they would have learned in the first three months of their first job after graduation”. And consequently they urge the students to stay on the master programs and finish a five year education. “It will only take you another 18 months” the students are told. This is also the reason why so very few students follow the bachelor track and take the five year education instead.

The supervisors in the master programs do not see the same kind of problems as their colleagues in the bachelor programs. They do not have the same financial problems and they see the student projects as very interesting. The close contact to the companies fills the student’s reports with interesting empirical studies that give the students an excellent opportunity to show their ability to combine theory and praxis. Most students demonstrate the ability to handle the complicated assignments they are handed by the companies and this is exactly what the study program wants to achieve. The problem the students have finding practicum companies and assignments is not a thing the supervisors should take care of. This is just another task the students have to deal with. It is part of the education that the students take this responsibility and learn and grow through struggling with this. The idea of having a central office is strongly opposed by the supervisors and program coordinators. “We do not need more bureaucracy and the students have to learn to work through this”, it is said. This, however, have the consequences that study boards, coordinators and supervisors are working more or less on their own. There is no collection of experiences with practicum. The experiences are made on an individual basis and the synergy that could have been the result of some kind of exchange is not only absent, but directly opposed by the faculty. “This is my field and I know it – I do not have the time to go to another meeting and support another bureaucracy”.

Bureaucracy is also where the problems for the study board managers really begin. First, they had to change the semester for all students, bachelors as well as master students. In order to be able send the diploma students into their six month practicum, all training courses have to finish late March or early April. This means a very intense course programme in the early spring, and the PBL model is challenged as the projects are postponed because of the dense training course programme. When the study boards had to change the study programmes in 2007, it was the third time within a year they had to change the programmes. First time was when the government abolished the traditional group exam, which was an essential part of the PBL-structure of Aalborg University. Second time was when the government introduced a new score system, going from a Danish scale 0 to 13 points, to a American inspired ABC system. Because of the change to the new Diploma program, they had to change the new programs again. In addition to the change in the study programmes the study boards had to introduce new courses - a course preparing the practicum and a course concerning knowledge transfer between university and businesses as demanded by the evaluation board. The study boards also have to provide supervision for the practicum students. Each supervisor is granted 30 hours for supervision, midterm evaluation and for the final examination.

The new courses, the supervision, the mid-term evaluation and the exams are all costly to the study boards and as the diploma program does not generate any income during the practicum semester, the study board managers will have to find the money somewhere else in an already tight budget.

This has of cause had implications for the implementation of the diploma-engineering program as the managers only implement it reluctantly. The implementation of the demands had to, according to the study board managers to be as less time consuming as possible and thereby as least costly as possible.

First of all they urge as many students as possibly to continue with the master program. This is done through the introductory lessons where the students are informed of the master and bachelor programs. This has so far worked well for the study boards, as only a very few students is choosing the diploma option - only app. 5%. Simultaneously, the supervisors are asked to use as little time as possibly. This, however, has not worked, as the supervisors are using the time necessary in order to help the students to write their project reports.

The Company representatives are all very positive towards the practicum. Of course they are, as there is a bias here. The company representatives have all deliberately chosen to invite a student into their company and they have deliberately given them an assignment. If they were not in favour of the idea of practicum they would possibly not have invited them in. So, they were all positive and only the company representatives hosting the master students expressed some concern regarding the level of information from the university. They did not really understand what the practicum was all about and they could not understand that there was no formalised contact to the university. If they wanted to, they could ask the students to sign a confidentiality and cooperation agreement, but this was all left to the student, even if it is strongly recommended by the university. In most cases there was no contact between the company and the supervisor. The company representatives give several reasons for participating in the practicum arrangements. Some say that it is only a natural thing as is the participation in research projects and other cooperation with the university. One company representative did not really understand the practicum as a separate part of the cooperation with the university, but saw it as an integrated part of the cooperation with the university and only natural, as this was a good way of finding job applicants and see them work before signing them on for real. Others saw them as a way of getting qualified labour into the company in times of scares resources. This was mainly seen in public organisations. But most company representatives saw the practicum as something which it was fun and interesting to do. Challenging, maybe, but certainly worthwhile, but, as said there is a bias in this as the company representatives have deliberately chosen to be part of a practicum arrangement.

To sum up, all parties involved see the practicum as both interesting and very rewarding and only a few expressed some critique of the arrangements. The critique of the bachelor program is mainly concerned with the financial and administrative arrangements around the practicum and no one at the university can do much to remedy this. This is a political decision that will not be changed in the foreseeable future. The critique of the university's role in the master program is of a different kind. The university is accused of not being very informative about the content in the master program; the reaction from the supervisors has been that they will not create a bureaucracy around the practicum. The process of searching for practicum placements is part of the education process and the students should take care of that. That is part of the learning process and when the students are on their own in addressing this aspect it is because this is what they will meet in the real life of the companies.

Conclusions and recommendations

Aalborg University has since its establishment in 1974 been a PBL university. This has proven very successful, as the students finish their studies in time, within the time scheduled in the study programs. The employability of the candidates is very good and the supposed conflict between university and labour market and theory and practice seems not to be a problem for the Aalborg candidates. The PBL structure of the Aalborg study programs has also proven a very fertile training ground for future practicum arrangements. Because the students are used to working with a problem orientation on projects, they see no problems in doing that in a real life setting in a company. The different practicum arrangements at Aalborg University are therefore seen as rather un-problematic. There are some minor problems concerning the practicum arrangements. The financing of the bachelor program is one and the lack of coordination of the activities in the master programs is obvious. It seems that those who could do something about these problems are unwilling to do so and the problems will therefore continue. Despite this the practicum arrangements are so successful, no matter which actor we ask – students, supervisors and company representatives – that there is every reason to continue and further develop the practicum. This could be to introduce the practicum to study programs that do not include such arrangements and to develop a more structured and less time consuming way of finding the practicum placements and assignments.

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CASE STUDIES OF EDUCATION IN BUSINESS PROCESS REENGINEERING THROUGH PBL

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ABSTRACT

PBL has been introduced as a new educational method in the core curriculum of the master program of Information Systems Architecture of AIIT. We try to take advantage of PBL for education of practical skills required in IT industry. The author has conducted PBL projects of business process reengineering for several years. The educational objective is for students to experience consulting activities to a customer which students cannot get otherwise. We use real cases for the PBL projects. Subjects of the PBL projects vary every time depending on the cooperation enterprises. Our methodology and learning objectives of our PBL are represented. We discuss teacher roles in real case PBL to achieve both educational objectives and satisfaction of customer expectation. Some actual charts created in our PBL are shown with discussion on what students could learn from them.

INTRODUCTION

Advanced Institute of Industrial Technology is a small public graduate school university which has one faculty of industrial technology founded by Tokyo Metropolitan Government. It was established as a graduate school for professionals in 2006. A graduate school for professionals is expected to teach practical skills of expertise rather than deep knowledge of special areas. There are two master programs in AIIT, one of which is Information Systems Architecture with 50 students a year. Most students are part-time students who work day time. Since the objective of the university is "graduate school for professionals", the curriculum of the university is specially designed for professional education. PBL (Project Based Learning) is ranked as the most important education method for industrial professionals. No master theses is required to complete the master program, instead PBL subjects are mandatory to be taken. Two years are required to complete the master program. Students are requested to devote themselves to PBL in the second year. PBL dominates half of students' activities in AIIT (Tozawa et al. 2009).

3 to 6 students are in one PBL project team. Contents of the PBL project, that is, project objectives and learning objectives are designed by a prime professor who is in charge of education through the PBL project. Two other teachers supervise students of the PBL team. There are 10 PBL projects in parallel in our master program, one of which is conducted by the author. The theme of author's PBL is business process reengineering. We reported our PBL activities earlier (Tozawa, 2009). This paper presents the succeeding results of our PBL activities. We show several actual outputs created by students in our PBL and discuss what are difficult for students to learn and what they learned.

We regard our PBL as successful based on comments of students after they finish the course. Some say that they use in their actual jobs what they got learned in PBL. Some say that they get a new insight through PBL. Some say that they find their skills are clearly improved.

Expectation to PBL education

Education for IT professionals in Japanese universities appeared to be a big issue by the report of the Japan Business Federation (JBF, 2005). Japanese universities in IT areas did not teach appropriate knowledge and skills needed in business of IT service industry. The report indicated that PBL would be effective as an innovative educational method for students to learn the needs of industry. Japanese government, such as the Ministry of Education, Culture, Sports, Science and Technology (MEXT) and the Ministry of Economy, Trade and Industry (METI), started to support PBL education in universities by several programs. The Japan Business Federation established in 2009 a non profit organization, NPO Center for Future ICT Leaders (CeFIL), to support university education which includes PBL.

PBL is a relatively new education method in the IT area in Japan. PBL is expected to be effective for students to learn practical skills which are difficult to learn by lectures. There are three reasons why PBL is considered good from the perspective of the IT industry:

1. Most activities done in Japanese IT industry are in the form of projects. Companies want new hires to have experience of working in a project. New hires are expected to know what is a "project". There are common goals of a project which all the project members pursue. Each project member has a specific role in a project. The project finishes when the goals are achieved. Project management must be done to control objectives, time period, resources, and costs. Project members had better know what behaviours are good in a project and what should be avoided in order not to fail in a project.

2. Communication skills are being emphasized for success in business. Many Japanese IT companies realize that lack of communication leads to failure of projects. Communication with a customer and communication among project members are extremely important. PBL can provide an environment for students to improve communication skills.

3. The business of IT companies is shifting from manufacturing business to services business. Current curriculums of IT education in most Japanese universities focus on engineering rather than services. Students can learn through PBL what is essential to services business success. There are much waste in IT service acquisition in Japan because of the industry structure. IT services should be much better focused.

PBL using real cases

Our PBL theme is business process reengineering, which includes IT strategy (Hammer *et al.* 1993). Motivation for this theme comes from how IT contributes to business values, or what should be done to make IT deliver business values. IT technology alone or the software system alone does not bring business values. Business values come from changes of current ways of work. There are usually many reasons why the current ways of work have been set as they are. Some capabilities have been considered impossible technically so far. IT evolution, however, can make things possible which were believed impossible before. Change is the source of business values.

Project objective of our PBL is to make recommendations for an enterprise what to change in the current ways of work toward better business. Activities in PBL are the same as that of a business consultant for an enterprise. In business process reengineering, issues or problems to be solved are usually neither clear nor well understood when the project begins. Discussions of PBL members are important to reach better conclusions. Hearing the recommendations from the PBL project team, management of the enterprise makes a judgement about whether they are acceptable or not. Evaluation of the recommendations is more subjective than objective. Students are given a real situation where they may experience all the aspects of consulting work.

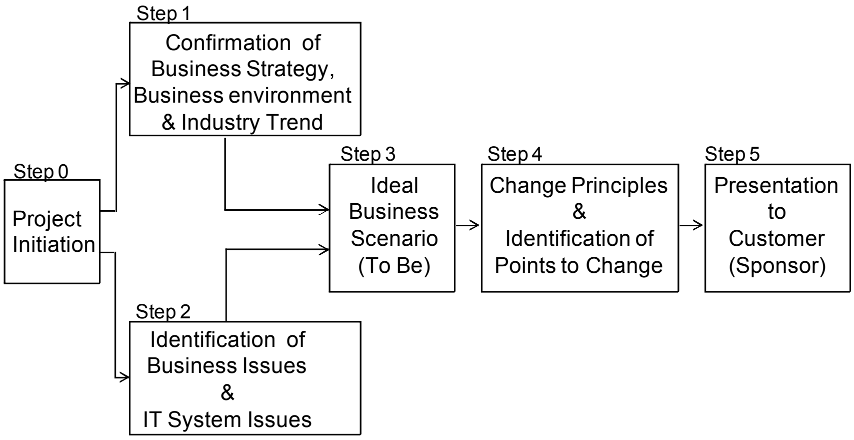
It seems almost impossible to create educational materials as a case of business process reengineering. We decided to use real cases for the PBL of business process reengineering. We asked several enterprises for cooperation. The following is a list of the cooperation enterprises so far.

- Tokyo metropolitan government (TMG)
  Ports and Harbours Bureau
  Construction Bureau
  Information Systems Department, Administrative Bureau
  Administrative Reform Department, Administrative Bureau
- Information systems department of general internet services company
- Health care portal site services company
- Development department of hi-fi audio manufacturer
- Surface treatment company

We call the cooperation enterprise the ‘customer’ in our PBL project.

PBL activity time

Since the students are part time, their work time for PBL is limited to evenings of week days and on Saturday. We assume students work at most 18 hours for PBL. The time includes self study, team discussion, review by teachers and supervisors, and meetings with the customer. We ask the customer to arrange the meeting in evenings, as overtime. The meeting time makes difficult to find cooperation enterprises in PBL. Since PBL project lasts about 5



Figre 1. Methodology of business process reengineering PBL

months, there are about 10 meetings with the enterprise. Total activities of a PBL project are as much as one month activities of full time consulting business.

Methodology

Figure 1 is the methodology we use for the PBL of business process reengineering. The methodology is designed to be industry independent. We clarify the issues of current ways of work (as-is) in step 2. We also depict the ideal business scenario (to-be) in step 3. The ideal business scenario mainly comes from the results of step 1. Then we identify what to change in the current ways of work in step 4. After completion of steps 1 to 4, recommendations are presented to the management of the customer in step 5. The presentation time is about 30 min.

We do not adopt the approach in which issues are solved one by one if any issue is found without consideration of issue levels. Our approach does not pursue improvement (or Kaizen), but reengineering. New business process is required to design from a broader point of view. The methodology is designed to suit to reengineering.

Learning objectives

From a view point of education, students learn required skills to execute the steps in the methodology. We set the learning objectives as follows:

- Capability to create recommendations of business process reengineering so that much more business values can be made with IT

- Capability to reach the root issue from many surface issues by hypothesis and verification thinking
- Ability to collect the right information (including interviews)
- Ability to create a persuasive logic and to make an easily understandable presentation so that customer management can accept
- Ability to re-apply the methodology

After identification of many issues, it is very important to grasp the root issue. Most issues found are surface issues. There must be a root cause of these issues. It is difficult to reach rapidly the root issue by analysis of data. Hypothesis and verification thinking is much better for approaching the root issue.

Roles of teachers

Project objective is to make recommendations for business process reengineering. A final presentation is made to the customer management. Students have to decide what to do to achieve the goals in consulting. Students have no experience of consulting before. Team discussion among students is the core of learning in PBL. However the discussion may not lead to the right activities, because students do not have sufficient knowledge or experience. A teacher needs to get involved for students to overcome the weakness in finding the right activities. A teacher should not give students answers before students think. Students need to exchange their ideas and to discuss to come to the answers for themselves. A teacher reviews their thoughts and conclusions. If their thoughts are insufficient, a teacher should give students hints about what to think, but not the answers. A teacher needs to wait until the students come up with the answers.

Since our PBL uses real cases, the customer expects valuable results. The customer spends time for the meetings for the PBL project, even in overtime. The customer must feel that the time spent is not wasted. A teacher must manage expectations of the customer. It is sometimes difficult for students to manage customer expectation. Customer expectation management is one of the subjects that students should learn. Even though students should take the initiative in proceeding with the PBL project, some controls over the students by a teacher is necessary.

Teacher's role is not give instructions to students in PBL. Students should work things out for themselves. A teacher needs to grasp what knowledge students have. Students should not be allowed to stay in a blind alley. Considering the students' situation, a teacher gives students hints for thinking. According to our experience, we review students after they discuss for about three hours. In the review we ask questions so that students can realize what they should think. We believe a teacher should patiently wait until students come to the right answer for themselves in PBL from educational point of view.

Mistakes students are likely to make

We encourage team discussion in our PBL. Students can learn from other project members who have different thoughts or views. Since students are part time, they have variety of experiences in daily business. A PBL team containing members with different backgrounds has the advantage that there are variations of thought in the team.

Mistakes are sometimes observed in the team discussion. The team comes to some conclusion after discussion. When a teacher reviews the team conclusion, the meaning of the conclusion is not properly shared by the members. The expression of wording is agreed by the members. But the meanings of the words are interpreted differently by each member. For example in our experience, it was difficult for students to express the proper meaning of "manage". As the word "manage" is so frequently used, they felt that they have understood it without thinking of the meaning. Students may make a mistake that they believe they are sharing the same ideas because of the words, but they don't share in reality because of the different interpretation. A teacher should point out when this kind of situation is observed.

Some results of the PBL

We show charts created by students to discuss what students learn through PBL. These are key charts in the context of presentation logic. They were well appreciated by the customers.

IT system acquisition of Tokyo Metropolitan Government

The cooperation enterprise was Administrative Reform Department, Administrative Bureau, TMG. IT system acquisition is handled by the usual procurement process in TMG. An IT system is treated the same as manufactured goods. The Japanese government reportedly fails terribly in IT system acquisition occasionally. Though TMG has never faced any big failure of IT system acquisition, most TMG people feel vaguely that IT system acquisition is not well done. This situation triggered the PBL. TMG has set the rule that all IT system acquisition must first be approved by the Administrative Reform Department. Actual acquisition is done by the department of business operation in charge in accordance with the defined TMG procurement process. Every TMG role changes in personnel every couple of years. Since IT system acquisition does not happen so often, it is usually a first time experience for the person who becomes in charge of acquisition. Skills, expertise, or past experiences are not considered in TMG personnel change. IT system acquisition is usually done by a nonprofessional.

At the point that the PBL project started, the nature of IT system acquisition was not well understood. Most people in the customer did not realize the difference between

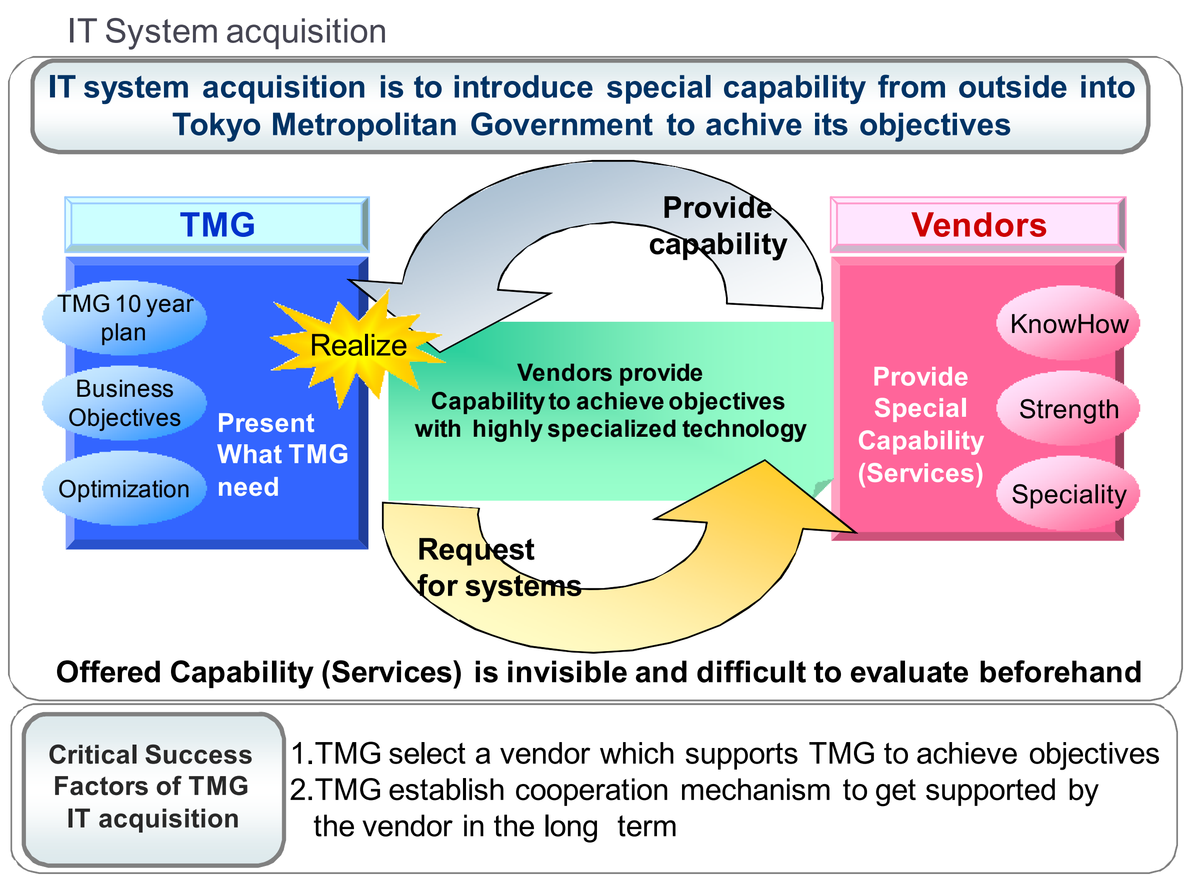


Figure 2. Example: TMG IT system acquisition (original in Japanese)

procurement of manufactured goods and IT system acquisition. Figure 2 was depicted to clarify the subject to consider in the PBL. Even though "IT system acquisiton" sounded understandable, there was no common understanding. The chart tells clearly that IT system acquisition is quite different from procurement. The contents of the chart is not new to the customer. But the customer had never seen it this way. The chart made the customer realize what is missing. The chart has value because it opened the eyes of the customer. Students learned that clear understanding must be established before any discussion starts.

Figure 3 shows the causes why IT system acquisition was not done well. Students came up with these charts after many discussions. They succeed in representing the root issues in the chart. Once this chart was depicted, it was not so difficult to define points to change. The chart is the key because every one can understand the root issues. Students learned that key messages should not be stated in sentences. The figures are much better at expressing the messages. The figures avoid the misinterpretation.

Development department of hi-fi audio manufacturer

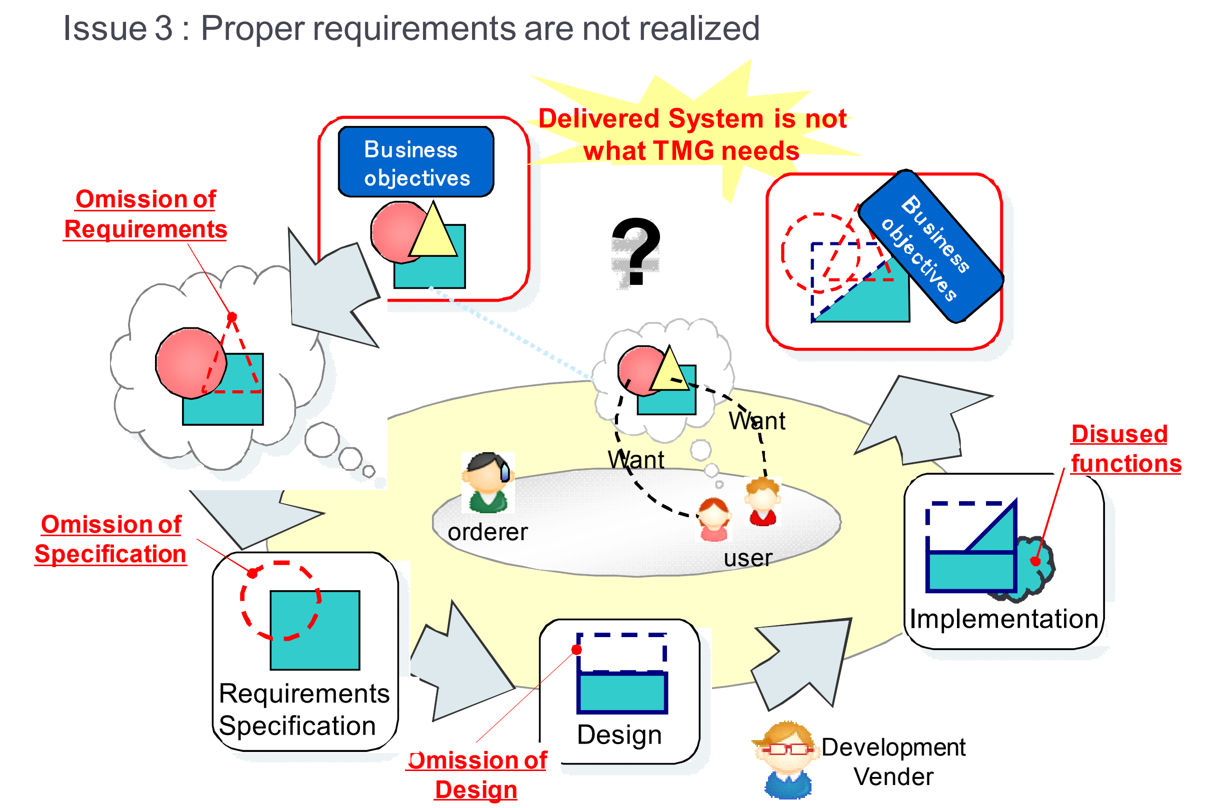


Figure 3. Example: What is wrong in TMG IT system acquisition (original in Japanese)

There were many business environment changes in the company, including mergers and acquisitions. The trigger of the PBL was that the customer wanted to know what were the issues in the development department. As the customer already knew about some big issues, we separated the known issues out of our scope. We tried to find the root issue which blocks productivity increase. We made many discussions with the customer before we reached the root issue. The customer had never noticed it was the issue. After all this the customer agreed when the Figure 4 was shown.

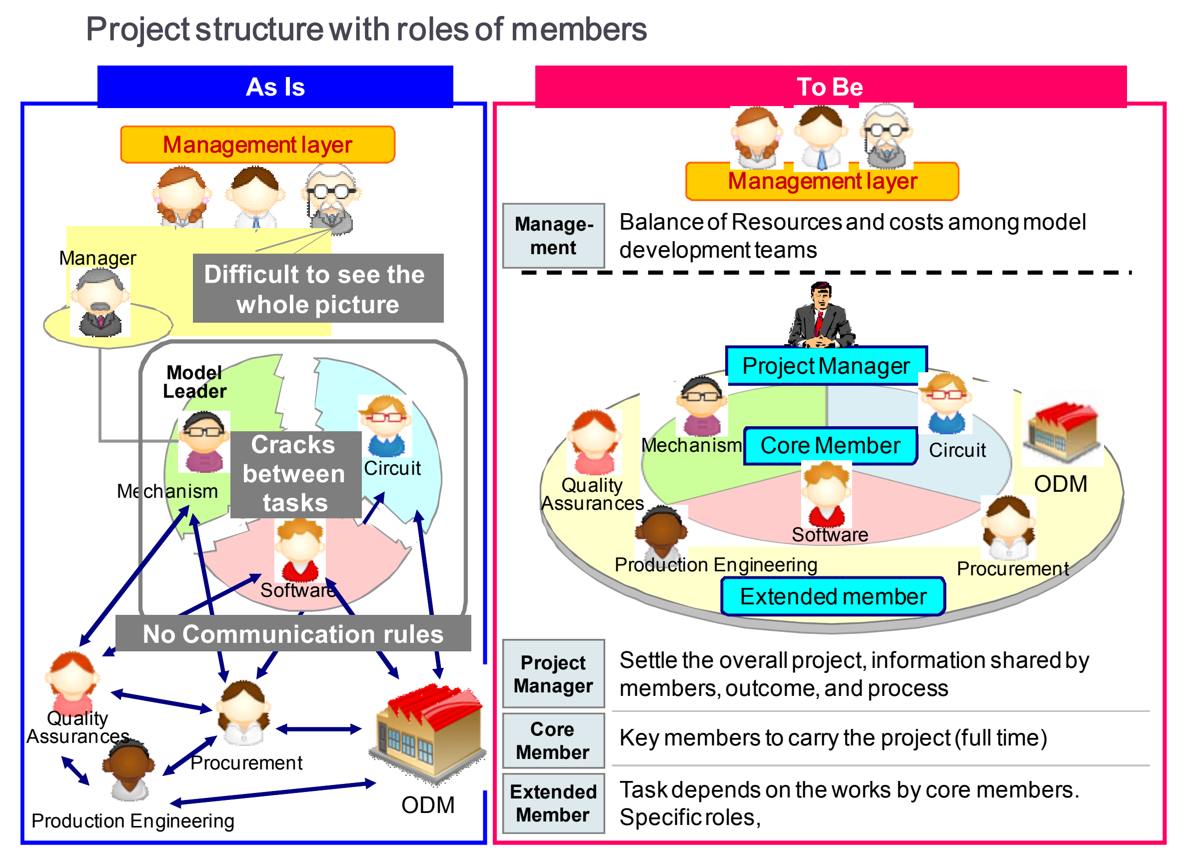


Figure 4. Example: Development department of hi-fi audio manufacturer (original in Japanese)

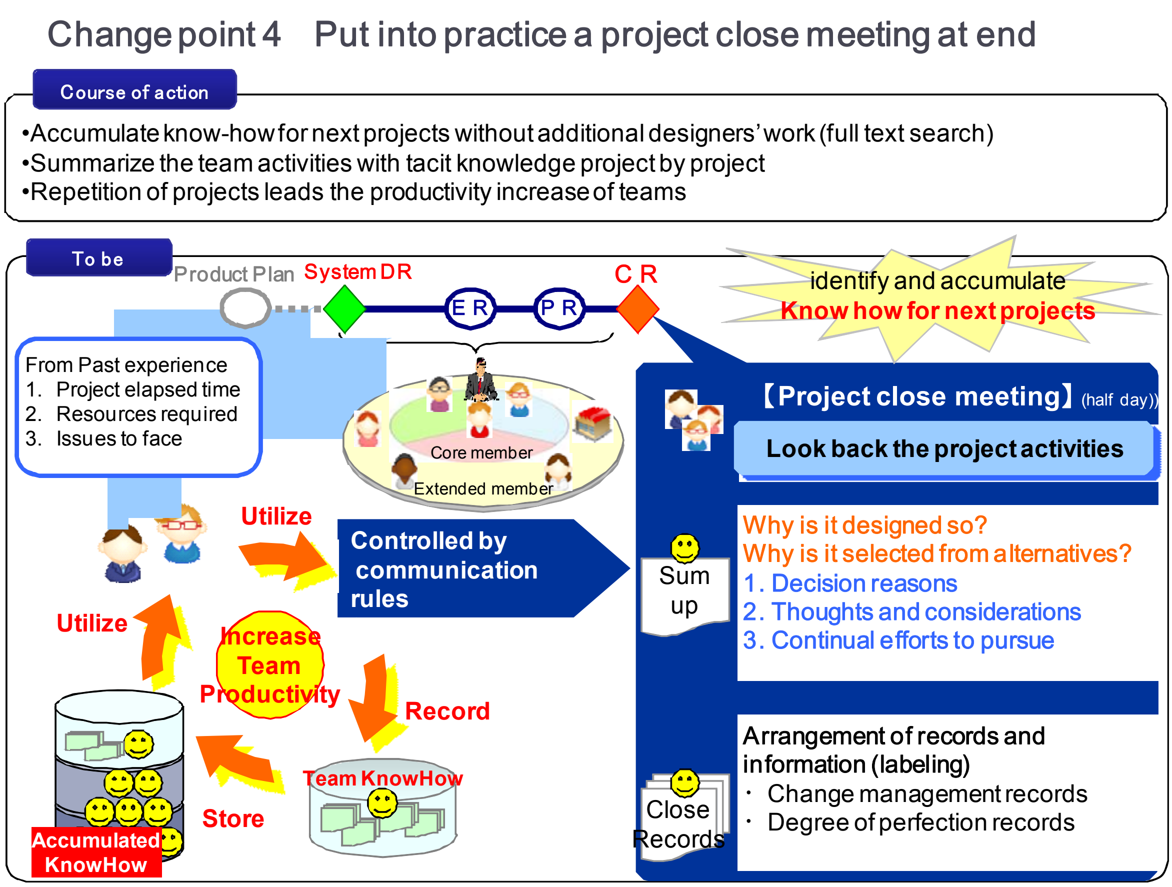


Figure 5. Example of change point: project close meeting (original in Japanese)

The customer uses the word "project". They believed that their project was managed as usual. However, from outside point of view, their project was not well structured as shown in Figure 4. We came up with the result when we investigated the communication among project members. The chart was the key because the company people can easily agree the current situation. As the chart shows the difference between as-is and to-be, the customer well understands the to-be status. Students learned that a good chart brings people to an agreement and common understanding.

Figure 5 is an example of the change points. As the concept of "project" was weak in the customer, nothing special happened at the end of the project. We recomended the project close meeting at the end of the project so that attention to "project" should be paid much more. There were several candidates of choice in defining a set of change points. Students learned how change points should be selected considering the impact to the customer.

Health care portal site services company

Figure 6 shows the strategic capability network (SCN) for the customer. SCN is often used in IT strategy consulting. The chart was the key because it suggested what the customer should focus on in future. It was used for the comparison of competitive companies. It clarified the potential new services the customer might provide. It is usually very difficult to draw up the SCN which is accepted by the customer. Students learned how to create SCN and the use of it.

Discussions

Customer acceptance is a key to success in consulting of business process reengineering. There are many things to learn from practical experience of customer responses. Real case PBL provides opportunities for students to participate with a customer. In order to get better customer acceptance, the amount of something new to the customer should be minimized. The messages to a customer in consulting should not be completely new but what has been heard before without much attention. A teacher makes comments on students' activities in PBL from the view point of the customer. Evaluation of activities is relative to the customer.

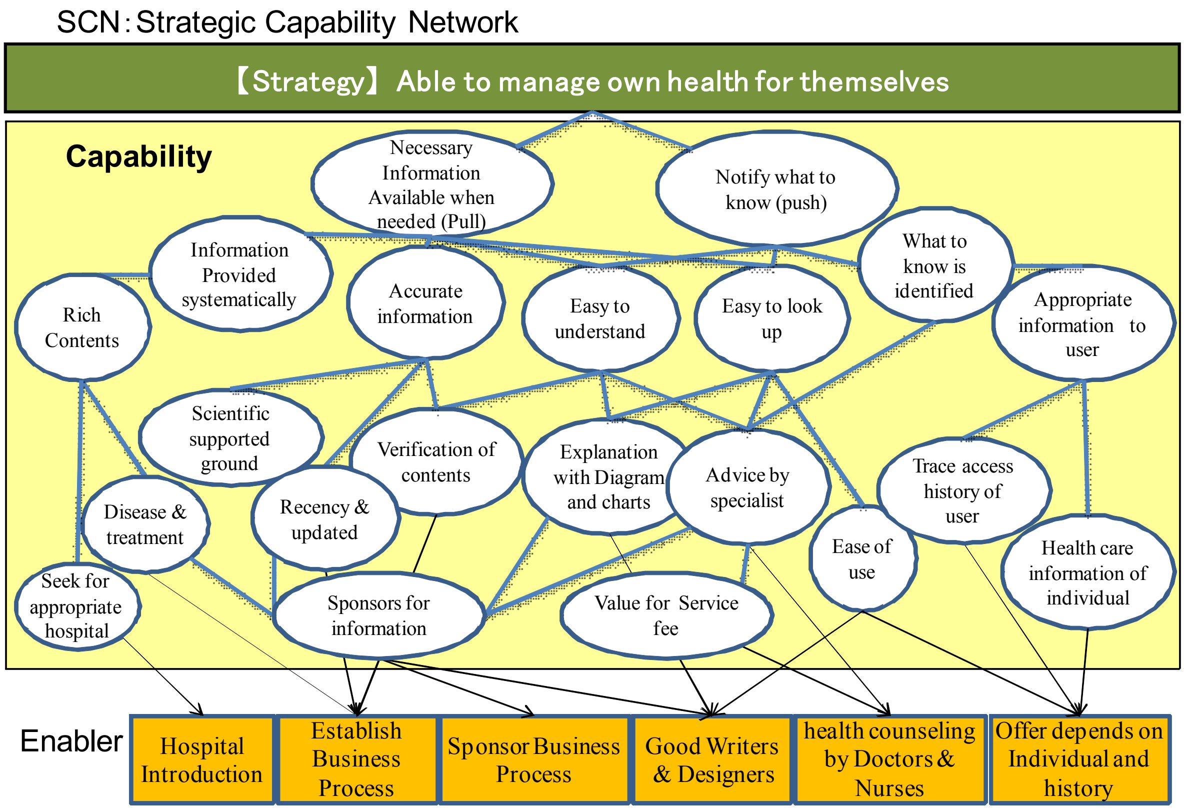


Figure 6. Example: Strategic capability network for the health care portal site services company (original in Japanese)

There is no unique correct answer. What is learned in PBL varies from student to student. As far as the educational objective is clear, PBL with real cases has the benefit that students learn practical wisdom in bringing business values. Customer acceptance can be confirmed realtime in PBL. Pointing out a link between stutents' actions and customer acceptance by a teacher is very valuable from the educational perspective.

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PEER SUPPORT IN PRACTICAL ACTIVITY-LED LEARNING EXPERIENCES

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ABSTRACT

The Department of The Built Environment at Coventry University uses student proctors within the context of activity-led learning to support the development of technical skills needed for project work, and to support the project work itself. Student proctors are students in later years of the course, selected for their proven ability in a particular area. They are paid to provide learning support under the supervision of academic staff. The paper places the scheme in the context of other peer support structures reported in the literature; it describes the appointment, briefing and input of proctors; it reports on a survey of student perspectives by means of a questionnaire and the perspectives of proctors by means of semi-structured interviews. It concludes that student proctors are well positioned to be facilitators of learning, and in fact can provide students with some elements of learning support more effectively than members of staff.

INTRODUCTION

Activity-led learning

Activity-Led Learning is an approach to education based on providing stimulating activity that engages and enthuses students and creates challenge, relevance, integration, professional awareness and variety. An activity is a project, problem, scenario, case-study, enquiry, research question (or similar) in a class-room, in a laboratory, at work, or in any other educational context. Activities will often cross subject boundaries, as activities within professional practice do. Activity-led learning is promoted strongly in Coventry University's Faculty of Engineering and Computing, where the term is favoured because it embraces a wide range of approaches, some with strong traditions in the Faculty, and some with highly practical (physically active) components. The term is seen as having an important role within the Faculty, not only in defining an approach to pedagogy but also in driving change by increased use of the approaches throughout the portfolio of courses. In the Department of The Built Environment activity-led learning takes many forms, including integrated project work, design projects, residential field courses, and practical group tasks. Practical classes in computer aided drawing (CAD) in year 1 support later design project work. Practical work in surveying develops skills in preparation for a residential field course in which students work in groups to achieve a significant challenge in setting out which involves teamwork, leadership and working to tight deadlines. Integrated projects also run through all years.

Student proctors

To provide high levels of tutor support for practical classes and project work, and to provide a significant personal development experience (and paid employment) for able and experienced students in later years, the Department has developed, since 2005, a programme of appointing and using 'student proctors'. The proctors are undergraduate students in later years of the course who are employed as teaching assistants for practical and project work within the context of activity-led learning.

In subjects such as engineering surveying and CAD, the significant practical content means that a good level of learning support, including staff and proctors, is needed if students are to become competent practitioners in these areas. The proctors (together with the academic staff) provide support as students acquire and apply the necessary practical skills.

Student proctors are also used to provide support for integrated project work. In year 2 of the civil engineering degree course, for example, students work in groups on an urban regeneration project in which they develop proposals for a brownfield site in Coventry. In complying with the brief they consider, at outline design level, engineering aspects such as ground conditions, structural configuration, access for vehicles, cyclists and pedestrians, and drainage. They also consider wider social, environmental and economic aspects. Proctors, who are in year 3 of the course and therefore have experience of the project from the previous year, provide support (Trujillo 2011).

Staff perspective

The obvious benefit of student proctors from a staff perspective is they provide additional learning support for students. Their rate of pay is low compared with all other employed support staff and therefore high levels of support can be achieved at a realistic cost.

They were first introduced to the Department following successful use within the Faculty in computing and maths, at a time when student numbers in Built Environment were rising and there was a strong desire to ensure that levels of support were maintained. Also, the benefits to the proctors themselves have always been recognised.

Another advantage of student proctors is that staff can have a high level of confidence in the skills of the potential proctors through knowledge of their performance in the specific area in a previous year. Some proctors have very high levels of skill, enhanced by work placement experience of using CAD software, or of surveying and setting out in construction practice. In project work, students who were particularly successful themselves in previous years can be selected. Fortunately it is not difficult to engage the best potential proctors because they can usually see the personal benefits of the experience.

It should be acknowledged however that there is additional workload for staff in the sense that they must brief and manage the student proctors working on their modules and projects.

Aims of study

Student proctors have been introduced in the Department because of the apparent benefits to students and proctors, and because their use had been demonstrated as effective practice in another part of the Faculty. This study aims to test these apparent benefits, by finding out how students find the experience of being supported by proctors, how much confidence they have in the proctors, whether students feel that proctors are sufficiently knowledgeable, and whether their learning experience is enhanced by the proctors. The study also seeks to find out how the proctors perceive their influence on the students' learning, how they find the experince, and how they view the personal benefits.

The paper presents a brief review of peer support systems generally in order to place this practice in context, describes the specific system in place in the Department, presents the results of surveys of students and proctors, discusses the results and draws conclusions.

Peer support - background

Black and MacKenzie (2008) give a comprehensive review of peer support, concentrating on the first year of higher education courses. They distinguish between **implicit** and **explicit** support. Implicit support involves students engaging with each other in academically or socially meaningful ways as part of the normal activities of a university: friendship/study groups, societies and online networks, for example. Explicit forms of peer support are specific schemes to increase students' opportunities to support each other. Black and MacKenzie make further useful distinctions. One is between **horizontal** peer support, where students in the same year group provide support for each other, and **vertical** peer support, where students in later years support students in earlier years. Another is between peer **tutoring**, where the primary aim is academic, and peer **mentoring** which is more concerned with orientation and integration within university life.

Some peer tutoring schemes, especially in the UK, are described as 'peer-assisted learning'. In the United States, and many other countries, a common term is Supplemental Instruction (SI). Some examples in relevant subject areas, mostly in the UK and one in Australia, are described briefly here as illustrations of different approaches.

The peer-assisted learning (PAL) scheme at Bournemouth University (Green 2007) involves experienced students ('PAL Leaders') facilitating weekly or fortnightly study support sessions for students in the year below. Content for PAL sessions is based on existing course material, and the coverage of the session is determined by the group rather than the leader, with the emphasis on the group working collaboratively.

At the University of Leicester (Levesley 2003), Peer Support (PS) in mathematics involves 'leaders' from the second and third years helping first year students with their understanding of course material. Timetabled groups contain typically 8 to 10 first year students with 2 to 4 leaders.

At the University of Hertfordshire (Davies and Fitzharris 2003), the term ‘student proctors’ is used. Student proctors in this scheme provide one-to-one support on a drop-in basis with advertised availability. The scheme covers the subject areas of engineering, mathematics and computer science.

Power and Dunphy (2010) describe the application the PASS (Peer Assisted Study Session) model of learning support at the University of Western Sydney, Australia, for a module on mathematics for engineers. PASS facilitators, students in later years, offer weekly sessions on study skills and improving understanding of course content. The content of each session is chosen by the facilitator in response to students’ suggestions at the previous session.

Appointment and briefing of proctors at Coventry

At Coventry University, Built Environment, to ensure that proctors are experienced and possess the necessary understanding and practical skills to act in the role, recruitment is from year two, three and four of the building and civil engineering courses.

Vacancies are advertised. The person specification calls for good oral communication skills in both one-to-one and group situations, good organisational ability, flexible approach to work, and experience in helping fellow students. A previous mark of 60% in the relevant subject area is normally required, and proven competence, especially in practical aspects, is obviously a key criterion. Proctors are particularly well qualified when an industrial placement has given them experience of site setting out (for surveying) or production of drawings (for CAD). Interviews are held, and appointments made. There is a reasonable hourly rate of pay. Proctors typically do this work for 4 hours a week.

Proctors are briefed thoroughly by the module leader. This covers, as relevant, aims, content, project brief, programme and assessment. Expectations of the proctor in the particular setting are made clear in terms of how best to respond to questions and how to support students’ learning without providing too much direct guidance. The experience, approach and effectiveness of each proctor is monitored and discussed throughout the year.

What student proctors do

Student proctors are used within Built Environment courses at Coventry University to provide learning support for students in practical classes in surveying and CAD, in some practical laboratory-based classes, and for integrated project work.

Practical surveying sessions are generally outdoors, and involve using modern surveying instruments to develop practical skills that are later needed for an intense period of activity-led learning on a residential field trip. Proctors are used to create a good coverage of support to respond to student queries, to challenge their approaches, conduct tests and advise on use of equipment. In the weeks running up to the field trip, students are engaged in a large element of preparation work which is vital if the trip is to be a success. Since proctors have already been through a similar experience as part of their studies, their input into these preparation sessions is particularly useful in reinforcing the importance of good preparation not only for the field course but also how this would carry forward into professional life.

The role in CAD is similar, but the environment is a computing lab. It is important that students develop mastery of the software as they will use it later in design project work, and in their careers.

In integrated project work, proctors are used to provide support in studio-type sessions where groups are working on their response to the brief, and to support structured activities aimed at developing particular aspects of the project. The students are advised that the proctors are there to provide guidance in a similar way to a senior colleague in the workplace, but their views are to be understood as opinions. They are not assessors, and cannot re-interpret or provide further detail to the brief. Indeed, this is supported in an early preparatory session for the project by role-play involving the lecturers/assessors and the proctors, acting out the roles of client and colleague respectively (Trujillo 2011).

Perspectives of students and proctors

Survey of students

To satisfy the aims of the study defined earlier, a short questionnaire was used to survey the students' perceptions of the support provided by student proctors. This approach was used because it allowed a representative sample to be surveyed and suited the structured nature of the contact with the students. The survey covered practical work in CAD and surveying. For CAD, 71 students completed questionnaires. These were year 1 students on building courses (architectural technology, building surveying and construction management). For surveying, 64 students completed questionnaires, a mixture of year 1 civil engineering and building students. The questions and responses are given on Tables 1 and 2.

The responses indicate a good level of satisfaction with the experience of proctor support. Comparing CAD and surveying, two questions offer noteworthy differences in response. In CAD a higher proportion strongly agree with the statement that proctors have good theoretical knowledge than in surveying. This response may reflect the fact that some aspects of surveying involve complex calculation, which the students do not necessarily associate with the proctors' skill sets. But it must be said that there is very little actual disagreement with this statement for surveying and no disagreement at all for CAD; also both subjects have comparably positive responses to the question about proctors' levels of technical skills.

The other noteworthy difference is that more than half of the students in surveying state that they prefer to be supervised by a proctor than a lecturer (a particularly interesting response), whereas in CAD more than half of the students prefer to be supervised by a lecturer than a proctor. Perhaps this points again to a separation in the students' minds between practice and theory for surveying. When setting up an instrument or attempting to take accurate readings, the students are actually more comfortable with a fellow student guiding them; but this does not extend to theoretical aspects. In CAD there is perhaps less separation in the students' minds between 'theory' and 'practice'.

There was a space on the questionnaire for comments. These were generally positive, reflecting the quantitative responses.

		Strongly disagree	Disagree	Agree	Strongly agree
1.	The proctors in the CAD classes have a good theoretical knowledge of drawing and design studies.	0	0	40 (56%)	31 (44%)

2.	The proctors have a good level of technical skill in the use of AutoCAD.	0	0	42 (59%)	29 (41%)
3.	Using proctors for these CAD classes has helped in my learning experience.	0	9 (13%)	40 (56%)	22 (31%)
4.	I feel I have met the learning outcomes for the CAD work in the module.	1 (1%)	6 (9%)	45 (63%)	19 (27%)
5.	I found that the proctors were approachable and helpful.	0	1 (1%)	31 (44%)	39 (55%)
6.	For this type of teaching session, I preferred to be supervised by a proctor than a lecturer.	2 (3%)	39 (55%)	19 (27%)	11 (15%)
7.	I would recommend that proctors are used in more of my modules where appropriate.	0	9 (13%)	39 (55%)	23 (32%)
8.	The proctors gained in confidence in their teaching as the module progressed.	0	9 (13%)	43 (61%)	18 (26%)

Table 1 Questionnaire responses - CAD

		Strongly disagree	Disagree	Agree	Strongly agree
1.	The proctors in the practical classes have a good theoretical knowledge of surveying and setting out.	0	3 (5%)	49 (76%)	12 (19%)
2.	The proctors have a good level of technical skill in the use of surveying equipment.	0	2 (3%)	41 (64%)	21 (33%)
3.	Using proctors for these practical classes has helped in my learning experience.	0	1 (2%)	41 (64%)	22 (34%)
4.	I feel I have met the learning outcomes for the practical work in the module.	0	2 (3%)	49 (77%)	13 (20%)
5.	I found that the proctors were approachable and helpful.	0	0	32 (50%)	32 (50%)
6.	For this type of teaching session, I preferred to be supervised by a proctor than a lecturer.	1 (2%)	19 (30%)	34 (53%)	10 (15%)
7.	I would recommend that proctors are used in more of my modules where appropriate.	0	7 (11%)	41 (64%)	16 (25%)
8.	The proctors gained in confidence in their teaching as the module progressed.	0	12 (19%)	44 (69%)	8 (12%)

Table 2 Questionnaire responses - surveying

Survey of proctors

The perceptions of student proctors were investigated through semi-structured interviews with three former proctors. This approach was used because it allowed responses to be probed in depth, and because contact with proctors was individual in nature. One had supported students in the area of surveying, one in CAD and one in experimental laboratory work. The emphasis in interpreting the interview data has been on seeking general perceptions of the proctor role rather than any specific subject-related aspects, so the responses of the three proctors are not identified separately below.

An area of clear consensus was that proctoring is a rewarding and valuable experience for the proctors themselves, and benefits them in terms of increased self-esteem and, potentially, employability.

> *'... makes you understand the subject better, gives you more confidence, it's good to put on your CV'*
> *'The sense of achievement is absolutely fantastic – that feeling, you want to feel again'*

They quickly gained confidence in their ability to contribute.

> *'Initially when I started I was a bit apprehensive about dealing with students and still being a student at the same time, and I was thinking whether they'd take me seriously or not ... but after a couple of sessions it was fine and I really enjoyed it'*

All three former proctors felt that a particular benefit for the students was that they tended to find proctors approachable and were prepared to ask them questions that they might have been reluctant to ask the lecturer. The result is that the proctors are not just providing additional support, they are providing support that might not otherwise be available.

> *'They weren't frightened of asking me questions however silly'*
> *'... they find us a lot more approachable so when they have a concern, rather than thinking "I'm going to look like an idiot", they'd ask you the question'*

All the former proctors pointed out the fact that they were supporting a learning experience that they had gone through themselves one or two years earlier, and were therefore well qualified to help.

> *'The students tend to feel at ease with you ... you will have gone through the same process'*

There was the sense that proctors can offer help from a student's perspective, and that they 'translate' concepts to make them more understandable to students.

'[I would explain] "this is how I work out the calculations; this is how I see that they're correct" ... and I think that's what you're passing on to your fellow students ... it's a translation service'

The proctors were asked if they felt the role involved some more general 'mentoring': offering advice about the course or study skills in general. All agreed that it did, and that as they got to know the students they found themselves being asked more general questions. However, they all saw this as an incidental benefit, and none raised it in the interview without first being prompted. One said that more general topics were being covered for about 10% of the total time, and another suggested that about 20% of the students asked more general questions.

When asked about preparation for the role, they described their briefing by the lecturer, and their personal preparation by practising or revising the relevant skills or knowledge. All suggested that they could have benefitted from more input on helping students to learn in a more general sense.

Discussion

The Background section earlier in the paper has described general approaches to peer support. Using the distinctions identified there, the Coventry Built Environment approach to student proctors can be seen to be very targeted at academic content, practical skills and project support. This is confirmed by the proctors' responses about providing more general 'mentoring'. It is therefore clearly an **explicit** support system consisting of peer **tutoring**. It is **vertical** in the sense that the support is provided by students in later years. In this scheme, in addition, the proctors for practical areas like surveying and CAD are required to have strongly developed technical/practical skills in the particular area, and in this context the relationship is 'doubly vertical' (proctors are in later years of the course than the students they are supporting, and are also known to have high levels of ability or skill). It is reassuring that the students confirm in their questionnaire responses that the proctors **do** have the practical skills to be successful in the role. Another characteristic of the scheme that appears to distinguish it from the examples from the literature presented earlier is that the proctors work side-by-side with lecturers, not in separate support sessions. Students are therefore in a position quite consciously to seek support from a proctor rather than the lecturer, and the questionnaires and interviews confirm that in some circumstance this is common.

The use of student proctors within the context of activity-led learning within the Department of The Built Environment takes the form of support for the development of technical skills (surveying, CAD and laboratory skills) needed for project work, and support for project work itself. In activity-led learning, the lecturer is typically a facilitator of learning. Student proctors, as we have seen, are also well positioned to be facilitators of learning, and in fact can provide students with some elements of learning support more effectively than members of staff. This statement is based on the results of the questionnaire survey of students which indicated both that students have confidence in proctors' levels of knowledge and skill, and that a significant number are at least as happy being supervised by a proctor as by a lecturer. The proctors who were interviewed confirmed that they felt that students were more comfortable asking certain questions of proctors than of lecturers. The concept that proctors provide a 'translation service' is one way of characterising the particular value of their input.

It is also clear from the interviews that the scheme provides a significant personal development experience for the proctors themselves. The comment by the proctors interviewed that they could benefit from more input on helping students to learn in a more general sense is significant and understood. Starting in 2010/11 a new optional half-module on preparing for this and similar roles has been made available to students.

Conclusions

This study has confirmed that student proctors (students in later years of the course who are known to have well-developed skills in particular areas) can provide effective learning support for students in the development of technical skills needed for project work, and for the project work itself. Student proctors are well positioned to be facilitators of learning, and in fact can provide students with some elements of learning support more effectively than members of staff. In some circumstances, for example, proctors may be better at identifying students' needs than lecturers. This helps students acquire practical skills (in CAD and surveying at least) and develop their ideas in project work.

Experience at Coventry suggests that proctors should be carefully selected and well briefed. The study exposed a need by the proctors interviewed for more training in learning support, and this is now being addressed within the Department. Carrying out the role provides a significant personal development experience for the proctors themselves.

The Department intends to continue using student proctors in the manner described in the paper, and this study has provided further confirmation of some of the benefits. Peer support, by students selected on the basis of their skills in particular areas, to enhance the development of technical skills and for project work, can be recommeneded for the following main reasons: it is beneficial for the proctors themselves; it is cost-effective; and it is successful in providing a type of learning support to students that might not otherwise be available.

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THE STUDENT EXPERIENCE OF ONLINE PBL IN STRENGHT AND CONDITIONING: AN EXAMPLE WITH POSTGRADUATES NEW TO ONLINE LEARNING

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ABSTRACT

Recent research has focused on the development of effective online Problem Based Learning (PBL). However, there is a need for research to examine experiences of online PBL in those new to online learning. This study used a single module blended approach to examine the student experience of online PBL in a group of postgraduates (n = 16) new to online learning. One problem scenario for each group (4 students per group) was employed as the central component of the module. Discussion boards were used to facilitate the learning process with other forms of delivery used as appropriate. Focus group interviews revealed that students believed online PBL developed skills related to employability and information retrieval/evaluation. These results confirm that online PBL was seen as beneficial for developing ideas and critiquing information. However, the artificial nature of the discussion board space was a barrier for some students, as was anxiety about online participation in the PBL tasks.

INTRODUCTION

Problem-based learning (PBL) has long been used within the context of medical education as a means to foster motivation, promote problem solving abilities and to encourage student interaction and independent learning (Willis, et al., 2002; Camp, 1996). More recently there has been an increase in the use of problem-based learning within teaching in Higher Education in a range of subject areas in general (Savin-Baden, 2003) and specifically sport and exercise science (Duncan and Lyons, 2008; Duncan and Al-Nakeeb, 2006), and also in the development of employability skills (Smith and Cook, 2011). Employability is beginning to find acceptance in the UK with the best curriculum designs helping learners to build understanding of the subject matter (York and Knight, 2006), whilst at the same time developing other complex achievements that employers value such as positive efficacy beliefs and meta cognition (York and Knight, 2004). In an attempt to facilitate the development of what have been termed by Bennett *et al*. (2000) 'generic' employability skills, Smith and Cook (2011) implemented PBL across all three levels of a Sport and Exercise Psychology Programme. Students were asked to rate whether they liked, disliked or were unsure about PBL developing seven generic employability skills. Results indicated that all three student groups [including the dislike group] reported the positive influence of PBL in developing their employability skills.

More recently, PBL has been used as a mechanism to increase student interaction in distance based and online courses (Luck and Norton, 2004). This is understandable due to increases in the process and nature of interactive media over recent years, which have provided greater potential for effective online learning, with PBL being employed in several media contexts within higher education (Savin-Baden, 2007). Despite this, although the term 'online PBL' is starting to feature in pedagogic literature, there is still a lack of clarity in relation to the extent that teaching and learning activities are 'online', the ways in which students interact online, and the nature and experience of students engaging in this form of learning (Savin-Baden, 2007).

Subsequently, it is not clear whether the experience of online PBL differs between student groups who have prior experience of PBL, online learning (or both) and those that do not. Nor is it clear whether the 'online' experience of PBL differs depending on the nature of the online delivery involved. This has led to online PBL being used as an umbrella term to describe a variety of ways that students use PBL synchronously, asynchronously, on campus or at a distance. This has comprised use of a range of media and software packages including chatrooms, discussion boards, wikis, blogs with synchronous online PBL employing webinars or, more recently, Web 2.0 environments that have been employed specifically for online PBL (Savin-Baden, 2007).

By using different approaches a number of authors have employed online PBL across a range of subject areas. For instance, Luck and Norton (2004) used online PBL in an early years distance learning course where students engaged in 5 PBL scenarios over 12 weeks. This was primarily achieved through asynchronous discussion board use with supplemental videos of lectures. Asynchronous discussion board use, as used in the aforementioned study, involves an individual posting comments on a discussion board. However, only one individual can post/comment at one time. Thus, the discourse surrounding the problem resolution does not occur in real-time.

This is in contrast to synchronous online learning where all members of a PBL team have the opportunity to comment in real time and at the same time. Likewise, Jones et al. (2006) used 5 (one/two hour) online discussions, with a mix of synchronous and asynchronous use, as a form of virtual clinic in a postgraduate sports medicine programme. The students who participated in this module reported that the virtual clinic PBL experience enabled them to engage with a wider range of material and that working in an online group provided an effective way to share ideas and reflect on different ways of approaching problems. In part due to the success of online PBL in distance learning courses, it has gained popularity as a teaching tool on campus based courses because of its potential to develop student independence, whilst offering flexibility and a student-centred learning approach (Savin-Baden, 2007). Likewise, online learning can also engage individuals in learning which reflects social networking, allows learners to construct their own knowledge based on their understanding of a topic or issue whilst also receiving feedback, support and building new knowledge based on virtual social interaction with their peers. Recent work with engineering students has also supported the idea that online PBL provides important aspects related to future employment and attributes identified as desireable by professional and industry bodies worldwide (Brodie, 2011; Brodie and Porter, 2008).

However, although the promise of online PBL is apparent, relatively few studies have documented the student experience of online PBL and its impact for the students remains relatively under explored (Savin-Baden, 2007). With advocates of this technology suggesting that staff and students sharing their knowledge in a social domain is a key tenant of successful online PBL, it would seem prudent to explore the student experience of this form of learning. Therefore, the aim of this study was to examine the student experience of online PBL in a group of postgraduates new to online learning.

Method

The impact of PBL on students' learning experience was examined using a single module blended approach (Savin-Baden, 2007) on a module titled 'Performance Physiology' within the institution's MSc Strength and Conditioning course. This ran on campus and at a distance and was congruent with guidelines for single module blended online PBL (Savin-Baden, 2007). The module was designed using the model suggested by Boud (1985) and employed one problem scenario as the central component of the module for each group of students (n = 4 per group). Asynchronous discussion boards were used to facilitate the learning process with face to face lectures and seminars used to feed in and around the PBL activity at an appropriate time.

The problem scenario began with delivery of a letter from one of 4 elite sports clubs/teams inviting the group to work with the governing body, in the role of strength and conditioning coaches in preparation for an upcoming atheltic event (e.g., European basketball championships). As part of a pitch to secure a job, a letter was given out which identified a date for each group to conduct a 10 minute presentation to the respective governing body/sports team of their ideas related to athlete preparation . Two weeks after this (so within the midst of problem resolution), the students were then provided with a phone transcript detailing a conversation between an athlete and coach relating to their current physical preparation. This essentially provided a case related to a business/organisational problem. The problem scenario was also matched to the actual activities of sports teams/governing bodies of sport and athletes, so sought to explicitly match the university learning environment with actual practice specific to the students' degree course. In this way, we tried to incorporate different constellations of PBL online within the one scenario and in particular PBL for practical capability and PBL for critical understanding (for a full outline of PBL constellations see Savin-Baden, 2007).

Module Structure

In accordance with suggestions for running online PBL and, as the students were new to both PBL and online learning, the first two sessions of the module were constructed as warm-up activities (Savin-Baden, 2007). The first session of the module comprised a module introduction and the onset of the warm-up activity. In this session students were shown the discussion boards they would be using throughout the module within the institutions virtual learning environment, were given time and space to 'play' with the discussion board while the tutor was available to assist in any technical issues that arose. At the end of this session students were split into teams of four students and allocated a team discussion baord. They were then allocated a short warm-up task centring on a topic from within the module indicative content estimated to take approx 60 min of online time. Following this, during the third session, students were presented with the main problem scenario described above. They were then left to investigate the problem in their wiki groups for the following six weeks of the module with the subsequent interview transcript being provided in week three of this period. During this time two lecture type face-to-face sessions were scheduled which comprised lectures and seminars focusing on the following issues: Metabolic Conditioning, Fatigue and Performance as well as one video lecture related to Resistance Exercise in Adolescents. Care was taken to ensure any information presented by the tutors was not explicitly related or linked to the problem scenario they were working on. Throughout this period students worked via their discussion boards collaboratively and asynchronoulsy. The tutor facilitated the online PBL by listening and lurking positively and by providing supportive, non-leading interventions as suggested by Savin-Baden (2007). The final session of the module comprised formal presentations from each PBL team.

Assessment Tasks

The assessment task used in the module adhered to guidelines for the assessment of PBL (Macdonald and Savin-Baden, 2003). Thus, the assessment was based in a practice context (i.e., it replicated a real scenario taken from the workplace), assessed process based activity (i.e., it focused on what procedures could be employed in the context of the scenario) and it necessitated working with people in a way similar to that they would experience in the workplace. In accordance with the suggestions of previous authors (Savin-Baden and Howell-Major, 2004) in respect to traditional PBL, the marking criteria were presented to the students at the beginning of the module and the objectives, learning outcomes and teaching methods were aligned accordingly. Likewise, the presentation did not simply assess the students' ability to provide knowledge but rather assessed the students' application of evidence, the ability to reflect on problem solutions and their ability to evaluate the way in which they came to their solution with emphasis on the specific context in which their problem was set. In addition to the presentation, students were also asked to select what they deemed to be their best three discussion board posts and provide a 500-750 word justification as to why the chosen posts contributed most to the final presentation provided by the group. This was used to provide a link between individual contributions within the PBL teams and the overall group work.

Evaluation on Online PBL

In order to examine the students' experience of the module, focus group interviews were conducted in groups of four students (i.e. in their PBL teams) at the end of the module. The whole cohort of students (n = 16) took part in the focus groups (i.e., 4 separate focus group interviews). Focus group interviews were chosen as they provide a more naturalistic data collection method compared to interviews or questionnaires (Wilkinson, 2004). Focus groups also allow respondents to build upon the responses of other group members and the relatively free flow of talk can provide an excellent opportunity for hearing the language and experiences of the respondents (Wilkinson, 2004). The students were also asked to complete a short, reflective questionnaire as part of an end of module review. Data from the focus group interviews was analysed using thematic analysis following guidelines and protocols proposed by Braun and Clarke (2006) and, in this way, sought to describe patterns within the module (Braun, & Clarke, 2006).

Results

The results from the focus group interviews revealed a number of themes within the student experience of PBL. Consistent across all focus groups were engagement with a more student-centred approach to learning, relevance of the learning experience to future employment and issues surrounding collaborative online learning. In regard to the theme of a more student centred approach to learning, the students felt that the use of wiki based PBL within the module allowed them greater autonomy, enabled them to engage with a wider range of literature, and develop greater engagement in the learning process in comparison to traditional lecture-led teaching. For example, students reported the following:Student A *'the thing with it is it forces you to go out and research, if someone puts something on there and you weren't too sure about it or wanted to argue the point against it, you then had to go out and read up on the literature, it's sort of self learning so like I think I went though more journals than I did for the journal review [the other piece of coursework in the module] but then I could do it how I wanted to and then relate it back to the group'*

This was supported by the following comments from Student C:

'I like the idea of it and the ease of it, y'know being able to post whenever and then you can catch up on what other poeple have done, it's more flexible and with there being no right or wrong it fits to what really happens in the real world'

This concept of the PBL tasks being more related to employment was echoed by a number of other students during focus group interviews. However, some students saw PBL as providing an effective link with their University learning experience whereas others suggested that the artificial nature of the online discourse of problem resolution may have been problematic.

For example Student D, who was working full time with a professional football club as well as studying, stated:

'But the thing is, which was good, was that it didn't matter what we suggested as long as there was some evidence base or support so we could bring, like stuff I did with football in the real world and use that as a start and then use literature or whatever to develop our argument so it makes a good mesh of real experience and then having to research to be successful

This was suported by Student H who stated:

You can see that it's the type of information we will have to deal with when we are actually out there working with clubs or athletes so I will be able to use what we have done here in terms of thinking things through and using baseline data effectively and then hopefully apply it when I am working full-time so that was good; it was good that we got to play with real data too cos that made it more more I dont know mmm like what we want to do when we finish the course'

Conversely, Student B commented:

'In the workplace you do stuff by email or do it face to face, we all live far away so it's a great tool for that but its more effective to organise a meeting and I felt Moodle was a bit of a bind and more a log of our meetings. The task was great and we really develop new thinking between all of us but through group meetings rather than online because when we get a job or whatever we will be working with athletes personally not via discussion boards'

There were a number of comments made by the students which also constituted issues or concerns related to collaborative online learning in a broad sense. Some of these comments appeared to relate to anxiety in committing thoughts to the discussion board and their subsequent judgement by their peer group. For example, student E noted:

'I got the idea alright but well I didn't want to be the first to put something down on the discussion board because you know well everyone uses that as a base and the other guys [in the group] will judge what you put down so the first post was the hardest'

Student D supported this by adding:

'Once you had put something on there [the discussion board] *you kind of felt better and maybe added a bit more. It was like jumping into a swimming pool once you have done it once its easy after that but until you do you are a bit apprehensive'*

Other students echoed some of these statements but saw some strategies used by other group members as a means to make it appear as if they were doing more work than was the case. For instance: Student A

*'I think some people liked to just put s**t loads onto the discussion board and at first it looked like they had done more work than anyone else but then when you got into it and read it is was s**t, like they had just cut and pasted from Pubmed or a journal or something whereas other people were actually providing more in depth summaries of their take on what they had read so that was more useful'*

This was supported by student B who added:

> *'Definitely, the posts where someone had digested some information and then gave you their ideas from it were miles better than those where people just stuck up something they had read exactly as they had read it'*

And Student C who commented:

> *'it can get a bit competivie too, I mean we are all a bit like that but it was kind of a race at first to put the most up and in the end that wasn't the best way to go about it'*

In relation to this point another student made the following point:
Student G (working)

> *'I think some of us missed the point especially at the start and it was like hey look at me I've read 20 journals and they all say this and here it all is. Almost like look I'm making the biggest contribution, but really I think some of the better contributions was where all the group had contributed and were all thinking the same way and then one of us would post and say somthing like "guys this is rubbish because....." and then we would rethink. Sometimes those really short posts got us to realise that we didnt know what we were talking about all the time so refocused us'*

Findings from the short reflective questionnaire also aligned with these comments in that students suggested the fact that there was no single 'answer' only multiple possible responses to the assessment task was useful and more akin to real world/vocational situations. Students also commented that the PBL tasks required them to enage in a wider range of literature as compared to other modes of learning. This was however seen as both a positive and a negative aspect of the module across the cohort as a whole.

Discussion

The results of this study suggest that online PBL using asynchronous discussion baords can add to the student learning experience in a number of ways. In particular, students felt that the PBL tasks led to a more student-centred focus in learning. This is not surprising and has been previously documented in studies of PBL delivered using face to face (Duncan and Al-Nakeeb, 2006) and online (Luck and Norton, 2004) methods. The student responses to focus group interviews were also simlar to recent work by Robinson (2011) which found that students perceived discusison boards to be useful in enhancing the student experience. Robinson's work also found that the discusison baord was useful for developing group cohesion. This is in contrast to the findings in the present study where there was initial anxiety in use of the discussion board for fear of negative judgement. However, in Robinson's work only 2 students form an entire module cohort were interviewed with the author subsequently stating that a large proportion of students did not fully engage with the discusison boards and did not assent to being interviewed regarding their use. The findings of the current study are also consistent with constructivist perspectives of learning and the concept of social justice in learning (Savin-Baden, & Howell-Major, 2004). By enabling students to engage with the module material at their own level, PBL automatically differentiates specific to the needs of each student whereas traditional didactic delivery does not. In addition, by using a problem-based assessment task students were placed in a position where they had to investigate a particular issue and construct their own understanding based on their own knowledge and skills base. Informal student feedback also suggested that being able to participate in a challenging, collaborative effort asynchronously and flexibly in terms of time, while adapting their efforts to their other academic, professional, and personal obligations was a positive factor. This is in agreement with prior research investigating student experiences of online PBL (Spinello and Fischbach, 2008).

Another key theme within the focus groups was relevance to employment. With students, C, D and H viewing the online PBL tasks as being reflective of the types of role they would experience in employment (Yorke and Knight, 2006; 2004). However, other students felt the use of aynchronous discussion boards was not congruent with the types of interactions they would have to engage in during full time work in the area of strength and conditioning. Prior studies with undergraduate students using face to face PBL (Smith and Cook, 2011; Duncan and Al-Nakeeb, 2006; Duncan et al., 2008) have reported that students feel the inclusion of PBL aligns well with the requirements of work. These findings also support prior work at the University of Southern Queensland which have specificlaly highlighted that online PBL (both synchronous and asynchronous) significantly increases employment related skills, both in terms of technical ability and wider graduate attributes, in engineering students studying via distance learning (Brodie, 2011). While some of the comments made by students in this study support these prior assertions it may be that the use of online PBL in the form of discussion board use is not fully congruent with the area of strength and conditioning where face to face working in a physical, practical environment is a key feature of that particular employment sector. Indeed, similar comments in relation to vocational relevance have been made previously by students using online PBL in public health (Spinello and Fischbach, 2008). Subsequently, it may be useful for researchers to explore whether there are more effective ways to link online PBL to these types of vocation. For example, use of 3D virtual worlds might provide a better medium for more effective discourse as the online experience can be better matched to the day to day job requirements of a strength and conditioning coach.

In addition, although the use of online PBL in this instance appears to have benefits, there were some significant comments centred around the concept of online collaborative learning. A number of students reported concerns or reticence to post initial comments on the discussion board for fear of being judged by their peers. This is not surprising as online PBL was a novel experience for all concerned and this form of initial anxiety has been reported previously (Vigentini, 2008). These results also echo recent research by Robinson (2011) who identified that lack of engagement in discusison board tasks by undergraduate students may be related to reticence to post due to anxiety or lack of confidence. This is obviously an important consideration for tutors who may be thinking of including online PBL in their teaching. All students were competent and regular users of Web 2.0 technology and social networking leading the authors to believe that competence in using the institution's virtual learning environment was not the cause of this initial anxiety. Perhaps there is a need for researchers to better consider how to foster greater confidence in using discussion boards for learning when students are new to this form of learning. Such strategies could include use of a greater number of warm-up activities with additional tutor or peer support (both online and face-to-face) at the outset of the module, possible partnering of students who have prior experience of online learning and those who do not, or 'drop-in' help sessions for students to get to grips with online learning tools at the start of the module. Within this theme, students also differentiated between the quality of posts made by their respective PBL groups and there was reflection that some posts made during the course of the online PBL tasks did not add to the overall problem resolution. In some cases, excess volume of information presented on the discussion boards may have been seen as a means to disguise lack of deeper learning in relation to the various problems.

The current study has attempted to investigate the student experience of online PBL in students new to both online learning and PBL. This information can potentially be used to enhance the learning experience of future groups of students. However, this research is based on experiences of one particular cohort of students in one particular module. Little research has been conducted investigating the student experience of wiki-based PBL and findings of the current study raise some interesting issues that need to be further investigated in different contexts. It is also important to note that discussion boards are one of many online learning tools that could be used to facilitate PBL. In the context of the current study, discussion boards were chosen as the means to facilitate PBL as they provided a social learning space that prior authors have suggested is easy to use and familiar to the majority of individuals who regularly use the internet (through experiencee of web content such as wikipedia) (Jones et al., 2006). Few studies appear to have compared the effectiveness of different forms of online learning (e.g. blog vs wiki vs discussion board) and a study of this nature might offer important insight for practitioners in future. Furthermore, clear parallels are evident between comments made by the students in the current study and other research reporting the student experience of face to face PBL (Smith and Cook, 2011; Duncan and Al-Nakeeb, 2006; Willis et al., 2002). Inclusion of a pre and post measure of student learning with and without an online PBL intervention might therefore be effective in determining the pedagogical effectiveness of online PBL.

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IMPACTS OF PEDAGOGY CHANGE ON JAPANESE UNIVERSITY LEARNING SPACE DESIGN AND STUDENTS' COLLABORATIVE BEHAVIORS

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ABSTRACT

Recently Problem Based Learning (PBL) has been introduced steadily into Japanese universities. PBL shifts the focus in learning from teachers to learners, yet such a change of

ideas is not reflected in new physical classroom layout design. A PBL course in Mie University was studied. The survey was based on observation to gain a better understanding of student behaviors. Special care was made to focus on the collaboration dynamics of students.

The results showed that a classroom with a traditional layout hinders the effective management of PBL courses. Communication between group members is the backbone of collaboration activities. A PBL classroom should be flexible to allow smooth transition between lecture mode, group discussions and group work, in addition to providing conversational configurations. Learners should feel clearly that they are the focal point of the learning process by neutralizing the teachers' authority and providing students with more control in the environment, which leads to innovation.

INTRODUCTION

Recently, changes that affected all aspects of life have resulted in the adoption of Problem Based Learning (PBL) widely in universities. It is not a new pedagogy, but has been known within the field of medicine since the late 1960s, yet its incorporation into university curricula within various disciplines has only recently gained momentum. Mie University is trying to cope with this worldwide trend by steadily introducing PBL into its courses, especially in courses intended to prepare freshmen for their university life. PBL is learning initiated by a posed problem that the learner wants to solve; the problem here becomes the focus of the student's activities (Boud & Feletti, 1997). Students usually start with a problem, and then they move to acquire knowledge and skills in a sequence of real world problems presented in context with associated learning materials and support from a teacher.

Complex real world problems motivate students to identify and research the concepts and principles they need to know to solve these problems (Duch, Groh & Allen, 2001). Students work in small learning teams, bringing together collective skills at acquiring, communicating and integrating information. PBL came as a response to the newly desired qualities in an undergraduate, including the ability to think critically in order to analyze and solve real world complex problems, to find and use appropriate learning resources, to work cooperatively in small groups, to communicate effectively and to use acquired skills to be an effective learner. Many traditional learning pedagogies have failed to equip students with such qualities. PBL starts with a set of problem scenarios to prepare students to become independent inquirers, students work in groups to engage the scenario and decide what information and skills are required to be learned to manage the problem successfully (Saven-Baden, 2003). Collaboration is the work done by two or more students, who work together and share the work load equitably as they progress toward intended learning (Barkley, Cross & Major, 2005).

In spite of recent developments in learning pedagogies, learning facility planners and even those using them have taken the layout of a classroom for granted as they continue to use outdated spaces optimized for the two-thirds rule; two-thirds of the time the lecturer is talking and the students are passively listening (Sommer, 2007). As this pedagogy shifts the focus of learning as a process from teachers to learners, the learning space should be reconfigured to reflect such a change; traditional classrooms with hierarchical organizations that give the teacher a spacious area in the front of a classroom and squeeze the students in rows of tables in the remaining area is no longer acceptable. In addition, the space should be optimized for group work, rather than passive learning by listening to lectures and memorizing information. Designers must consider the needs of the emerging generation of campus users who prefer to work together collaboratively in small groups (Steelcase Inc., 2005). There is a divide found between the current learning environments and what is known about the learning experience; to overcome this contradiction, more research is required, with focus on the four key elements forming the core of the student faculty learning experience: human needs, teaching, learning and engagement. Understanding these elements will pave the way to create innovative learning spaces (Herman Miller Inc., 2009).

Research purpose and methodology

This paper focuses on the university learning space; it aims to firstly shed light on PBL and its introduction into the curricula of Mie University. Secondly, it attempts to investigate the effects of applying nontraditional pedagogies on classroom spatial use, collaborative behaviors, and obstacles to learning posed by the currently available classroom layouts. Understanding how users would adapt their learning environment to cope with PBL, observing their actual collaborative behaviors, and grasping the process of problem solving would provide valuable feedback, which would lead to better designs of learning space so that it would create an ideal environment to promote the emergence of independent inquirers.

As a methodology, this study was based on qualitative methods. In a Mie University case study, classroom observations were held by video recording as a tool to capture the behaviors of students and faculty during the lecture hours. The survey was conducted on two separate days, on the 26th of April, 2010 and 9th of June 2010, from 13:00 to 14:30 covering an interval of 1.5 hours. Two DV cams and three web cams where used to cover 80% of available tables in the classroom. In addition, an observer attended the observed class sessions and used a digital camera to record important events, besides taking notes and recording own impressions. The first survey included more time devoted to group work, and was therefore chosen for further analysis. The collected data was analyzed on two levels; first trying to grasp a general understanding of the events and issues seen to be important to apply PBL smoothly. Secondly, a more detailed analysis was conducted by tracking individuals within each group to understand each individual's activity profile and group interactions dynamics. The frequency and duration of activities were measured per individual for the entire period of group work. The charts that follow were based on these measurements.

A case study from MIE University

As a part of Mie University's efforts to introduce PBL and other innovative pedagogies into its curricula to achieve educational goals, the university established the Higher Education Development Center (HEDC) in 2005; the center promotes PBL by providing tutorials for faculty and facilitating the application of relevant innovative information technologies as well as E-learning initiatives. A course named "4 Skills-startup" seminar; which is a class based on PBL and is dedicated to the undergraduate students (freshmen) was chosen as a case study. This course aims to introduce the students to university life by equipping them with necessary skills and providing them opportunities to learn how to learn. It includes a selected combination of activities to develop IT application skills, effective communication, group work and problem solving.

The selected course was held once a week between 13:00-14:30. The course was held in a special classroom dedicated to courses applying PBL, yet its layout followed the traditional classroom configuration; a rectangular classroom, with rows of tables, movable chairs and 5 whiteboards, and the main projection screen at the center of the front wall. The class included

42 students who were divided into 14 groups of 3 students. The majority of students were males and the ratio of females to males was 1:4, although an effort was made so that each group would include one female if possible. The faculty, assisted with two teaching assistants (TAs), managed the classroom and provided student support. The observed class consisted of three parts in terms of activity duration: receiving new materials and handouts, a lecture that explained some general ideas about the posed problem and gave some instructions, and then group work where students tackled the problem under concern (Figs. 1&2).

Fig. 1. Lecture Mode

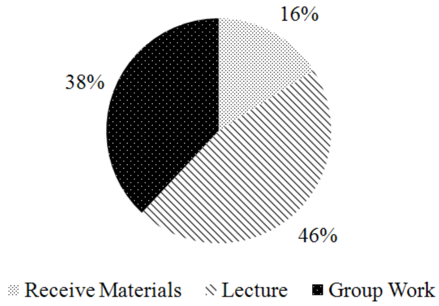
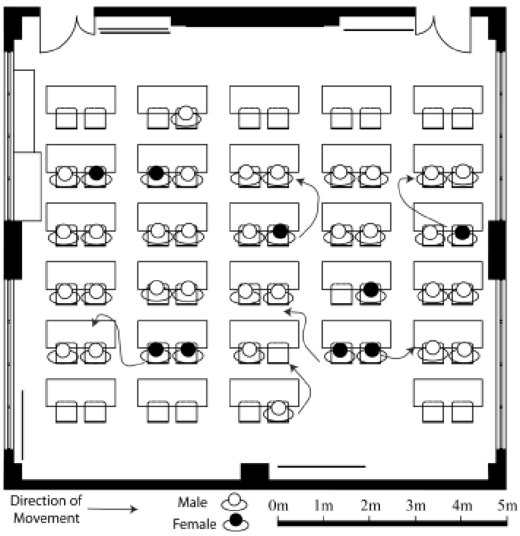


Fig. 2. Duration of Class Activities

General observations:

The current configuration of class provides for traditional lecture based courses. The class is single focused; all students face the front with clear hierarchy of space, in addition to the use of parallel rows of tables, which are the characteristic of the traditional classroom. This was clear at the transition moments from lecture to group work. Students needed to move from their places, move tables and chairs to sit in more interaction-promoting configurations, and this transition created some sort of interruption of the learning process, because students required some time to settle down and go back to learning activities. Students tried to position themselves in a configuration that helps them to maintain eye contact with group members (Fig.3).

Two-student groups -the third member of these groups was absent on the survey day- managed to achieve that by tilting chairs toward each others; students either sat beside each other or faced each other over the table. The first configuration was seen to be more effective, because sitting beside each other facilitates sharing materials, conversation and collaboration. İn addition, as PCs were introduced, students could still communicate and work on a PC simultaneously. For the three-student groups, students tried to either tilt their chairs so that all three students could have continuous eye lines to enable them to have sustained conversations, or sat beside each others. While the first configuration was successful before introducing PCs, after which many students tried to sit beside each other to ensure better contribution to PC work. İt is worthwhile to mention here that many students hesitated to move their chairs or to tilt tables unless they were encouraged to do so by either the faculty or one of the TAs; which indicates the strong authoritive image students hold for a teacher built through their previous schooling years. There is a need to stress freedom of action and movement of students in order to encourage them to take control of their own learning.



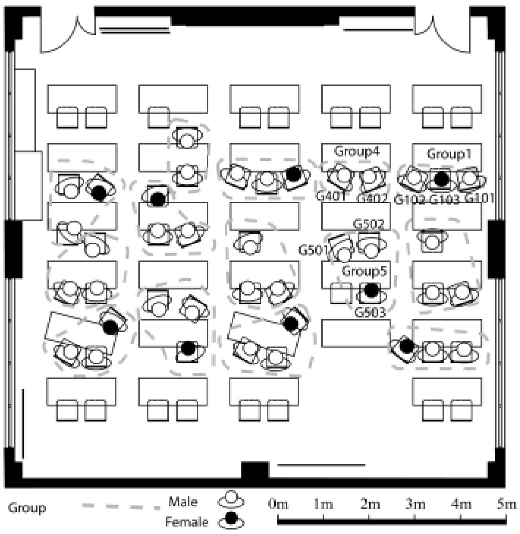


Fig. 3. Student Adaptation of the Classroom Environment for Group Work

The classroom was stacked with tables, leaving narrow spines for movement; those spines seemed to be congested and when the transition was made to group work, many students moved their seats or tilted some tables. The new configurations, in addition to the students' belongings and electrical plugs on the floor, blocked some spines, which limited the freedom of movement for both the students and the lecturer who frequently moved around the groups. Moreover, it was noticed that the students needed to move around to see some resources posted on a whiteboard at the front of the classroom, but the lack of space and obstacles made it difficult. Several students were seen to move around other groups to interact and share points of view with other students before going back to their own groups to continue their discussions of the given problem (Figs. 4&5).

Fig.4. Narrow Spines Blocked by Chairs, Electric Wires and Bags

Fig. 5. Students Moved Frequently to See The Resources Posted on a Whiteboard

Students required more table surface work area to spread their belongings, because many students used papers, books and the provided PCs. İn many cases, students were seen to make use of two tables; they would interact with group members and then tilt their bodies towards the other table to write down notes or read and then go back to interact with group members again, which seemed to make collaboration a cumbersome task. Although some whiteboards were available, they were not used, but instead students made use of A3 paper and some Post-it notepapers. Students would engage in interaction and brainstorming regarding the posed problem and use such papers to share their thoughts and develop their ideas. The noise level within the PBL classroom was higher than traditional classes, all those dynamic interactions and lively movements of students created a different image of learning as being an enjoyable experience, although the lecturer was sometimes required to talk louder to be heard, the classroom noise level seemed to be acceptable.

Laptop PCs were distributed to each group by TAs after sometime of group work that mostly consisted of primary discussions of the given problem. This distribution interrupted ongoing communication and wasted some time as students settled down again and went back to work. The use of such PCs in unsuitable configurations led to ineffectiveness; only one student could clearly see the PC screen, which created an uncomfortable atmosphere for collaboration and lowered the level of group engagement. As a consequence, some isolation effects were observed in some groups, where one member would seem to be detached from the group, which hinders constructive collaboration. It is worthy of mention that some students changed their seating locations in the group when the PC was introduced, to be able to see the screen and participate more effectively in the group activities; which led many students to sit beside each other, a configuration that does not help in maintaining eye contact and negatively affects interaction (Figs. 6 &7).

Fig. 6. Making Use of an A3 Paper During Group Brainstorming

Fig. 7. Isolation Effect as Noticed Due to The Use of Conventional PCs

Collaborative behaviors

The collected data was analyzed in more detail; each individual was tracked for the entire group work period. The focus was on understanding the collaborative behaviors of students. The results of three groups will be discussed. All collaborations consisted of a combination of activities including communication, PC use, observation, reading, writing and moving. The most important activity was conversing among the group; as such communication would create a link between group members, facilitate sharing relevant tasks and guarantee smooth collaboration. Communication with the teacher was noticed to be marginal, except for the case of a female member of group 5 (G503), which had more communication with the teacher compared to communication among group. Limited communication with the teacher helps to enforce independent learning and the teacher would be seen more as a facilitator rather than an authoritive source of knowledge. The frequency of activities differed among individuals; within each group, PC use was conducted more frequently by one of the group members (G101, G401, G502), and this may be attributed to the layout that enabled one user to easily handle the PC while others participated every once in a while. The observation activity, which is a combination of thinking, watching and listening to instructions, seemed to occur evenly within all group members. Most users, except for one (G502), left their seats and moved to see resources or to interact with others (Fig. 8).

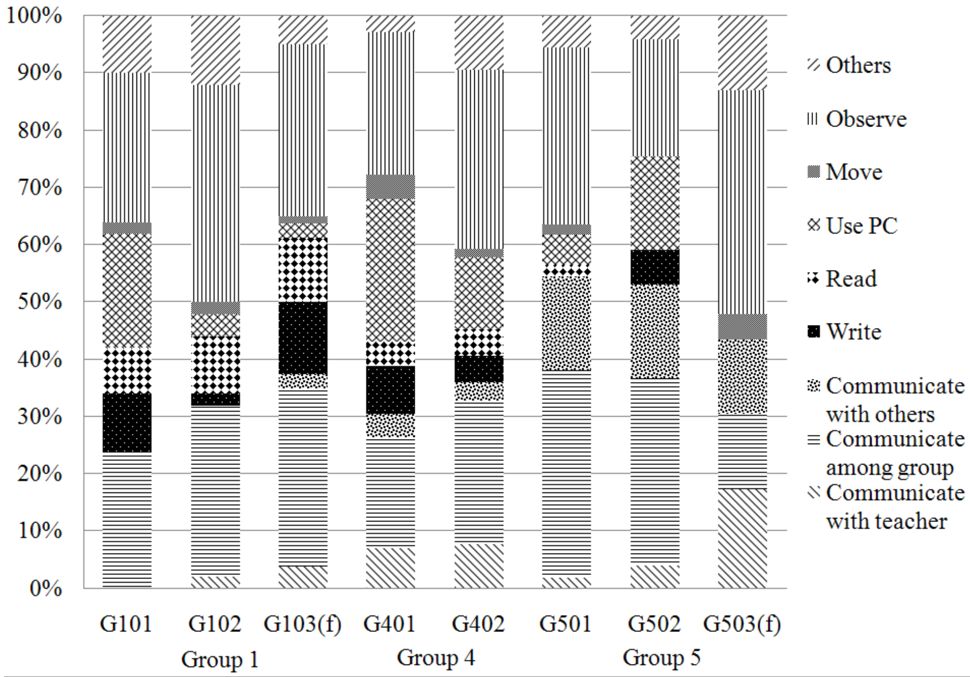


Fig. 8. Activity Frequency

The collaborations consisted of many repetitive activities with each activity lasting for a relatively short time; the average activity duration for all selected individuals was 40 seconds, which demonstrates the lively nature of collaboration (Fig. 9). Communication activity was mostly related to observing and using a PC; an individual would communicate with other group members, then observe and think or work on the PC and then go back to communicate with group members. When a person is more engaged with the group, his/here his activities will be more frequent and diverse, although communication with group members would seem indispensable.

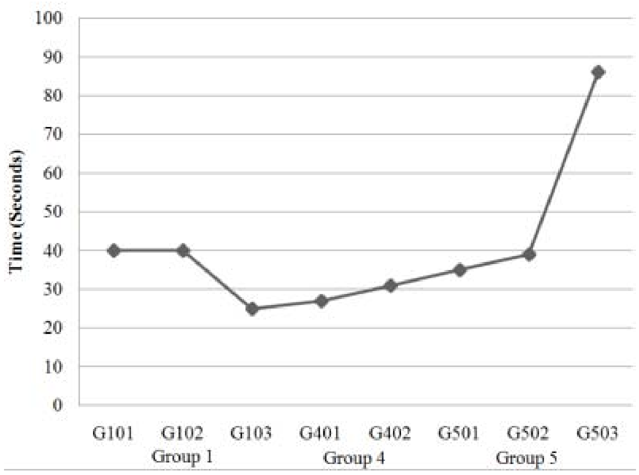


Fig.9. Average Activity Duration

The groups with effective collaborative behaviors are thought to make use of its individual capabilities to achieve the intended learning goals, the members of a group would participate in the learning activities in equal shares, and more importantly they would communicate with each other with almost similar duration. Group 1 is an example of an ideal case, where all members took part evenly in communication, while both Groups 4 and 5 exhibited unbalanced patterns of communication; particularly, one member in Group 5 (G503) had a low level of communication. Further investigation showed that this student (a female) did not participate at all in collaboration activities, but she spent most of the time just watching silently, looking at her watch continuously as if she was waiting for the class to end as soon as possible (Fig. 10).

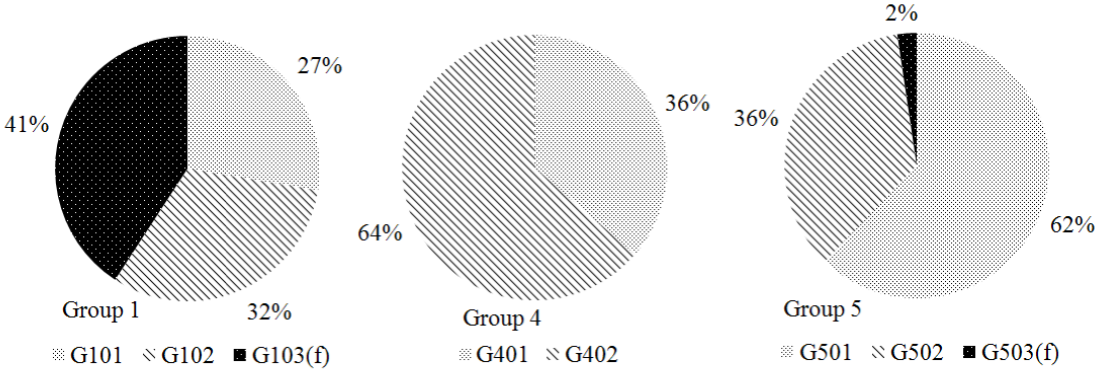
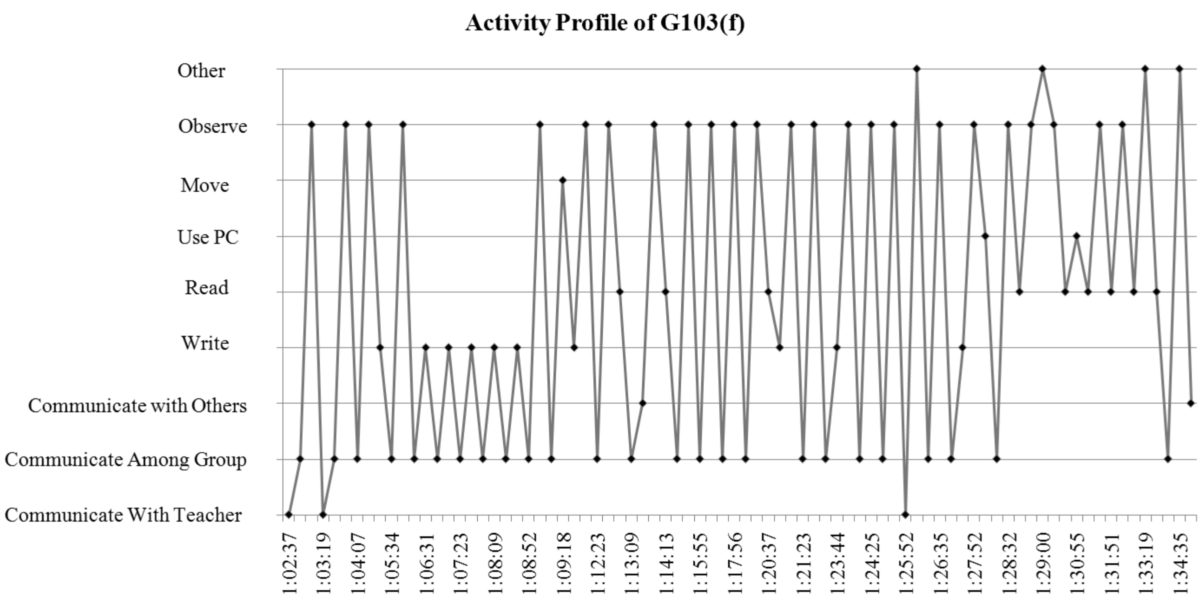
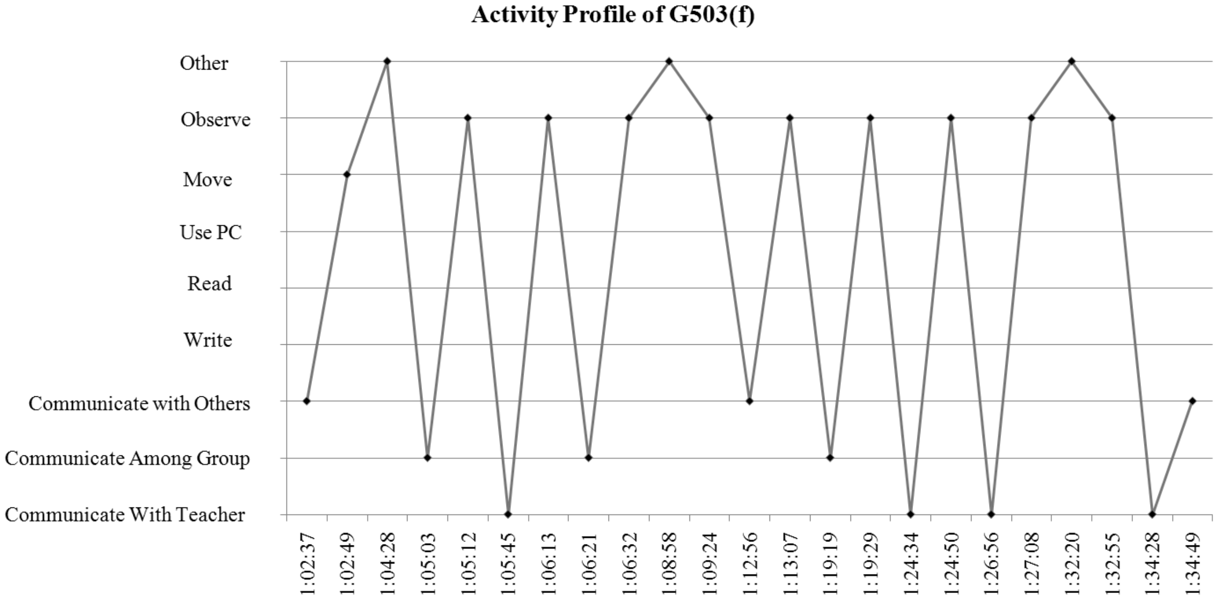


Fig. 10. Cumulative Communication Duration per Individual For Selected Groups

Studying the activity profile within time for two female members from Group 1 (G103) and Group 5 (G503), showed that a student with an effective collaboration profile would show a highly repetitive pattern of learning activities, less interruption, and communication with group members would be dominant and mostly related to other activities either by following them or preceding them as the case in Group 1 (G103) (Fig. 11).



A. Activity Profile of Female G103 from Group1



B. Activity Profile for Female G503 from Group5

Fig. 11. Differences in Activity Profiles between G103 and G503

In the start of the group work period, the female student of Group 1 (G103) communicated with other members who tilted their seats toward her. She also took the initiative in learning by using A3 paper to record the results of the group's brainstorming every once in a while, as seen in her profile. Later on, when the PC was introduced she changed her seat to sit beside other group members to continue active contribution to the group's problem solving task by using the PC occasionally; a similar level of engagement is seen as desirable in all students to guarantee achievement of the PBL class learning goals.

Conclusion

A PBL classroom design should meet the needs of PBL, which places focus on students rather than on the lecturer. The layout should be different from traditional class designs that are based on rows of tables and gives the teacher more space, as a reflection of the traditional learning methods; such traditional layouts hinder the effective application of PBL courses. Innovative PBL classroom designs can make use of nontraditional shapes by avoiding rectangular or square shapes and by canceling the front and back sides of the space to emphasize neutralization of the teacher's authority. In addition, such innovative classrooms need to stress flexibility to facilitate transition between different learning modes with minimum interruption to the learning process.

All possible student learning preferences and needs should be catered for, in addition to using whatever means necessary to encourage collaboration and generally increase the level of student engagement with group work and class activities. Table configurations that are optimized for group work and collaboration are an indispensable part of a PBL classroom; such table configurations would guarantee continuous sight lines between students and provide sufficient table work areas to collaborate and use different necessary tools. Moreover, the classroom should have sufficient space to provide ease of movement for the lecturer and students alike. In addition, the class should be equipped with tools and IT resources to facilitate sharing knowledge.

Effective collaboration can be achieved by promoting group work skills that stress the need for equal participation in learning activities, as well as providing appropriate configurations that induce communication. The group work dynamics and collaboration skills should be emphasized and monitored by the faculty or TAs. For instance, observing a tendency by one of the group members to control communication or to deny others from participating in collaboration requires direct intervention by the faculty to highlight mistakes and provide chances for healthy group work practices. Finally, a PBL classroom needs to enable students to have more control of their learning environment, which would provide more comfort and consequently less distractions and more engagement in the learning.

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ICT SUPPORT FOR STUDENTS' COLLABORATION IN PROBLEM AND PROJECT BASED LEARNING

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ABSTRACT

This paper reports and analyses quantitative and qualitative data from a study, which seeks a better understanding of how students use various technologies to support their project collaboration activities in a problem and project based learning environment. More generally the aim of the study, and the present paper, is to shed light on students' technology practices within higher education – particularly in relation to problem and project based learning. The reasons for undertaking these studies are that we aim to develop a mobile application to support the students' problem and project based learning. The methods are an online survey, narrative reflections, observations and interviews. The analysis reports the differences in collaboration practices of students with different levels of experiences with the pedagogy and students from different faculties at Aalborg University. The results show students in problem and project based learning environment use several tools to support their group work and they have potential to adopt mobile technology to enhance their group work collaboration. Additionally, the results also lead to discussions about how to provide a better group working

environments, whether institutions should provide applications with full functionalities or facilitate students to use tools which are available on market, either free or commercial services.

INTRODUCTION

A number of studies have discussed the notion of digital natives or the “net generation”, i.e. the generation who were born after 1982 (Sandars & Morrison 2007). Some have claimed that the net generation kids have different brain structures, different learning practices, and different knowledge perception from earlier generations (Prensky 2001). This is attributed to the impact of technologies in their daily life since their birth. Digital natives or the net generation are argued to be part of a creative and participatory culture where they produce, re-mix and develop advanced learning capabilities through their informal use of technologies. Therefore, it has been argued, that there is need for fundamentally rethinking the entire educational system to accommodate and cater to the needs of this generation (Prensky, 2001). This is because of their advanced skills, but also because they are bored with traditional education and want learning environments which reflect their proclaimed rich advanced use of technologies. However, it has become increasingly clear from many studies that the idea of a whole generation of digitally very literate students is problematic and misplaced. While students do use a variety of technologies, it is also becoming clear that they find it more difficult using technology as a means to support their learning than the notion of ‘digital natives’ would suggest (Bennett & Maton 2010, 321-331). Rather than assuming that there is a generation of digitally literate students entering the university, there is a need to enhance our understanding of how university students actually use technologies to enhance their learning. This study therefore aims at exploring the patterns of students’ collaboration (project work) and their use of e.g. Web 2.0 tools in problem and project based learning environments. The aim is to achieve a better and more nuanced understanding of university students’ use of technology, with a particular focus on learning in problem and project based learning environments.

Some of the main characteristics of problem and project based learning (e.g. as practiced in Aalborg University) are that students collaborate in groups over an extended period of time to produce a shared written product (project report) reflecting their work with their problem. This is self-directed and student-centred learning, where students are in charge of the learning process. For example they choose what problem to work with and how, both in terms of choosing theory and methods, but also in relation to managing the collaboration as a process (Kolmos et al. 2004).

As mentioned, one of the goals of the research project in which these data have been collected is to develop a mobile application to support students' problem and project based learning group work collaboration which may support either face to face or distance group work. A high level of student-control combined with a high level of technological competence would seem to suggest that questions of how to use technology for project work are better left to the students. However, as indicated above, and as our data and analysis reveal, this might not be so straightforward. Therefore, we will discuss what strategy institutions should take in relation to providing virtual space for problem and project based learning group work collaboration, which are relevant when aiming to develop new software for the students. Should institutions provide applications with full function services or should they provide support for and guide students in taking advantage of external services which are available?

Problem and Project Based Learning

Problem based Learning (PBL) is based on social constructivist theory. It provides framework to form pedagogies that take strategy on self-direct learning, and social interaction as its strategy. Students not only get the respective knowledge of academics but also acquire social skills and critical thinking. Aalborg University has employed this PBL model since 1974, which is also referred to as problem oriented project pedagogy (POPP) (Dirckinck-Holmfeld 2002). In POPP, the students themselves define the problems to engage with and also how to organize this project work (theoretically, methodologically and practically), but work closely with a project supervisor. Ownership of the problem is where POPP differs from traditional PBL (Dirckinck-Holmfeld, 2002). This is what we refer to as problem and project based learning – there is a product (project) which is based on continuous inquiries into a particular problem and discussions and negotiations of the problem itself.

Students in Aalborg University have to do group projects every semester. Aalborg University therefore has some experience employing technologies to support student groups e.g. by using Lotus Quickplace, Moodle and Mahara (Tolsby et al. 2002). The university has a strong infrastructural support for physical space for group work discussions within each department and libraries, uninterrupted wireless Internet connectivity and discipline specific technological resources in different departments.

Methodology

To answer the research question, we chose a multi-method approach combining quantitative and qualitative methods to understand how students use technologies to support their problem and project based learning.

- ***Tools and collaboration Questionnaire:*** An online questionnaire was developed on basis of an initial test phase with paper questionnaires and short interviews with students to test and refine the scope of the questionnaire and test the relevance of the questions asked. The final questionnaire had 4 sections, namely: background (6 questions), mobile life style (4 questions), project collaboration (5 questions), and web 2.0 tools (4 questions). In the Web 2.0 tools section there were 40 tools and questions about the diffusion stage of each tool. Based on Roger's (1995) 5 stages the researchers made 9 response categories for each tool students use. These options were: (1) I don't know about it, (2) I know about it BUT I am not interested, (3) I know about it AND I plan to try it someday (4) I tried it BUT I don't need it, (5) I tried it AND I might use it later, (6) I am using it BUT I shall stop soon, (7) I am using it AND I shall continue using it, (8) I stopped using it anymore, (9) I stopped using it but I may use it later. Responses to these categories or diffusion stages will enable identification of how the prospective users should be approached by the change agent. Names of tools against which students responded were identified through initial list of tools from tools introduced by an institution (mentioned in the narrative reflections section), students' reflections, test phase of questionnaire, and interviews. The questionnaire was distributed to students across four faculties. The director of study administration at AAU approved and assisted in the random selection.

- ***Narrative reflections (blog posts) as part of course work:*** In Fall 2010, first semester students of "Humanistic Informatics" program (in the Faculty of Humanities) followed a course taught by one of the authors. Furthermore, with support from E-learning cooperation at Aalborg University (ELSA) (Official site of ELSA 2011), students were introduced to a number of web applications (Møller 2010) which they might find useful and consider exploring for academic purposes. The semester course was conducted in Danish and at the end of the semester students were asked to submit reflections and respond to the following questions.

"*What technologies have you met and which do you actually use - both in relation to courses, project work and for social purposes. What is the role and importance of technologies in relation to studying and in relation to student life, learning and socialization? Give an overall assessment of the benefits of the various technologies that have been made available (and the ones you actually use). (Moodle, Mahara, Dropbox, Facebook, Google services, Wikipedia, etc.) and also add suggestions for improvements. Max 2-3 pages."*

The students used the university's installation of the open source Mahara system as part of the course activities and to write their blog posts. Students were asked whether their contribution could be used for research or not. The posts of those agreeing were anonymised by one of the authors before they were made available to the research group. Then the reflections were translated by Google Translator (Google Inc. 2011) with proving from one of the authors who is a native speaker. A sample reflection was thoroughly read for identifying names of web applications frequently mentioned and for exploring positive comments, negative comments and reasons behind such comments about the applications.

- ***Observation and Focus Group Discussion:*** In the spring 2011 semester (February to May 2011), the researchers followed a group of students who were in the second semester in *Humanistic Informatics* program. We were allowed to observe, interview, access to their discussion on Facebook, and access to their shared documents on Dropbox. There were 5 members in the group with 3 female and 2 male students. The researchers started following them after they had formed their group and began project activities.

In this way we have gathered data at three different levels of scale and for different analytic purposes – across faculties (survey - quantitative), within a semester (analysing blog posts through semi-quantitative categorisation coupled with more analytic, interpretavist readings of the posting) and ethnographically inspired observations and interviews with a small group of students (to attain a qualitative deeper understanding of particular uses of technology in a project groups).

Analysis

Questionnaire

Sample and Respondents:

The survey was activated from 30th May to 10th June 2011, and sent by email invitation to 3,000 randomly-selected students out of approximately 15,000 students at Aalborg university. 365 visitors visited the link, 310 students participated and 253 students completed. There were more male (57.6%) participants than females (42.4%). Relatively higher degree of respondents were from the faculty of Engineering and Science (41.7%), followed by faculty of Humanities (28.1%), faculty of Social Science (25.5%) and Medicine(4.6%); the ratios reflect to the actual number of each faculty. About 28.4% are in the end of first year and 24.8% are in the end of fourth year and the others are in second, third and fifth year. 94.4% participants are fulltime students, 5% of part time students. In terms of PBL experience, 32.2% have 2 semesters, 18.8% have 4 semesters, 10.1% for 6 semesters, and 11.4% have 8 semesters experience in PBL. We can see that most of the participants were relatively new to the PBL environments. However, they had had at least 2 semesters of study and they had experienced at least 2 PBL projects. Therefore, they were assumed to understand some level of the nature of PBL project collaboration.

Place	%
Project/Meeting room	66.01
Supervisor's room	0.99
Canteen	0.99
Library	4.93
Other place within AAU	1.48
Home	18.23
Cafe	1.48
Other place outside AAU	5.91
Total	100.00

Figure 1. Percentage of students who always meet to do project at different places

Results:

- *Student Working places*

Student project groups mostly comprise 4-5 members and the maximum group size is 7. To understand how students work in groups we first looked at where they work, as this is of particular relevance in relation

	meet group	work alone	use tools
Social Science	17.91	10.71	22.73
Humanities	6.72	3.57	15.91
Engineering and Science	70.90	78.57	56.06
Medicine	4.48	7.14	5.30
Total	100.00%	100.00%	100.00%
Overall	49.10%	10.40%	48.50%

Figure 2. Percentage of students perform different project activities at project room by faculty

to potentially developing a mobile application for students. We looked for both group and individual activities.

Figure 1 demonstrates where students meet to do project work. We can see that the main places that students work are in project rooms at the university (66.01%) or at home (18.23%). While the university provides project rooms and maintain good environment for working (privacy, whiteboard/blackboard, and furniture), but there are not enough rooms for all students. This becomes visible if we look closer at these two settings which are displayed in figure 2 (working at university) and 3(working from home).

	meet group	work alone	use tools
Social Science	16.22	30.89	25.00
Humanities	64.86	34.15	29.76
Engineering and Science	13.51	29.27	41.67
Medicine	5.41	5.69	3.57
Total	100.00%	100.00%	100.00%
Overall	13.90%	44.60%	60.60%

Figure 3. Percentage of students perform different project activities at home by faculty

From these figures it becomes clear that while approximately 70% of the students from Engineering and Science work at the University the numbers for the other faculties are significantly lower. Engineering and Science students also perform activities at project rooms 49.0%; and they use web tools to support their work 48.5%. When look into different faculties, students from Engineering and Science faculty are the most active in doing project in project rooms (70.90%). They not only perform group work activities in project rooms, but after dividing tasks they also work in the project rooms individually and they are active in using web tools to support their project activities in the project rooms more than other students from different faculties. Figure 3 indicates that 44.6% of students work at home on projects alone and 60.60% use tools in support. When we look into different faculties, students from Humanities faculty (64.86%) are active in performing their project activities at their home. This is because the faculty cannot provide enough project rooms for students. When looking at the number of students doing project alone at home students from Social Science,

Category	Web Tool	%	Category	Web Tool	%
Groupware	Wiggio	96.1	Others	FastStone	94.9
	Google Groups	54.4		Doodle	57
	iGroups.dk	91.4		SignAppNow	96.1
Google Tools	Docs	29		Lectio.dk	73.8
	Calendar	19.7		TeamViewer	70
Brainstorming	MindMeister	93		LogMeIn	89.1
	Mindmap	77.9		SoundScriber	95.7
Diagram	Dabbleboard	95.3		Prezi	91.4
Bookmarking	Delicious	87.5		Pageflakes	97.7
	Digg	81.6	Blog	Blogger	70.4
	Diigo	94.6		Wordpress	60.5
Document Management	Dropbox	10.8		Twitter	14.7
	Box.net	92.6	Messenger and Chat	Skype	5.1
	Slideshare	88.4		MSN	5
	Evernote	79.7		Yahoo	40.3
	Etherpad	92.6	Project Management	Basecamp	93
	MS OneNote	65	Email	Gmail	8.1
Image Sharing	Flickr	45.5		Hotmail	5.8
Social Networking	Facebook	1.9		Live.dk	70.8
	LinkedIn	35.9	Reference Management	Zotero	95.7

Figure 4. Percentage of respondents 'do not know' about web applications

Engineering and Science, and Humanities are almost equally active (30.89%, 29.27%, 34.15%). Engineering students still has higher percentage using computer or mobile devices to support their project work from home (41.67%). Humanities and Social science are equally active in using tools to support their work at home (25%, 29.76%). It is maybe because of the nature of Engineering and Science students, always working with technologies, that makes them active in using tools to support their group work. Overall students tend to use tools to support their group work when they are away from each other (at home). They use tools to contact each other. On the other hand, when they come to face-to-face meetings, they seem to use technologies less to support their work. In fact technologies have potential to support both face to face and distance project group activities.

- *Students' web tools use for PBL project collaboration*

There were questions about web tools for collaboration differing between institutionally-provided tools and self-acquired tools. In relation to the responses about the knowledge of or use of web applications we explored these through nine multiple choices building on Roger's diffusion theory. The significant observations are summarized here. According to figure 4, it is interesting that a significant number of students do not know about the existence of tools which benefit learning activities and collaboration. Therefore, strong initiatives have to be taken so students to know about emerging tools and the prospective benefits in efficiently handling learning activities. Regarding the online services operated and maintained by the university these appeared to have less success. The 'diffusion confirmation' expected from the answer choice 'I am using it AND I shall continue using it' is lower for Mahara, AAU email, AAU library database, and Projekter which is the students' project database.

- *Students' use of mobile devices*

Figure 5 shows that a quarter own an Apple iPhone or iPad, as handheld mobile device, which is the priority as the project is related to the Apple's capabilities. The largest group does not have a smartphone while a few are not sure if their mobile phone is a smartphone or not. It is interesting that some respondents do not use a handheld mobile device (among the options in the

	%
Apple iPhone	17.28
Apple iPad	4.63
Android Phone	20.06
Other kind of Smartphone	10.19
Other kind of tablet	2.47
Not a Smartphone	41.98
Not sure	2.47
Not having any phone	0.93
Total	100.00

Figure 5. Ownership of mobile devices

question). In terms of the Internet connection with mobile devices, in general, more than half of students use the Internet on mobile devices with 3G connection and some use only WIFI connection. A quarter connect to the Internet on a mobile device by using a data package. These users have higher possibility of 'trialability' (Rogers, 1995) and thereby adoption of mobile applications. However, the University provides WIFI connectivity in all establishments. WIFI connection is available in most of the places where they study, work or spend leisure (i.e. home, project room, library, and canteen). Data package, 'pay as you go' and subscription users can use WIFI connection in all these places. In order to introduce a new mobile application, it is good to consider WIFI connections which can cover more users and bigger bandwidth. Figure 6 shows that half of respondents have installed extra application(s) in their mobile devices and some more are potential mobile application users. Therefore, 63.3% are prospective users of mobile applications.

	%
Download by themselves	45.18
Downloaded with the help of friends	1.66
Downloaded with the help of technicians	0.33
Not yet, but it is possible	16.28
No, it is not possible	29.24
Not sure	7.31
Total	100.00

Figure 6. Installation of mobile applications

An open-ended question on listing use of web tools which were not mentioned in the questionnaire and the University provided are: Refworks (a reference management tool), Agenda.aau.dk, and studentersamfundet.aau.dk. Tools which are self acquired and were used for collaboration or other academic activities are: Google scholar, Google wave, Google book, ResearchGate, Gliffy, Blogspot, Fronter, Mendeley, and Springpad.

The results relating to location of group working, location of working alone, knowledge of tools, owning mobile devices, and mobile application self-installation can tell us about students' needs and potential for group work facilitation tools. They work at different locations mainly project rooms for Medicine, Science and Engineering students and at home for Humanities students. From the number owning mobile devices (smartphones and tablets), there is potential to promote students to use Web 2.0 tools for their collaboration. The tools should be accessible from both mobile and non-mobile devices. Mobile devices can provide more functionality.

Students' Narratives

There were 133 student narratives from 51 males and 82 females. The reflections were analyzed using model of *Stages in the Innovation-Decision Process of Rogers* (Rogers 1995, p.163) by reading the narratives and identifying their reflection to understand their level of adoption of each tool. Following is the brief analysis of the narratives.

- *Moodle*. The institution provides Moodle service for communication, and sharing course materials between teachers and students. There were 127 students wrote about the use of Moodle and most of students like Moodle.
- *Mahara*. The institution provides the Mahara service for students and teachers and expected it to be used as a social network and to support group work. 128 students wrote about the Mahara service. Most of students have a *bad impression* of the Mahara service. They thought it was too complicated and most of them have already used Facebook as a social network so they did not find any need for the Mahara services.
- *Dropbox*. The students were introduced to Dropbox to share files. It is quite successful. Most of students wrote about using Dropbox and almost everyone liked it especially user-friendly aspects. There was a person did not like it because his group wanted a tool which allows editing documents simultaneously so they preferred to use Google docs.
- *Facebook*. There were 115 students who wrote about using Facebook and almost everyone liked it. There was a person did not like Facebook because he was afraid of losing his privacy, but he prefers to use Skype which is not opened to unknown persons.
- *Skype*. There were 51 wrote about using Skype for their project work. Most of students like it and others know about it but do not use it.
- *Google services* (includes Google docs, Google wave, Google Calendar, and Google group). There were 94 replies about using Google services and most of students like Google but there are 2 students who dislike Google because did not see any use for it in project work.

They adopt Moodle but not Mahara (too advanced and complicated); they adopt Dropbox but not Zotero, Diigo, Etherpad; they adopt Facebook and Skype, and Google services. It appears that introducing tools with a presentation does not significantly encourage and enable trial and adoption of tools. Rather, there has to be a continuous facilitation for encouraging use of tools for different activities. There were contradicting comments about use of some tools by students working in different groups. Regarding University-provided services students had a greater volume of comments and criticisms on the expected improvements.

Observation and Focus Group Interview

These methods help gaining an insider viewpoint in doing a project. This section describes the process of group work rather than the support availed from the ICTs. Every semester students at Aalborg University have to do projects in groups.

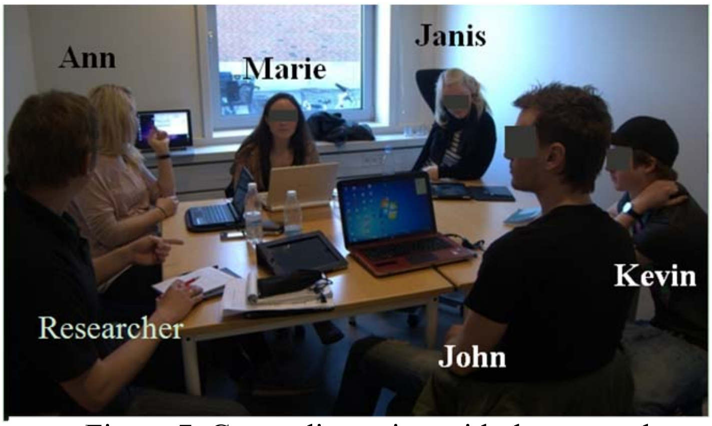

Figure 7. Group discussion with the researcher

When the researchers came to observe them the group was discussing about theories on the project. The room that they used as the project room was not fixed; they had to book project rooms every week. The group members were Ann, Marie, Janis, John and, Kevin (nick names). They have separate roles in the group as an organization. Kevin had been elected to be the group leader who makes final decision. Marie was a secretary for the group who took notes and kept track of every discussion. Ann was the most active member in the group, she maintained the schedule and agenda of meetings. Janis and John did not have any specific task but helped everyone. Female members stayed in a city which takes 45 minutes by train to Aalborg University and two male members live in Aalborg. Because of distance and commuting time, they cannot meet everyone at the University every time; they managed to work with subgroups and as individuals. Sometimes they worked at home and communicated through Skype and put commitments on Facebook and shared meeting files in Dropbox. Kevin seems to be active for tool adoption (a technology agent); he had tried Zotero and wanted to use for this semester project. However, the group did not use Zotero as part of reference management or for the report writing. They created a closed-group in Facebook and they discussed through Facebook. Many topics were discussed on Facebook, for example, theories used in analysis, meeting time, meeting with supervisor, task assignment etc. It was also observed that Facebook was used for discussion all along the project life. However, they did not use group work facilities which Facebook provides; for example, group chatting, document creation and event creation. Skype was used when they have both scenarios: working alone and subgroup activities.

From the observation, the group implemented technology to support distance collaboration. They implemented technologies which they are already familiar with.

However, they use only basic functions even though the tools have the potential to enhance project collaboration. Dropbox is the only new technology that they adopted which was introduced by social contacts (classmates) and the institution (ELSA). In fact, they had been introduced to several tools which are both institution-provided (e.g. Mahara service) and free access services (e.g. Zotero, Diigo, EverNote, and Etherpad) but they did not adopt these tools.

Summary and scope of future work

The research methods found that the use of ICT by the students, including web applications, mobile devices and the Internet connectivity, is not sufficiently advanced to claim their ability to efficiently adopt or explore it to facilitate academic or professional activities. The result shows that students who are claimed as digital natives still have problems with implementing digital tools into their professional life. Thus they can be made efficient by appropriate facilitation. Compared with access to resources, significantly fewer web tools are known to students. Apart from facilitation for learning by the supervisor, a separate facilitation for technology adoption appears to be important. In order to facilitate student work group, it is necessary to discuss about whether institutions should provide software with full functionalities to support the group work or let students use tools which are available on software market and the institutions will take roles of a facilitator instead of a provider. We can see a significant number of students who already have experience of using tools for learning using the internet on a mobile. They have the potential to adopt mobile technology for their project collaboration.

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IS WIKI ANXIETY A BARRIER TO PARTICIPATION IN PBL FOR THOSE NEW TO ONLINE LEARNING?

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ABSTRACT

The aim of this study was to examine perceptions of an undergraduate module delivered using online PBL in a cohort of students new to both modes of learning. The impact of PBL was examined using a single module approach whereby one problem scenario as the central component of the module. A team wiki was used to facilitate the learning process. Focus group interviews revealed that students believed online PBL was vocationally relevant and enabled them to engage in student centred learning. However, there were barriers to participation in online PBL. In particular, anxiety regarding wiki use including reticence to post comments for fear of negative peer judgement. Students were also critical of students who 'lurked' during PBL activities despite the potential benefit lurking may have. These results indicate that online PBL can enhance the student experience but, on initial presentation, may need to be implemented carefully to avoid student anxiety and ensure active participation in online tasks.

INTRODUCTION

Problem-based learning (PBL) has long been used within the context of medical education as a means to foster motivation, encourage student interaction and independent learning (Willis, et al., 2002; Camp, 1996). More recently, there has been an increase in the use of problem-based learning within teaching in Higher Education (HE) in a range of subject areas in general and sport and exercise science specifically (Duncan, & Al-Nakeeb, 2006). A PBL approach has several advantages compared to other teaching methods. This is possibly due to the ability to build on previous knowledge, immediate application of knowledge to construct problem solutions and a team based learning environment that facilitates student learning (Camp, 1996). PBL is also consistent with current philosophical views on student learning in HE and, in particular, constructivism (Savin-Baden and Howell-Major, 2004).

There has also been an increase in the process and nature of interactive media over recent years which has led to media based forms of PBL being employed in various contexts within higher education (Savin-Baden, 2007; Gijbels et al, 2006) and while terms such as 'computer-mediated PBL' and 'online PBL' are starting to feature in pedagogic literature there is a lack of clarity in relation to the extent that the teaching and learning activities are 'online', the ways in which students interact online and the nature and experience of students engaging in this form of learning (Savin-Baden, 2007). Online PBL has therefore been used in a generic sense to describe a variety of ways that students use PBL synchronously, asynchronously, on campus or at a distance (Savin-Baden, 2007).

Various authors have employed online PBL across a range of subject areas and using different approaches. For instance, Luck and Norton (2004) used online PBL in a distance learning course where students engaged in 5 problem scenarios over 12 weeks through asynchronous discussion board use. Other studies by Lee (2006) and Lycke et al. (2006) have employed online PBL effectively in distance learning courses. Despite, this work by Gijbles et al (2006) has suggested that presenting students with new learning environments, such as that encountered in online learning, can pose particular challenges to constructivist learning.

To date a variety of vehicles have been used to facilitate online PBL, these have included chatrooms, discussion boards and Web 2.0 content with most of the current research relating to this topic has used institutional virtual learning environments (VLEs) as the main point of contact for students undertaking this form of learning. Web 2.0 technology comprises a range of interactive tools such as blogs, wikis and virtual environments that provide an opportunity for both students and academic staff to become their own content or knowledge producers (Savin-Baden, 2007). This technology can engage individuals in learning which reflects social networking, allows learners to construct their own knowledge of a topic or issue whilst also receiving feedback, support and building new knowledge based on virtual social interaction with their peers.

One specific form of Web 2.0 technology that has been identified as a tool that may be particularly useful in enhancing student learning (Parker and Chao, 2007) is a wiki. A wiki is web-based tool that can be used to engage students in learning with others in a collaborative working environment. It is particularly applicable to PBL and constructivist paradigms as it involves learners in construction of their own learning (Boulos et al., 2006), engages students in interactions and exploration of learning material and enables integration of new ideas with prior knowledge to make meaning (Parker and Chao, 2007). Although the wiki was introduced more than 10 years ago, its use in teaching and learning is in its infancy (Chao 2007). Despite this, wiki use in HE is increasing but there is still a need to explore the value of this mode of learning in enhancing the student's experience of HE. Some studies have explored the usefulness of wikis in icebreakers, online learning aids to share information (Augar et al., 2004) and even as a way to construct an online textbook (Evans 2006). Parker and Chao (2007) have commented that social software such as wikis and blogs may provide students with skills for the future but, there is a need for research examining the use of wikis as teaching and learning tools in order to explore what works well and what works badly. The aim of this paper is to explore the student experience of wiki based, online PBL with a group of learners new to PBL.

Method

The impact of PBL on students' learning experience was examined using a single module blended approach (Savin-Baden, 2007) on a year 2 undergraduate module titled 'Exercise and Health' within the institution's BSc Sport and Exercise Science course. This ran both on campus and at a distance and was congruent with guidelines for single module blended online PBL (Savin-Baden, 2007). The module was designed using the model suggested by Boud (1985) and employed one problem scenario as the central component of the module. A team wiki (comprising 6 students, 7 wiki teams in total), was used to facilitate the learning process with face to face lectures and seminars used to feed in and around the PBL activity at an appropriate time.

The problem scenario began with delivery of a formal letter from the city council inviting teams to submit a tender presentation to run a 'health-enhancing intervention' in the city's main shopping centre. The letter also identified the date for presentation of the bids, the time allocated for presentation (10 mins) and highlighted that the city council were interested in evidence based practice. This essentially provided a case related to a business/organisational problem. The problem scenario was also matched to the actual current activities of the council in question, so sought to explicitly match the university learning environment with actual practice specific to the students' degree course. In this way, we tried to incorporate different constellations of PBL online within the one scenario and in particular PBL for practical capability and PBL for critical understanding (See Savin-Baden, 2007 for a full outline of PBL constellations). The assessment task therefore explicitly linked the module learning outcomes to a real scenario. In this way, the author hoped to provide a mroe effective stimulas for developing vocationally related understanding and skills as well as providing a scenario with which the students would be superfically familiar with due to their connections with the environment in which the scenario was based.

Module Structure

In accordance with suggestions for running online PBL and, as the students were new to both PBL and online learning the first two sessions of the module were constructed as warm-up activities (Savin-Baden, 2007). The first session of the module comprised a module introduction and the onset of the warm-up activity. In this session students were shown the wiki spaces they would be using throughout the module, were given time to 'play' with the wiki while the tutor was available to assist in any technical issues that arose. At the end of this session students were split into teams of 6 students and allocated a team wiki space. The wiki team was allocated arbitrarily from class registers. They were then allocated a short warm-up task centred on inequalities in health estimated to take approx 60mins of online time. During the third session, students were presented with the main problem scenario described above. They were then left to investigate the problem in their wiki groups for the following 6 weeks of the module. During this time several lecture type face-to-face sessions were scheduled which comprised lectures and seminars focusing on the following issues: Coronary Heart Disease and Exercise, The Metabolic Syndrome, Obesity, and the Environment and Physical Activity. This was student led in that students could decide which topic they wanted to discuss at which point in the module and although the topics were relevant to the module title, care was taken to ensure any information presented by the tutors was not explicitly related or linked to the problem scenario they were working on. Throughout this period students worked via their wikis collaboratively. The tutor facilitated the online PBL by listening and lurking positively and by providing supportive, non-leading interventions as suggested by Savin-

Baden (2007). The final session of the module comprised formal presentations of each team's tender bid.

Assessment Tasks

The assessment task used in the module adhered to guidelines for the assessment of PBL (Macdonald and Savin-Baden, 2003). As a result, the final tender bid presentations were used as the assessment task for the module. Thus, the assessment was based in a practice context (i.e., it replicated a real scenario taken from the workplace), assessed process based activity (i.e., it focused on what procedures could be employed in the context of the scenario) and it necessitated working with people in a way similar to that they would experience in the workplace. The objectives, learning outcomes and teaching methods were aligned accordingly. Marking criteria were presented to the students at the beginning of the module and, in accordance with the suggestions of previous authors (Savin-Baden and Howell-Major, 2004) in respect to traditional PBL. Likewise, the presentation did not simply assess the student's ability to provide knowledge but rather assessed the students application of evidence, the ability to reflect on problem solutions and their ability to evaluate the way in which they came to their solution with emphasis on the specific context in which their problem was set.

Evaluation on Online PBL

In order to examine the student's experience of the module focus group interviews were conducted in groups of 6 students (i.e. in their wiki teams) at the end of the module. Focus group interviews were chosen as they provide a more naturalistic data collection method compared to interviews or questionnaires (Wilkinson, 2004). They also allow respondents to build upon the responses of other group members and the relatively free flow of talk can provide an excellent opportunity for hearing the language and experiences of the respondents' (Wilkinson, 2004). The students taking this module were also asked to complete a short, reflective questionnaire as part of end of module review. Data from the focus group interviews was analysed using thematic analysis following guidelines recently proposed by Braun and Clarke (2006) and, in this way, sought to describe patterns within the module (Braun, & Clarke, 2006).

Results

The results from the focus group interviews revealed a number of themes within the student experience of PBL. Consistent across all focus groups were engagement with a more student-centred approach to learning, relevance of the learning experience to future employment, issues surrounding collaborative learning and wiki use/wiki anxiety. In this context wiki anxiety was conceptualised as experience of negative emotions in relaiton to wiki use (Cowan and Jack, 2010).

In regard to the theme of a more student centred approach to learning, the students felt that the use of wiki based PBL within the module allowed them greater autonomy, enabled them to engage with a wider range of literature, develop greater engagement in the learning process in comparison to traditional lecture-led teaching. For example, students reported the following:

> *'It puts the onus on us, like we are in charge so you end probably end up looking through more stuff, reading more, chatting more either on the wiki or to people directly than with normal lectures but because of how its done I felt I could push the topic in the direction I wanted so it was almost, like always at my level and that was the best thing about it all, l decided what I wanted to learn'* (Student D)

This was then followed by the comment:

> *'It was good that we could modify when we got specific sessions from the tutor though, that made me feel like I could control what and when I got the information I needed, that was good'* (Student E)

And in regard to engaging with a wider range of literature and becoming more engaged in the learning process the student experience in probably best summed up by the following two quotes from students:

> *'With this type of thing, you know, you had to go out and think of an idea, actually go out and look for something and then if there was no research on what you had decided to base your idea on you had to go back and relook at it, I suppose I ended up doing more work in this module than in some of the others I am taking but then I feel like I have learnt more here, I get what you and the other lecturers mean now when they go*

on about evidence based practice because I think this is what we were doing really' (Student A)

In respect to relevance to future employment, the students consistently commented that the PBL task had clear application and use in terms of careers after they had completed their university course. For example, student L reported:

> '*I liked the task you have to think outside of this academic university box a little bit so it was like a real world task you could see that people in the city council or primary care trust would be doing the same kind of thing so that was ace, it made it realistic and put a background story into the work we were doing so it felt like it was important to do it properly'*

The results from the focus group interviews also raised several issues related to collaborative learning. This was the first time these students had used a wiki and was also the first time they had experienced PBL. This appears to have created some issues whilst also prompting some positive aspects to this experience. In terms of the positive aspects that students raised about wiki based online PBL, the students seemed to think that using the wiki for collaborative learning was useful for sharing of information, speeding up the process of information acquisition and for reflection/idea generation. To illustrate this, student L stated the following:

> '*I agree its good for that cos its not like we all think the same way so you get to see different people's perspectives on things and that's useful cos you might be sitting there reading comments or about to add a comment and then you read something and go oh that's interesting I never thought of that and then you go away or think for a minute and it maybe changes what you were going to add or write'*

Likewise, student E commented:

> *'I think it was really clever, you know set around where we all know but it was difficult cos the Westfield [The Shopping Centre in the PBL Scenario] its so different in terms of size, floor spaces and with a clean slate to start from it made me work hard at first to generate something sensible that could be backed up, but then once I had the idea I had to find research to back it up and that ended up being the best thing for me, people on*

the wiki ended up doing the literature review but for me, I could discuss ideas on it but I also got to ask people about research papers and they helped with my literature search'

Although these comments appear positive, there were also some barriers to the use of the wiki for PBL. These tended to centre around students being disgruntled at members of the group who did not contribute greatly, students who were more lurkers than contributors and suggestions that ownership of what was put up on the wiki was also important. To illustrate this, one student suggested:

'W*hat really annoyed me as well was not the people who just tried to avoid the wiki but the people who just logged on and looked at what we were adding, its like voyeurism for a degree'* (Student A)

Some students also suggested that the actual wiki contribution should form part of the assessment rather than simply the presentation which was the central element of the PBL scenario. One student was particularly strident in their view on this and stated:

'*Yeah make the wiki assessed not just the presentation if you gave people a grade for what they put down they would have to contribute instead of just looking at other peoples stuff then stealing it and making out that it was their idea too'* (Student L)

This was also echoed by a number of other students in various focus groups and although these comments broadly relate to the concept of collaborative learning they might also overlap with comments made around the concept of wiki use and wiki anxiety. Issues surrounding this were a particularly strong theme across all the focus group interviews. This is understandable as the students were new to wiki based PBL. Overall, the wiki was received well and students commented about positive aspects of its use. For example:

'It was like a maths exam paper, you know where you have a paper with your maths answers then a paper where you can do your workings out, the wiki is like the working out paper, you can try things, see if they work and then the presentation is like your final maths answer' (Student G)

One student also suggested that the wiki enabled more equitable group work. They commented:

'Its harder for people to dominate this too with a group meeting or face to face session you always get one or two people who want to tell everyone else what to do. With the wiki its easier for everyone's voices to be heard so you can state your position and no one can interrupt until its on the screen' (Student H)

Despite these positive comments, students did outline a number of issues broadly relating to anxiety about the evaluation of others based on what is posted on the wiki. This seemed particularly pertinent to initial usage of the wiki. The following comments from one of the focus group interviews illustrates this issue well:

'It was like I don't want to put the first bit of information on in case everyone else slates it' (Student C)

This was followed by student D who noted:

'That was the worst bit you put something up and then you know other people might like make a judgement about you based on what's up there because they can see who added the comment so you don't want people to think you are thick'

This was supported by a further comment from student K who reported:

'But you know some people might have found it hard to do, personally it was a bit foreign to me, I hadn't really used a wiki and didn't even know what one was. I don't think this type of distance learning has been used in our modules before and it took me a while to, not get the courage to contribute but, you know because its up there and the other members of the group will judge it'

Discussion

Overall, the experience of wiki based online PBL appears to be positive with students reporting that online PBL offered a different learning experience compared to traditional, lecture led teaching. In particular, wiki based PBL appears to have offered a more student driven approach to learning that better facilitated skills such as information retrieval, development of an evidence based stance and collaborative learning strategies that could also be used in other areas of study. These findings are consistent with research from other studies on the impact of traditional PBL (Palmer, 2003; Duncan, & Al-Nakeeb, 2006) as well as online PBL (Lee, 2006; Lycke et al., 2006)**.** It is also interesting that all the focus groups of students highlighted the move to a student centred form of learning as an important aspect of PBL. For the most part his was seen as a positive feature of their learning experience in the module, students seemed to enjoy this level of autonomy and the challenge of wiki based PBL, and greater enthusiasm for the subject was evident. However, for some students more attention was focused on the assessment of the module, gaining a good grade or passing the module compared to their peers. Although there seemed to be an acknowledgement that online PBL required them to engage more with the subject content, there seemed to be resistance to this with some students expressing a preference for lecture-led delivery as it provided them with the information that the tutors or markers expected back from them in any assessment task. Such observations are consistent with suggestions made by Gijbels et al (2006) when student perceptions are examined after moving from a didactic to constructivist learning environment. This is an important consideration within the implementation of online PBL. The current study was trialled with a group of Year 2 undergraduate students who had no previous experience with PBL or online delivery of module content (other than powerpoint slides being posted on their VLE). It may be that by the second year of an undergraduate degree, students are more assessment driven, more likely to have picked up ‘bad habits’ and have developed a surface approach to learning.

Students also seemed to develop a sense of ownership of the information they posted on their wiki and seemed happy to support other contributors to the wiki but were more negative regarding students who remained as lurkers or when they felt their contribution would be used by students without reciprocal information being passed back to the rest of the group. This is clearly an important issue for practitioners when employing this form of learning and anecdotally, was challenging for the tutors to manage in some instances. The feelings expressed by students in this case are not uncommon for collaborative learning in general (Lea, 2001) and online based learning activities in particular (Savin-Baden, 2007). Future scrutiny of online team dynamics might be interesting in terms of elucidating the underlying issues here to a greater degree. Moreover, the allocation of students to wiki teams arbitrarily from class registers may have resulted in imbalanced groups in terms of competencies and skills. This means of allocation was taken to ensure a spread of academic abilities across all wiki teams but may have resulted in skewed wiki groups in relation to experiences and skills. Future research may therefore benefit from more structured and balanced determination of wiki teams prior to beginning online, wiki-based PBL.

Conclusion

The use of wiki-based PBL, as opposed to traditional PBL, appears to have offered a number of advantages and challenges in the student experience. The students acknowledged that inclusion of an online element to the module added flexibility to their learning, allowed more effective collaborative learning and that the content posted on the wiki aided their learning. The comment made where online PBL was compared to a maths exam paper with an answer and a working out section appears to be particularly pertinent, with students using the wiki to test out their understanding, make suggestions, 'brainstorm' and reflect based on each others comments without it influencing their actual assessment. This possibly provides a way for practitioners to scaffold the learning process in a way that offers students freedom to think and construct their own understanding. This comment is certainly indicative of claims previously made about the effectiveness of wikis in student learning (Vigentini, 2008).

Although the inclusion of wiki-based PBL appears to have been positive, there were some significant barriers to learning centred around the concept of wiki anxiety. A number of students reported concerns or reticence to post initial comments on the wiki for fear of being judged in a negative way by the peer in their teams. In some ways this is not surprising as wiki use was a new experience for all concerned and this form of initial wiki anxiety has been reported previously (Vigentini, 2008). This is an important consideration for tutors who may be thinking of including wiki-based PBL in their teaching and is worthy of future scrutiny with those new to wiki based learning.

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INTELLIGENT TUTORING SYSTEMS: HOW WELL CAN THEY GUIDE STUDENTS IN PROBLEM-BASED LEARNING SCENARIOS?

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ABSTRACT

Problem-based learning (PBL) has a strong focus on skills and requires students to use self-regulated learning (SRL). However, SRL puts considerable demands on learners and often leads to students making frequent requests for guidance.

This paper reports the outline design, construction and evaluation of a simple prototype web-based Intelligent Tutoring System (ITS) which was constructed to provide guidance for self-regulated learning activities in a PBL scenario. It was constructed using Chatbot technology which provides extended dialogue with students in order to guide them through the initial stages of developing learning objectives. User testing with undergraduates suggests that the system prompted them to analyse the scenario in more detail (one of the foundational skills needed in a PBL task) and that the technology can be both usable and provide the adaptability required.

INTRODUCTION

PBL is a learning system that has a strong focus on helping students acquire relevant learning skills rather than just knowledge, and one of its aims is to develop Self-Directed Learning (SDL) skills (Barrows and Tamblyn 1980; Norman and Schmidt 1992). There are many variations of PBL but typically it will involve presenting students with an ill-structured and authentic problem, to which there are no simple solutions or answers. Students work in groups on the problem with the tutor acting as a facilitator. The process requires students to understand and analyse a scenario, identify personal / group learning objectives, locate suitable learning resources, monitor their learning and evaluate and reflect on their achievement at the end of a scenario. These skills correspond exactly with self-regulatory processes that are components of Zimmerman's (2000) model of Self-Regulated Learning (SRL). Furthermore, motivational beliefs, such as self-efficacy, task value and goal-orientation that are part of the model are also important for success within PBL.

While it is widely accepted in the pedagogical literature that the most effective learners are self-regulating (Butler & Winne, 1995; Zimmerman, 2000), SRL puts considerable demands on learners (Loyens *et al,* 2008) and managing the uncertainty in this process often leads to students making frequent requests for guidance and may lead to a high cognitive load which can result in anxiety and frustration (Dyck, 1986). Furthermore, the first author's experience as a facilitator suggests that students have difficulty in constructing well-formed learning objectives in PBL as well as in selecting appropriate resources.

PBL facilitators can provide guidance that is appropriate to a particular student team's needs, but there are two major challenges: firstly the demands on a facilitator can be very high if they are simultaneously dealing with several teams and secondly, students can require individual guidance during the independent research phase of PBL. In order to address these issues, this project sought to explore if a web-based application (known as a PBL coach) based on conversational agent (Chatbot) technology could be constructed to provide effective guidance to students.

The next section of this paper discusses the guidance required by students in PBL, and then explores how a type of conversational agent could provide guidance. The outline design of a prototype system is described followed by an initial evaluation of its usability and usefulness by undergraduate students.

PBL guidance requirements

The requirement for guidance that has been identified as an issue by the first author in his PBL classes is also supported by studies by Lloyd-Jones and Hak (2004) which reported that students experienced uncertainty with respect to what to learn and that they relied on their peers and given faculty resources instead of selecting resources independently. Kivela and Kivela (2005) also showed that inexperienced PBL students still sought the teacher's approval to be sure they were on the right track and to overcome their uncertainty in their new learning environment. Kuhlthau's (1988) study of high school and college students involved in research assignments noted that the stage of prefocus exploration is often the one which generates the highest level of anxiety. In PBL terms this corresponds to goal setting and identification of learning issues where the formulation of learning objectives and evaluating the research to ensure it is fit for purpose is problematic (Uden & Beaumont, 2006). Studies analysed by Loyens et al (2008) highlighted that the self-generation of learning objectives is crucial for students' learning process (Verkoeijen et al. 2006) and that self-monitoring showed a significant correlation with performance.

Newman's (2008) analysis of help-seeking behaviour identified *adaptive* help-seeking – an indicator of cognitive, social and emotional maturity which is indicated by consideration of the necessity, content and target of the request. He further suggests that affective factors such as self-esteem and self-efficacy are important by enabling them to persist in the face of factors that can undermine help-seeking (eg ridicule from peers). In contrast, examples of non-adaptive help-seeking are *dependent help-seekers* –asking unnecessary questions before attempting the task or seeking help to complete all tasks as quickly as possible rather than to improve learning. Help-avoidance (when help is necessary) is another form of non-adaptive behaviour. In a study by Ryan et al (2005), help avoiders and dependent help-seekers had low learning goals, high performance-avoidance goals (not looking stupid), low perceived competence and experienced high anxiety in class. Newman (2008) suggests strategies for combating these non-adaptive behaviours such as teacher involvement with students to provide a supportive environment; supporting autonomy and stressing learning goals rather than grades while understanding personal learning goals and finally support for competence through modelling questions, scaffolding knowledge construction through use of hints rather than direct answers.

Whilst these studies indicate the areas in which guidance is required, additional detail was needed in order to determine specific requirements for the PBL coach; the authors therefore identified patterns in the type of guidance required in a multi-staged (11-week) PBL scenario which would subsequently be used as the test case for the PBL coach. This study analysed individual on-line dialogue in scheduled weekly 20-40 minute sessions in a small sample of students (n=19). Whilst some students actively sought guidance, the number of questions asked varied from (a rather depressing) 0.5 to 9 questions per session.

Guidance required, gathered from normative suggestions of students and objective claims from the analysis of the data were categorised most usefully as:

- *Task-guidance* (clarification, planning, analysing, deadlines, deliverables, monitoring, evaluating fitness for purpose of research and assessment);
- *Scenario guidance* (clarification and requests for further information);
- *Learning resources*; (how and where to find information)
- *Group-work* (roles, dealing with issues) and
- *Subject-guidance* (understanding, elaboration, application).

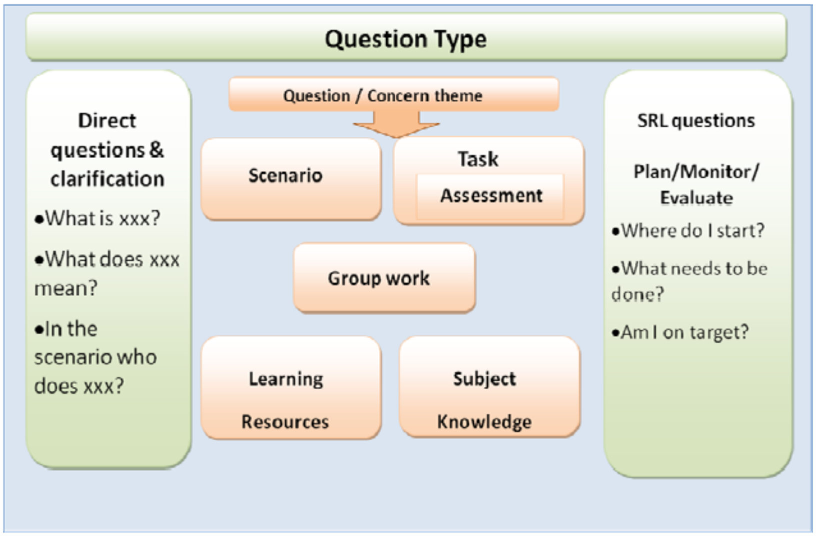

Figure 1 Detailed guidance requirements in a PBL scenario

Reassurance and motivation were also frequently reported as essential aspects of guidance required. Furthermore, students expected to be able to find out grades and obtain further information regarding assessment feedback. The most common concerns/questions expressed related to the task and assessment and subject knowledge (79%), closely followed by groupwork concerns (74%) with learning resource concerns (37%) and scenario clarification (32%) being less prevalent. Figure 1 also shows that questions can further be classified as those that relate to planning, monitoring and evaluation (SRL) or simpler, more direct clarifications.

Intelligent tutoring systems and pedagogical agents

The PBL coach needs to provide responses to natural language input from learners and which is adapted and personalised for their needs. This requirement suggested that an Intelligent Tutoring System (ITS) would be appropriate technology. Such systems have a long history (Evens & Michael 2006) and more recently the technology has been adapted for the development of web-based pedagogical agents (Kim & Baylor, 2005). Typically, ITS and pedagogical agents are complex, take many years to construct and are highly specialised with a focus on teaching *subject-specific* content. A typical ITS comprises a number of components: a learner model to represent a learner's knowledge and which is updated as the learner progresses; a pedagogical strategy to determine how to respond and interact with the learner; an inferential technique for reasoning; a subject knowledge base, and an interface which enables mixed initiative dialogue.

Now given the alignment of PBL with social constructivist principles, and the benefits of prolonged and focussed dialogue (Alexander, 2006), pedagogical agent technology appears suitable for providing support of PBL learners, particularly in the development of SRL skills. Developing an ITS from scratch is a huge undertaking, particularly if natural language input is being processed. However, technology is now available that can reduce the time to build simple systems by providing a framework for input and recognition of natural language text and selecting suitable responses. Chatbots are systems that provide natural-language conversation with users and have been used in education, commerce, and the public sector (Kerly *et al*., 2006) often with an avatar to provide an impression of a persona. Lingubot™ is one such commercially available technology which uses pattern-matching on input words and phrases to identify rules which match the input, and then executes the highest priority rule. This provides a ready-made framework for constructing a simple ITS: The pedagogical strategy and knowledge are coded into the rules, the chatbot can also store and retrieve information from a database, which together with a scripting language can provide both flexibility and persistence of data suitable for adapting responses and storing learner model data.

The design of a prototype PBL coach

Students' guidance requirements, as described earlier, were used to inform the design of a prototype coach which was constructed using the Lingubot Chatbot and is intended to provide guidance to learners in the initial stages of PBL; namely analysing the scenario and identifying suitable learning goals. The coach can operate in one of two modes: a 'quick consultation' and a 'full consultation'.

In a quick consultation the coach provides answers to students' questions (including a set of FAQ's). These questions were derived from the primary study of students' concerns, for example: 'What should I do next?'; 'When is XXX due?' relating to clarification of the task and scenario and some help on monitoring progress.

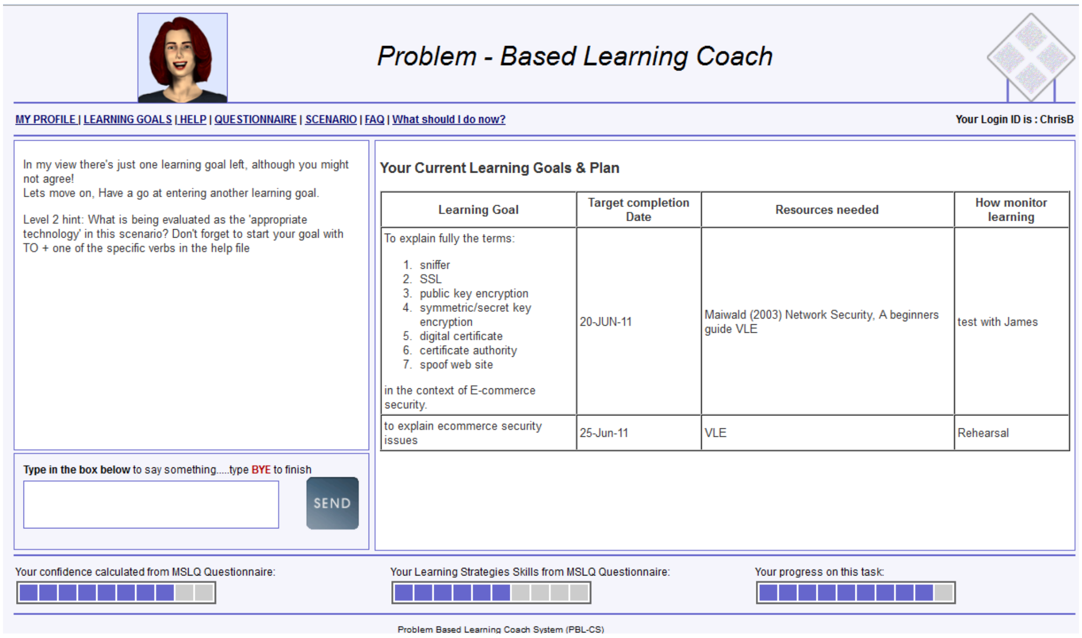

Figure 2: PBL Coach Interface, showing example dialogue and learning goal.

In the 'full consultation' mode the coach takes a more proactive approach by guiding students through the analysis of the scenario and prompting them to plan the structure of a report and create well-formed learning objectives. Well-formed objectives are defined as those which are specific enough to be achievable, and include the outcome, context and criterion for achievement. The coach also prompts students to identify the learning resources used to achieve the objective, set a completion date and state how they will monitor the completion of the objective. Learning objectives and progress are stored in the learner model, and can be retrieved and printed by the student.

Given the pedagogical imperative of an emphasis on SRL, the system has also been designed to incorporate a self-report measure of SRL: an abbreviated form (42 questions) of the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich *et al*., 1991) together with a help file to provide guidance on learning strategies and writing well-formed learning objectives. Students can view and explore their profile produced from their questionnaire results. In the study reported here, the self-efficacy and control of learning beliefs measures are used to predict a confidence value which is used to determine the level of guidance provided (higher confidence, less specific guidance). We hope to use these data, together with analysis of transcripts to refine the pedagogic strategy of the dialogue in our future development of the PBL coach.

As is common in an ITS, the coach provides hints to assist students. The coach currently provides 3 levels of hint, with higher levels of guidance providing more detail. The level given depends on the students' initial stated confidence, and can dynamically adapt depending on the quality of a student's answers throughout the dialogue. This aspect of adaptation was considered to be one of the most important design features in order to customise the guidance to students' individual needs.

PBL Coach Implementation

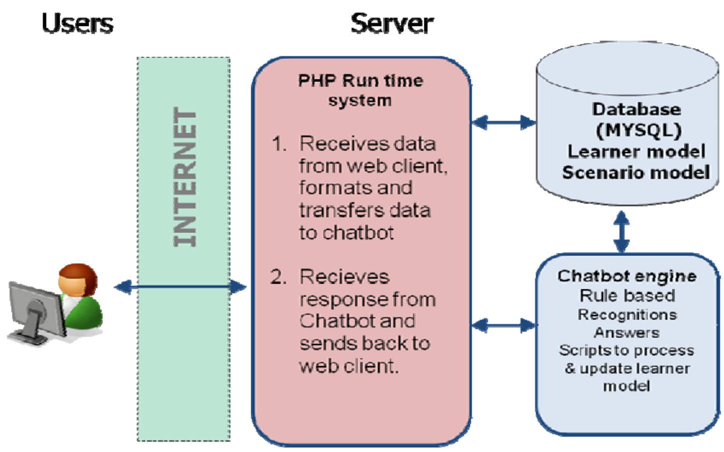

Figure 3: Block diagram of PBL coach structure.

The basic architecture of the system is shown in figure 3. Student users login through a web-page and their learner model, together with scenario information is stored in a database. The interface (fig 2) is provided by PHP scripts which communicate with the database and the chatbot engine. The chatbot incorporates over 1350 production rules which recognise the natural language input and trigger appropriate responses and update the learner model. The rules also cater for 'smalltalk' and 'safety nets' to deal with off-task or unrecognised input. The interface comprises a dialogue area for chatbot conversational output, together with a larger display area for situations where more persistent or larger volumes of data are required (e.g. learning goals or a list of FAQs). Students' progress and their skills/ confidence summary are shown in progress bars. The avatar image changes depending on the input, to represent different emotions (e.g. excited, neutral, unhappy).

Testing and evaluation

Testing of the usability and usefulness of the system has occurred iteratively over several months, as each test revealed shortcomings, particularly in the recognition of user input. Initial tests were carried out with an opportunity sample of second and final year (n=30) undergraduates using a PBL scenario based on Information Security. Data were collected from logs of the dialogue and post-test focus groups. A subsequent set of tests were also conducted which involved an in-depth individual evaluation of the coach by a purposive sample of first and third year undergraduates (based on academic achievement, n=8). These tests focussed on usability and usefulness of the PBL coach and employed observation, think-aloud protocol, questionnaire and interview and analysis of PBL coach logs.

Students in the initial tests were generally positive about the coach in terms of usability and usefulness for the task, but three key areas for improvement stood out: the need to cater for a much larger range of responses; the need to abbreviate the MSLQ from its original 81 questions (subsequently halved) and the tendency of some students to indulge in 'gaming' behaviour, i.e. they attempted to break the PBL coach by going off task and in some cases using offensive language (a recognised issue with this technology).

The in-depth testing of each individual student showed some overall consistent messages, but also a wide variation, revealing differing approaches to studying the task. For example, while most students considered that the volume of text was appropriated, two stated that there was 'too much text'. Some students read the entire help file, and followed every help link, whereas others preferred to try out a response before using any help. The PBL coach was able to conduct prolonged dialogue inputs (from 34 to 84 inputs over a period of 32 to 72 minutes) over where all participants were able to specify appropriate learning goals. Overall, students considered that the usability of the interface was good, with particular strengths being reported that it was clear what the student *should* do next, it helped students recover from mistakes, was intuitive, relevant to learning needs, consistent and easy to gain information needed to complete the task. The usefulness and adaptation of the hints to their level of confidence was cited as a positive feature and perhaps, most importantly, it helped them focus on the scenario and analyse it in detail.

The PBL coach was specifically designed to be encouraging and build confidence, and, students volunteered that it had a positive influence on how they felt, this small sample unanimously liked using it, using words such as "*useful*", "*helpfu*l", "*encouraging*" to describe it and all agreed that they would recommend it to others and stated that "*it felt good*" when they received positive feedback. Most students stated that it "*didn't make them feel bad if they got something wrong*".

There were, as mentioned above, a number of weaknesses cited by students, the most common being the inability of the coach to respond appropriately to all dialogue. At best there are minor issues which cause frustration, but at worst these can be confusing and impede learning, for example if the student entered something appropriate, which the coach rejected. While the coach cannot be programmed to recognise all input, it is possible to overcome this issue by providing a safety-net in which the coach explains it does not understand but asks the student if they wish to record the input.

A further issue cited with the current version was that students were not always clear what it was *possible* to do next. It would have been an improvement to be able to see the complete history of the dialogue, and on occasions "*go back*". One student with specific learning difficulties pointed out that he had short term memory issues and so this feature would be essential.

Conclusion

In this paper we have argued that self-regulation is an essential ability for success within Problem-based Learning and students, who are inexperienced in this type of learning approach, require scaffolding and guidance in order to develop effective SRL skills. In particular, task-related guidance, such as analysing the scenario, setting goals, planning, and monitoring learning were shown to be areas of high concern to the PBL students in our study. A coach was constructed to test the potential for using a conversational agent (chatbot) to provide the guidance. Key features that suggested that the chatbot was suitable were the use of extended natural language dialogue, shown to be important in learning (Alexander,2006) and adaptability to the student's input and level of confidence/ knowledge.

The chatbot technology helps reduce the time and skill needed to produce a pedagogical agent; basic rules for language recognition using keywords/ phrases are simple to create, though some programming skill is required to create the scripts that will orchestrate the dialogue. The system took the equivalent of about 3 month's full time work to build. Commercial chatbot systems typically take from 10-12 weeks to build, and 12 to 18 months to optimise (Elzware, 2011).

It is still early days for the development of this PBL coach; tests showed that there is much to do to improve the dialogue, in particular in the adaptive help system which provides hints and follow up questions. Such improvements can only be made through iterative user testing, and they also shed light on the variety of meanings that students infer from text. A particular surprise to the first author was the lack of attention that these students initially gave to reading a scenario, and the variation in level of understanding; students needed repeatedly detailed guidance from the coach to direct them to parts of the text in order to locate key terms, concepts and issues for their learning objectives. This is a finding which has implications far beyond that of PBL and relates to the increasing concerns that academics have about students' readiness (and indeed their ability) to read in depth (e.g. Coburn, 2008)

Despite these shortcomings, initial indications suggest that chatbot technology can be used to create a simple adaptive guidance system that engages students effectively to analyse a scenario and plan their learning objectives. In particular the tests from a small sample showed positive affective influence, and students self-reported that it helped them analyse the scenario:

> *"It made me think more.. not letting me miss anything out, ..making me find from the scenario what I need to put in"*
> *"cause it made me see which terms I didn't fully understand, ... I wouldn't have looked at those at the start."*

These are not comments we would expect from a surface or superficial approach, and suggest that the technology has the potential for significant learning benefits for students who are asked to take a problem-based learning approach to their studies. The next challenge is to measure the learning benefits.

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PBL APPLICATION FOR VIRTUAL COLLABORATIVE INTERACTION: A STRATEGY USING BLACKBOARD 9.1

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ABSTRACT

This study presents the comparison of three undergraduate Physics courses for engineering students. Course I and II both based their activities on a PBL scenario, course I using Blackboard collaborative tools, while course II used the model in conventional face-to-face work. Course III was traditional with lectures and individual study activities and set as a control group. The study compares students' learning gains based on Pre and Post-Tests, and describes the frequency use of Blackboard collaborative tools by students on course I. The preliminary results show no significant differences in the learning results of the three groups, suggesting that the outcomes of the PBL model might not be of a kind, possibly recorded by a standard test, but that their relevance relies more on promoting working skills, self-learning

abilities and collaborative skills. According to students' opinions, current LCMS collaborative tools are not motivating enough to promote student interaction.

I. INTRODUCTION

Problem Based Learning (PBL) is an educational strategy that promotes the development of the student's critical and creative thinking through carefully designed activities (Derby, 2011; Sola, 2005; Duch, 2004). The purpose of such activities is to encourage students to discover and process information in order to generate knowledge and give a sound answer to a realistic given problem or scenario (Blumenfeld, 1991; Bonwell, 1991). To solve a PBL scenario is usually a complex activity so it is necessary to develop it in small teams, in such a way that each team member participates collaboratively in an effective way (Koschmann, 1992). Thus, research work has to be organized in order to promote teamwork, which leads to collaborative learning. This enriches student knowledge as compared as when the student work alone (Johnson et al, 1991; Sola, 2005).

Collaborative learning techniques such as PBL are useful tools to achieve effective active learning. This process however, often comes with challenges both for the students to organize their teamwork, and for teachers to promote, monitor and ensure well-balanced collaboration among team students (Colazzo, 2009). On one hand, students do not easily find the appropriate space or time for face-to-face collaborative work and discussion, and the workload as well as the learning should be meaningful and as equitable as possible among group members. On the other hand, for teachers is not easy to follow student work face-to-face due to time and place limitations. Planning meetings between work teams and teachers for monitoring student progress on the project solution and giving them on-time feedback are necessary, but it is often difficult to organize this in the classroom and it is also very time-consuming. For students that do not easily find the appropriate space or time for face-to-face collaborative work and discussion, the use of virtual collaborative tools could be the key to success and achievement. In the same way, such a virtual collaborative tool would allow teachers to monitor student interaction and learning, and it also benefits the teacher in providing the students with adequate and opportune feedback whenever it is necessary. On the other hand, platforms such as Blackboard 9.1 (hereafter Bb9.1.1) could help to this end since it includes collaborative learning tools intended to promote and managing student teamwork.

Thus, in this work we discuss our experience of tracking work team for a PBL scenario using the collaborative tools provided by Bb9.1. In the next section we introduce a brief review of Virtual Collaborative Environments applied to active learning and address the collaborative features of Learning Content Management Systems (LCMS). We then include a proposal for a Virtual Collaborative Environment to work PBL scenarios. Next we describe the implementation of the Bb9.1 collaborative tools to monitor the application process of a PBL scenario for an undergraduate Physics course at Tecnológico de Monterrey, Mexico City Campus. Next we present our results in terms of student learning gains, and also include a study on students' participation frequency through Bb9.1. Finally, we discuss our results and outline guidelines for future work.

II. Virtual collaborative spaces for active learning

Computer-mediated collaborative distance learning (CMCDL) environments started to receive attention due to the development of the World Wide Web and the reported positive outcomes of collaborative learning studies in the classroom (Gokhale, 1995; Johnson & Johnson, 1994). One of the most common approaches to CMCDL is collaborative writing. Although the final product may be anything from a research paper, a PBL documents or a short story, the process of planning and writing together encourages students to express their ideas and develop a group understanding of the subject matter. Web 2.0 tools like blogs, interactive whiteboards, and custom spaces that combine free writing with communication tools can be used to share work, to develop new ideas, and to write synchronously (Onrubia, 2009; Larusson, 2009).

III. LCMS collaborative features

Learning Content Management Systems (LCMS) enable the creation, management and distribution of course-content through Web applications. Several LCMS manufacturers are integrating collaborative features with their tools to facilitate and promote group interaction for system users. Some representative works of these efforts are shown below.

Moodle has several features considered typical of an e-learning platform (Moodle, 2011). Moodle is a LMCS and can be used in many types of environments such as education, training, development, and business.

The Sakai software includes also many of the features common to LCMSs, as document distribution, grade book, discussion forums, live chat, assignments and online testing (Sakai, 2011). In addition to the course management features, Sakai is intended as a collaborative tool for research and group projects.

The Blackboard Learning System is a Web-based server software platform (Blackboard, 2011). Its features include: course management, a customizable open architecture, and a scalable design that allows integration with student information systems and authentication protocols. Its main purpose of is to add online elements to courses traditionally delivered face-to-face and to develop mainly online courses with few or none face-to-face meetings. Bb9.1 does this through the Discussion Board, E-mail, Groups, Assignment Manager, Lightweight Chat, Virtual Classroom, Blogs, Journals and Wikis.

IV. Proposal of a collaborative virtual environment to work PBL scenarios

As seen in the previous section Bb9.1 integrates new collaborative features. Due to the availability of access to Bb9.1 at Tecnológico de Monterrey, Campus Mexico City we decided to use it. There is no specific preference for Bb9.1 tool; we believe that the collaborative virtual environment can also be implemented in the LMCS mentioned above. Among the collaborative tools provided by Bb9.1, we considered as relevant the creation of groups, blogs, discussion boards, journals and wikis. Figure 1 presents a conceptual map that shows Bb9.1 collaborative tools, including those that were used in this project.

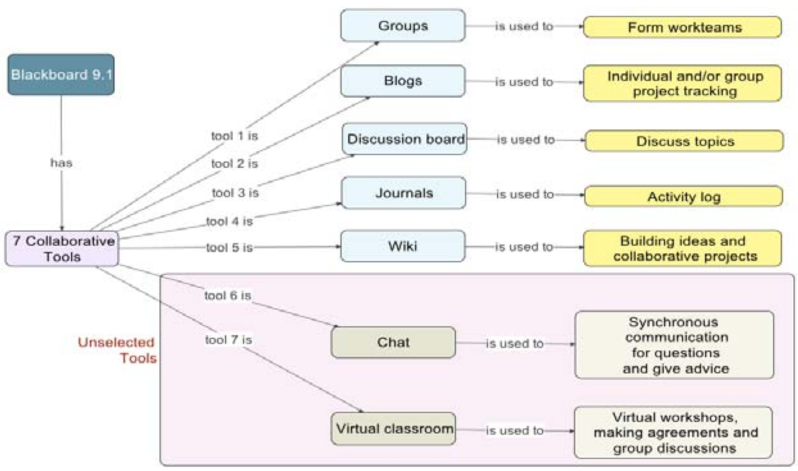

Figure 1. Blackboard 9.1 Collaborative Tools Conceptual Map

Within a class, groups usually consist of small formal teams of students. From a group page within Bb, students can e-mail, exchange files, open new discussion forums and collaboration sessions or participate in already existing ones. Tasks allow organizing activities and / or projects by priority. Each user can add their personal tasks. Blogs are an open communication tool, which allow students to share their ideas and experiences about the project being built. A discussion board allows communication between students and the instructor about a specific topic. A journal is a tool to register group activity and keep track of student self-reflection for the student. The journals can only be commented by the professor, but can be made public to allow other students to access the entries. Entries can include text, images, links, and public attachment by individual students. Wiki is a collaborative tool that allows students to contribute and edit one or more pages of material related to the course at the same time.

Using these collaborative tools, the monitoring process consists of the following:

- Definition of the active learning process by the teacher-using task (the PBL scenario).
- Team organization by the teacher using groups.
- Development of student collaborative work using tasks, blogs, discussion board, journal and wiki.
- Activity Tracking by the teacher using blogs, discussion board, journal and wiki.

We report results by the students using journal and wiki. Figure 2 shows a use case diagram that shows the activities proposed in the environment.

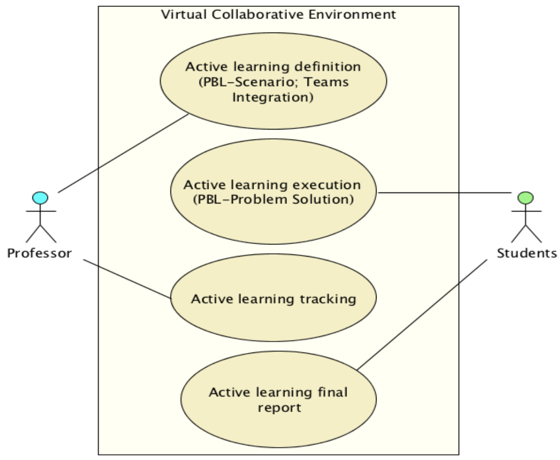

Figure 2. Use Case Diagram

The proposed collaborative environment is intended to provide the necessary services for remote collaboration among members during active learning work and monitoring tools to help teachers. As shown in Figure 3, this architecture allows the implementation of a virtual environment that integrates collaborative, teaching, learning and monitoring activities.

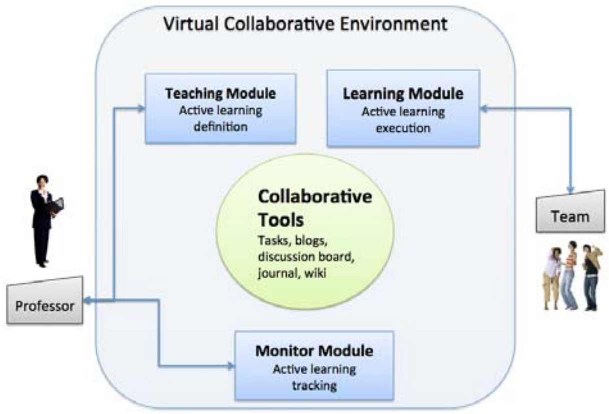

Figure 3. Virtual Collaborative Environment

V. Evaluation process

We have carried out an initial assessment of the impact of the use of the collaborative tools provided by Bb9.1 on student learning, during the January-May 2011 term. For this purpose, we have selected three undergraduate Physics groups (hereafter groups I, II and III) for engineering students at Tecnológico de Monterrey, Mexico City Campus. Groups I and II were divided randomly in work teams with 3 – 4 members, and each team was asked to work with a previously designed PBL scenario along a two-week period. The scenario's main goal was to identify the main phases that a parachutist has when he/she is falling down vertically from a stationary helicopter. Group I work teams were asked to collaborate and document their work using the Bb9.1 Collaborative Tools, while Group II teams worked with the same PBL scenario on a face-to-face setting. Finally, Group III served as a control group and did not work with the scenario at all. Work teams of Groups I and II had to investigate what the minimum height the parachutist must jump from in order to not get injured when reaching the ground, to study the forces acting on the parachutist in these different phases, and to calculate the acceleration and velocity that he/she acquires at different times and heights from the ground. At the end of the two-week research period each work team had to present their results in class and to give a written report to the teacher.

All students of the three groups were asked to solve a Pre-test before Groups I and II started to work on the PBL scenario. The Pre-test consisted on sketching Free-Body Diagrams for the parachutist at the different phases, identifying the sources of the forces acting on the parachutist, and estimating the direction and relative magnitudes of his/her velocities and accelerations in these phases. As said before, teams of Group I interacted and documented their work using the Bb9.1 collaborative tools, while teams of Group II worked face-to-face during the same period of time, and Group III continued with the traditional lectures on the same subject. At the end of the period a Post-test was applied to all three groups, which was identical to the Pre-test in order to study student learning gains as explained below.

Group I was actually divided in 5 work teams labeled A, B, C, D and E. The teacher assigned a working space in Bb9.1 for each work team, and suggested the students to use Bb9.1 collaborative tools as follows:

1) Journal. Here each work team had to load documents defining students' roles assignment, a template specifying the initial research plan and research progress reports, among others.

2) Wiki. It was reserved to integrate the team's final investigation report.

3) Blog. It was used for team members to discuss ideas and suggestions and to upload individual contributions to the research project.

4) Discussion board. Use to discuss on a given subject among the students and also between the students and the teacher.

Each team member was allowed to enter to Bb9.1 platform and use the desired collaborative tools within the two-week period as much as needed

VI. Results and discussion

In order to compare the results between students in the different groups, we have followed a similar procedure as the one described by Neri et al. (2010). The following definitions are used, where N is the number of students for a given group and "i" stands for individual students:

Average Pre-test grade $$\langle Pre \rangle = \frac{\sum_i Pre_i}{N} \quad (1)$$ Average Post-test grade $$\langle Pos \rangle = \frac{\sum_i Pos_i}{N} \quad (2)$$

Relative gain for each student $$g_i = \frac{Pos_i - Pre_i}{100 - Pre_i} \quad (3)$$ Average relative gain $$\langle g_i \rangle = \frac{\sum_i g_i}{N} \quad (4)$$

Integrated relative gain $$G = \frac{\langle Pos \rangle - \langle \mathrm{Pr}e \rangle}{100 - \langle \mathrm{Pr}e \rangle} \quad (5)$$

The sample standard deviations of <Pre>, <Pos> and <g_i> were also calculated. The results are shown in Table 1.

Group	N	$\langle Pre \rangle$	$\langle Pos \rangle$	$\langle g_i \rangle$	G
I (PBL + BB9)	20	65 ± 11	71 ± 13	0.19 ± 0.29	0.16
II (PBL face-to-face)	18	61 ± 13	66 ± 15	0.12 ± 0.36	0.12
III (Control)	11	52 ± 14	60 ± 23	0.19 ± 0.39	0.17

Table 1. Students' populations, average pre-test and post-test grades, average learning gains and integrated learning gain.

It can be seen from the table that the average relative gain and the integrated relative gain for the three groups are rather small, and there are no significant differences between these groups due to the relatively large data standard deviations. Indeed, the learning gains were modest and very similar for all three groups. That is, according to these initial results PBL activities do not appear to have an important and direct impact on students' learning gains as measured by these particular pre-test and post-test assignment tools. (Neri, 2004) reported that students working on PBL activities get a higher autonomy on their learning process, even though their academic yield does not improve meaningfully as measured by traditional quiz exams (Jonassen, 2011). This is a preliminary conclusion because the student sample is still too small. It is necessary to study in more detail the relation between the implementation of PBL activities and the corresponding students' learning gains, if any.

For the present data, a possible explanation of our results could be related that the control group was given lectures with similar topics during the two-week research period, so masking in some extent any additional effects that the application of the PBL activity may have had on Group I and Group II students. Another research issue may be related to the pre and post-test design itself, in which other dimensions besides the cognitive domain could be included. For example, to design individual or small group oral tests in which student's research, communication or collaborative skills could be assessed, given the fact that PBL is intended to promote these students' working skills. Another goal would be to assess the way in which students pose, state, and solve a problematic situation, since we would expect that students working with PBL scenarios would be more skillful than students working only in a traditional learning group.

These issues need to be studied more carefully in the future, taking into account larger students' samples and different ways of assessing students' learning outcomes and the extent to which students' strategies and skills are developed to face problems. Our research group is currently addressing this project.

Besides studying learning gains we have also made an attempt to assess student collaboration using the Bb9.1 collaborative tools. Thus, we have registered the students' frequency participation for each team of Group I within the two-week period. In Figure 4 the participation frequency for each team for the different Bb9.1 collaborative tools is presented.

Based on the quality of the final result and comparing with the contributions made in each case, a simple scale was developed to assess the use of collaborative tools (Mayo, 1993). We assigned to each team a qualitative score for posting contributions in blogs, forums, journals, and wikis: 0 to 10 contributions were given a *low* score. 11 to 21 contributions got a *sufficient* score and 21 or more participations got an *outstanding.*

This is an arbitrary scale created from the experience of teachers implementing PBL activities using Bb9.1 collaborative tools.

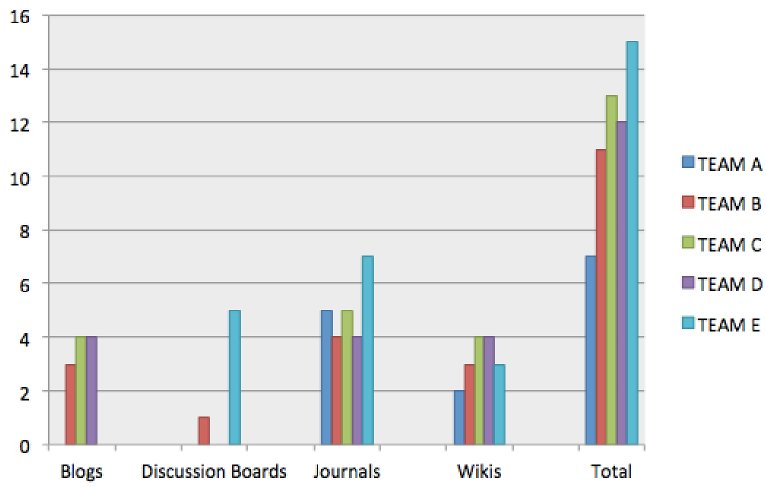

Figure 4. Teams' participation frequencies using Bb9.1

Work team's participation frequency was graded as follows:

team A = low, team B = Sufficient, team C = Sufficient, team D = Sufficient, team E = Sufficient.

Based on contributions count (Figure 4) we observed an interaction just sufficient and in some cases low to perform the PBL activities. Part of this is because the team students had the opportunity to interact face to face in the classroom and to use other communication tools they are used to (e-mail, Facebook, Twitter, chat, and file exchange).

One of the goals of the present study is to determine the degree of student acceptance in the use of collaborative tools within PBL activities. We used an online survey system to out total student sample (*N* =20). The questions were: 1) Do you think that the Bb 9.1 collaborative tools facilitate collaborative work with your teammates? 2) Do you consider that the order of presentation of the collaborative tools is adequate? 3) Do you consider that collaborative tools allow you to maintain a better communication with your teammates? 4) Was there a greater integration and trust with your teammates using Bb9.1? 5) Does the tool "Blogs" help you to efficiently share ideas with your colleagues and to keep track of teammates' contributions? 6) Did the tool "Forums" help you to discuss concepts with your teammates? 7) Did the tool "Journal" help your team to keep track of your activities? 8) Do you consider the "Wiki" tool adequate and complete in order to develop the final PBL report? We used a Likert scale 1 to 5 to answer the questions where 1 equals "strongly agree" (SA), 2 equals "agree" (A), 3 equals "indifferent" (I), 4 equals "disagree" (D) and 5 equals "strongly disagree" (SD). Our results are shown in Table 2 below.

# QUESTION	SA	A	I	D	SD
1	11.1%	**50.0%**	16.7%	11.1%	11.1%
2	22.2%	**27.8%**	22.2%	11.1%	16.7%
3	5.6%	27.8%	**33.3%**	16.7%	16.7%
4	0.0%	33.3%	**50.0%**	5.6%	11.1%
5	11.1%	**44.4%**	11.1%	11.1%	22.2%
6	5.6%	27.8%	**33.3%**	16.7%	16.7%
7	**44.4%**	27.8%	11.1%	5.6%	11.1%
8	11.1%	**27.8%**	22.2%	11.1%	**27.8%**

Table 2. Collaborative Tools Acceptance Survey.

From the survey we can see that although most students feel that the collaborative tools facilitate their overall activities, the above answers show that this does not apply to all the tools. Students found Journals a particularly useful tool, however, Discussion Forums did not seem relevant to most teams and in some teams did not use Blogs at all. Regarding the Wikis, we see a situation that requires further examination: while many students did not like the tool, others considered it just appropriate. Finally, the answers to questions 3 and 4 indicate that there is no perceived improvement in communication and integration between team members.

A comparison between the final PBL written reports of the students using Bb9.1 and students working face-to-face was made. Group I teams were asked to use the Wiki tool to build their research report, while Group II teams did standard written reports. It was found that the reports written by Group II teams were on the average, larger and more complete than the reports written by the Group I teams. That is, students were more familiar to use traditional text editors to write down their reports than using the Wiki capabilities. It seems that Wiki capabilities were not as friendly or attractive enough as expected for most students. Nevertheless, there were some Bb9.1 teams that were actually able to take advantage of the platform tools and could design adequate reports including appropriate equations, figures and tables, and also included links to other documents and web sites. It seems that having a friendlier platform with bigger editing, interactive and multimedia capabilities will motivate students to do more complete, appealing and adequate reports for their research.

From the teacher's viewpoint, it was observed that, in spite of the large capabilities of Bb9.1 collaborative tools, teams' work tracking and monitoring was not as friendly as desired, and it was also very time-consuming. Indeed, the teacher had to enter into each tool for each team to give feedback and supervise student work. We consider that it is necessary to have an on-line tool with a friendlier navigation and an editing tool, and with a more adequate tracking tool to follow students' participation when working with a PBL scenario.

VII. Conclusions and future work

From our study, we have found that learning gains for students working the PBL scenario using Bb9.1 collaborative tools were relatively small and similar to those for students working face-to-face. These students´ learning gains were also similar to that of the students that did not worked with the PBL scenario. Our students' sample is still small and we need to enlarge it in order to reach sound conclusions about this point. In this sense, we consider that the main goal of a PBL activity is not only to improve the student ability to solve short exercises – as those contained in the Pre-Test and Post-test assessment tool – but rather to develop students research and collaborative skills. We are currently exploring methodologies to assess these more qualitative student skills.

On the other hand, even if Bb9.1 has many and powerful collaborative tools, it is important to have a friendlier navigation and organizing tool to organize, monitor and conduct teamwork. Students were not very motivated to use more extensively Bb9.1 because they found difficult to navigate inside it and also because the system did not allow them to load multimedia material in an easy way. In the same way, teachers found difficult to follow, monitor and give adequate feedback to students' work during the PBL activity. As future work we are planning to design an architecture that could fulfill this expectation.

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SUPPORTING PROBLEM SOLVING IN PBL

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ABSTRACT

Although the characteristics of PBL (problem focused, student centered, self-directed, etc.) are well known, the components of a problem-based learning environment (PBLE) and the cognitive scaffolds necessary to support learning how to solve different kinds of problems with different learners is less clear. This theoretical paper identifies the different components that may be used to support PBL, including a problem to solve, worked examples, case studies, analogues, prior experiences, alternative perspectives, and simulations. Additionally, different cognitive scaffolds necessary to help students interpret and use those components include analogical encoding, causal relationships, argumentations, questioning, modeling, and metacognitive regulation. Recommendations for which components and scaffolds are needed to learn to solve different kinds of problems are provided.

INTRODUCTION

There are many issues in implementing PBL into various curricula. An important issue has to do with the extent of the curriculum that is converted to PBL. Many reports illustrate the effect of single PBL modules inserted in courses. Many other implementations have converted existing semester-long courses to PBL. The most successful implementations have covered the entire curriculum to PBL, enabling students to develop the study strategies and self-regulations skills necessary for success in a PBL environment. Because PBL represents a significant shift in learning for most students, those students require support in adapting their learning methods. We cannot assume that learners are naturally skilled in problem solving, especially complex and ill-structured problems that are required in most PBL programs.

Another important issue focuses on the nature of the problem being solved and the nature of the learners. Based on fifteen years of research on probem solving (Jonassen, 2011), problems vary in terms of perspective, dynamicity, structure, difficulty and content (see Figure 1). Based on these differences, Jonassen (2000) suggested a typology of problems on a continuum from well-structured to ill-structured, including algorithms, story problems, rule using/rule induction, decision making, troubleshooting, diagnosis-solution, strategic performance, policy, design, and dilemmas. The principle claim is that solving different kinds of problems calls on different kinds of knowledge and skills Jonassen & Hung, 2008).

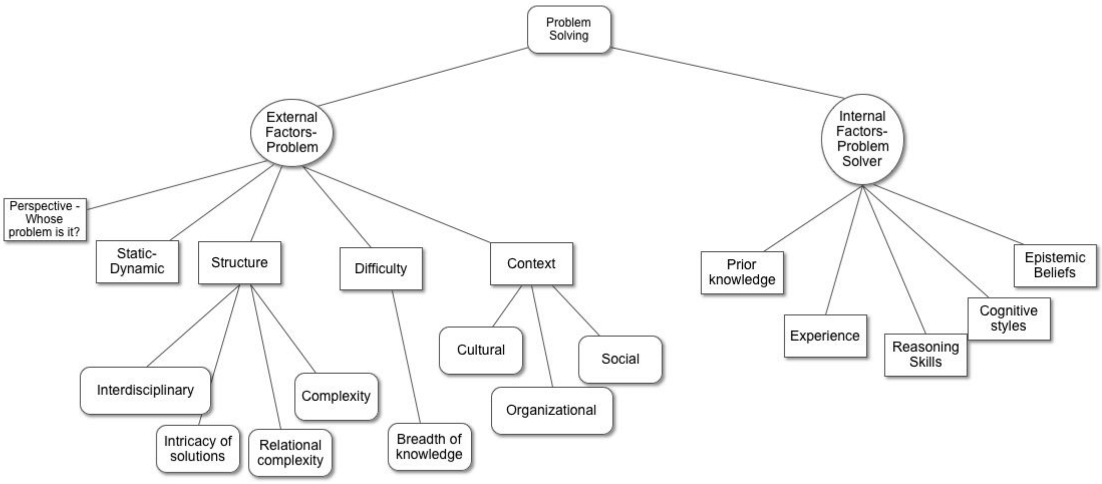

Figure 1. Factors in problem solving.

In medical education programs, students learn to solve diagnosis-solutions problems. An unexplored question is the range of problems that can be converted to PBL. Are some problems too complex or too easy, too well-structured or too ill-structured, too static or too dynamic, too simple or too difficult?

In addition to the kind of problems learning to be solved in a PBL program, the learners' abilities to solve problems depends on prior knowledge, experience, cognitive styles, and epistemic beliefs, among other potential factors. Is PBL equally effective for K-12, university, or post-graduate students? What skills must be learned in order to facilitate different kinds of problems solving? There exist a host of research questions related to learners' abilities related to the demands of PBL programs.

Components of problem-based learning environments

Again, based on fifteen years of research, Figure 2 conveys the different instructional components that can be used to support problem solving. The problem to solve is the focus of all learning. Solving well-structured problems is supported by worked examples and structural analogues. Ill-structured problems are supported by case studies and prior experiences (based on case-based reasoning), and alternative perspectives (based on cognitive flexibility theory) may be accessed to help learners interpret and solve the problem. Simulations are useful for trying solutions to all kinds of problems.

In order to engage students in appropriate cognitive activities, cognitive scaffolds may be layered over the problem. Scaffolds to help learners comprehend problem schemas include analogical encoding. The cognitive basis for all problem solving is causal reasoning, which may be scaffolded by questions and model building. For ill-structured problems that may have no convergent answer, argumentation provides the best evidence of problem solving and comprehension. Finally, metacognitive regulation is most often scaffolded with questions, although newer means are being tested.

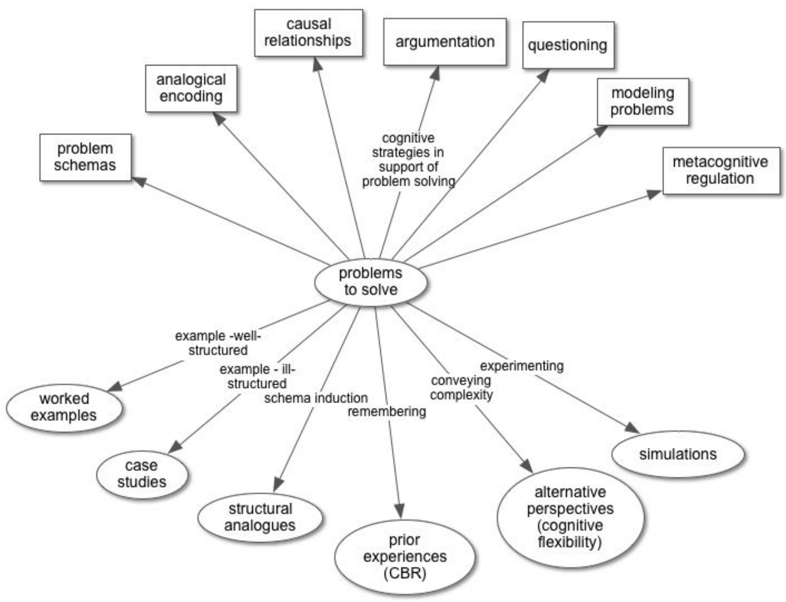

Figure 2. Components and scaffolds for problem-based learning environments.

Case Components of PBLEs

The building blocks of problem-based learning environments are cases. The concept “case” has many interpretations. To professionals, a case represents “real world” examples from their practice, such as a “case of measles” to a physician or a “case of libel” to an attorney (Shön, 1993). For purposes of building PBLEs, a case is an instance of something that may comprise anything from a sentence level example to a complex, multi-page or video-based case study. As instructional components, most of these cases are provided to help learners to make sense of the problem to be solved (see Figure 2).

Cases as Problems to Solve. The focus of any PBLE is the problem to solve. The use of problems as the focus of learning is supported by problem-based learning principles. According to those principles, learning is anchored in an authentic problem to solve. Traditional models of instruction assume that students must master content before applying what they have learned in order to solve a problem. Problem-based learning reverses that order and assumes that students will master content while solving a meaningful problem. The problem to be solved should be engaging, but should also address the curricular issues required by the curriculum. The problem provides the purpose for learning. For example, in a geography course focused on the use of maps, we challenged students to design a route from two interchanges in order to alleviate traffic problems at a third intersection. The students were required to use topographic maps, real estate maps, aerial maps, and soil maps to design and justify the route from one section of the map to another. The problem in second problem addressed where to locate a new landfill, a complex decision with many perspectives.

Cases as Worked Examples. The most common method for supporting schema construction is the worked example. When learning to solve problems, cases in the form of worked examples are typically provided as a primary form of instruction. Worked examples are instructional devices that typically model the process for solving the problem (Atkinson, Derry, Renkl, & Wortham. 2000). Worked examples that focus on problem type and sub-procedures involved in the problem-solving process are cognitively very demanding. Worked examples should break down complex solutions into smaller meaningful solution elements, present multiple examples in multiple modalities for each kind of problem, emphasize the conceptual structure of the problem, vary formats within problem types, and signal the deep structure of the problem (Atkinson et al, 2000). Because research with worked examples has always focused on well-structured problems (usually story problems) with convergent solutions and solution methods, it is not doubtful that worked examples are effectively applicable to very ill-structured problems, despite the claims of cognitive load theorists who conceive of cognitive load theory as a universal theory of learning.

Case Studies. The most common application of case-based learning is the case study. In case studies, students study an account (usually narratives from one to 30 pages) of a problem that was previously experienced. Frequently guided by questions, students analyze the situation and processes and evaluate the methods and solutions. This analysis is usually ex post facto. In most case studies, students are not responsible for solving the problems, only analyzing how others solved the problems and engaging in what-if thinking. Case studies are stimuli for discussions. The goals of the case study method are to embed learning in authentic contexts that require students to apply knowledge rather than acquire it. Case studies are examples of more ill-structured problems that may be used to support problem schema construction for more complex and ill-structured problems.

Cases as Analogues. Learning to solve problems can also be supported by providing analogous problems. When students examine similar problems for their structures, they gain more robust conceptual knowledge about the problems. There are two theoretical approaches to using cases as analogues: analogical encoding and case-based reasoning. Mapping analogues to problems to be solved is affected by the similarity of objects between the examples and problems being solved, especially story lines and object correspondences. Learners often fail to recall or reuse examples appropriately because their retrieval is based on a comparison of the surface features of the examples with the target problem, not their structural features. When the target problems emphasize structural features that are shared with the example, generalization improves (Catrambone, & Holyoak, 1989). The theory that best describes the required analogical reasoning is structure mapping theory (Gentner, 1983), where mapping the analogue to the problem requires relating the structure of the analogue to the structure of the problem independent of the surface objects in either. In order to do so, those surface features (which attract the attention of poor problem solvers) must be discarded. Then the higher-order, structural relations must be compared on a one-to-one basis in the example and the problem, a process known as analogical encoding.

Cases as Prior Experiences. Another way of using cases to support problem solving is by analogy directly with the source problem without attempting to construct a schema. Problem solving consists of finding the nearest case in an organized library of annotated problem cases and reusing or adapting it. When a new problem is encountered, most humans attempt to retrieve cases of previously solved problems from memory in order to reuse the old case. If the solution suggested from the previous case does not work, then the old case must be revised (Jonassen & Hernandez-Serrano, 2002). When either solution is confirmed, the learned case is retained for later use. Case-based reasoning is based on a theory of memory in which episodic or experiential memories in the form of scripts (Schank & Abelson, 1977) are encoded in memory and retrieved and reused when needed (Schank, 1990; Kolodner, 1993).

Case-based reasoning is applied to instruction in the form of case libraries of stories that are made available to learners. The stories in the library are indexed in order to make them accessible to learners when they encounter a problem. Those indexes may identify common contextual elements, solutions tried, expectations violated, or lessons learned.

Cases as Alternative Perspectives. Ill-structured problems tend to be more complex than well-structured problems. In complex knowledge domains or problems, the underlying complexity should be signaled to the learner, who considers alternative perspectives on the problem in order to construct personal meaning for the problem (Spiro, Coulson, Feltovich, & Anderson, 1988). Cognitive flexibility theory prescribes the use of hypertexts to provide random access to multiple perspectives and thematic representations of content, enabling students to criss-cross the cases that they are studying through the use of multiple conceptual representations, linking abstract concepts to different cases, highlighting the interrelated nature of knowledge via thematic relations among the cases, and encouraging learners to integrate all the cases, as well as their related information, into a coherent knowledge base. The interlinkage of concrete cases and perspectives with abstract themes allows students to develop a much more complex and coherent knowledge base (Jacobson, Maouri, Mishra, & Kolar, 1995). Most ill-structured problems demand the use of cases as alternative perspectives.

Cases as Simulations. Typically, problem-based learning is practice based. That is, students must practice solving problems. You cannot effectively teach students about problem solving and expect them to be able to solve problems without practicing and receiving feedback. Simulations are environments where components of a system are able to be manipulated by learners. The manipulations that are available are determined by some underlying model of the system, "the main task of the learner being to infer, through experimentation, characteristics of the model underlying the simulation" (deJong & van Jooligan, 1998, p. 179). When learners interact with the simulation, they can change values of some (input) variables and observe the results on the values of other (output) variables. These exploratory environments afford learners the opportunities to test the causal relationships among factors in the problem. The feedback provided by the system confirms or rejects student understanding of the relationships in the learner's mental model of the problem.

The most common kinds of simulation include laboratory exercises in the sciences. Simulations may also be provided for more complex kinds of performance.

Cognitive Scaffolds in PBLEs

Cases constitute the building blocks of problem-based learning environments. Studying cases in relation to the problem to be solved enhances students' understanding of the problem and their abilities to solve it. Next, I describe different forms of cognitive scaffolds to assist students' analysis and comparisons of the different kinds of cases. These cognitive scaffolds focus student attention on important relationships among the elements in the problem and between problems.

Analogical Encoding. Analogical encoding is the process of mapping structural properties between multiple analogues. Rather than attempting to induce and transfer a schema based on a single example, comprehension, schema inducement, and long term transfer across contexts can be greatly facilitated by analogical encoding, which involves the comparison of two analogues for structural alignment (Gentner, &

Markman, 1997, 2005). When learners directly compare two examples, they can identify structural similarities. If presented with just one example, students are far more likely to recall problems that have similar surface features. Analogical encoding fosters learning because analogies promote attention to commonalities, including common principles and schemas. During analogical encoding, students must compare analogous problems for their structural alignment. Problems are structurally aligned when the relationships (arguments) among problem elements match (Gentner & Markman, 1997).

Causal Reasoning. When comparing the structures of cases, the designer and the students must examine the underlying causal relationships among the elements in the problem. Understanding the causal relationships among the elements in the problem is essential for comprehension and transfer. Understanding causal relationships means the students can make predictions and inferences involved in a problem. Reasoning from a description of a condition or set of conditions or states of an event to inferring the possible effect(s) that may result from those states is called prediction. Predictions are used for forecasting an event (e.g., economic or meteorological forecasts) and testing of hypotheses to confirm or disconfirm scientific assumptions (e.g., predicting the effects of a hormone on an animal's growth rate). When an outcome or state exists for which the causal agent is unknown, then an inference is required. A primary function of inferences is diagnosis, as in medicine. Based on symptoms, historical factors, and test results of patients, a physician attempts to infer the cause(s) of that illness state.

In order to understand causal relationships well enough to make predictions and inferences, students must comprehend both the covariational and mechanistic attributes of the relationships (Ahn, Kalish, Medin, & Gelman, 1995). Covariation is the degree or extent to which one element consistently affects another, which is expressed quantitatively in terms of probabilities and covariance. The mechanism describes the causal relationship in terms of its qualitative effects.

Questioning. Questioning aids problem solving in many ways. Answering deep-reasoning questions articulates causal processes as well as goals, plans, actions, and logical justification (Graesser et al, 1996), all of which are essential processes for solving problems. During problem solving, questions are essential for guiding student reasoning as they work to comprehend the problem and generate solutions. Question-driven explanatory reasoning predicts that learning improves to the extent that learners generate and answer questions requiring explanatory reasoning (Graesser et al, 1996). Questions can be included in problem-based learning environments in the form of inserted questions to support thinking at the moment of need. By embedding questions in learning environments, students can practice and learn to generate their own deep-level questions, which is predictive of problem solving abilities. Finally, questions may form the primary interface in the form of an Ask System. An Ask System is an interface comprised of a sequence of questions that function as links to different information.

Argumentation. Although problems differ, argumentation is an essential skill in learning to solve most, if not all, kinds of problems, as well as a powerful method for assessing problem solving ability for both ill-structured and well-structured problems alike (Jonassen, 2011). When students answered well-structured physics problems incorrectly and later constructed an argument for the scientifically correct answer, Nussbaum and Sinatra (2003) found that those students showed improved reasoning on the problems. When the students were retested a year later, the quality of their reasoning remained strong. This strategy engages students in refuting misconceptions. As in the case of Nussbaum and Sinatra (2003), students are refuting their own misconceptions.

Argumentation pays a more obvious role in the solution of ill-structured problems. Cho and Jonassen (2003) showed that the production of coherent arguments to justify solutions and actions is a more important skill for solving ill-structured problems than for well-structured problems. Ill-structured problems are the kinds of problems that are encountered in everyday practice. Such problems have alternative solutions; vaguely defined or unclear goals and constraints; multiple solution paths; and multiple criteria for evaluating solutions; so they are more difficult to solve (Jonassen, 2000). Groups that solved ill-structured economics problems produced more extensive arguments. Because ill-structured problems do not have convergent answers or consistent solution criteria, learners must construct arguments to justify their own assumptions, solution paths, and proposed solutions.

Modeling. "Scientific practice involves the construction, validations, and application of scientific models, so science instruction should be designed to engage students in making and using models" (Hestenes, 1996, p. 1). The same assumption applies to all disciplines. Internal, mental models are enhanced and confirmed by the construction of external models. Those models may be quantitative (equations) or qualitative. Both are essential to understanding and solving problems. Several types of modeling tools, including databases, concept maps, expert systems, systems dynamics tools, and graphic tools may be used to construct external models (Jonassen, 2006). While students are analyzing problems, they should be constructing models of the components and relationships in the problem. Those models will help students to hypothesize and confirms solutions to the problem.

Which components and scaffolds support different kinds of problem-solving?

Which kinds of cases and cognitive scaffolds shall we present to learners so as to support them in learning how to solve different kinds of problem? Table 1 provides a list of recommended components for different kinds of problem-based learning environments. Although there exists empirical support for some of the instructional components and scaffolds recommended, many of my recommendations require empirical validation. Rather than positing these recommendations as truths, I rather believe they are hypotheses that will require myriad studies to support. I believe that the field of instructional design should focus more of its research and development efforts on problem solving because, as I stated at the beginning of this paper, in everyday life and work, problem solving is a ubiquitous activity.

Problem type	Case Components	Cognitive Scaffolds
Story	Problems, Examples, Analogues	Analogical, causal, questioning, argumentation, modeling
Rule-using/induction	Examples, problems, analogues	Analogical, causal, questioning
Decision making	Problem, case studies, prior experiences, alternative perspectives	Causal, argumentation, modeling (scenario construction)
Troubleshooting	Problems, prior experiences	Causal, argumentation, modeling
Policy analysis	Case studies, problems, prior experiences, alternative perspectives	Analogical, questioning, argumentation, modeling
Design	Problems, prior experiences, alternative perspectives	Causal, argumentation, modeling
Dilemmas	Case studies, alternative perspectives	argumentation

Table 1. Case and scaffold requirements by problem type.

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THEORISING ABOUT THE PROBLEM-BASED LEARNING TUTORIAL AS A POTENTIAL SITE FOR DIALOGIC KNOWING

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ABSTRACT

The purpose of this paper to explore how problem-based learning (PBL) students' language-in-use helped develop a conceptual understanding of the nature of PBL tutorials. The naturally occurring talk of two teams of PBL students was analysed using a critical discourse analysis approach. This paper illustrates how the illuminative concept of the PBL tutorial as a potential site for dialogic knowing, was derived from an abductive analysis that combined the inductive analysis of how students talked about the PBL tutorial, and the deductive analysis of informing theoretical perspectives. This paper discusses three dimensions of the PBL tutorial as a potential site for dialogical knowing that emerged from the study.

INTRODUCTION AND CONTEXT

Clouston (2007, p. 183) suggests that discourse analysis methods, including critical discourse analysis (CDA), "could enable an understanding of how effective problem-based learning is constructed". Although the problem-based learning (PBL) tutorial is the piviotal learning site in PBL initiatives few studies have researched the dialogue of PBL tutorials (Hak and Maguire 2000). PBL is a student-centred methodology and I consider that this student talk in PBL tutorilas is a very appropriate focus for developing a theoretical understanding of the nature and potential of the PBL tutorial.

Two teams of eight lecturers were completing a module on problem-based learnng that was part of an education development Postgraduate Diploma in Learning and Teaching in Higher Education. The PBL students in this study were all lecturers in higher education in Ireland. The lecturers came from a variety of disciplines including engineering, business, art and design, nursing and architecture. These participants were problem-based learning students for the module. The aim of the module was to enable participants to design, deliver, assess and evaluate problem-based learning curricula critically and creatively in their own contexts.. The content of the module developed from the students' work in teams on two consecutive problems about PBL. The participants used a PBL process guide as an aid in assisting them working through the PBL process. Thus, both the content and the process of this module were problem-based learning. This paper focuses on addressing the research question *"What can we learn about the problem-based learning tutorial from how problem-based learning studens, talked it in the naturally occuring talk of these tutorials?* These students were lecturers in higher education and became PBL students for the module.

Research methodology

This research study was based on the video and audio-recorded dialogue, of the full set of tutorials for the module for two teams (Barrett 2008). Pseudonyms were given to these PBL students, the two PBL teams, the title of the programme and the name of the institution. The data analysis was in two stages. The first stage was the identification and exploration of the interpretive repertoires of how each team separately talked about the PBL tutorial. Interpretive repertoires are the building blocks that people employ to construct the different versions of topics, processes and events that they are experiencing. My analytical unit was not one student but the set of interpretive repertoires used to talk about the tutorial. This exploration of the interpretive repertoires was informed by critical discourse analysis. The three dimensions of critical discourse analysis are respectively: a description of the formal properties of the text, an interpretation of the relationship between the text and the interactional process, and an explanation of the relationships between interaction and social contexts (Fairclough, 2003; Bloor and Bloor 2007). The second level of analysis involved deriving the illuminative concept of the PBL tutorial as a potential site for dialogic knowing by analysing the interpretive repertoires about the tutorial across both teams, and relating the emerging ideas to relevant literature.

The concept of the PBL tutorial as a potential site for dialogic knowing

I propose three interrelated arguments. Firstly, dialogic knowing has to be constructed discursively in the language-in- use of the conversations of the tutorials; it does not happen automatically in PBL tutorials and is not present at the start of the first PBL tutorial. In the students' language-in-use in the PBL tutorials, dialogic knowing in this study, was constructed through a movement towards more democratic social relations, the co-construction of knowledge through co-elaboration and the relinquishment of individual control and the embracement of shared control of PBL tutorials and the products produced in these tutorials. Secondly, understanding the three dimensions of the PBL tutorial as a potential site for dialogic knowing facilitates the use of the tutorial as a discursive site for realising dialogic knowing. Thirdly, combining understandings from how these students talked about the PBL tutorial with Freire's concept of dialogic knowing provides ways of thinking about maximising the potential of the PBL tutorial for dialogic knowing. Dialogic knowing is the means by which people create and recreate acts of knowledge together as "dialogue unites subjects together in te cognition of the object that mediates them" (Freire 1985: 49). The main theoretical perspective that I draw on for this chapter is that of dialogic knowing (Freire 1985, Shor and Freire 1987, Buber 1964). The other ideas I draw on in this chapter include Vygotsky's (1978) idea of proximal development, Schmidt's (1993) idea of elaboration and Barnett's (2000) idea of a radically unknowable world.

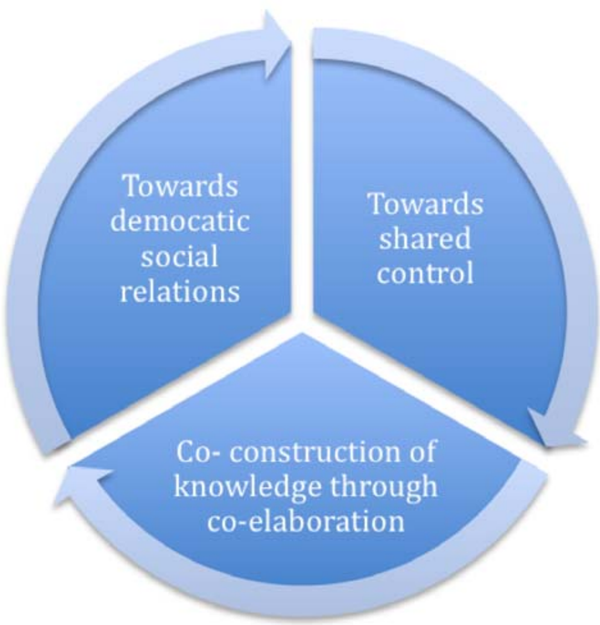

Figure 1 The Illuminative Concept of the PBL Tutorial as a Potential Site for

Towards more democratic social relations

The movement towards democratic social relations means a shift toward lower levels of social hierarchy and lower levels of social distance. Frank , the chairperson of the Glendalogh team, talked about democratic social relations at the first tutorial in terms of:

Em, free expression, collective responsibility.

The Glendalough team talked about the PBL tutorial in terms of movement from a traditional committee meeting genre towards the PBL tutorial genre**.** The following extract is from the opening minutes of an early tutorial of the module and shows a traditional committee meeting genre in the language-in-use. It also shows some language that is not part of the traditional committee genre but rather the language of the PBL tutorial. The first tutorial began with a long monologue by the chairperson, Frank

Frank: If I could say just a few words, I do write speeches and then don't say them but em just to kick us off, the thing that I am very aware of I think, I am very task orientated. I would be very aware of the time scale we have. .... We need to be aware of the group rules and keep reminding ourselves, try and be honest. ..Em, free expression, collective responsibility that touches on what I said before. Once we make a decision or once we are heading in a direction lets stick with it.... And if someone has a problem with the way we are going just say it to me maybe after a meeting or some other time, if you think there is something radically wrong. A few things that I normally say at these stages for getting the ball rolling is that failure is not an option. Em. we need to produce a product we need to agree what the product is etc. We won't fail, we will do a good job and that is what we are going to do here. Em, what I would like to see at the end of the day is a good product produced. ..... And we learn so much from this particular group project, we have another one directly after it and we can learn from all the mistakes we made and all the things we did right and we can try and do it slightly different the next time. Are you happy enough with that? That is all I got to say. I won't speak again unless I have to. But anyway, em, just on the agenda then we are going to do the minutes but its suggested, again this was just thrown out just to get you thinking and a few people came back to me which is great. ...*(monologue of 1096 words in total.)*

In this excerpt, there are actions and interactions associated with a traditional committee meeting, these include the chairman's address, discussion about an "agenda" and "minutes" being read, and a discussion about a "product" being produced. In this same excerpt, there is also talk about "learning" in the PBL tutorials from the work on one "group project" to inform ways of working on the next group project and this interaction is associated with a PBL tutorial. We can see the hybridity in the text, where there is both the talk of the traditional committee meeting genre and the talk of the PBL tutorial genre in one short extract. In other words, there is genre mixing. During a later tutorial in the module, these students discussed what the difference between the genre of the traditional committee meeting and the genre of the PBL tutorial had meant to them, in terms of ways of interacting with one another. They linked the traditional committee meeting genre that they used at the start of their first experience of the PBL tutorial with their social practices of being on academic committees in the wider social structure.

This Glendalough team employed the interpetive repertoire : *PBL Tutorial: Traditional Committee Meeting versus PBL tutorial.* The students' language of traditional committee meetings (e.g. 'agenda' and 'minutes') was transformed through the tutorials into a language of the PBL tutorial (e.g. 'action-plan' and 'whiteboard'). The traditional committee meeting was viewed as emphasising "product", whereas, the PBL tutorial was seen as giving importance to "process "and "product". There was a genre chain that began with a traditional committee meeting genre, which first moved to a hybrid genre that included some elements of the PBL tutorial genre and then moved to a PBL tutorial genre. I argue that the dimension of a movement toward democratic social relations is fundamental prerequisite to dialogic knowing. Democratic social relations means that there is a level of respect, openness, reciprocity and equality that facilitates the students to actively listening to other students' ideas and to freely expressing their own ideas. The situation that the Glendalough team moved to was a case of "everybody sharing. Authoritarianism, where one person sets the agenda and makes the decisions is a barrier to dialogic knowing. Strategies that stimulate democratic social relations are:each team making and reviewing their own ground rules, the agenda being set by the learning issues and action plan as decided by the team, self, peer and tutor assessment of students' teamwork and the functioning of the chair and using the whiteboard as a shared learning resource.

The co-construction of knowledge through co-elaboration

The PBL students in this study talked about building their knowledge together ("group knowledge") through elaborating their own "ideas", listening to new ideas from other students, linking what one student said to what other students said and "editing" their work together. This co-construction of knowledge through co-elaboration contrasts with an individualistic view of knowledge creation and Philip, from the Skelligs team, distinguished between the two perspectives as follows:

> Well, my opinion of the idea of the PBL working in groups, if I was working independently I couldn't have been as creative as the group has been. And the number of ideas that were thrown around and developed by the group is very, very, I think it creates a whole new dynamic.

This co-construction of knowledge meant that there was a greater "number of ideas" being considered by the team compared to when someone works individually to construct knowledge. Philip said that this co-construction of knowledge was more "creative" as many ideas were "being thrown around" and were bouncing off one another. Creativity can be an important element in developing new identities.

The PBL students in this study made use of ideas and prior knowledge on various topics to exploit the potential of PBL tutorials for co-elaboration and co-construction of new knowledge. In Philip's words, the group discussions in the PBL tutorials created " a whole new dynamic." compared to "working independently". When the students of the Skelligs team talked about the PBL tutorial they contrasted it with individual research that they talked about in terms of individual knowledge and individual control. They described the PBL tutorial as being characterised by a sense of our knowledge and our control.

Two extracts are presented in which the students were talking about the PBL tutorial. One extract is from a presentation the Skelligs team gave, and the other extract is part of a question and answer session that took place directly after the presentation. The second problem that the team was working on was entitled "Help!" It was about being asked to help with a PBL workshop for Heads of School by doing a presentation of their experience of PBL. The students of the Skelligs team chose to do the entire presentation through shadow acting. This presentation involved four students talking behind a screen with one student also holding a puppet, who was the fifth character. Two narrators and a stage manager were also involved.

In this extract the four studets are talking about the group process of the PBL tutorial.

(PBL students were talking as shadow actors behind a screen)

Philip: I feel the whole process is very messy and a lot of time was wasted at our group meetings. I would much prefer to be in control of a learning discussion or decision making myself.

Maura: No, I don't really agree, I enjoyed the whole process of discussion and sharing of ideas, workload and presentation. I feel a form of shared ownership in the solution of the problem.

Michael: I feel it depends on the group dynamic. You were all over the place at times, its difficult to know where the learning starts and where it finishes.

Betty: I enjoyed the process, but I prefer the case study method where you are given some formal lectures to build up your knowledge base. However, I felt the action plan gave us direction and everybody knew what they had to do for the next week.

This Skelligs team team employed the interpetive repertoire: *PBL Tutorial: My knowledge and control versus Our knowlwedge and control.* The Skelligs team talked about the co-construction of knowledge of the PBL tutorials in terms of shared control and "shared ownership." They contrasted the PBL tutorial with the transmission model of knowledge creation where "knowledge" was "given" in "formal lectures." In the transmission model, the lecturer possesses the knowledge and presents it to the students. Some students in this team were critical of the PBL tutorial for wasting time and being all over the place. The PBL tutorial has the potential of being a discursive site of a shared space, where PBL students can construct their knowledge together. After the shadow acting presentation, the tutors and the students from the other team asked the Skelligs team questions arising from the presentation. In this extract the tutor from the other team is asking them a question.

Ann: Could I ask you, you were saying that individually there was a sense in which you couldn't maybe produce the final product up to the standard that you would require yourselves. I am just wondering in relation to PBL what are your reflections around that?....

Betty: I think what that question is more addressing is control as opposed to the standard. As an individual you have control over the start and finish of a product whereas you need to give this up as this is group knowledge and it's a group process, you don't have control over it, what the finished piece is. That is different, its different, …. .....

Michael: But I think the group gives a value to this, it's almost like an editing process. like when you get an idea you can go off on a tangent and develop it yourself, so you are in a situation where you hand up a thesis to the tutor, they mark it, correct it, it becomes very, very closed system almost. And often you get a tutor who likes what your approach is, this is brilliant, maybe the research isn't that great. But then maybe you get a tutor who hates what you are doing and then you can get the same level off somebody else, if you like a worse mark or you get a roasting over it because he doesn't like what you are saying or she doesn't like what you are saying and doesn't like your research methods. Whereas in a group like this you can't feel, like sometimes you put in something and its rubbish and the group will tell you pretty quickly. You feel okay, that idea didn't work, or that was a crazy idea and then you think about that, and then maybe that is a good idea, so it helps if a lot of people are thinking the same way, it validates your idea better. I think that is the strength of the group work.

These students talked about giving up individual control for a sense of shared control and "group knowledge" in the way that they co-construct their knowledge together in the PBL tutorials. They talked about the PBL tutorial being like an "editing process", where the group, rather than the individual, decides which ideas to run with and which not to pursue. Through the co-elaboration of ideas, the PBL students as a group validated some ideas as the most appropriate to develop to work on the problem and to further their knowledge.

Genres vary in terms of purpose and social interaction. The students were saying that, in an individual research project, the purpose is to produce a product that shows individual ideas, research and learning. This was contrasted with the purpose of the tutorial which is to produce a group product that reflected the group's ideas, research and learning to co-construct knowledge together. In terms of social interaction, the individual research project was characterised, as a "closed system" with the only interaction mentioned as that occurring between the student and the tutor. In regard to the social interaction of the PBL tutorial, the students talked about it in wider social terms, for example, "sharing ideas", "shared ownership", "group knowledge", and "group process". They talked about the individual research project as a "closed" form of interaction between the supervisor and the student and contrasted this genre with the more open interaction of the PBL tutorial where various students co-elaborate their ideas to produce "group knowledge."

I argue that the language in the dialogue of the PBL tutorial is both being constituted and constituting the ways that knowledge is viewed. In other words, the students are not only constructing their knowledge about PBL in the PBL tutorials, their knowledge about PBL is also being constructed by their talk in PBL tutorials. I would argue that Freire's (1972) concept of dialogue best captures the nature of this dialogic way of knowing. From this perspective the concept of dialogue is much more than a technique, it is as an epistemological position that sees knowledge as not something static but something that is made and remade through dialogue.

> What is dialogue in this way of knowing? Precisely this connection, this epistemological relationship, the object to be known in one place links the cognitive subjects leading them to reflect together on the object. …Then instead of transferring the knowledge *statically,* as a *fixed* possession of the teacher, dialogue demands a dynamic proximation towards the object.
> (Shor and Freire 1987:100).

Dialogue is the means by which people together create and recreate acts of knowledge. Although Freire acknowledges individual acts of knowing, he strongly emphasises that, in the final analysis, knowing is a social event. For Freire, knowledge is viewed in terms of "our" knowledge rather than “my” knowledge, knowing is “…not strictly a ‘I think’ but a ‘we think’: “It is not the ‘I’ think that constitutes the ‘we’ think’ but rather the ‘we think’ that makes it possible for me to think” (Freire, 1985: 99-100).

In PBL tutorials, it is not a case of individuals just elaborating their knowledge by making links between their own prior knowledge and the current problem, rather it is a question of students co-elaborating together, with one person’s elaboration of prior knowledge building on another person’s elaboration**.** Schmidt (1993:428) views the “elaboration on prior knowledge through small group discussion” both before and after new knowledge has been acquired as a cognitive effect of PBL on student learning.

I agree that the particular and unique contribution of Freire to the conceptualisation of dialogic knowing:

> is not only the central place it is afforded within critical pedagogy, but more importantly because of the extent to which it is considered to be a creative and aesthetic act. In speaking, challenging and overcoming the word, Freire like Buber, argues that one is defining and redefining the relationship between oneself and the world. This is the tension between “being and not being” … or being and being more human (Curzon-Hobson 2002:189).

As problem-based learning makes use of the diverse level of the participants’ prior knowledge on various topics, it has possibilities to exploit the potential for co-elaboration and co-construction of new knowledge. One main strategies for promoting this are encouraging student behaviours that foster co-elaboration including students sharing prior learning and independent study as it relates to the problem., teams constructing concept maps and summarising learning in the review phase. A second strategy is tutors and students asking question that facilitate students developing the depth, breath and applicability of their knowledge.

Movement towards shared control

I argue that unless there is also some degree of shared control then the potential for the PBL tutorial being a site of dialogic knowing will not be fully realised**.** A third dimension of the PBL tutorial as a potential site for dialogic knowing is shared control. Betty contrasted this shared control with individual control as she comments at the end of the team presetation:

As an individual you have control over the start and finish of a product whereas you need to give this up as this is group knowledge and it's a group process, you don't have control over it, what the finished product is. That is different, it's different.

I consider that if there are democratic social relations and co-construction of knowledge through co-elaboration then it is possible for some degree of shared control to follow. I argue that without some degree of shared control there is no real dialogic knowing**.** Shared control was seen by some participants negatively, as having to give up control while preferring to be in control. Shared control was seen positively by some participants as a sharing of ideas and a sharing of ownership. Philip and Maura expreesed these different views during the team presentation.

Philip:	I feel the whole process is very messy and a lot of time was wasted at our group meetings. I would much prefer to be in control of a learning and discussion or decision making myself.
Maura:	No, I don't really agree, I enjoyed the whole process of discussion and sharing of ideas, workload and presentation. I feel a form of shared ownership in the solution of the problem.

Participants of the Skelligs team discussed the issue of shared control at the participant validation session. Having experienced this lack of individual control as enhancing their learning as students they were, as tutors consequently more open to giving more control to their students. Betty discussed Freire's concept of dialogue and highlighted the fact that "context, students and tutors are all variables and that is why dialogue and conversation are important. They are not static. That is why we are saying we don't have control." She continued to elaborate:

> We have lack of control. We really don't know what the end product is, we are less afraid. That is difficult for designers not having control. We are helping colleagues not to be afraid and concerned about not being in control.

At the Glendalough participant validation session, Kate also talked about it being "painful" not to be in control as PBL student and that she would only be happy on a plane if she was piloting it, and that she was a bit of a "control freak". Kate noted that the experience of being a PBL student made her realise how she liked individual control. The experience of PBL has made her aware of this and she has moved to giving over some of the control to her new PBL students. At the time of the participant validation session she had chosen to implement PBL for the first time. Yet she was very conscious that she still did not consider that she was effectively giving control to the students. She said:

> they break into groups and work on the problem. I am not good at getting them to reflect. I am directive and not good at staying out and letting them be confused.

From the experiences of being a PBL student and a PBL tutor, issues of control emerged that the participants needed to face. For some participants this involved a repositioning of themselves in relation to student control and a redevelopment of their teacher identities. For others, this has also involved a movement away from individual control of their teaching towards a more shared team approach to teaching responsibilities. A strategy to enhance the developemt of shared control is teams reviewing what they have learned about teamwork and reflecting on issues of power, decision-making and control that emerged in the team.

Conclusion

I conclude that just because an initiative is designed as a problem-based learning one with tutorials there is no garuntee *per se* that dialogic knowing will occur. Rather, dialogic knowing has to be constructed in the oscillations of students talk in the tutorials. Dialogic knowing involves a movement towards more democratic social relations, co-construction of knowledge through co-elaboration and movement toward shared control. The concept of the PBL tutorial as a potential site for dialogic knowing gives us new ways of both theorising about and facilitating PBL tutorials. For details and examples of practice strategies informed by an understanding of the three dimensions of this concept see a chapter on maximising the PBL tutorial for creating dialogic knowing (Barrett and Moore 2010**).**

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LEARNING THROUGH PROBLEMS: PERSPECTIVES FORM NEUROSCIENCE

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ABSTRACT

The founders of problem-based learning (PBL) saw it as a natural, effective process for human learning. Independent research supports the educational and philosphpical principles of PBL, but neuroscience now offers opportunities to examine the hypothesis further. This theoretical paper explores how PBL may relate to some current understanding of the neuroscience of learning, spotlighting four important characteristics of PBL. *Starting with a real problem*: salient topics and empathy maximise frontal lobe activation. *Learning in small groups*: witnessing other people's feelings and reactions to life events leads to emotional contagion via Mirror and Spindle cells. *Structured reasoning and discussion*: complex thinking supports neurogenesis; moments of conceptual development are marked by higher-frequency brain waves. *Making learning enjoyable*: deeper mental processing stimulates endogenous opiods, while a more social, relaxed atmosphere improves blood supply to the brain via the influence of cardiac ganglia. New knowledge of the working brain seems to support PBL processes.

INTRODUCTION

PBL was designed by clinical teachers in medicine during the 1960's, when they observed students struggling to recall basic science information learnt during earlier campus years (Barrows 1979). Interacting with real patients changed students' perception of need for theoretical subjects such as anatomy, enhancing learning outcomes. It therefore seemed logical to *begin*, not end, programmes with true-life 'cases', to integrate rather than separate the informing subjects, and to use guided small discussion groups to increase interpersonal interaction and stimulate dialectical conceptual development.

PBL activities happen to match the findings of influential research into how university students learn, pedagogy that began in Europe (Marton and Saljo 1976) contemporariously with PBL's inception across the Atlantic. It became clear in these studies into higher education that the design of the educational environment was paramount: learners *approached* their tasks in different ways, depending on their perceptions of the need of the material (Entwistle 1977). Students around the world seem to use their social intelligence (see Goleman 2001) to adopt approaches to studying – deep, or surface – according to how they perceive their teacher's expectations. Unseen examinations, for example, can press students to adopt techniques such as rote memorisation, which temporarily stores information in short-term memory, whereas PBL has been shown to very much reduce this need for such surface approaches (Sadlo 1997). Ramsden (2003) identified features of the learning and teaching environment that foster deep approaches to learning – sense of relevance to life, friendly teacher style, not too externally-pressured a workload, assessments salient to real life requirements…… all characteristic of PBL.

PBL matches the innovative philosophies of progressive educators, and even to historical views of human learning. Thousands of years ago the Upanshads advocated talking together in small groups as the pathway to wisdom (Olivelle 1996). Socrates taught through discussing questions (and was executed, because this was seen by the authorities as so powerful, reducing the authority of the State). During the 20th-21st centuries progressives like Dewey, Montessori, Steiner, Piaget, Rogers, and Robinson have promoted educational systems that cohere with the ethos of PBL (Sadlo 2010).

PBL thus applies both ancient wisdom about learning and current research, which makes it a form of evidence-based higher education practice. Research-informed knowledge of the adult learning process can be transformed into ways of teaching in universities. Now another researched-based tool for examining the potential of PBL is becoming available which might have powerful implications in regard to educators' acceptance of PBL. During the last two decades neuroscience has made dramatic advances in our understanding of the conditions that promote human learning. This paper, part of a work in progress, attempts to bridge the gap between neuroscience and education within the field of PBL, as recommended by Tommerdahl (2010). This enquiry also advocates a wider view of the domains of intelligence: cognitive, emotional, social, spiritual and (most recently) heart intelligence.

The applicability of neuroscience is examined using the *history of ideas* (HoI) qualitative research methodology (Wilcock 2006), a multidiscipline approach which traces the development of current understanding through critical appraisal of existing relevant studies. HoI categorises and relates already known facts in a different way, from a particular focus (i.e. PBL) and reviews publications from different disciplines to form a new perspective. It synthesizes prior empirical evidence into a novel construct that may form into testable components (Fuster 2008). HoI aims at interpretation and unification; allowing issues to emerge, and fresh connections made. A researcher can seek theoretical 'saturation', develop themes and go on to construct further hypotheses.

This short paper can focus on only some of the principle features of the PBL process. Its basic, central characteristics, such as starting with a problem, learning in teams, structuring conceptual development, and fostering enjoyable learning are approptiate places to begin this type of scrutiny of PBL.

Starting with a problem

There is evolutionary evidence that problem solving is a hallmark of our species (Nataraja 2008). The human brain grew in size as our predecessors had to learn new information to solve the problems of living in new types of territories (Wilcock, 2006). Our huge pre-frontal lobe in particular is 'designed' to analyse new complex situations (cognitive processing). At 1.3 kilos the human brain is 6.3 times bigger than other species of our size (Wilcock 1995), with 100 billion neurones each with up to 1000 connections (Nataraja 2008). The more extensive the cortex, the more an animal can 'think' for itself, in contrast to behaving in a proscribed manner (Greenfield 1997). The human brain is designed to learn through trying to solve everyday situations. The prefrontal lobe, twice the size in humans as in apes, relates to memory, planning, cognitive flexibility, abstract thinking, and extracting relevant information from sensory input (Gazzaniga 2008). It is seen as the 'doer' cortex, responsible for deciding on purposeful actions, and when the required actions are novel and complex, or uncertain and ambiguous, it becomes even more highly activated (Fuster 2008). Thus, it is appropriate to present messy real-life PBL scenarios.

PBL triggers can therefore be potent forms of sensory stimulation, which is needed to elicit executive attention. Being presented with problem *first* attracts interest, engagement, motivation and empathy. Problems which *need* to be solved attract our sustained attention most (Greenfield 1997). The greater the attention a person pays to a stimulus, combined with the complexity of the demand (effort required) and a perceived genuine need for the material, accelerate activation of the prefrontal cortex (Fuster 2008). Verbal stimulus leads to more left hemisphere activation, whereas non-verbal may lead to more right-sided stimulation, which supports the use of multi-media rather than paper triggers. Stimuli need to be goal-directed for the greatest pre-frontal activation, which explains how pertinent, even urgent real-life practical situations that need specific resolution NOW can the best way to improve student engagement. Teachers who insist that students need subject knowledge first, miss that point?

Emotional intelligence (Golman 2007) also relates to this problem-first technique. Observing real people in difficult situations has the potential to help students identify their autonomic physiological responses to negative emotions they might feel in reaction to the problem presented, as these are 'felt' in the body (Gazzaniga 2008). When we witness others' pain, the same regions in the brain are activated as if we ourselves are experiencing that pain (Goleman 2007). It is been discovered that the emotional centre of the brain deep within the midbrain, the amygdala, receives messages directly from the sense organs, en route to their relevant cortical centre. For instance, a branch of the optic nerve goes directly to the amygdala, en route to the visual cortex, so that we quickly 'feel' facial expressions. This phenomenon can infuse the trigger with even more power to captivate students' attention and empathy, which should further raise their level of engagement. Biederman & Vessel (2006) hypothesise that we are "info-vores" with a craving for learning, especially when we clearly perceive its high relevance and become emotional connected to the material.

Understanding more about moral, ethical and spiritual (meaning) aspects of life may be inbuilt when classes *begin* with real scenarios. If a trigger presented a person with a terminal medical condition who does not have access to needed medication due to financial circumstances, vital aspects of healthcare, society's attitudes to life and death, and personal approaches may be further disscussed and explored. These conditions may foster development of students' spiritual intelligence (see Zohar and Marshall 2000).

It seems then, that *starting* with a problem – PBL's real hallmark - is a vital educational strategy utterly in tune with the brain's highly-evolved natural ability to respond in its rapid and complex way to encountering threats (problems) within the environment.

Active learning in small groups

Collaborative active learning in small groups is very much supported by the fairly recent neurological research into emotional and social intelligence. Mayer et al (2001) suggest that emotional intelligence relates to the perception, use, meaning and management of emotions (feelings) in oneself and others. Acting on a project with others in a small group is the ideal environment to develop this attribute. Apparently whenever we engage with another person, we are drawn into a "neural linkup" (Goleman's 2007:5), which strengthens when we develop our emotional connectiveness. To use Goleman's (2007:4) term, the human brain is "wired to connect". Emerging social neuroscience is rapidly exposing new findings in the field of human relationships, supporting Savin-Baden's earlier findings regarding the ability of small group learning to develop concepts of self - as a learner, and as a group member (Savin-Baden 2003).

Emotional Contagion (empathy), facilitates sociability and apparently activates Mirror cells and Spindle cells (Golman 2007) when people observe each others' feelings and reactions, as students do with their peers during every PBL tutorial. Mirror neurones in the pre-motor cortex, sense the movement a person we are with is soon to make as well as their current feelings, and because these neurones fire so rapidly this quickly prepares us to move in a similar way, and to feel in a similar way. The movements that are particularly important to the sensing of each others' feelings are the movements of the face. Students in a group begin to adopt similar postures, positions and expressions, and may quickly begin to share feelings, even if these are not always expressed verbally.

When people rehearse a movement mentally, such as when students go through the sequence of a skill in their mind, or talk this through with each other, the premotor cortex activates in the same way as if the movement was actually being played out (Fuster 2008), making it seem worthwhile to discuss a new skill within the PBL group before and during specific skill practice sessions. This also supports the PBL practice of learning of pertinent skills at then time when they are relevant to the presented problem.

These mechanisms go towards explaining some of the complexities of our social intelligence: how we read our fellow group members. Such regular stimulation of Mirror neurones via regular group participation seem to build the high level of cohesion that groups develop; students need this regular and quite long contact to experience how they feel for each other, and then the group members begin to 'resonate'. Because these neurological developments in students take time and experience, and yet are crucial to high levels of team membership during professional life, arguments that small groups are too expensive to sustain within higher education today seem counter-productive indeed. Graduates need even higher level of social skill in the complex future world, and skill is developed only through repeated practice (Sennett 2009). Students may come to realise that they are not isolated members needing to look after just themselves, but are members of highly sophisticated interdependent social and multi-professional groups. Higher levels of social skill and team work have been reported as outcomes of PBL programmes. PBL therefore also seems essential for interprofessional education (IPE), enabling students from different professions to feel the subtle variations in response to triggers, and to appreciate the different perspectives taken.

Spindle cells provide another mechanism for developing our social interaction ability (Goleman 2007), providing very rapid communication across our large brains. They multiply manyfold after birth if a child experiences positive interactions with other people, and these cells are deemed to have a central role in the development of intelligent responses and decision making regarding the first impressions we form of each other. They also explain the speed of our social intuition. Spindle neurones have the longest cell bodies and their lengthy single dendrites and axons rapidy connect thinking (cortex), emotional (amygdala) and action (brain stem) regions of the brain. Feelings of liking or disliking a newly-met person are experienced almost immediately, and over time students have to learn about and moderate their reactions to each other, just as they have to do within the world of work. This supports the practice of keeping PBL students together in stable groups for about a year, and then re-arranging the groups, in order for them to experience and adapt these responses again with different people. Spindle cells seem to be a major factor in human beings' uniqueness, and higher order social functioning; we have 'a thousand times' more of them than apes, while other mammals have none (Goleman 2007). These enable us to function as the most socially aware and socially sensitive species on the planet, placing prime importance on small group learning within all high quality education.

Yet another reason to learn in small groups is to increase task engagement. The emotional aspects of learning (mid-brain) have been found to reign over logical decision making (cortex) in terms of heightening motivation and effort within human learning (Immordino-Yang & Damassio 2007). Our need to be seen as helpful group members may be more important to motivation and learning than subject relevance, and the reasons for learning are often explicitely social – to enter a certain profession, to become a learned member of society, or to gain social standing through a degree. Neuroscience now emphasises the strong relationship between emotion, social functioning, and decision making of which teachers should be more aware. Our social natures means that the cognitive, rational decision-making types of learning do not take place in a world devoid of emotion. The connections between emotion and cognition have been previously underestimated. 'Soft' skills can be now more more scientifically understood by tutors. Learning, attention, memory, decision making, motivation are all profoundly affected by emotional processes. Immordino-Yang & Damassio (2007:8) describe this as "emotional thought" - thoughts trigger emotions, while body sensations influence thought.

Moreover, during the past decade neuro-cardiology has revealed how peoples' hearts literally react to being within small cohesive groups. Electro-magnetic fields of the heart radiate several feet from each body, and when human beings meet these fields apparently merge and enhance non-verbal communication and sensitivity to each other (McCraty *et al* 2005). This may explain the advantages and richer feelings of meeting personally together, rather than via the internet. The heart has been reclassified as a major sense organ, central to how the autonomic nervous system reacts and responds. It houses its own 'brain', a complex network of neurones which regulates the heart's role even without interference from the central nervous system. Heart intelligence research shows that the heart plays an important part in regulating the cortical reactions to environmental conditions. Very relevant to PBL tutorials, perceptions of stress quickly restict blood to the brain, inhibiting learning. In today's world, our strong stress response can be activated by perception of environmental threats that are more social (embarrassment) rather than real (big bear). These aspects of personal interaction encourage tutors to support the development of positive rather than negative group dynamics. Learning within social groups is therefore imperative to high quality learning and to the development professional competence, even if the processes are complex and the groups may often experience negative effects, which must to be worked through to learn how to resolve similar issues in 'real' life. Too often these 'soft' personal social skills are seen as unteachable – that students either have them or not through thier personality - not so.

Structuring and challenging the discussion

The guided format of the tutorials, peer and tutor dialogue, identification of learning needs, the independent study and peer learning stages are all designed to foster intellectual growth. PBL tutorials are very purposefully structured to facilitate conceptual changes, adapted to the student's chosen profession. Reasoning is built gradually, starting with discussion of present understandings to activate prior learning (Norman & Schmidt 2000). Explanations, dialogue and challenges may eventually lead to conceptual leaps (Wisker et al 2008) and neuroscience has revealed that such events bring changes in brain activity, especially when creative insight takes hold. Electroencephalograms (EEG) reveal that just before an "aha" moment, there is a sudden burst of high-frequency brain waves centred in the right temporal lobe (Jung-Beeman, 2008). (The well-known image of a light bulb above a person's head which represents a new idea forming is thus rather accurate!)

Tutors need to appreciate that developing new concepts might be perceived as really difficult by students, due to the fact that learning only occurs when new dendrites are formed, through real desire and struggle to understand, which gradually changes the structure of the brain by increasing the number of connections (Greenfield 1997). New insights form via new physical connections, neuronal density increasing as students they learn. Learning can feel 'hard' during challenging tutor/group questions and discussion, but as tutors we can in this regard theorise about the practical relevance of recent research into neurogenesis (Doidge 2007). Discrediting previous understanding, new research shows how that well into later life, many (maybe 10,000) new neurons are 'born' into the hippocampus (mid-brain) each day, to become embedded during following weeks, but *only* if they are really needed. We have to really want and need the new material, and grapple to understand difficult new concepts or to practise complex skills. If learning is insufficiently challenging, these new neurones may not develop to become part of the brain's infrastructure. This new appreciation of neuro-plasticity is one of the most important happenings from the last decade of neuroscience, and this supports the idea within PBL of the tutor gently 'stretching' students' current understanding. Connections in the brain somehow form, die away, or reform according to their use, and re-use. Thus repetition strengthens the connections towards becoming more 'hard wired' and more tacit, implicit and unconscious.

The paramount importance given in PBL to integrating different subjects around each problem is supported by recent theories of Mental Synthesis (Vyshedskiy, 2008). New concepts become synchronised within the pre-frontal cortex from separate 'ensembles' of neurons (items from memory) that reside within various areas of the cortex, during special conditions of attention. "Mental Synthesis is a new never-before-seen image formed from two or more mental images" (Vyshedskiy, 2008: 22). Evidence of new concepts is best detected through language, which is another advantage of the discussions within PBL tutorials. Vyshedskiy demonstrates that visual planning and imagining actions within the mind (a common PBL activity) is a uniquely human trait. Thus the structured logical format of the PBL tutorial and the cycle of different tutorials is supported by these new findings from diverse areas of neuroscience, although at present we can only hypothesise about the potential application of these studies.

Fostering enjoyment in learning

One of the main intentions of PBL is to create an enjoyable, more natural learning environment, and now neuroscience does support the idea that quality of learning is enhanced in such circumstances. Recent studies reveal some of the mechanisms that - in theory – seem to reward higher learning: termed cognitive pleasure. İt seesm like a paradox, but students' reported enjoyment of PBL may actually be associated with their struggle with new concepts as described above - because the more complex conceptualizations are processed deeper into the parahippocampal cortex, where it happens that there is greater density of opioid receptors (Biederman &Vessel 2006). There is growing evidence that internally generated endorphins may be released to reward our innate hunger for information (Le Merrer 2009). The human brain is "wired for pleasure" according to Biederman &Vessel (2006:249) and we have been using substances to stimulate these particular neural systems for millenia. Morphine is the potent ingredient within these natural (endogenous) opiods, which of course is also a pain killer. According to these authors, the reward-for-learning system is seen to have evolutionary and reproductive advantages, with our preferences for clever or skilled mates.

If difficult learning makes us feel good afterwards, we are more likely to continue to challenge ourselves through seeking ever greater conceptual leaps, or to learn even more complex skills, which in turn facilitates material increase in the structure of the brain. This phenomenon relates to the expotential growth of information sites on the internet, so hungry are we for more understandning of our world. Spindle neurones may also play a role in the nice 'feelings' of social interaction and learning new things together during the tutorial, being rich in receptors for serotonin and dopamine (Goleman 2007) which play key roles in social bonding and improved moods.

Another possible neurological explanation for PBL being an enjoyable way to learn is that students may enter 'flow' states during their tutorials and self-directed learning (Barrett 2010). Awareness of the Self switches off during complex mental processing, which may explain how students become so fully engrossed in their discussions (Goldberg et al, 2006) and lose track of time during the tutorial, or during reading. Flow is a state of altered consciousness produced during deep engagement in the most complex activities, which has also been described as optimal human experience (Csikszentmihalyi 2002). People report greater perceptions of connection during flow, and even spiritual feelings. Spirituality can relate to the profound meaning of the material to a person, and it facilitates the perception of connections with the wider world (Zohah & Marshall 2000). Learning for human beings can be thus a positive force, a natural way to enhance our experiences.

The absolutely crucial importance of a relaxed supportive atmosphere during PBL tutorials is supported by neuro-cardiology research: cognition is enhanced when stress is low because the heart sends more blood to the cortex (McCraty 2002). The heart's own intelligence, via the extensive cardiac ganglion, instantly responds to our emotional states in very refined ways. Perception of threat increases blood supply to the limbs by cutting it to the brain, the very opposite of the conditions students need for learning. Teachers who use techniques that induce stress in students should realise that their efforts will have the opposite effect. Reducing stress within the learning environment needs to become the highest priority for teachers everywhere, because chronic stress is such a killer, reducing the immune system's capacity. Creating a relaxed, fun, socially interactive but supported atmosphere during tutorials needs to be an imperative for all PBL tutors.

Conclusion

In these ways and many more (for example, that learning in context enhances memory) PBL is a form of education whose efficacy can now be analysed and explained through our growing understanding of the neurology of learning. We need to *begin* with relevant problems to stimulate the human brain's primary design for solving problems, and to activate our motivational and reward systems. Learning in active small social groups is vital to developing students neural networks for social intelligence and empathy, while structured discussion potentially offers the right conditions for increasing brain mass, supporting neurogenesis. Creating a relaxed atmosphere within the PBL tutorial is a good technique to enhance the quality of learning, because it allows the heart's own intelligent system to respond by maximising the cerbral cortex's energy supply. The last decade of neuroscience has greatly enhanced our understanding of how human beings learn, and PBL processes stand out strongly in this light. Traditional, separate subject lecture-based courses do not seem to be supported by this new knowledge in the same way. However, we do need to share more about how exactly we actually play out PBL, for it has become a too widely-interpreted term.

In the future neuroscience may reduce the guess work and controversy regarding how best to design courses which support students' learning and enhance their experiences. For future PBL research, brain imaging studies could be designed. Isn't it time that educators everywhere took advantage of the explosion of findings from neuroscience, to more fully understand and appreciate the optimal conditions for human learning?

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CONTEXTUALIZING A PHYSICS COURSE IN A PO-PBL MODEL: STUDENTS' PERCEPTION

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ABSTRACT

This document brings in a comparative study of the perceptions of medicine and biology students at the end of an obligatory physics course in Los Andes University (Colombia). The comparison was made between students that took the course with the original design implemented by the physics department based on lectures, and students that took the course run under a new proposal based on the PO-PBL model. Both sections were taught by the same teacher. For this, interviews and open-questions surveys were used to explore the activities carried out and their pertinence for the learning of physics, as well as the relevance of the course in their professional future. The results show that the design of the course has direct influence in the pertinence that the students find in it for their profession; moreover, the course based on the PO-PBL promotes learning involving abilities, beyond the usual contents of the course.

INTRODUCTION

Most of the university level physics curricula have been designed based on the model provided by the Physical Science Study Committee (PSSC) at the end of the 1950s, whose main focus was to identify the next generation of physicists (Gunstone 2004). However, in the last 50 years many other disciplines as chemistry, biology and medicine have made important progress based on the developments achieved by physics. Physics has become fundamental in the formation as scientists of new students of these disciplines, but few or none of these students want to become physicists in the future. They need a more contextualized use of physics tools in their respective disciplines. This situation is a challenge for academics that teach these courses, in relation to the meaning of learning physics for other scientists and how to achieve it in one year, which is a short period of time compared to the four years for the physics major.

Since the 1970s, *Physics Education Research* has been developing as a field of research focused on the teaching of physics. Gil Pérez (1994) presents an assessment of this field which identifies that one of the great challenges is to get university teachers involved in the process, since most of the research nowadays is addressed and carried out in the teaching of physics in school. The Andes University in Bogotá (Colombia) does not escape this problem. During several semesters, some teachers from the physics department have had difficulties in the physics courses taught to biology and medicine students: the number of students that withdrew or failed the subject was high and in many cases the students that remained memorized the exercises, far from making any sense of them. For this reason, at the end of 2009, a cooperative process between the teachers and a group of researchers of the *Centro de Formación e Investigación en Educación* (Center for Research and Teaching on Education – CIFE), started to design, implement and evaluate a proposal to reform these courses.

In the first semester of 2010, the team found that the students of these disciplines considered that the course was not useful or relevant for their professional education (Hernandez et al. in press). In addition, many students complained about having to devote too much time to the course for poor results. The teachers' concern was then to think of alternative class designs that could help the students in two main aspects: 1) the course should be relevant for their disciplines; 2) the learning process should be more focused on making sense of the contents and ways of thinking physical phenomena rather than memorizing.

In the second semester of 2010, two physics-1 courses were developed simultaneously: the first one with the original design used by the physics department and the second one inspired on the Problem Organized -Problem-based Learning model (PO-PBL) proposed by the CIFE. The purpose of this document is to present a comparative study between the perceptions of the students that participated in these courses into two categories: 1) Course design and relevance to the students' disciplines, and 2) Ideas about learning. The paper begins with the course's description, then introduces the methodology used, and finally it presents and discusses the results found.

Design of the courses

The original course model has five hours of attending class and four hours of students' autonomous work. Three out of the five hours of class are lectures given by one of the teachers of the department who is a PhD in physics. These lectures are taught to a large group of students (between 40 and 90) and do not consider their professional orientation; the teacher presents the contents of the course, carries out some example exercises and answers the students' questions. The students must attend the lecture and they must have read the material they were given so that they can interact with the teacher. The other two hours, called problem session, are under the responsibility of a student of the master's programme in physics and are carried out in groups of maximum 25 students. The students are expected to try to solve the exercises provided in the textbook and in this session they are able to discuss their difficulties and see how these text problems are solved. In many cases, they have to answer quizzes or are requested to hand out their exercises as a pressure mechanism to have the students up-to-date with the course.

The course evaluation is done by means of three written exams, with exercises similar to those solved in the problem session, a mark given to a work developed in the problem session and a final exam that covers the entire course content. This type of evaluation assumes that the students must be able to solve problems similar to those they developed, since solving them demands recovering the relevant information from the memory and applying it to the new problem (Ceberio et al. 2008). The vision of teaching of this course design is more focused on the teacher (Laurillard 2002), and the emphasis is on how the teacher organizes the contents of the course in a structured way so that it is easier for the students to approach this discipline.

The new design was inspired by the Problem Organized - Problem Based Learning - PO-PBL- model of Aalborg University in Denmark. The vision of teaching of this model focuses on facilitating students' learning and is called student-centred teaching (Laurillard, 2002). For this purpose, the teacher assumes a double role: in the first place, that of a designer of courses and activities that guides the students in their learning; in second place, that of a companion that helps the students to appropriate tools and ways of thinking of the discipline they are learning. Kolmos (2004) explains that PO-PBL is based on guiding the learning process from a particular problem. This problem determines the direction of learning and emphasizes the formulation of questions instead of answers. Through the project, it is envisaged that the students will determine the problems that are relevant from a specific theoretical framework; they are also the ones who look for a possible solution; all this, taking into account their particular interests. This long-term process using problems opens the opportunity to relate concrete experiences of the students with the theory; this is decisive to develop the ability to analyze in the learner. In this way, the students are expected to attain a deeper comprehension of some selected and complex problems, so as to address new fields or fields similar to their subject in a more skilful manner.

On the other hand, within the PO-PBL framework, two realities of the problems have to be dealt with naturally in a concrete context: its interdisciplinary character and its team-based approach. First, many of the problems that are interesting to solve break the boundaries of traditional disciplines. Second, the most natural way to try and solve a problem is in a team. From the teaching perspective, this model makes it explicit for the students the need to cooperate in a group and to promote processes that will let them progress and finish the project. Hence, the project is assessed in a comprehensive oral examination at the end of the semester on the basis of a 75–100-page type-written report. The implementation of the PO-PBL takes different shapes according to the careers and faculties, but in general its intention is that the students will devote half of the semester to the courses and the other half to the project (Kolmos et al. 2004). It is foreseen that half of the courses will support the work on the project, and the other half will provide theoretical bases in areas that are considered fundamental for the profession.

Thus, the CIFE's proposed design included a project so that the students, in groups, would look for a problem in their discipline that could be addressed from physics. The project took 20% of the total time of the course, and every four weeks there were specific sessions in class for feedback. The remaining time was re-distributed into two two-hour lecture sessions per week; these sessions are attended by the teacher, the teacher assistants and all the students of the course. During the first session of the week, the Peer Instruction proposal developed by the physicist Eric Mazur (1997) was implemented. In that session, a dialogue within the students is generated starting from questions focused on the concepts; then, the teacher joins the discussion, helping the students to negotiate meanings and to discuss theory in a deeper way. In the second session, the students were divided into groups of three to develop workshops more centred in the mathematical procedure, but introducing problem-solving strategies (Becerra Labra et al. 2005; Ceberio et al. 2008; Selçuk, et al. 2008). Both strategies also correspond to student-centred teaching proposals.

Finally, Biggs and Tang (2007) talk about the importance of designing aligned courses. The main characteristic of the aligned courses is that the teacher explains clearly what the students are expected to learn, using verbs such as generalize, argument, justify. Then, the teacher designs class activities through which the students are able to execute these actions. To finish, the course evaluations measure the level of performance of the student in these same tasks. In our case, aligning the course implied including criteria in the evaluation to estimate the quality of the project, and two changes in the written tests: first, introducing open questions to assess the qualitative appropriation of the concepts in addition to the usual problems; second, students were allowed to have resources such as the book or summaries for personal use during the examination.

Methodology

Ending the second semester of 2010, as part of a bigger study, we conducted a survey with closed and open questions, which was answered by 39 students in the original course and 26 students in the new course. In addition, six students were interviewed in each course, using a semi-structured protocol. In both instruments, the questions addressed the difficulties identified in the first semester of 2010 (Hernandez et al. in press), with the purpose of identifying strengths and weaknesses on the different activities carried out in each course, and their relevance for learning physics, as well as the students' and the teacher's role in these activities. Part of this material is used in this paper as qualitative data about the students' perception of the physics course developed.

The interviews and surveys were transcribed by the research assistant, and then analyzed by the main researcher in this paper. The categories are the result of identifying patterns and combining them with the initial purpose. In the first category - Course design and relevance for students' disciplines - we analyze the students' view of the activities in each course, the time used, and if the learning appropriate by them is relevant to their professional careers. In the second category - ideas about learning - we discuss the most relevant learning for the students and some of their conceptions about how they learn physics. The results found are presented below, using some relevant excerpts from the interviews that have been translated from Spanish (*in italics*).

Results and discussion

Course design and relevance to the students' disciplines

The students from the two courses that were interviewed were between second and third semester of biology and medicine. The experiences of the majority were related to the physics courses in school, since only one of them had taken a physics course at the university before. They all considered that there was a great difference between the two experiences. One of the students said:

> "*I did great [at school] and I thought that I had good bases; when I arrived here, I realized that definitely I did not, because of many things I do not know, and that this is much more complex and I am still far from being at a good level*".

They also said that they had references of the course from students of other semesters that considered that the course was difficult and not very relevant. Many of them said that they feared their results on the course at the start of the semester.In the original course, the general view of the students was well expressed by one of the students who stated:

> "*the lecture is where the teacher gives the bases and the complementary section is where you complement with exercises, you improve what the teacher has explained*".

All of them agree that the teacher "*is excellent; the effort he does so that we understand is notable; he is very didactic, illustrates a lot; he gives examples, brings material to the* *classroom to show us things and he was concerned about us*". Several of them also said that "*the teacher not only explained the theory but also did exercises and gave advice for problem resolution that was of great value for evaluations*". However, the opinion of the students about the teacher assistants (Master's students) that assisted them in the workshop sessions was divided. While some students considered that this was the opportunity to "*ask about difficult exercises for him to explain them and with his help I can see my mistakes*". There were also statements as:

> "*I felt that he did not understand what I was asking and he answered something completely different that made me more confused*".

In this sense, for the students the utility of the problem session depended a lot on the teaching skills of the Masters' student.

During the autonomous time, the activity they did the most was developing exercises from the textbook, especially during the week before the evaluation; this activity was infrequent in other weeks. A student said that in many cases she studied with a group of peers because "*we support each other, we make each other calm and we solve questions together*". Nevertheless, also many of them manifested "*I am studying a lot and I see that the results do not correspond to the time I am devoting to the subject; I study and I expect the evaluations to be easier... I don't know... What the teacher says is easy and then half the group fails... I don't understand what's happening*". This sensation goes hand in hand with the difficulty to find the relevance of the course for their career: "*a student of engineering that does not know physics, hum... But if a doctor does not know physics, it doesn't matter*".
Another student said:

> "*this course must have a utility, but I don't know yet what it is... The teacher sometimes does applied exercises and there you can realize... But not that much*".

In contrast, the students from the PO-PBL oriented course considered that the two sessions they attended were relevant and they were related to each other; comments like the following were common:

> "*in class we were able to apply both the conceptual aspect and the mathematical abilities, since developing the problem in the mathematical aspect allowed as well a*

view of the conceptual aspect, and the conceptual aspect guided me in the development of the problem".

Many of them said that the conceptual session "*motivates you to study on your own; it is almost impossible to attend if you haven't done anything; you have to be prepared and ready to solve your questions*". They also mentioned that "*time is used in a better way because the teacher solves the questions we have instead of spending the whole class explaining things that you can read in the book on your own*".

Only one student said:

"*it bothers me that the teacher does not answer my questions accurately; I would prefer him to explain*".

As regards to the workshops, they said:

"*these are more complicated than the conceptual session; sometimes I feel frustrated when I cannot do the problems... But the teacher or the assistants are there to help and I feel supported*".

Most of the students considered that "*at the beginning the relationship with the teacher and the teacher assistants was difficult because they did not explain but asked questions instead... But then it improved because I felt that I could do what they asked me to do and discuss with them*". In addition, they identified that work with students "*is an academic support because with our own language we are helping each other; there are different levels of learning and the good thing about that is that someone takes the initiative of starting the problem and the others pay attention, ask questions and we solve it together*". However, many expressed difficulties due to absence of some group members or communication problems.

As regards to the project, the six students manifested ideas such as "*the transversal project lets us study and apply the course depending on our likings and our major, so that is more interesting*". Several agreed that "*in the project you focus on some matters but it would be good to see what others did; for sure like this, the whole course will be covered*". The great inconvenience they find in the project is that "*there hasn't been enough time to talk to the teacher about many questions that arise with the project and which need to be clarified to submit it*". They considered that the class sessions devoted for this purpose were not enough.

When asked about the activities in the autonomous time, all the students said they had used an average between three and four hours every week to "*read and write summaries before class and work in the exercises left in class*".

Many of them identified a change in their study habits:

"*I frequently do things in the last minute, close to the exams, and am in a hurry; but here, because of the workshops and questions during class, you have to be there, week by week, studying; thus, when the time of the exam comes, you have really devoted time to everything*".

One of the students said:

"*I have learnt a lot; the fact that I don't like physics is something else, but I have indeed learnt*".

Likewise, the six students see a clear relation between the course and their professional education; one of them said:

"*as physicians, they are guiding us towards research and this course, especially the project, helps me a lot for that*". Another student also manifested: "*the project helps us in research because those are not simple problems and they are problems that we can apply in our career; there's biology and medicine problems, not only forces or cars*".

In our interpretation these results show an important relation between the design of the courses and the relevance these may have for the students. As has been discussed for several years now (Laurillard, 2002; Lueddeke 2003; Lindblom-Ylänne et al. 2006), courses with a view of student-centred teaching generate greatest motivation and commitment in them. However, a great extent of this relevance of the course for the career is related to the development of the project, which is consistent with research on the PO-PBL model (Kolmos 2004; Kolmos et al. 2004), and implies that the students can identify for themselves the areas in which physics is relevant for biological or medical problems. For our study, this point is particularly important because in many cases the teaching of physics tradition does not highlight this relevance for the future of students from other disciplines, as we presented in the data for the original course.

Ideas about learning

Original design (39 students)		Design inspired in PO-PBL (26 students)	
Learning perceived	Students	Learning perceived	Students
Quantitative problems solution	13	Group work	9
Work and energy	11	Bio-medic applications	6
Force	10	Problem analysis	6
Organizing information	6	Energies	6
Torques	6	Fluids	6
Physics-everyday life relation	6	Integrating topics	1
It is not enough to attend class	1	Autonomous work	1
Vectors	1	Management of study time	1
Loose fear of physics	1	Analyzing graphs	1
Analyzing graphs	1	Participate	1
Claiming about evaluations	1		

Table 1 Results of the open questions survey that explored about the three most relevant learnings that the students considered they had acquired.

In their interviews, the students of the original model highlight the importance of problem resolution, as mentioned by one student:

> "*the teacher's explanations enable the development of the ability to have more options at the moment of solving problems, and you progressively adopt diverse paths to get to the solution*". They identified that "*in the problem solving session they explain things in a more procedural way, with more steps, how things are done*".

These fragments are consistent with the results of the Table 1 and with a vision of teaching centred in the teacher, in which contents are most relevant (Laurillard, 2002); also, problem resolution is considered the evidence of learning, as it recovers the pertinent information from the memory and the application of this information to the solution of a new problem (Ceberio et al. 2008). Constantly, the students consider the explanations of the teacher as a key for learning, to the extent that a student manifested:

> "*I would not like to be in that other section [the new design], because I have been told that the teacher does not explain and you have to start directly to do exercises at ones*".

Only one of the interviewees expressed that the passiveness of the student generated by a lecture may become an obstacle for learning:

"*you are here and the teacher is there doing things and you think that you are understanding, but the fact that you are passive, sitting without doing anything, without the need to do an exercise... So you say, ok, this is the explanation, but then they give it for you to solve it and then I ask myself: 'What do I do now?'*".

In the interviews with the students that were in the PO-PBL inspired course, there were expressions such as "*if you are going to do research, you will always need help, interact with many people and work in group... The class is useful because I am used to being very independent and here I was asked to work with other people, to discuss and draw conclusions from different ideas*". Or "*the course enables a more critical thinking for the analysis of any medical problem, since beyond the medical aspect there is a biological and physical substrate. Thus, although you don't apply formulas at the moment, you have the ability to think critically*". These statements are consistent with the information of Table 1, which comprises a diversity of disciplinary concepts and abilities. In particular, we observe that these students use more contextualized physics concepts referring to bio-medic applications and they give great importance to the abilities developed. These results may be directly related with the abilities that the PO-PBL model intends to develop, such as team work, the ability of relating theory with practice, decision making and the possibility to address new problems in a field of personal interest, using the tools developed through the process (Kolmos et al. 2004; Ceberio et al. 2008). Finally, we identify a clear perception about the relation between learning and experience, as stated by a student:

"*the practice, the experience, reinforces what you are learning*".

Conclusions

The results of our research show that the students from the original course felt comfortable with the design of the course; however, their academic results were not as expected and they did not find much pertinence or applicability of the course in their professional careers. In addition, the learning they perceive is directly related to the contents of the course and problem resolution, and greatly conditioned by the activity of the teacher.

On the other hand, the students that participated in the course inspired in the PO-PBL model described changes in their study habits and in the way they interact with the teachers and the other students; there were uncomfortable at the beginning of the course but then gained the trust and support they needed to finish the course. They identified learning both in content and in the development of abilities such as group work and analysis of problem situations. Through the development of the project, they found pertinence of the course for their professional education and identified physics topics that are useful for their disciplines.

Throughout the document, our data do not provide new insights into the effectiveness of student-centred teaching or the PO_PBL model. However, for the design of physics courses for other scientists our research opens a door in relation to the meaning of learning physics in Higher Education. For the students, developing the project allowed the possibility of contextualized physics research, and for the physics teacher could be a way to involve students from other disciplines in the process of *making physics*. This perspective is new for these academics and implies a particular challenge in giving the necessary support to the students in the project.

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SMALL PROJECTS: A METHOD FOR IMPROVING LEARNING

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ABSTRACT

New methodologies, associated with the Bologna process, are needed. Ideas concerning problem-based learning (PBL) developed after running different experiences in different Spanish Universities, are discussed. The driver for introducing PBL has been the requirement for studying Mathematics by the Engineering students. After describing some experiences carried out during several years in different Spanish Universities, drawing some general conclusions and after analysing advantages and disadvantages of the introduction of PBL in the mathematical curriculum a hybrid of problem-based learning methodology for Mathematics in Engineering studies is proposed. The model is a combination of formal lectures, practical and laboratory sessions with autonomous small projects.

INTRODUCTION

The teaching of mathematics in Spanish engineering schools still uses in a significant way the traditional methodology: plenary lectures and practical sessions mainly. However, adaptation to the European Area of Higher Education (EAHE) must involve a new teaching and learning model, based on competences, with active methodologies. Therefore it will be necessary to adjust all methodological resources to this new scenario and analyze the influence of the new methodologies and evaluation procedures in the development of competences required.

In this paper we analyze a methodology proposed for Calculus and Linear Algebra for engineering students that is thought to contribute to competences development. It could be said that the meta-competence associated with Mathematics courses for first year engineering students is the ability to master the mathematical techniques that allow students to solve engineering problems. These techniques are beyond mathematical concepts. Thus, the teaching of mathematics should always be mindful of problem-solving strategies.

Problem-based learning (PBL) is a student-centered instructional strategy in which students collaboratively solve problems and organize their learning process, with support from a tutor or instructor and connecting disciplinary knowledge to the real world. Basic concepts needed to solve the problem are acquired during the process. This learning strategy enables engineering students to develop competences such as self learning, teamwork, use of new technologies, etc.

The use of PBL started in 1969 at McMaster University in Canada, for the study of Medicine. Today it is successfully implemented in many Medical and Engineering programs in different universities (Maastricht, Aalborg…). A study about the suitability of PBL for Engineering Education can be found in (Perrenet *et al*. 2000).

PBL contributes to raising the motivation of students and generating more interest in their subject matter. However, there are drawbacks to implementing this model as the principal teaching strategy in a first course of Mathematics in Engineering because, at least in Spain, very often students do not have enough technical and mathematical knowledge to understand and solve problems in a PBL context. Certainly PBL is useful when learners become more competent. But early in the learning process, learners may find it difficult to process a large amount of information in a short amount of time.

There are teachers suggesting that for beginners, minimally guided instruction is likely to be ineffective (Kirschner, Sweller and Clark, 2006). Because novice learners should be provided with direct instructional on concepts and basic procedures required by a particular discipline. Learning implies to effectively combine new information with old information stored in long-term memory. If nothing changes in long-term memory, nothing has been learned (Sweller, 2006).

Furthermore, several studies show that PBL early in the learning process is a less effective model than other hybrid methodologies (see Kirschner *et al*. 2006). In (Sweller 2006), worked example methodology is defended as an effective instructional procedure, using knowledge of human cognitive architecture. In the other hand, the presence of domain-specific knowledge is necessary during the different stages of the problem-solving process (Segers *et al.* 1999).

Strobel and Barneveld (2009) summarized, compared and contrasted the findings of several meta-analytical researches on the effectiveness of PBL in comparison to traditional forms of instruction. They established four categories:

- Non- performance, non-skill oriented, non-knowledge-based assessment.
- Knowledge assessment.
- Performance or skill-based assessment.
- Mixed knowledge and skill-based assessment.

For the *Knowledge assessment* category, measures tended to favour traditional learning approach. But for all the other categories measures are superior for PBL

However the teaching of mathematics in the first year of engineering school has its own peculiarities. Even some of the institutions promoters of PBL learning, (for example Aalborg University) do not use PBL as the unique learning strategy in mathematical topics in the first year curriculum.

Mathematical problem-solving within engineering asks for knowledge of mathematical concepts, skill in solving techniques and insight in the relationships between them. Definitions, concepts, methods and strategies need guided learning. Furthermore, computer technology is now commonplace in teaching and learning, and Computer Algebra Systems (CAS) have become indispensable tools for solving mathematical problems in engineering. Obviously, students need some training in the appropriate use of these tools.

Therefore, after several successful and unsuccessful experiences, we propose a hybrid problem-based learning methodology in Mathematics courses for Engineering called *The Small-Project model*.

The following sections introduce some of these experiences and the final section describes in detail the proposed model.

Experience in projects in the subject of linear algebra

At the Polytechnic University of Madrid in the new Degrees (Mechanical Engineering, Electrical Engineering, Chemical Engineering, Electronics and Automatics Engineering and Industrial Design and Product Development Engineering), that began to be delivered the academic year 2010-2011, 6 ECTS were assigned to Linear Algebra, whose content is the standard one: vector spaces, linear applications, Eigen values and eigenvectors , Euclidean space and transformations (orthogonal and similar). The face-to-face teaching (5 hours per week) is divided in to two hours of formal lectures, two hours for practical sessions and one hour of computer laboratory or tutorials.

Students' personal work includes the solving of problems posed by the instructor and the drafting of a project in which some concepts of Linear Algebra seen during the course are used. Both activities are done by groups of 3-4 students. The project contributes 10% to the final grade.

The students are free to choose the project topic, although the professors offer a guiding list including: *Kirchoff laws for circuits, discrete dynamic systems, matrices and cryptography, sets of linear equations and magic squares, distribution of temperatures in equilibrium on a square plate, the Fibonacci sequence and the golden ratio, Leontief economic models, applications of eigenvalues to genetics and population growth*.
All groups of students chose some of the projects quoted in the above list.

Some characteristics of the experience:

- A list of books, articles or web sites, together with the instructions about the project, has been provided for the students.
- The number of hours estimated for dedication to the project was 15-20.
- The students were able to attend tutorials with their instructor as often as they felt necessary in order to check the progress of their work and make the requisite consultations for the elaboration and understanding of the topics of the project and the best way to present it. Some of the groups never took advantage of these tutorial activities.
- The work had to be presented in class and the students had to contribute a Power-Point presentation and a report in Word or PDF format (10-15 pages).

Some conclusions from the experience:

- The difficulty of the projects was not homogeneous. In some of the projects the students were asked to provide a previous study of the problem to be analyzed or technical knowledge that is not usually available to first-year students.
- The presentations and the quality of the projects were very inhomogeneous and there was a fair degree of correlation between the quality of the work and the other grades obtained by the students. There was also a tight relationship between the grade obtained by the groups of students and the number of tutorial sessions they attended.
- Instructor proposed questions after the presentation, for guarantee the minimum aims for all members of the group.
- Taking into account the questions proposed by the students in the tutorial sessions we can conclude that the greatest difficulty found by the students in certain projects was the modelling of the problems and their translation to concepts in Linear Algebra.

Project experience in the subject applies mathematics I

Since 2009-2010, Salamanca University (Zamora Polytechnic School) has been offering a Degree in Construction Engineering. Its curriculum includes the subject of Applied Mathematics in the first semester. This subject is worth 6 ECTS and it has a fairly generalist content, mainly oriented at the fundamentals of Calculus in a single variable. The degree is offered to 130 students, divided, for formal lectures, into two groups of 65 students each.

The initial mathematics training of the students is highly heterogeneous and the course essentially serves to achieve common training objectives, supported by a very exhaustive tutorial system with the students who have basic initial deficits in their knowledge.

The autonomous work of the students (organized in groups of no more than 3) involves the solution of different problems related to the course contents, doing practical work on the computer, and the drafting of short projects in which some mathematical technique related to the course contents is used. The final grade is obtained with autonomous work (60%) and individual written exams (40%).

Each of the quoted projects involves work lasting about 15 hours and the electronic document should address different aspects related to the problem posed: a historical overview of the problem, the mathematical modelling and solution, the industrial or technological solution, and the sources used in the work. The students attend an initial tutorial with the instructor to receive additional information about the project chosen and a final tutorial to solve any doubts that might have arisen while the project was being prepared.

Below we analyze the results of our experience gained over the past two years with two projects from the list of projects proposed to the students in their first year: *The golden ratio in constructions* and *Why TV antennae are parabolic*?

The above projects were addressed by 10 groups of students, with a total of 25 students involved. The mean grade was 7.23 (none of the groups failed) and all the students who performed these works successfully passed the subject at the end of the course.

Regarding positive aspects, the following are of interest:

- The students were comfortable working as a team and were able to share out the various tasks under the supervision of the instructor.
- The students were happy that the learning process was linked to “real situations” and worked more enthusiastically. Motivation was easier.
- The students attended specific tutorials with a different spirit and participated more willingly.
- The students were able to extract appropriate information from very different sources: books, photos, videos, etc.

The negative aspects would be as follows:

- The students had great difficulties in handling a scientific text processor. In some cases, the tutorial sessions were confounded because of the student’s lack of knowledge of the specific technologic applications.

- The knowledge deficits of the students have made a difficult task the selection of the possible projects. Not all the projects proposed had the same mathematical difficulty and, above all, many of them were not directly related with engineering problems.
- The students try to choose the most attractive project according their professional context and the simplest one from the mathematical point of view.

Finally, there are two problems that must be addressed. The first refers to the work of the instructor, and the second to the work of assessing the students.

Regarding the instructor's work, the compilation of a suitable list of projects (attractive, accessible and with adequate mathematical level) is difficult (more difficult than setting problems and exams) and generates much more work for the instructor (only one instructor for 130 students).

Regarding assessment of the students' work, the numbers involved does not allow them to report their findings in the classroom or the instructor to ask questions aimed at elucidating the true participation of each of the members of the groups. As well as the quality of the work presented, the only indirect assessment instruments that we use are the active participation of the students in the tutorials performed in relation to the projects.

The exposed conclusions were obtained through enquiries (designed for the teacher and general inquiries of the University) with the involved students. Also different feeling about motivation of students and tutorials activities has been appreciated by the teacher.

The main detected problems have been: a correct election of the proposed projects and the design of a personalized evaluation system using projects realized in teamwork.

A project experience in calculus for computer engineering

This experience has been carried out, in the academic years 2009-10 and 2010-2011, at Polytechnic University of Madrid, with students of a first-year course of the Degree of Computer Engineering. The subject Mathematical Analysis includes 1 ECTS devoted to several topics related with Integral Calculus: Indefinite Integrals, Riemann Sums, Definite Integrals, Fundamental Theorems of Integral Calculus, Numerical Integration, etc. The last topic (Numerical Integration) has not been addressed in formal lectures and a small-project was proposed to the students.

The aim of this activity was to develop generic competences (teamwork, use of technology, self-learning and problem-solving) and specifics competences (the use of appropriate mathematical language to describe algorithms and define concepts and the ability for applying knowledge of Integral Calculus and Numerical Methods in a world-real problem).

The students' tasks for the project included:

- To use integration for modelling a problem (different for each students group).
- To autonomously learn two algorithms on numerical approximations of integrals (Composite Trapezoidal rule and Composite Simpson's rule) using references as (García *et al*. 2008), and write a theoretical report.
- To program the appropriate functions to implement these algorithms using the CAS Maxima (Gaertne 2005).
- To test the programmed functions by means of a comprehensive test battery.
- To solve the proposed problem.

The previous experience has been used to improve the project evaluation model and contrast that the estimated work time for the project (10 hours) was consistent with the actual time reported by students. We provide an assessment rubric of the project for clearly showing the student how their work will be evaluated and what is expected. Each group submits a report and a Maxima-file for which they receive a mark. This mark contributes (10%) to the final grade of the subject.

Results: Last year, the above project was addressed by 15 groups of two or three students, with a total of 36 students involved. The average mark in the project was 6.25, very similar to the average final grade for the same students (6.29). Only one student with a mark greater than 6 in the project does not pass the course. The following graph shows the marks obtained in the project.

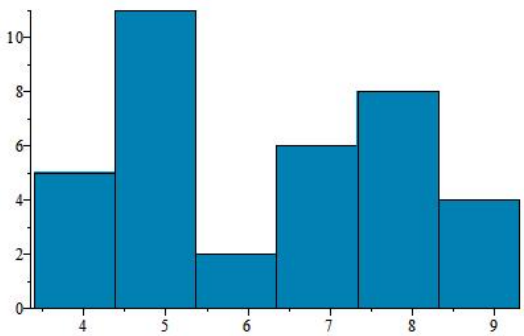

Figure 1: Histogram of the marks obtained in the project

Conclusions and proposed model

In addition to analyzing the experiences carried out in their own universities, the authors of this paper have organized and participated in several meetings in Spain, for exchanging information and opinions with other teachers (I Congreso Internacional sobre Metodologías de Aprendizaje Colaborativo a través de las TIC www.cimac2011.blogspot.com, held in Salamanca in June 2011 or Workshop for Innovative Education at basic subject for Engineering held at the Polytechnic University of Madrid in January 2011)

As results we found:

1. Enhance a mathematics course with some small projects allows students to increase their motivation, improves their understanding of course concepts and a greater satisfaction is obtained.
2. Some students decline to participate in these projects because the contribution of the marks obtained in the final grade is small in relation with the time spent in the work.

Taking into account the literature (see for example Henderson *et al*. 2008 and Hmelo-Silver *et al*. 2006) and our previous experiments detailed in previous sections, we have developed a proposal for future action, focusing on methodological issues, logistics, guidelines and content of a project and evaluation aspects.

The methodology for a course of Mathematics for Engineering students must combine lectures, work sessions, in which students solve problems (sometimes using a CAS) under the supervision of the teacher, individual student work and small collaborative projects.

The basic concepts and skills are taught with a traditional methodology, some specific contents are devoted like a part of the time student work, to develop certain competences, through autonomous cooperative work in small projects.

The framework for projects is:

- Each group (2 to 4 students) must do at least two different small projects in a course of Calculus or Linear Algebra.
- The title of each project must include a driving question anchored in a real-world problem or in a professional practice.
- The problems must be well chosen to be accessible and stimulating for learners (see Wertz *et al.* 2005).
- The selection of the topics involved in the project should balance the understanding of the problem, the motivation and the difficulty for solving the proposed problem.
- For appropriate working in the project students should use essential contents and skill and learn something new.
- Each project should take between 5 and 10 hours of student work.
- The instructions must be clear and precise, including timing, format and tools for using (bibliographical references, mathematical software, etc.)
- Feedback and revision are necessary. Then, for each project at least two tutoring sessions are required: The first one, at the beginning, for organizing the work, and the second one when half the work has been done, for supervision of the project.

Students' work on every small project must include:

- The work planning, defining clearly the tasks to be performed and separate those that are distributed among the members from the ones to be conducted jointly.
- The mathematical modelling of a real-world problem.
- The self-learning of an algorithm or some concrete result of those collected in the course objectives.
- The application of mathematical concepts and results studied for solving the problem (using software if necessary) and the answer to the driving question.

In our model summative and formative assessments are contemplated, together with continuous feedback to students during the academic year. With the projects, the assessment of the application of knowledge when solving problems is the heart of the mater. Then, we propose:

- Projects must contribute at least 20% to the final grade.
- The use of the co-responsibility principle: all student of a group are responsible of the group work. Therefore, we propose an oral presentation, with questions, when possible, or alternatively a small validation test to ensure that all students have achieved the minimum targets.
- A variety of assessment tools is preferable to a simple tool (Macdonald *et al*. 2004)

As a final remark we point that this methodology requires a significant effort of the teachers in order to conceive problems and projects which would lead to significant learning.

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PROBLEM SOLVING, HUMAN SCIENCE AND COGNITIVE COMPETENCIES IN AN ENGINEERING COURSE ACTION RESEARCH IN SCIENCE OF EDUCATION

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ABSTRACT

What do engineers need to be fully operational today? This question covers how and what engineers are taught. A shift of emphasis from knowledge-based to competency-based curriculum has lead to the development of Problem-Based Learning (PBL) as a methodology for teaching future engineers. This case study underlines the strong assets of such a methodology to pass on knowledge and competencies in terms of autonomy, responsibility-taking skills and scientific intellectual abilities when conducting scientific investigations in heritage with the help of an ICT platform. In addition it reveals the need to build strong links between human and engineering sciences to achieve common cognitive goals on a curricular level and forecasts how PBL could be taught to trainee teachers via international networks such as UNESCO's Online Educational Resources (OER).

BACKGROUND INFORMATION ON THE CASE STUDY

This case study was the basis for a research project conducted for Aalborg University's single module training in Problem Based Learning (PBL) at Troyes University of Technology in France. It is one of several study cases which were used to gain an insight into PBL as a methodology of teaching and researching in social and human sciences. Applied to research, PBL is a methodology in which action-research and study cases are encouraged because it allows researchers to work from within a learning environment as much as from without. In fact using this methodology of research it is possible to generate knowledge, to adapt learning scenarios according to ongoing results, to interact and to intervene while conducting the research rather than just observe and record phenomena. (Judith M. Newman and Zhiping Chen 2002).

The content-dependent nature of case studies mentioned by Bent Flyvbjerg (Bent Flyvbjerg 2006) also means that the starting point has to be a real problem encountered in a concrete teaching environment and although it might not lead to theoretical discoveries, it nonetheless relates to a wider context. Josephine Muir (Josephine Muir 2010) mentioning Yin Robert sees study cases as a methodological technique using a protocol in which qualitative observations are backed up by individual coded tools to record quantitative data in the observation of phenomena within a larger phenomenon. This present case study added to two others has led to changes at institutional level in terms of delivering new programmes of study. The starting point for this particular case study is that although students are able to analyse data using some analytical tools, they often lack the ability to identify a problem, to synthesize their experiments and research and therefore to bring new ideas and suggest solutions. In scientific subjects, teachers also note that students' lack of writing and literacy skills means that they are often unable to use linguistic tools to develop logical arguments. Consequently, their reports are narrative rather than discursive and scientific, which becomes a problem when training in companies or industries. So, the first hypothesis for this case study arose quite simply by wondering if the awaited cognitive competencies in engineering subjects could be fully developed through research projects in social and human sciences, and if so what form the training could take using an ICT platform to support the protocol. To answer this question quantitative and qualitative data was collected through the use of formative and normative evaluations, surveys, videoing of oral presentations, questionnaires, and note-taking as well as observations in tutorials or class time. Some individual coded tools have also been used, first to establish the different parts of the cognitive process involved in the research project in heritage, and second to record some of the meta-competencies.

The need for a common European training model

In response to engineers' contemporary needs to adapt to complex problems and suggest creative solutions, Aalborg University has developed a model of education based on problem/project based learning which advocates a holistic approach. This means that students are perceived in relation to their cultural backgrounds and the society in which they live, have to work and are educated. (Anette Kolmos and Jette Egelund Holgaard, 2007) Furthermore, the constructivist theory of education and the way we are now conceptualising the layering of skills intertwined with knowledge and perceiving the interaction between learners' own responsibility and active role in their learning has also fed this kind of methodology. (Biggs 2003). Hence, the development of sustainable, adaptable and transferable competencies is also crucial to the designing of models of education based on problem solving and within them task-based activities, interdisciplinary scenarios, tutorials, the use of ICT, team work and project-based curriculum. However, the role of social and human sciences in the development of these competencies within an engineering study course has not yet been clearly acknowledged.

Social and Human sciences (SHS) and engineering

As Bruner mentions (Bruner 1996), SHS also called '*soft sciences'* are often perceived as good to '*enrich the mind*' but '*hard sciences'* are still recognised as '*pure sciences'*. However, discussions taking place in France seem to show that educationalists and education policy makers are reviewing their position. In fact, an organisation called the Agence d'Evaluation de la Recherche et de l'Enseignement Supérieur (AERES) has triggered some discussions about the place of social and human sciences in engineering study courses following a recent report which puts forward a model of education which encourages problem solving as a methodology of teaching and in which human and social sciences are perceived not only as disciplines to broaden the mind, but also to develop the four transversal competencies they recognise, which are: autonomy, critical thinking, adaptability to an international context and team work. In terms of knowledge, SHS according to the same report, ought to contribute to the bulk of common knowledge and should involve disciplines such as communication, sociology, history, geography, philosophy, sustainable development, to name but a few, as well as languages, interculturalism and management. The disparity in terms of classification means that the palette of courses offered to engineering students is not stable and very much depends on institutions' will and conceptualisation of the place of the SHS in their curriculum. At Troyes University of Technology, the palette is rather wide and the minimum of credits allocated to social and human sciences is 17% over a 5-year course. However, the specificity of the Universities of Technology, only three in France: Compiègne, Belfort-Monbéliard and Troyes, means that there isn't a set of courses to be followed and validated, but rather that an open palette is offered from which students help themselves. This specificity also means that students leave the university with very different backgrounds in those disciplines. So, if students leave with a statutory minimum in English (a B2 level in the common European framework for languages) the rest of the credits are often validated in a patchwork manner across a variety of subjects from management to sports. Therefore, it is difficult to ensure that cognitive competencies are fully and equally developed in all disciplines.

The case study

As the development of critical thinking and the cognitive process involved are the targets, it seems important to spend some time understanding the intricate patterns and the interactions between analysis and synthesis. Riemann, cited by Richter, argues that analysis and synthesis are scientific methods which are complementary and cannot be separated (Richter, 1991). He also underlines the relationship between analysis and synthesis, each one being at play in turn and sometimes simultaneously. The coming and going nature of the cognitive development and process competencies means that a breakdown in fine meta-slices is necessary to be able to assess them. Hugh Dubberly, Shelley Evenson, and Rick Robinson (Hugh Dubberly, Shelley Evenson, and Rick Robinson 2008) came to the same conclusion in terms of the interplay between the processes of analysis and synthesis. They point out the fact that from an inventory, data is analysed, filtered and ordered as the process of investigations moves forwards. After having framed the situation a problem can then be identified. Once the problem has been formulated, documenting on the subject and visualizing the analysis make it easier to go back and forth as images of alternatives and definitions unfold.

In terms of influences on these competencies Kurt W. Fischer and Samuel P. Rose (Kurt W. Fischer and Samuel P. Rose 1998) mention that the capacity for learning and thinking, although happening in spurts according to the age of humans, does not happen in a linear manner and is grounded in neural networks. These networks allow the shaping and reshaping of organized cycles which can feed on previously formed networks and readapt to new ones. However, they stress the fact that such neural activities and networks are only activated when optimal support via the learning environment is given. So, the growth of cognitive competencies seems to depend on the environment and in this sense the teacher's role is crucial to their occurrence and development. In terms of action-research it means that to be truly reflexive, teachers have the responsibilities to modulate the activities in relation to the observations made and the results obtained taking into account that they can vary from class to class.

As for intellectual development and intellectual growth, Bruner (Bruner 1966) says that using words and symbols allows children to go from self-accounting of events to self-consciousness and logical behaviour, which in reference to philosophy he calls the analytical mode. In his opinion, language is used to bring an order to the world that surrounds us and through this ordering process going from enactive actions to iconic representations and symbolic words, language depends on one's ability to internalise a system and to go beyond this system, i.e. to get into the world of abstraction. According to him, language is therefore an '*instrument of thoughts*' and this instrument can interfere with behaviour and cognitive processes. To be able to see several alternatives is therefore linked to the level of the encoding experience, manipulating grammar, vocabulary and syntax to express these experiences, but also at a higher level to the manipulation of categories, classifications, conditionals, hypotheses and counterfactual information. On this basis, experiences are constructed and then kept in storage for later use. Bruner's concept of the layering of experience, solving problems and self-consciousness through language helps build a database of models based on having physically experienced the world. His work is reflected today in the constructivist theory of learning and the way the mind is perceived.

Individual classification of cognitive competencies

The learning objective was to help students move from initial random research to specific areas of research in a given subject, and from analysis to synthesis with some degree of awareness. In order to do so it was vital to develop some tools to record students' initial meta-skills and to record their progress as the course unfolded and activities were created. To visualise and map the classification of the targeted competencies, a variety of taxonomies was applied to heritage and to this case study, i.e. Kolmos Anette, DU Xiangyun, de Graff Erik; Ronald Barnett (Barnett 1994); Philippe Perrenoud (Perrenoud 2005) John Bowden (Bowden 2003), Stephen Fallows and Christine Steven. (Fallows and Steven 2000); Sharon E. and Strauss (Sharon E. Straus et al. 2009).

The competencies were classified as: know-how (savoir-faire), personal and interpersonal skills (savoir-être), and situational skills (savoir-agir). The French terminology is kept here for they form a word family which is not the case in English. If the first two competencies are often known, the latter includes the other two as much as knowledge in action in a given situation to solve a problem. Sometimes some of the meta-competencies seem to belong to more to more than one category or seem impossible to quantify.

Figure 1: table of meta-competencies in step 1: knowledge gathering

Step 1 **Knowledge gathering**	**Know-how**	**Personal / interpersonal skills**	**Situational skills**
	Knowing background field knowledge	Using people's research to inject knowledge	Reusing knowledge covered in class
	Defining subject	Using people's research in personal argumentations	Planning further steps
	Showing understanding interrelationship	Evaluating own progress	**Reacting to group findings**
	Developing an overview of subject	Managing time	**Posting results**
	Using people's research in personal argumentations	**Sharing knowledge with others**	**Planning tasks for each member**
	Using a variety of sources appropriate with field	**Using multimedia interactive tools/platforms to share knowledge**	**Solving conflicts in group**
	Organising meetings		

The process of cognitive competencies was recognised as made up of four steps from random initial research on a given subject (step 1) from which a problem or a question will be identified (step 2), analysed (step 3) and synthesised and solutions proposed (step 4).

The interpretation of the above definitions is individual since they have been created to suit this research. In that sense the definitions proposed here may have to be enriched and meta-competencies within each step changed accordingly even if the process is acknowledged as stable. A detailed analysis and synthesis of meta-competencies was therefore needed for assessment purposes.

Figure 2: table of meta-competencies in step 2: formulating an open-ended question

Step 2 **Formulating an open-ended question**	**Know-how**	**Personal / interpersonal skills**	**Situational skills**
	Situating own question in relation to existing research	Situating own question in relation to existing research	Identifying a question related to the above
		Evaluating own progress	**Formulating a group question**
		Managing time	**Planning further steps**
		Sharing knowledge with others	**Reacting to group findings**
		Using multimedia interactive tools/platforms	**Solving conflicts in group**
			Planning tasks for each member

Looking at the tables below, we can immediately see the different parts of the process and the added value in terms of competencies developed when a research project in done collectively, in bold in the table,. It shows how PBL can be a catalyst to enhance them.

Step 3 **Analysis of individual question**	**Know-how**	**Personal / interpersonal skills**	**Situational skills**
	Expressing cause/effect	Using people's research in argumentations	Formulating more questions from developed parts
	Expressing inter relationships of context	Managing time	Using results from methodological tools
	Expressing hypothesis	**Sharing knowledge with others**	Planning further steps
	Giving explanations for events	**Using multimedia interactive tools/platforms**	**Reacting to group findings**
	Giving factual information		**Solving conflicts in group**
	Drawing conclusions from developed parts of research		**Planning tasks for each member**
	Using a variety of resources used in field		**Adjusting personal methodological tool/results in relation to the others findings**
	Using a variety of methodological tools		**Writing an d posting results**

Figure 3: table of meta-competencies in step 3: Analysis of individual question

Step 4 **Synthesizing**	**Know-how**	**Personal / interpersonal skills**	**Situational skills**
	Giving an overview of findings	Understanding limitations of research	Using results from methodological tools
	Answering individual question	Managing time	Giving alternatives answers to existing research
	Understanding limitations of research	**Sharing knowledge with others**	Formulating future areas of research
		Using multimedia interactive tools/platforms	**Suggesting new developments according to field**
			Reacting to group findings
			Writing and Publishing collective research

Figure 4: table of meta-competencies in step 4: synthesizing

Results of the case study

Thirty-two students chose the course in heritage for which the only enrolment requirement was a minimum level in English. Moodle was used to layer the targeted competencies and knowledge in heritage for each session. The platform allowed a variety of open-ended questions to be posted as examples for students to get used to doing spontaneous and collective research. As the teacher's input was kept to a minimum in class much of the work was done prior the sessions, except for the 'come-together, let's clear misunderstandings and let's synthesise together moments'. So it became clear that the more invisible teachers are in class, the busier they are outside the class working on the ICT platform planning and adapting activities designed to target the step by step cognitive process outlined above. Following Maggi Savin-Baden's guidelines (Savin-Baden 2007) the ICT platform helped in the modelling of the research process and from the beginning students were taken through the different steps of the cognitive process, starting from formulating open-ended questions that lead to knowledge gathering, to group analysing, using a variety of methodological tools normally used in heritage, such as tangible traces, interviews, reports and surveys and synthesising. In terms of collaborative tools, students chose to use Google pages in and outside the class for collaborative projects or group posts. Working in a small multi-media room also implied that there was a maximum of 16 students in each class, which was a big asset in terms of quality time given to them, either in individual or group tutorial settings or as a whole class.

The first table for the 1st step of the process shows that if compiling background knowledge and using a variety of resources seem to be spontaneous, the rest of the meta-competencies needed to be activated through a variety of activities and formative evaluations.

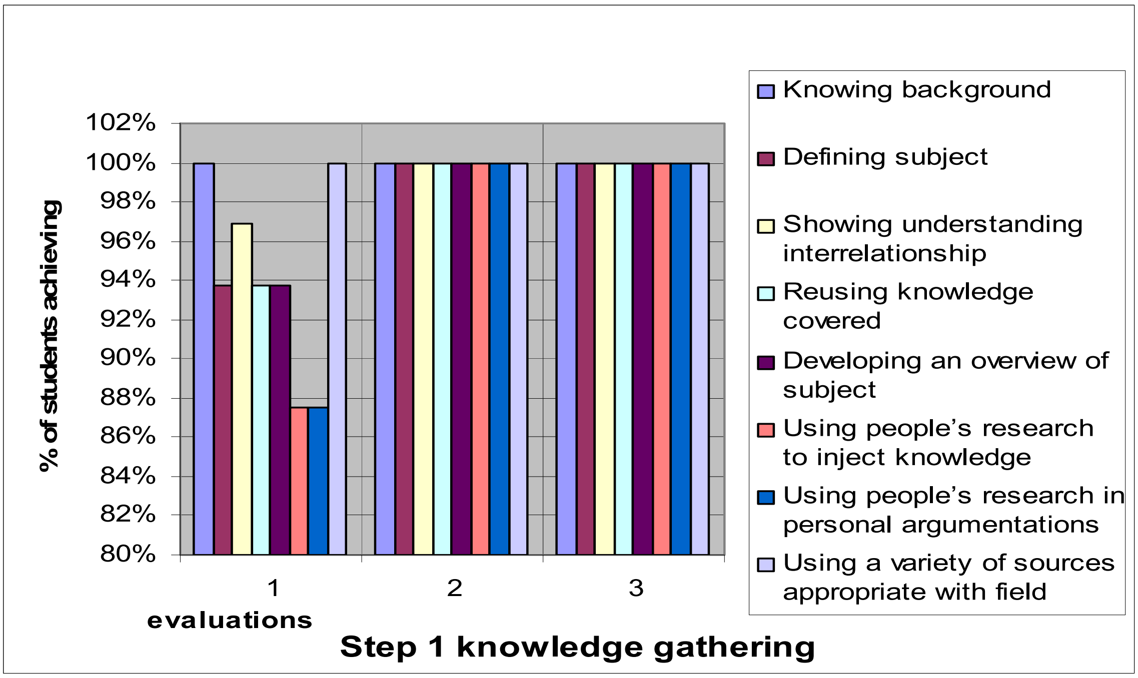

Figure 5: acquisition of competencies trough time step 1

As the objective was to establish what students would do naturally, the evaluation sheet with all the steps and the meta-competencies was not shown to them before the first evaluation but after it. Students seem to agree that if they had known about it before they would have respected it, which might suggest that teachers' targeted learning outcome ought to be made very clear to them before any evaluation.

However if this was true for step 1, figure 6 below shows that for the second step of the process being aware of the targeted competencies does not guarantee their manifestation.

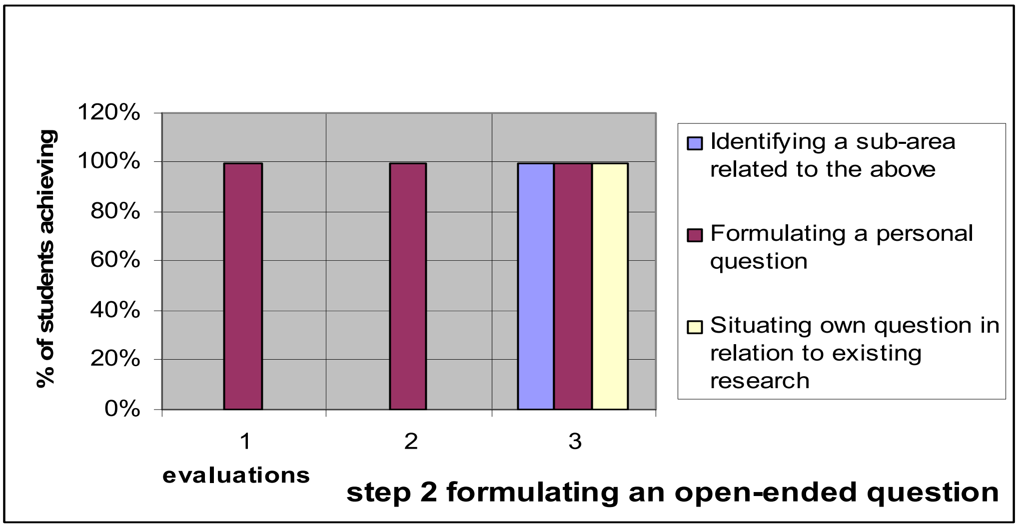

Figure 6 acquisition of competencies trough time

The third step contained a higher number of meta-competencies and students were able to situate their hypotheses in relation to other research and identify a sub-area from which sub-questions emerged only in the third evaluation. The most difficult problem was the formulation of questions or quests since students did not understand straight away that ill-formed questions in heritage could lead to different answers, and that personal interpretations and memories of scientific facts could contradict each other. So it is not until the third evaluation that hypotheses in heritage were formulated by all the students.

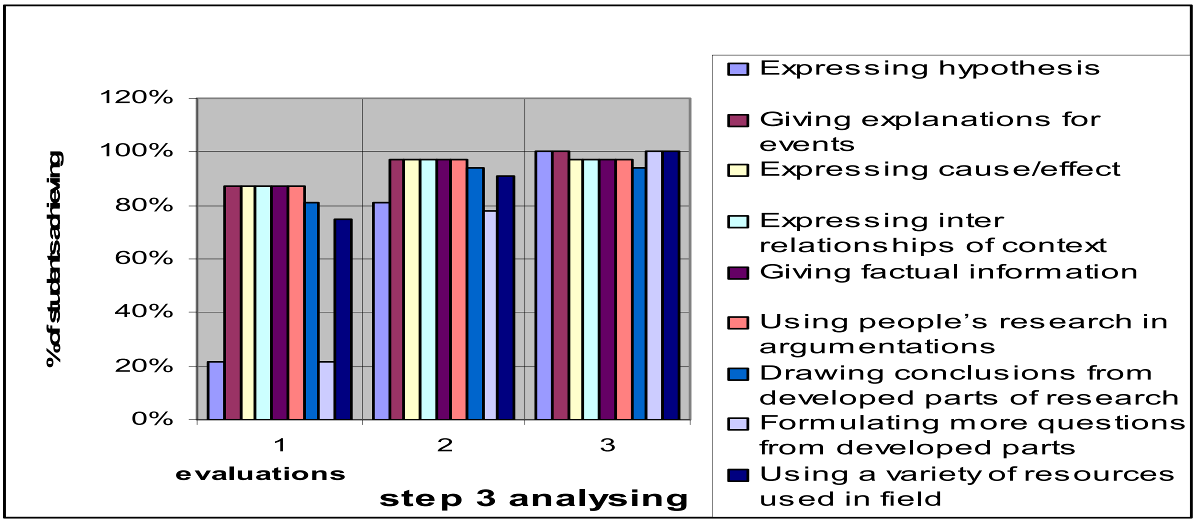

Figure 7 acquisition of competencies trough time

A question then naturally appeared: at which point does a piece of factual information become knowledge? If students could use people's research they did not necessarily use it in their argumentations but stated it as a mere fact and therefore sub-questions and conclusions were difficult to generate. As some research show, knowledge takes much longer than a semester or a year to master (Fischer et al., 2003; Salomon & Perkins, 1989). It is therefore impossible at this stage to really know the impact of these scientific investigations done in heritage on future research projects. In the second evaluation done in pairs, the interactivity seems to enable the students to perceive sub-questions and to relate the parts to the whole which was missing in the first evaluation. But even after having manipulated many open-ended questions, students still could not understand what a hypothetical question was, and a specific activity was designed on this subject. It is only after the second evaluation and after analysing what a hypothetical question could be in the field of heritage that each class agreed on a single hypothetical question to be analysed by the whole class. This meant that the students had to find a hypothesis and related sub-questions; they had to organise themselves as a group of 16 and find ways to create different sub-groups in the class. Each sub-group had to formulate and analyse a relevant sub-question, which enabled students to see the scientific interrelationships between sub-questions. Then each sub-group presented the result of their analysis to the other groups and finally each student wrote an individual synthesis. By the time they finished the semester nearly all 32 students had moved up to the fourth step but giving alternatives and suggesting new developments or giving solutions as the table below shows still seemed to be difficult to reach in heritage, which does not mean that it would be the case in other fields. Although it could be argued that the way a question is formulated or an analysis conducted can be creative, being able to synthesise did not necessarily lead to being creative.

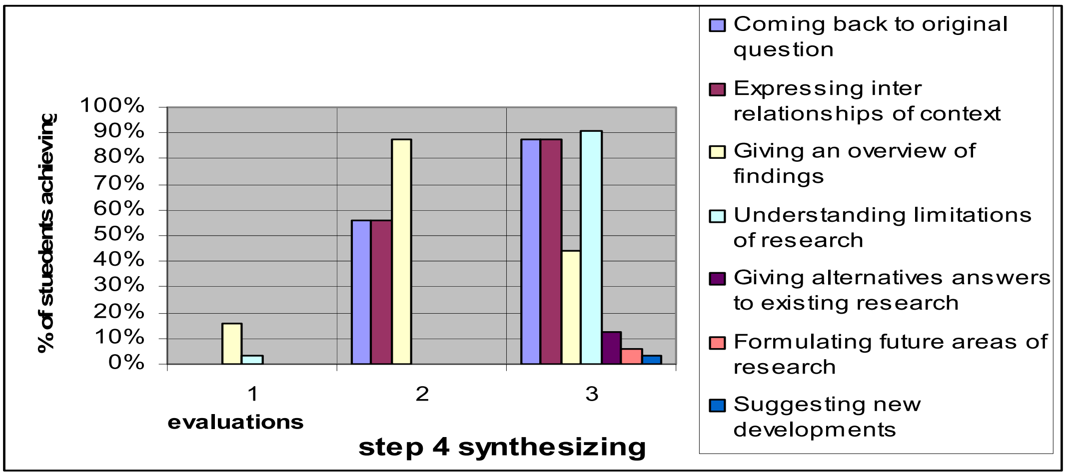

Figure 8: acquisition of competencies though time

Showing students the targeted meta-competencies made a difference in terms of knowing what the teacher wanted and in terms of having an overview of the learning process they were going through. A significant number of students eventually understood the limitation of their class research project, as this following example of a formative evaluation written by one of the groups reveals.

> '***Hypothetical question:*** *Imagination / unpredictability in the future. We do not know the future. We've looked at the document: "hypothetical questions" on moodle.* ***We*** *need to know what is needed to answer it: creativity (a new point of view, theory/knowledge. Methodological tools: archives, surveys/statistics, books, tangible, intangible traces. Usually, not just one answer. Can be used to test, validate, to understand, outline, highlights alternatives, lead to new proposals/discoveries/theories/solutions'*

Conclusion

Analysing, synthesising and suggesting new solutions or ways at looking at a problem also relate to the complex question of creativity which has not been fully explored here. What appears though in the given context is that creativity seems to belong to the 'situational competencies' (savoir-agir) category and is an active process, which was also highlighted in the Osborn's Creative Problem Solving Process (CPS) in the 1950s and his later work. (Osborn 1993) What must also be taken into account in what Ritcher (Ritcher .T 1991) calls, '*availability of knowledge'* either empirical or theoretical, since it seems that the depth of new proposals will be directly influenced by both. This is also true for teachers looking for gaining an insight on how to transmit knowledge and cognitive competencies effectively in their daily practice.

As education is becoming global, there is a need to generate deep critical thinkers to solve complex problems and to train teachers to help them developing critical thinking. For instance UNESCO's project Online Educational Resources (OER) wants to generate what is called '*capacity building'*. Projects such as wikieducator Learning4Content programme recently launched with **77** participants in 25 countries, is an example of this worldwide ambition. This type of mass education shifts the role of trainee and experienced teachers from passive to active learners involved in solving their own specific problems. Although, as James C. Taylor reckons, what is needed is to train teachers to develop innovative methodologies. In this case what would the role of PBL be? If it was the chosen methodology of teaching, how would wikieducators be trained to use it? Furthermore, as Leonard Annetta, Michelle Cook, and Maya Schultz (Annetta Leonard A., Cook Michelle, Schultz Maya, 2007) mention, the dynamic PBL/ serious gaming has much potential in terms of teaching and learning and so we can imagine that in the future online courses for teachers will use virtual classroom environments to practise teaching/learning scenarios in order to apply and transmit PBL's related knowledge and competencies.

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RELEVANCE OF THE PROBLEM AND PROJECT BASED LEARNING (PBL) TO THE INDIAN ENGINEERING EDUCATION

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ABSTRACT

The recent employers' survey (2009) indicated that Indian graduate engineers lack critical employability skills such as problem solving, teamwork and communication. Owed to this issue the Indian engineering educators are searching for the suitable alternative. Problem and Project Based Learning (PBL) could be one of the alternatives. Why PBL is a suitable alternative to Indian engineering education is discussed in this article. The skill set required by the Indian industry is mapped with the learning outcomes achieved by PBL. The skill set demanded by the industry is obtained from the Indian research and the PBL learning outcomes are discussed with the support of existing literature. Based on the mapping results, it is concluded that PBL could be a suitable alternative to acquire the skills demanded by the industries. However, PBL implementation in India needs to be considered carefully as Indian educational settings are different from PBL settings.

Keywords: Engineering Education, employability skills, PBL, literature review.

INTRODUCTION

Engineers play a significant role in the economy of any country. They are expected to work in different areas and difficult situations at workplaces. The engineering profession became demanding as Indian (world) industries demands different skills such as professional, soft and personal skills (Blom, 2009, Goel, 2006). Although, profession became demanding, it did not inhibit the requirement of professional and employable engineers in India (in the world). To cater the demand of skilled engineers, more engineering educational systems were set up in India. It resulted in an increase in the volume, but the quality of the graduate engineers became questionable (Rao, 2006). Recent surveys conducted by National Association of Software and Services Companies (NASSCOM, 2005, Blom 2009) reported that Indian engineers lack critical employable skill. There is a gap between industry expectations and graduate engineering skills. It is also reported that, the academic settings offered in India do not push for development of skills. Also, various government reports indicated the deep concern about the quality of an engineering education and hinted for radical changes in the curriculum and teaching learning practices in India (Rao, 2006, Knowledge Commission, 2008, Yashpal, 2010).

In this paper, the outcome of one of the most remarkable Indian study is discussed. This survey was conducted in 2008 jointly by Federation of Indian Chambers of Commerce and Industry (FICCI) and World Bank. It was supported by Ministry of Human Resource and Development (MHRD), India. It outlines that 64% Indian graduate engineers are unemployable and lack in higher order thinking skills and process skills. This survey proposed an urgent need to focus on skill development.

Considering the previous results Problem and Project Based Learning (PBL) could be one of the alternatives to address an issue of competence development. Why PBL is a suitable alternative to Indian engineering education is discussed in this article. Relevance is judged by matching skills demanded by the Indian industries reported in a survey to the learning outcomes attained in PBL. The PBL principles and research data were used to emphasize PBL strategy could be connected to address most of the skills demanded by the industry. However, it is also recommended that PBL implementation in India needs to be considered carefully as Indian educational settings are different from PBL settings. The article concludes with a list of possible PBL implementation issues in India.

Research methodology

To address the research topic, most of the initial data (skills demanded by the Indian industries) is referred from the FICCI, and the World Bank survey. The secondary data was collected from the existing international publications. The literature review was restricted to the cases in which PBL is applied at an engineering institute and published after year 2000.

The cases reported here are from the articles published in the journal, conference proceeding and books. Only those articles are included in which authors reported effect of PBL on skills or learning outcomes of students. This qualitative data are compared and mapped with the survey data. An outcome of this comparison is reported and discussed based on PBL characteristics and principles. Finally, article concludes with possible barriers of PBL implementation in India.

Indian survey-background and results

In this section, significance of the FICCI survey is discussed in the back drop of various studies conducted by Ministry of Human Resource and Development (MHRD), India arranged in chronological order. In 2005, the NASSCOM and McKinsey came with the report that, only 25% of the engineering education graduates are employable by a multinational company. Most of the surveyed employers linked this situation to the shortcomings from the education system. In the same year, the Planning Commission, Government of India came with the broad agenda to focus on enhancing the quality of educational institutions and an emphasis for appropriate arrangement for the development of skills and transforming learning patterns (p-13) at these institutions. In view of recommendations by Planning Commission National Knowledge Commission (NKC, 2006) on higher education was constituted in June, 2005. The purpose is to prepare a draft for transformation of India's knowledge related infrastructure. The NKC submitted recommendations to the Government in 2008.

Following this report in February 2008 MHRD, higher education department constituted a committee under chairmanship of Prof. Yashpal. It reported a deep concern in respect of growing engineering colleges by saying they have largely become, mere business entities dispensing very poor quality education (p-05) and indicated that there exists a gap between learning from institution and expectations from industries. Committee also recommended that the universities must adopt a curricular approach which treats knowledge in a holistic manner to create opportunities to bridge the gap by relating to the world outside (p-12). It hinted that Indian higher education system needs a drastic overhaul (p-54) with proposal of curricular reforms at undergraduate programs to enable students to have opportunities to access all curricular areas and integration of skills with academic depth (p-64). In view of these reports there was an increasing demand from teachers, administrators, and policy makers to identify the kinds of skills demanded by the employers from an engineering graduate. So, to identify skills demanded by the employers an Employer Satisfaction Survey was carried out in 2009.

This survey was supported by Government of India, the World Bank and the (FICCI). İt was designed by considering 10 learning outcomes out of 11 (in abbreviated form) and previous employers' surveys. These learning outcomes are established by India's National Board of Accreditation, (NBA) which is the only official accreditation body for assessing quality of engineering education in India. In this survey 157 industries across the India responded. According to the survey, 64 percent of surveyed employers are not satisfied with the quality of engineering graduates skills. A major skill gap exists among Indian engineering graduates. The skill gap is considered as the difference between the importance rating (highly demanded skills) and the satisfaction rating. A high skill gap signals that the skill is important and that the graduates do not meet the expectation. As can be seen from figure 1, the graduate engineer lacks in process skills such as teamwork, lifelong learning and communication skills.

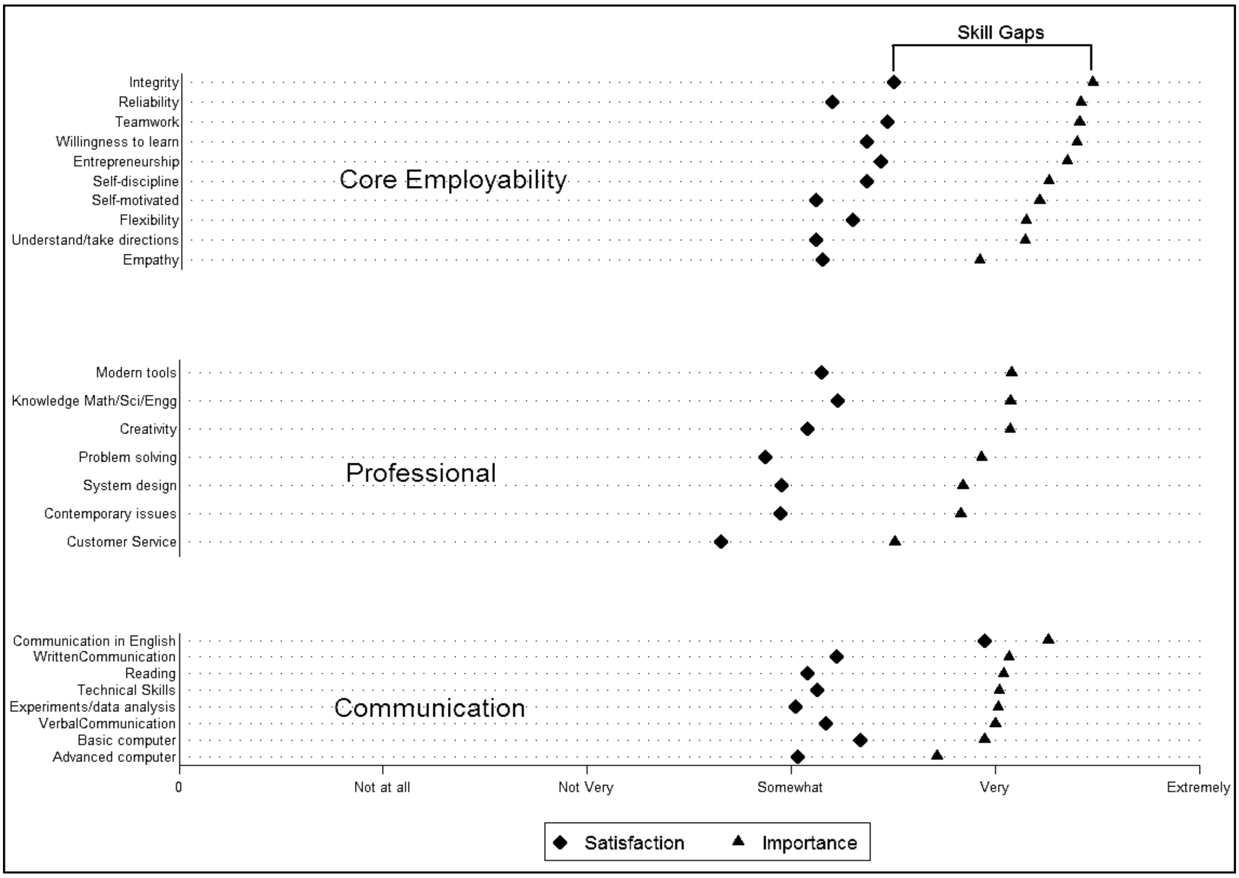

Figure 1 Skill Gaps (Source: Blom, 2009)

As can be seen from figure 1 the graduates lack in higher-order thinking skills, such as problem-solving, conducting experiments, creativity, and application of modern tools. The survey recommended the need of improvement in the assessment methods, and to build curriculum with emphasis on soft skills [Blom, 2009]. An essence of this report is that Indian engineering institutions needs to raise the quality of education imparted and must make provisions to ensure that the graduate engineers' skill are getting developed to meet industry demands.

Reflection on the survey results

In this section, the survey outcomes are reflected to understand why engineering graduate lacks in skills? The engineering education institutions in India can be broadly classified into three categories – Central Government, State Government & Self-financed institutions. The Central Government and State Government institutions are financially supported by Indian government and are generally considered as institutes imparting quality education. The self-financed (privately owned) institutes are the institutions which get very little financial support from government and contribute 90% of current capacity of engineering education system (Goel et al 2004). These institutes (sometimes more than 100) generally have an affiliation to any of the state University who decides the curriculum. Typically, the undergraduate degree curriculum in India has a period of four years divided into the eight semesters.

In most of these institutions instruction based pedagogy is followed with a high emphasis on the grades. The evaluation of the learning is based on the written examination in which students' ability to remember and reproduce the knowledge is tested. As a result the focus of the pedagogy is to facilitate the students to obtain good "grades". The students tend to focus to obtain good grades (at least 60%) in these written examinations as industry (in general for campus placements and jobs in reputed organizations) demands for the students with grades 60% or more. Also, lack of motivation and innovative methods in teaching process had an impact on the student's psychology; they tend to seat in the classrooms for mere fulfillment of attendance criteria decided by university. So students are increasingly becoming passive learners with less engagement in learning process.

As discussed above, all the students' in the institutions have to follow a common written examination organized by a university. It means that semester after semester, as per the Bloom's Taxonomy students are tested for low level cognitive skills (remember, understand and apply) (Goel & Sharda, 2004). Furthermore, the students higher level cognitive skills (analysis, synthesis, and evaluation) were not tested enough. So the curriculum settings do not promote to develop higher order thinking skills and process skills of the engineering students. As a result students lack in these skill and are unemployable. These observations are confirmed by the different national level studies as discussed in preceding section. In the next section how PBL can be suitable alternative to address this issue is discussed.

The PBL principles and the characteristics

The first university to develop and implement the Problem Based Learning curriculum was McMasters University, Canada in 1968 for medicine courses. Later in Denmark, a problem based and project organized model was implemented at Aalborg University in 1974 for engineering education [Kolmos, 2004]. The six core characteristics of PBL was described by Barrows (Barrows, 1996), in 1996 are

1. The learning needs to be student-centered.
2. The learning has to occur in small student groups under the guidance of a tutor.
3. The tutor acts as a facilitator or guide.
4. The learning starts with the authentic problem.
5. The problems encountered are used as a tool to achieve the required knowledge and the problem-solving skills necessary to eventually solve the problem.
6. Self-directed learning for acquisition of new information.

Since then the PBL strategy has progressed well and embraced by many leading universities in the world. Although at present many PBL models coexist, Graaff and Kolmos (Graaff, 2009) pointed out that these models share common principles of learning: cognitive learning, contents, and social.

The cognitive learning approach means that the learning is organized around the problems and will be carried out in the projects. A problem becomes central part of learning process and becomes motivation for learning. The students learn by his experiences while confronting to tasks involved in the problem solving process. A content approach especially concerns disciplinary and interdisciplinary learning. It is an exemplary practice carried out to address learning objective of the subject or curriculum. It also supports the relationship between theory and practice. The third principle emphasize on the concept of working in a team. The team or cooperative learning is a process in which learning is achieved through dialogue and communication between the team members. Students not only learn from each other, but also share the knowledge. Also, while working in a team they develop collaborative skill and critical project management skills. This is called as learner centric and participant directed approach in which students own their projects and make decisions to get desired outcome.

A PBL process

Based on the principles, PBL process can be explained as follows. In PBL settings students learn while solving the problems working in a team. Problem becomes a motivation for learning. To address the problem they will decide what is needed to learn and will search the relevant information from various source (Self Directed Learning). They will find most relevant information for problem solving and will share the same with the team members. By sharing the information, the team members learn from each other (peer and cooperative learning). In this way student will acquire information management, and collaboration skills. They will also understand the process, method and engineering tools which are used to solve these problems. They learn to make critical decisions and manage their work by applying project management principles (Du, 2004).

To receive a theoretical background of the subject they will attend the lectures in a classroom. This background will help them to understand and to decide the direction of their project work. During project work emphasis is also given on laboratory work so that they have hands on experience of working on experimental set ups and tools. This will help them to acquire working knowledge of machines, engineering tools and practices. Finally, students will submit the report of preliminary findings to the supervisor for suggestions. The report will be finalized in consultation with the supervisor. The students have to appear for the examination which generally comprises of group presentation and individual oral examinations. Students will be awarded the grades based on their performance in the presentations and responses to the questions in oral examination. In this way communication (written and verbal) and presentation skill will be improved.

As discussed above, PBL environment provides ample opportunities for learning. This learning is achieved in various modes (self-directed, peer, classroom, reading and sharing the literature). In addition to this, students will acquire the skills as PBL setting offer them several situations to practice and apply knowledge to solve the problem. Based on the above discussion it can be established that in PBL setting, higher order cognitive skills such as problem solving, critical thinking, creativity and application of theory to practice will be enhanced. Also, important process skills such as teamwork, communication (oral and written), project management and lifelong learning will be improved.

Effect of PBL on knowledge and skills

One of the frequently cited literatures about the effect of PBL on knowledge and skills is done by Dochy (2003). He pointed out there is a strong positive effect of PBL on the skills of the students. He concluded that students in PBL gained slightly less knowledge, but remembers more of the acquired knowledge. Empirical studies conducted at Aalborg University concluded that PBL helped students to improve process competencies. Process skills are the skills which are used in the application of knowledge. These include problem solving, critical thinking, communication, teamwork, self-assessment, change management and lifelong learning skills. The PBL environment provides ample learning opportunities in which students learn by cooperation, and collaboration with peers [Du, 2004, Shinde, 2011b].

An increasing number of cases have adopted the PBL method in engineering education to boost students' problem solving skills (Uden and Dix, 2004). Research undertaken by four British Universities showed that well-structured project work can improve students' key transferable skills and information retention rate [Willmot, 2003]. The problem-based learning (PBL) method can be adopted in engineering courses to create learning environments that help students develop problem-solving, collaboration, communication, and self-directed learning (SDL) skills, as well as content expertise (Dunlap, 2005). PBL method was found to be effective in developing and enhancing generic skills in students at University Technology, Malaysia (UTM). The survey results indicated that the generic skills of the 70% students had improved due to introduction of PBL at UTM [Khairiyah, 2005].

Effectiveness of PBL instructions on knowledge and skills of the undergraduate engineering students at Chitkara institute of technology, Rajastan, India was assessed over a period of four semesters by Mantry et al. Their results indicated that the students achieved better scores in knowledge and skill tests, showed better attitudes towards learning in PBL environment. Also, process skills were largely improved in the PBL class [Mantry et al 2008]. Singh et al realized the impact of Robotic Competition on students of the Indian Institute of Technology (IIT) Delhi. They realized that the project helped students to understand aspects of product development, teamwork and project management [Singh et al 2008]. As discussed in this section, the previous studies indicated that when the PBL method is applied in the curriculum, there is significant increase in the skill levels and learning motivation of the students.

Mapping of PBL outcomes with skill gaps

In this section, skill gaps identified by Blom as seen in figure 1 are mapped with the learning outcomes achieved by the students in a PBL setting. The mapping exercise is done based on the discussion and result of empirical studies reported in preceding section. The 'X' mark in the following table denotes that the skill can be achieved in the PBL environment. In the original survey an author used many terms which may require explanation. These terms are explained in the table 2 below.

Skill	Explanation
Flexibility	responds well to change
Creativity-	identifies new approaches to problems
Empathy	understands the situations, feelings, or motives of others
Reliability	can be depended on to complete work assignments
Integrity	understands/applies professional and ethical principles to decisions
Self-discipline	exhibits control of personal behavior
Basic computer	e.g., word-processing
Creativity	identifies new approaches to problems
Advanced computer-	e.g., spreadsheets, databases

Table 2 Terms and their explaination.

Core Employability Skill gaps	Learning outcomes achievable by PBL	Professional Skill gaps	Learning outcomes achievable by PBL	Communication Skill gaps	Learning outcomes achievable by PBL
Reliability		Problem solving	X	Experiments/data analysis	X
Self-motivated	X	Creativity	X	Reading	X
Willingness to learn	X	Use of modern tools	X	Technical Skills	X
Understand/take directions		System design to needs	X	Written Communication	X
Integrity		Contemporary issues		Verbal Communication	X
Teamwork	X	Apply Math/Sci/Engg know.	X	Advanced computer	X
Entrepreneurship		Customer Service		Basic computer	X
Self-discipline	X			Communication in English	X
Flexibility					
Empathy	X				

Table 3 Alignment of skills demanded by employers and PBL learning outcomes

Results and discussion

In the table as can be seen 18 skills out of 25 skills are matched. It is to be noted that the matching is done to understand the normative view. Also, in some cases it is assumed that the skill is matched as it is not possible to show exactness of the matching as in case of empathy. The meaning of empathy is ability to understand others. It can be assumed that the collaboration between the team members is not possible unless and until understanding between the team members. Skills such as teamwork, problem solving, project management and communication are the part of the PBL process, hence can be assumed to be perfect matching. In PBL students ability to apply the knowledge is tested, hence ability to apply science and mathematics, experimental data analysis skills can be said to be matched. In PBL settings curriculum is designed in such a way that students are in general exposed to use of computer platforms (word, excel, internet) and modern tools such as modeling and analysis software during their work. So, it’s natural that computer skills get enhanced during the process. It can be concluded that by using PBL settings most of the skills demanded by the Indian employers can be achieved. This may lead to bridge the gap between employers’ expectations and learning achieved at the education institute.

Perspectives for Indian cases

Based on the different PBL cases from the world, it is confirmed that PBL is an accepted educational strategy. Also, it can fittingly address issues such as low motivation and skill levels of the students. PBL can be a suitable alternative to traditional pedagogy in Indian engineering education. Indian institutes are built for traditional teaching, PBL implementation at these institutes seems to be difficult. There seems to be multiple barriers for PBL implementation, important ones are listed here. Historically, teachers and students in India are practicing traditional teaching in which most of the focus is on content coverage. It can be expected that teachers and students will resist the change. Furthermore, the students in India are habitual to traditional teaching and evaluation methods. In PBL settings they need to be active learners which may pose challenge.

A lack of literature and guidance in PBL curriculum design, shortage of trained faculty in PBL hindered the further progress of PBL in India. Most of the institutes or universities in India are built by considering traditional teaching. For example in PBL setting the group rooms are important to facilitate the group work. Also, the library equipped with reference books, on line database of the journals is important source of information to support the project work. Such facilities are not the regular feature of Indian institutes.

Generally, an educational system; especially privately owned have conservative approach to embrace innovative methodologies due to financial implications. Also, these institutes do not promote educational research as compared to research in traditional engineering disciplines. Furthermore, engineering education research (EER) is not a recognised field in India. PBL as an alternative is just started to get the recognition in few of the universities in India. Although, PBL seems to be a suitable alternative to Indian engineering education, concentrated and scalable efforts are required to make PBL as an acceptable method in India.

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DEVELOPMENT OF FEEDBACK PROCESS FOR COMPETENCE BASED PROGRAM

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ABSTRACT

In the engineering school of Mondragon University, the curriculum is based in competences. In order to achieve defined competences, active learning methods need to be applied. One of the more extended methods in our school is POPBL (Project Oriented Problem Based Learning). As several courses are involved in each competence, teachers need to work in teams and offer the students a general view of their activities and achievements. Teachers' objective is also to improve the overall learning quality in order to increase students' performance and satisfaction, and minimize dropouts. In this context, a three level feedback process has been developed and implemented based on (Biggs & Tang, 2007) and (Gibbs, 2003) works.

In this paper we are going to describe the used theoretical framework and the learning context where the feedback process was implemented. Finally, some preliminary results are shown.

INTRODUCTION

It is commonly accepted that 1st year engineering studies have a high dropout rate and low performance indicator. In Table 1 we can see the Mondragon University's 1^{st} year Computer Science engineering studies' indicators: dropouts, performance and satisfaction. Dropout indicator represents the percentage of students that leave their studies. Performance indicator is the ratio between the number of credits the student has achieved and total amount of credits in the students' registration for the course. And, satisfaction indicator is a satisfaction value (between 0 and 10) given by students.

	03-04	04-05	05-06	06-07	07-08
Dropout indicator	16%	15%	13%	14%	14%
Performance indicator	65%	58%	63%	55%	69%
Satisfaction indicator	6,09	6,17	6,17	6,31	6,48

Table 1 – Mondragon University's 1st year Computer Science engineering indicator

Those indicators were unsatisfactory for the society and the university. Our aim was to improve those indicators, mainly by making the learning process more effective. To achieve this objective, we made various changes. The main ones are: curriculum changes (nowadays is based on competences and learning outcomes), learning method changes (more active learning methodologies are introduced) and assessment changes (widespread use of continuous and formative assessments where the feedback is included).

In the next section, first we will describe the theoretical framework. Second, we will present our competence based model. It helps to understand the context where the feedback process has been implemented. Third, we will explain the implemented feedback process and tools, and we will compare it with the theoretical framework. Finally, some preliminary results and the conclusions are summarised.

The official framework

The theoretical framework is based in two authors John Biggs and Graham Gibbs. Biggs proposes the "constructive alignment" theory (Biggs & Tang, 2007), where it is recognised with a more general label "outcomes-based education" (OBE) or "outcomes-based teaching and learning" (OBTL). This is defined as "a convenient and practical way of maintaining standards and of improving teaching. Standards are stated up front and teaching is tuned to best meet them, assessment being the means of checking how well they have been met". In our case, the standards are defined by the learning outcomes (see Table 2) and the teaching is based in active learning (POPBL). Gibbs (Gibbs, 2003) suggests that assessment can support the learning process. He proposes eleven conditions, which we recall below:

1. *"Assessed tasks capture sufficient study time and effort."*
2. *"These tasks distribute student effort evenly across outcomes and weeks."*
3. *"These tasks engage students in productive learning activity."*
4. *"Assessment communicates clear and high expectations to students."*
5. *"Sufficient feedback is provided, both often enough and in enough detail."*
6. *"Feedback focuses on learning rather than on marks or students themselves."*
7. *"The feedback is provided quickly enough to be useful to students."*
8. *"Feedback is linked to the purpose of the assignment and to criteria."*
9. *"Feedback is understandable to students, given their sophistication."*
10. *"Feedback is received by students and attended to."*
11. *"Feedback is acted upon by students to improve their work or their learning."*

In conclusion, Biggs proposes that the teaching and learning activities need to be aligned with the learning outcomes and Gibbs adds that one of those activities, the assessment, where the feedback is included, can support the learning. This means that by improving the assessment, and in consequence the feedback, the effectiveness of the learning process can be improved.

Competence based curriculum

In this section the competence based model is briefly described. The presented curriculum is based on competences. The starting point was the professional functions described by the ANECA (Spanish quality evaluation and accreditation agency), and the final point was the learning outcomes that the students need to achieve in their learning process.

Professional functions are the main functions that the engineer needs to fulfil in the labour market. ANECA specifies the professional functions for a Computer Science engineer in the white paper for Computer Science Degree.

The competences are divided in two groups: the general competences (Hansen & Rosenørn, 2005), also known as social competences, and academic ones (Hansen & Rosenørn, 2005), also known as specific competences. All the defined competences are the base to achieve the professional function defined by the ANECA.

Learning goals or learning outcomes are defined as “learning results” which have to be measurable in an academic context. Some questions were defined in order to help to describe the learning outcomes: Is it measurable? Does it have any impact on the competences? Can they be achieved in the given time frame? In order to define them, the next phrase structure was taken into account: *Verb + object + condition*, where the verb was taken from Bloom taxonomy (Bloom, 1956). For example: “Design a computer based program respecting the user specifications”.

Semester	Learning Outcomes	Competences 1	Competences 2	Competences 3	Competences 4	…	Competences 10	Competences 11
Course 1	1	X			X			
	…			X			X	x
	5	X						
Course 2	6			x POPBL				
	…						X	x
	10	X						
	…				X			x
Course n	n							

Table 2 - Competence vs. Learning Outcomes

Summarizing, first, the professional functions were defined, next the competences (social and specific) and finally, the learning outcomes (see Table 2). The learning outcomes are grouped into subjects.

Once the learning outcomes were defined, the next question was to select the learning methodology. The main active learning method used in the engineering school is the POBPL (Project Oriented Problem Based Learning) proposed by Aalborg (Moesby, 2004), (Akbar-Hussain & Rosenørn, 2008). But it is not the only method used, other non active and active methods are also used.

In conclusion, the engineering school offers an exciting learning context, aligned with the competencies and current students' active behaviours. This was a great step that helps to improve the effectiveness of the students' learning. However, more steps can be taken by working on the assessment.

Feedback process and tools

In this section, we will explain the implemented feedback process. The feedback is given in different moments along all the semesters. There are three main levels: Course, semester/year and diploma. The goal of the feedback in each level is different.

The feedback process aims to respect Gibbs' eleven contitions (Gibbs, 2003) it is why they are compared with those contitions.

Gibbs's items		Comments
1		*"Assessed tasks capture sufficient study time and effort."* Our model is based in continuous evaluation. Those assessments need to focus on learning outcomes. The challenge is to make those assessments productive and engage the student in the productive effort.
2		*"These tasks distribute student effort evenly across outcomes and weeks."* Each semester there is has a teachers working group with specific functions. At the very beginning they need to design the semester (see

		Table 2) and plan mainly the assessment tasks. And during the semester, this working group supervises the planning and if there is any planning change they balance the workload.
3		*"These tasks engage students in productive learning activity. "* This item is related with an alignment described by (Gibbs, 2003). His proposal seems logical and straightforward to apply but it is not as simple as it seems to be, maybe because the teaching-learning culture is based in a teacher-centred approach and it is not easy to change the perspective to a student-centred approach. Furthermore, changing teachers' previous methodology culture is probably the main challenge.
4		*"Assessment communicates clear and high expectations to students."* The defined learning goals and their associated criteria are transmitted at the beginning of the semester. Sometimes unclear assessment is confusing to the students.
5		*"Sufficient feedback is provided, both often enough and in enough detail."* One of the big challenges was to organize the feedback process at various levels. The learning outcomes and their associated criteria help in transmitting the feedback with the required detail.
6		*"Feedback focuses on learning rather than on marks or students themselves."* Again, the defined learning outcomes and their criteria help in this condition. Anyway, it is difficult to avoid giving marks. Students are always asking for marks. Finally, Gibbs says that feedback focused on students needs to be avoided, but working with competences (like in our case) we need to focus on attitude and this is related with the students (Rosenørn, 2006).
7		*"The feedback is provided quickly enough to be useful to students."* As shown in the Figure 2, in order to give a continuous response to the students, the main feedbacks are scheduled during the semester. This planning is a big help but it is not enough, mainly at course level. At this level more and quicker feedback is needed.
8		*"Feedback is linked to the purpose of the assignment and to criteria."* As it has been explained before, there are three feedback levels, each

		of them with different purpose. But there is not always enough alignment between the tasks and the learning outcomes.
9		*"Feedback is understandable to students, given their sophistication."* If the defined learning outcomes or competences are used the feedback is quite easy to make and understandable.
10		*"Feedback is received by students and attended to."* One of the greater difficulties is to establish a real communication between the students and the teacher, maybe because we come from a teacher centred culture.
11		*"Feedback is acted upon by students to improve their work or their learning. "* This remains a challenging item for us. We see that there are improvements but we don't really know in which degree.

Table 3 - Gibbs' eleven conditions analysis

The first level is at the **course level**. The course level feedback is given after each assessment point. This feedback's goal is to improve the course's learning outcomes. The responsible for this feedback is the course teacher. The semester project (POPBL) is considered at this level.

The second one is at the **semester level**. The curriculum is based on competences. Depending on the competences' results, students are allowed to pass, or not, the year. The learning outcomes of the courses impact in the competences. In fact, several courses' learning outcomes can impact in the same competence (see table 2). For example, in Computer Science engineering, when the student works they design complex systems where electronic, hardware, programming and network courses are involved. Therefore, at this level competence-based feedback is needed. The responsible for this feedback is the semester coordinator. In the figure 1, we can see the application where the teacher introduces their marks and general coments. With this application we can easily analyse the progress of students from a competence point of view and give them the appropiate feedback.

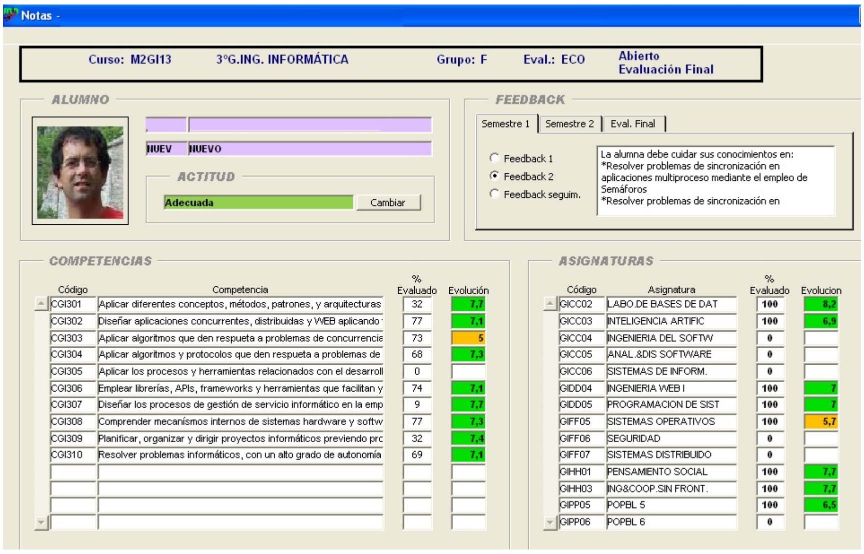

Figure 1 – Feedback planning

The third level is at the **diploma level**. This is a more general view. The feedback is focused on diploma competences and the professional profile. Another goal of this feedback is to discuss with the student about the possibilities and challenges they will find in the next semesters and in the professional life. The responsible for this feedback is the diploma coordinator.

For semester and diploma levels, different feedback sessions are organized along the learning process. Those sessions are the more formal ones. There are three moments during the first two semesters and two times during the rest (see figure 2). In each feedback session, all the semester's teachers (one of them is the semester coordinator) and the diploma coordinator are present. Each student receives individual feedback.

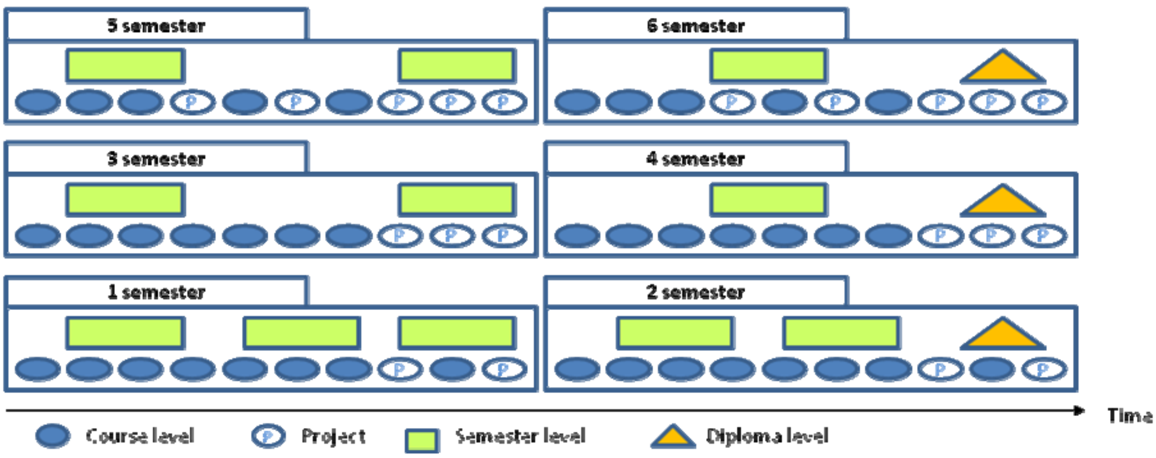

Figure 2 – Feedback planning

Results

In order to verify the implementation impact, dropout and performance indicators were captured from the school's general database. The satisfaction indicator is obtained using an specific satisfaction survey that students are asked to complete.

As we can see in the table 4 the last two years (08-09 and 09-10) the results are better. The dropout indicator is between 9% and 11%, while before, it was between 13% and 16%. The performance indicator is higher, between 70% and 78%. Before the changes, it was between 58% and 69%.

	03-04	04-05	05-06	06-07	07-08	08-09	09-10
Dropout indicator	16%	15%	13%	14%	14%	9%	11%
Performance indicator	65%	58%	63%	55%	69%	78%	70%
Satisfaction indicator	6,09	6,17	6,17	6,31	6,48	6,81	6,72

Table 4 - Mondragon University's 1st year Computer Science engineering indicator

Conclusion

All the changes (curriculum, learning method and assessment where the feedback process is included) described in this article and made in the last few years seem to have a good impact. The changes have been made in all the semesters of all the diplomas, but only the first two semesters of Computer Science engineering were analysed. Indicators like dropout, performance and satisfaction have been improved. Our main conclusion is that learning outcomes, learning methodology and assessment are more aligned and coherent and in consequence it increases the effectiveness of the student learning process. The implemented feedback process plays an essential role in the understanding of all the learning process.

The implemented feedback process was also described and compared with Gibbs's eleven conditions. The main conclusion is that not only a feedback process but, in general, the assessment process needs to be considered in order to align the learning process better. The identified difficulties (see table 3) are twofold: On the one hand, to which degree are the students' tasks are productive? And on the other hand, how good are we communicating the feedback?

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PUTTING WISE HEADS ON YOUNG SHOULDERS - A FIVE YEAR JOURNEY OF SCENARIO BASED TEACHING AT UCL

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ABSTRACT

This case study describes how UCL has successfully transformed its core strategy over the last five years to fully embrace scenario based learning and an integrated systems approach. The aim is to meet the future challenges of a more demanding business environment and increasingly complex, interdisciplinary, projects - as well as provide a more exciting and attractive learning environment for future leaders in engineering. The paper, prepared as a personal perspective by an experienced business leader (working as the Visiting Professor throughout), shows how complex, major projects can be replicated through carefully designed scenarios to overcome the limitations of the traditional "siloed" approach - thereby transforming the learning experience for students. The paper describes the challenges of change, the barriers and enablers to transformation as well as insights into the design and development of an exemplar scenario. Finally, the paper provides some invaluable guidance to those following UCL's lead.

INTRODUCTION

For decades engineers have been educated in tightly controlled and separate work-streams focussed on discrete engineering sciences. Feed back from industry shows that the traditional "siloed" approach to engineering education has its limitations. Modern enterprises and major projects are, essentially, systems based and multidisciplinary – requiring business and management skills as well as technical breadth. This means that successful engineers, who aspire to be leaders, need to master the dynamics of this complex and challenging new world as early as possible in their careers.

Demographics and a growing capability gap show that the UK can no longer rely on a decade or two of “on the job” training. The educational “duty cycle” and professional development process needs to be shortened and made more effective.

To meet these modern challenges and to provide graduates with a broader appreciation of engineering and the business world, the civil engineering courses at University College London have adopted a new approach. For the first two years the traditional specialist work-streams are put on hold four times a year and a series of “scenarios” are run. These take a full week and are designed to replicate a real world approach to a project with systems integration as the backbone discipline (Simons, 2009; Simons et al 2009; Simons et al 2010).

Well over 600 students have now graduated and the feed back has been very, very positive. Students have used their scenario experience to enhance their CVs and anecdotal evidence suggests that this has helped them in their search for rewarding career opportunities with leading firms.

The department’s reputation has also grown during this period and the number of applicants applying for places is now at record levels. This is a major transformation and represents a huge achievement for the department as a whole and for Professor Nick Tyler and the team at UCL.

Since the introduction of scenario based teaching the department has also been subject to a very exhaustive review by the Joint Board of Moderators. This occurs as a matter of routine every five years as part of the normal accreditation process. The scenario approach has been under particular scrutiny as it is regarded as “new”. However, it has been “approved” and many of the industrial representatives on the panel appeared to be very enthusiastic about the applied and practical nature of the scenario approach as well as the introduction of systems integration.

The department’s Industrial Advisory Board has always been very supportive of the new approach. Feedback from broader sources in the industry has not been analysed systematically but anecdotal evidence suggests that UCL graduates are highly valued and much sought after.

Informal discussions with alumni have reinforced the message that scenarios and the systems approach have helped them get prestigious jobs ahead of stiff competition and that the lessons learned have "stuck"- providing valuable insights into the way engineering and business is managed. It is hoped that these insights will provide real, fast track career opportunities and early leadership roles – only time will tell.

Example scenario

The following Scenarios have been run at UCL in various forms over the last 5 years.

- Traffic and pollution in St Albans – concepts
- Bridge design
- Shrimp farm in the Thames Estuary
- St Albans ii – detail
- Community Centre
- Offshore wind farm
- Airport expansion
- Drought in SE England

The Airport Expansion Scenario is considered to be one of the more challenging and it is the one described here as an exemplar.

Scenario objectives

The teaching objective of this scenario was "to create a challenging, realistic, credible project environment - which demonstrates how good systems engineering practice drives the application of civil engineering science and theory across multiple disciplines to achieve a successful "best fit" solution".

Learning outcomes

Graduates of the scenario will have a working knowledge and practical experience of how to apply systems techniques to a complex, real world problem involving a number of disciplines. Graduates will also have a better understanding of leadership style and team working and its critical importance in managing major projects and business as a whole.

In addition, graduates will understand the social, economic, environmental and political drivers which form the working environment for every engineering project.

More than anything else graduates will have experienced the sense of excitement, achievement and self satisfaction which only comes through cooperation and working successfully together as an organised group.

Scenario Strategy

The aim is to connect a systems level analysis and a systems level solution with detailed engineering analysis and calculations developed from each discipline. Case studies are insufficient to satisfy these objectives and live engineering projects have far too much data for students to digest in a week. Scenario based teaching provides the only practical solution.

Scenario scope

The scope is designed to cover as many of the subjects taught at second year as possible. Systems Integration teaching and workshops cover:- Systems Lifecycle, stakeholder analysis, requirements, tradeoffs, best fit systems architecture, test and validation, risk, cost, pricing and business case. Civil Engineering subjects include:- Transport, Soil mechanics, Structures, Materials, Environmental, and Fluids. All these are integrated into the Airport scenario's scope and subsequent challenges.

For the Airport Expansion Scenario - Students are provided with an artificially created Landscape and Map with various Road and Rail networks overlaid on top. An Excel spreadsheet provides some traffic loads and performance data showing how the airport may be better connected to its principal city. A variety of bridges, embankments, tunnels and other physical barriers are also superimposed on the landscape.

The students, who are arranged in three competing teams, are invited to find the "best fit" solution. In order to do this they have to analyse the overall system performance, and conduct a trade-off analysis against each possible option. This in turn requires them to re-engineer the bridges, tunnels etc and calculate the costs.

All scenario work has to be completed by students in a week.

The Scenario task and its challenges

A city is considering a number of options to expand and upgrade the transport infrastructure which serves the local community as well as the local airport. The current network is saturated and slow such that the airport itself is underutilised. Further expansion is seen as uneconomic until the transport links are improved considerably. An expansion of the airport is seen as essential to the future growth of the city.

A network of road and rail links is shown - overlaid onto the city boundaries and its coastal environs. The network services local villages as well as the airport and other regional destinations. A link to a local motorway is shown together with rail links to mainline routes and other major cities. See Figure 1.

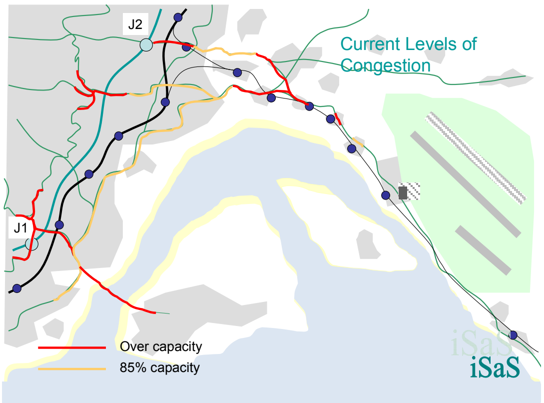

Figure 1 Scenario Layout

The performance of this network and its principal characteristics ie distance, traffic flow, vehicle speed, are provided on an Excel spreadsheet with some simple algorithms, built in, to represent the interaction of varying flow rates and speed etc along the main routes. Additional information shows parametric cost metrics for various works and materials as well as the notional cost of rolling stock and platform development.

Separate drawings are provided to show the outline of various civil engineering structures such as road bridges, rail bridges, tunnels and embankments which are themselves overlaid onto various locations throughout the scenario. See Figure 2.

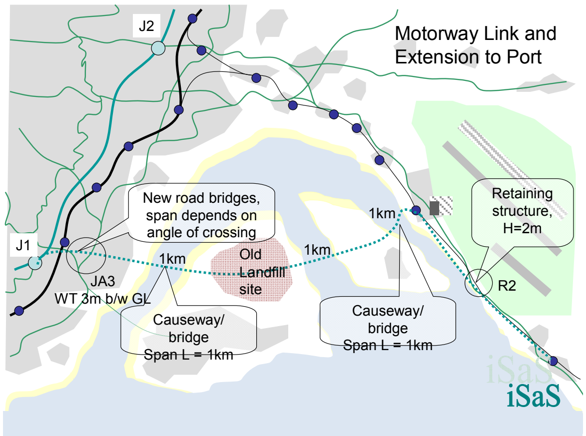

Figure 2 Engineering challenges

The student experience

The students are given a full briefing pack including the Excel spreadsheet.

Stakeholder analysis and requirements definition is followed by a series of design options. These are meant to find the most efficient way of delivering passengers to and from the airport in the shortest possible time, at capacity levels which meet the longer term forecast demand.

Potential costs and ticket pricing represent other complications that the students have to conjure with as part of the overall systems wide trade-off analysis to determine the "best fit" solution.

It is impossible to decide which option, or combination of options delivers the best fit solution without performing detailed engineering analysis. In other words the students are forced to design or modify bridges, tunnels and embankments, calculate the cost and assess the impact on traffic flow to achieve a series of trade-offs.

The engineering tasks themselves are nontrivial and given the number of permutations the scenario begins to represent a very complex series of interactions and a heavy work load. This begins to represent a real world scenario where a similar analysis would be required to determine a "best fit" solution for the city and the airport.

Students therefore get to experience, in one short week, something which approximates to a live project which could take years.

Selecting and organising the scenario teams

In this scenario, the group of 70 students was split into three - representing three competing consortia. The teams were chosen by the Scenario staff so that each team had a good balanced match of skills, capability, personality and diversity. This paid off as the final results were very close. Each of the three competing teams had to select its own leaders and divide up the work amongst the team. Day to day management was delegated to the students.

Scenario deliverables

At UCL the scenario week ends with formal presentations to a Client Board. Staff members are invited to attend and they play the part of the Board. Students have to present their solutions and answer questions from staff and from the floor - all good experience in presentation skills and advocacy. Staff are invited to ask questions and to mark the presentations, including the way students handle Q and A.

In addition the students have to hand in a report which is also marked.

Feedback and support

During the week students have access to their tutors and to other members of staff with specialist knowledge. A week or so after Scenario week and the final presentations, a feedback session is held while the event is still fresh in everyone's mind. This provides generalised comment on what was done well and what wasn't, by all the groups. The orientation is towards lessons learned and how the tough lessons learned now provide advantages and competitive edge when it comes to future career opportunities. The marking process continues in parallel and reports are handed back when the marking is complete.

Airport scenario outcomes

Feedback from staff attending the final airport presentations has always been extremely positive. Feedback from the students has also been very positive (see below). In their opinion, this scenario continues to be the most representative of a real world project.

The presentations delivered at the end of the week are invariably classed as "outstanding".

An independent external observer (a lead manager from a highly respected firm of civil engineers) was present on one final afternoon and his comments were also very positive:- "I wish some of my engineers would operate like this". Other external observers have also made comments along these lines.

Airport Scenario Conclusion

Judging by the quality of the written reports and the final presentations and the students' overall commitment, engagement, enthusiasm and feedback this scenario has been extremely successful.

It also complies fully with the original learning objectives - enabling students to see how different disciplines have to work together, using good systems integration principles, to achieve a technically robust solution. As a consequence the learning experience was regarded as "first class" and "highly realistic".

On introducing a scenario based approach
Introduction

As the foregoing airport example shows - considerable effort is required in the design and management of a scenario. Introducing eight of these and reworking the curriculum to create dedicated scenario space four times a year is a significant undertaking. The further introduction of systems integration and a cultural shift in teaching methods equates to a major change programme. Experiences described here may help others as they navigate their own journey towards a scenario based approach and systems integration.

Managing change

The whole curriculum had to be changed to accommodate the eight scenarios. This was planned a year in advance and regular meetings were held to coordinate both the modified teaching schedule and the development of each scenario. The aim was to ensure that students had been exposed to sufficient learning to be able to perform the tasks required in each scenario.

On some occasions the synchronisation between formal lectures and scenarios did not quite tie up as expected, particularly in the early days. For example, some students were asked to design tunnels without sufficient preparation. However, this provided an excellent opportunity to show that this sometimes happens in the real world. Professional engineers need to adapt and to learn new skills or call for expert help.

The author also gave series of Systems lectures to staff so that they had an idea of what the students were likely to experience. These made a valuable contribution to the change process.

Feedback was always sought from the students so that lecture content and issues with the scenarios could be identified ready for the following year.

Scenario concepts and plans were rehearsed and reviewed. This again was another key part of managing change, setting expectations and setting standards. Some members off staff had not worked in industry or on projects and so they too had to become familiar with this as part of the scenario design process. This became a key part of the author's role and is seen as the key enabler to successful scenario design.

A series of management meetings were also held - chaired by the teaching directors. The agenda, frequency and attendees varied but the aim was always the same - to maintain progress and a steady path towards the scenarios' technical goals and scope as well as the programme of lectures.

Enablers

Most of the driving force from within the Department came the Head of Department as the chief sponsor for this whole approach - a definite "enabler". Without his support and energy this initiative would not have succeeded.

Success is also due to the drive and commitment of the two Teaching Directors who used their influence and enthusiasm to shape the revised curriculum and to run the day to day changes and solve problems.

A number of scenario managers were appointed from departmental staff. It was their job to design scenarios, gather data, prepare briefs, manage the scenario week, coordinate teaching input and prepare the evaluation and assessment processes. Their support as enablers and champions was also critical to success.

As an "agent of change" the author's role was to help, wherever possible, the scenario managers design the scenarios such that they represented a "real" project and an integrated systems approach. This input is seen as vital in developing a marriage between the academic engineering science and practical project based implementation.

It was also the author's responsibility to introduce the backbone systems integration methodology through a series of lectures and workshops. The author also became the scenario manager for the airport project. A member of staff took on a lot of the detail for the airport scenario and key elements of the assessment process.

The students themselves were "enablers". They accepted the new curriculum and entered into the spirit of role play and the scenario based teaching approach. Their enthusiasm and energy and their ability to challenge and question became a channel for change - drawing in interest and commitment from others in the department.

A key enabler was sponsorship from the Royal Academy of Engineering and the Visiting Professor Scheme. This provided the framework which allowed the author to engage and participate in the department's transformation. Given the intellectual and professional rewards, the author has continued to support UCL in a number of other areas well beyond the original scheme.

Barriers

Not everything was straightforward, however. Traditional attitudes and a lifetime of working within specialised technical "silos" was a factor in the overall change process.

One has to constantly bear in mind that professional engineering bodies (of which there are 35), Government research funding and the research assessment are all geared toward specialisation. Many academics are entirely focused on their own specialist subject and have developed, over a lifetime, distinct reputations in their own respective fields. There is clearly a place for this but it should not be at the expense of a joined up, integrated approach - in line with industry practice and business needs.

The established focus on specialisation ripples downwards, making the transition to a cooperative multidisciplinary, industry-led, project-based methodology and culture more difficult than it needs to be. Anyone moving in the direction of scenarios or project based learning within an academic environment needs to be aware of these issues as a potential barrier.

Teaching styles also became an issue during the change process. There were those who found it difficult to come to terms with the fact that the real world and therefore, scenarios, don't always have a right or wrong answer. It's a series of value judgements and tradeoffs based on imperfect data.

Their expectation is perfect information and a precise answer. But engineering is all about people and judgements and students need to be acclimatised to this at the earliest opportunity in their careers. Precision and engineering science has its place but it has to be balanced against real world situations. This is the essence of scenario learning.

This mismatch in expectations also became an issue for the assessment process where judgement had to be used by the scenario managers. This proved to be very difficult for some - as there are no precise, predetermined answers. Some members of staff take a very deterministic view. Considerable effort was put into providing guidelines to assist the assessment process (see below).

Others came to scenarios from a different direction based on their own preferences. One scenario manager, for example, adopted a project management approach, where the rules were changed half way through - to represent this aspect of the real world.

These differences in style triggered debates about whether there should be a preferred "in house" style for a project and its design life cycle. In the end, we decided that, as a University, it was important to expose different styles and techniques during the scenarios - as long as the differences were pointed out and formed part of the learning process.

Evaluation and assessment issues

As discussed previously this presents a tangible challenge for those with a more deterministic approach. Scenarios produce a range of different results and there are no right or wrong answers. Judgements have to be made about the means of arriving at a solution as well as the solution itself.

In our case expert knowledge of a range of engineering disciplines, management and systems integration all help. For some, with a lifetime of industrial experience as background, this form of evaluation comes as second nature. But not everybody in the Department had that level of experience. Guidelines and templates were drawn up and marking criteria established to provide some guidance.

It is part of the scenario manager's job to make sure all parts of the report are marked. Specialist aspects such as stress calculations are marked by specialists who support the scenario. It is also given an overall read, at a systems level, to make sure it tells a consistent story and complies with good practice and what the students have been taught. Some of these reports are over 200 pages so marking is non-trivial. The reports contain signature sheets so that individual sections or chapters can be traced back to the student who wrote them. This helps determine individual marks.

The presentation mark and report mark are combined to make a single group mark. Students are also invited to submit a personal "critique" which describes their role and contribution. They are also invited to comment on the work of others in their team. Sometimes, this is brutally honest. Individual marks are based on the group mark, each individual's contribution to the report, the personal critiques and from personal observations from staff during scenario week.

Assessments can sometimes be contentious. Students who work hard on one part of the report suddenly find that it has not been included by their own project manager. Students who have worked hard on one team feel disadvantaged against others who they feel have put in less effort on another team. Another tough lesson from the real world - one should work smarter not harder.

Marking in this highly charged environment has to be tough and disciplined but it should also be structured, transparent and as fair as possible. Invariably the students work really hard, often through the night and they expect high marks for effort.

Sustaining interest and refresh whilst maintaining standards

Each scenario has evolved over time. This is based on feedback and lessons learned as well as the normal professional desire to refine and improve. It is also important to provide fresh opportunities for students to learn. Staff have been rotated to assist the refresh process and new scenario managers have brought their own styles to bear. Some scenarios have changed completely and new ones have been introduced.

Student reaction and feedback to their scenario experience

Student feedback has always been very positive. They recognise that a major project, which normally takes many years, has been packed into just a week - providing a very unique "fast forward" real world and real project experience. They also recognise that it gives them a competitive advantage and many of them include their Scenario experiences in their CVs.

Alumni who are now at work have reported at a recent meeting that their ability to work in teams has given them tremendous advantages over their contemporaries from other universities and from other professions. The lessons in systems thinking has also given them particular insights into analysis and problem solving as well as an aptitude for a multidisciplinary systems approach.

Feed and quotes back from students on Scenario 7 -

- Having a manager of the consortium was invaluable in this respect, as it was clear who everyone was ultimately working for, and deadlines could be set. The consortium set up definitely felt more realistic,
- The concept of this scenario week was very good. Getting three large consortia to compete against each other was quite a fun idea…
- All-in-all I think this scenario was a success, although extremely stressful, it gave a real interpretation of the real world as the truth remains that there will be times during construction projects where you will have to push yourself to get the job done.
- I would say that the scenario is good one that brought systems and management to another level. Working as a team of 18 was a challenge but that put a real world perspective into the scenario.

- I believe that this Scenario ideally demonstrated the different systems and processes encountered in the industry. Furthermore it was the first time we got to work in large groups which was realistic and enjoyable.
- This scenario was very successful in exposing the issues surrounding systems engineering and large projects. This is true in the preliminary analysis, the design process itself, and the best-fit solution selection. In addition, having managing, and dependencies between group members gave a thorough insight into group projects and management.

Overall lessons learned

- Change is hard. It requires a lot of help and a lot of support from a lot of people. The effort taken to engage and communicate is never wasted. Sponsorship from the top is essential.
- It is important to have a well defined view of the objectives and where you are trying to get to. These include learning outcomes, competencies, capabilities, scenario definition and curriculum change.
- Not every one will be with you on the journey and you have to be determined, tough minded and focussed to achieve results. 75% of change projects fail.
- It’s worthwhile identifying barriers and enablers well in advance.
- There should be a plan and regular reviews of progress against time and against objectives.
- Efficient communications between all the parties should continue unabated throughout.
- Management roles should be assigned and accountability maintained throughout. Champions are essential.
- Each scenario should be well designed with an appropriate level of data to support it. Students expose weaknesses very easily and care should be taken to minimise embarrassing oversights and errors. Scenarios should represent real world challenges which students can visualise and identify with.
- Each scenario should be reviewed and rehearsed thoroughly - perhaps more than once.

- Supporting staff and tutors should be briefed and ready to answer the testing questions which fall outside their normal terms of reference. It is important that they are actually one step ahead of the students.
- Deliverables should be carefully defined and unambiguous.
- Evaluation criteria should be systematic and well thought out - capturing the real lessons to be learned at group level and at individual level.
- General feedback should be given as soon as possible after the scenario.
- Create a sense of excitement and fun. Scenarios can be stressful and very demanding and it's important to maintain perspective and a sense of humour.
- Be available to help with problems, stimulate thinking and innovation.
- Encourage and motivate. Take time out to talk to every one. Take an interest. Walk the job.
- Reward success and effort wherever possible. Your enthusiasm will rub off on others.

The role of "scenarios" in the future

A personal view - after over five years working on scenarios and 25 years at Director level in industry, I can see an increasing need for scenario based learning particularly where a multidisciplinary approach is required for success. These days - that means almost everything in almost every sector, both public and private. We need to learn how to put wiser heads on young shoulders.

The word "complexity" has become a universal way of characterising our world. The future offers much more of the same and we have to adapt our behaviours and our way of learning to stay on top. We also have to increase the pace as old "on the job" training paradigms and professional development processes cannot cope with the increasing pace of change.

Within this context most experienced project managers and industry leaders agree that it's the soft people skills that make the difference between success and failure. You can't get leadership skills or experience from a book or off the internet. Likewise, you can't build a successful team remotely. It requires face time and human interaction. Good leadership and teamwork are contact sports.

Can an environment be created to practice these essential skills where risks are limited and real lessons can be learned? Airline Pilots have flight simulators. For engineers, project managers and business leaders, carefully designed scenario based training can provide rehearsals for real life situations. When conducted in a learning, supportive environment everyone emerges as a winner. Practical experience and wisdom are key.

I would like to see scenarios becoming more widespread as industry recognises that single disciplined training just won't deliver the capability that's required in today's complex world. We can't afford to make mistakes on projects or fail in the way we manage our businesses or our enterprises. We should take the opportunity to learn, rehearse, make mistakes and fail off line - BEFORE we step into the limelight where the stakes are much higher.

I believe that UCL has developed some unique capability and has helped demonstrate that scenario based teaching can make a real practical difference - ordinary people doing extraordinary things.

More than that, I think UCL has demonstrated that you can put wise heads on young shoulders

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A LEARNING APPROACH ARISING FROM THE PBL MODEL WHEN TRAINING LAW UNDERGRADUATE STUDENTS: A CASE STUDY

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ABSTRACT

There is wide agreement that Problem Based Learning (PBL) is a key strategy to promote individual abilities for "learning how to learn". The present research is based on the analysis of 30 reflective journals of law undergraduate students participating in a PBL module, where they were invited to reflect upon their learning experience. The analysis of their reflections has allowed us to identify different key issues concerning their experience. The degree of interest among students and the identification of the different type of self-regulation processes experienced are paramount elements to it. Two dominant aspects arise when implementing and developing a PBL approach: (i) PBL tutors assume a more complex role as facilitators of students' learning in comparison to traditional teaching styles; (ii) students do not necessarily have the set of skills required to learn autonomously. Such skills, instead, have to both be thought over and developed through different learning experiences, with projects and specific interventions of tutors.

PROBLEM BASED LEARNING AS AN STRATEGY FOR PROFESIONAL TRAINING

In this paper, Problem Based Learning (PBL) is assumed to be a leading strategy towards the acquisition and development of skills and competences of future law professionals. PBL enables students to develop explicative hypotheses and to identify their own needs along the learning process, to better understand the problem or scenario that has to be solved and to reach the attained learning purposes. However, PBL is more than a teaching methodology. It is a pathway to understand education as a learning style. For some authors (Barrows, Wee Keng Neo 2007; Bridges 1992) problem solving becomes an essential element of what is entitled as aPBL (*authenticPBL*).The ability to solve problems is the core element of learning. Furthermore the two main competencies that PBL can provide for lifelong learning are: the ability to search for, contrast with and make synthesis between different sources of information and its contribution to learning how to learn. This can be achieved through the challenges embedded in the proposed problems and with the facilitator's role, when supporting students along the process of problem-solving.

Consequently, the leading purpose of PBL should be to provide professional training to students facilitating their process of building up their own intellectual categories. This requires an environment hoping to encourage and stimulate learning. When students are able to identify their targets they also can assume responsibility to be engaged significantly in their own training. According to Kolb's (1984) learning model, by sharing aims and goals of their learning processes, students benefit from a greater commitment and receive more feed-back. This approach is well aligned with Boud´s proposal (Boud 1985) of PBL basic trends and its incidence in professional training. These are listed as follows:

- Building learning from the students' experience and knowledge, and the multidisciplinary nature of the problems.
- Emphasising the students' responsibility for their own learning.
- Learning focused on the process of acquiring knowledge rather than on the expected outcomes.
- The lecturer/tutor playing a key role as facilitator of the learning process.
- Focusing the assessment on student self-reflection procedures and peer assessment, rather than on the learning outcomes anticipated by staff.
- Paying special attention to the learning of interpersonal and communicative skills.

The use of a problem as an instrument that addresses student learning requires the use of analytical thinking skills. These skills aim to allow the formulation of explanatory hypotheses of facts or phenomena that have been subjected to prior tests of such reasoning.

According to Barrows and Tamblyn (1980) the ultimate goal of education is to train a professional who can solve problems in a competent and human way, and with the ability to use different types of knowledge. In this sense, learning 'as action' can be prioritised over learning 'in action'. So according to a new educational paradigm the concept of learning is understood as an active process that assigns students to a key role within it. Thus, PBL affects the three temporal dimensions of action. It also facilitates students' motivation to new situations and real problems that they explore through the neo-Piagetian concept of *(socio)cognitive conflict*. Learning takes place within an environment where interactions happen among members of the group of students and between them and the teaching staff. Finally, students receive constant feedback from the PBL tutor in different situations, as well as from their own reflection and tutorial sessions, or by email inquiries. Therefore, the action becomes the context (and the necessary condition) for students to develop their own learning competencies.

STUDENTS' REFLECTIONS AROUND PBL CONTRIBUTION TO QUALITY LEARNING

Having established the basic purpose of PBL as developing quality learning it comes to light that there is diversity in perception. This quality, as a property of a system, or as part of complex and participatory processes of different agencies and agents can be evaluated from different approaches, so it can be perceived in many different ways (Laughton and Montanheiro 1996). In the project discussed here, a well-known approach to quality was adopted. In it, Harvey and Green (1993) establish five categories to define quality in Higher Education. According to this framework the students' reflections about the contributions of PBL to their training were analysed from the transformative perspective, where the internal changes and the skills developed among students are emphasised.

Some research on students' learning shows that students adopt different approaches according to their previous learning experiences, and the particular contexts in which learning takes place (Ramsden 2003). Several studies also show how deep learning approaches are associated with learning outcomes of higher quality (Gibbs 1995). Previous work (Rué et al. 2010) shows significant results regarding the contribution of PBL in a comparative study assessing its impact within various groups of students. The evidence from research shows that PBL students were those who displayed better reflection on the key issues identified as being facilitators of quality learning. They also show better ratings to the perceived quality of their training and a better orientation towards developing self-regulative learning, or functions such as exploring and re-structuring new conceptual relationships. In this research we consider as being *transformative* the evidence related with learning key issues such as:

- Assigning relevance (social, professional, academic) to learning situations.
- Engaging and empowering students in learning.
- Enhancement of learning autonomously.
- Enhancement of their self confidence in complex problem solving.
- Development of strategies towards resources for learning.
- Development of strategies and tools to critically reflect and investigate.

When analysing the data of the current case study, the main purpose is to identify the extent to which it is possible to find evidence of the aspects aforementioned. Secondly, it is considered to which extent these aspects are thought to have a positive or negative impact according to the students' reflections. In relation to students' ratings in assessing the quality of learning it may sometimes be argued that satisfaction is not dependent on quality, and in some cases they oppose each other. However, the students' ratings analysed here are not self-reported, and the above key aspects were adopted, in line with other authors work (Marton and Säljö 1976; Lindblom-Ylänne, Trigwell *et al.* 2006; Handal and Lycke 2004).

THE RESEARCH, METHODOLOGICAL APPROACH AND ANALYSIS OF THE REFLECTIONS OF STUDENTS

The present research is based on the analysis of 30 reflective journals of law undergraduate students participating in a PBL module. The students worked in teams of four, assuming the role of becoming a legal consultant in charge of developing comprehensive responses to different demands presented. In later stages of the academic year, the working scenario assumed a narrative form, which required greater involvement of students in a work setting, closer to the professional reality. The research made reference to the ratings of a group of 36 final year law undergraduates, relating to a module developed in two phases. The data analysis considered a set of factual information coming from two main sources: the students' journals and semi-structured interviews at the end of the course, conducted by the tutor, in order to evaluate their learning outcomes. The journals were organised around the free thoughts of students related to their own learning. The interviews, conducted by the tutor, were designed to attempt to analyse relevant aspects of the learning process made by the students. Both types of data were gathered once the module learning was finally assessed, which excluded the possibility of any impact in or from the teacher assessment marks or exerting any consequences of academic value whatsoever. The investigation was designed subsequently as a way of exploiting the data previously collected. Data from the oral statements and those expressed in the journals of the students were broken down into information units, i.e. units of information which in themselves had full meaning and any reader could understand and interpret in the same way. For each unit was assigned a reference source and was codified with the framing reference model. This model is represented as follows (Figure 1), based on the notion of *functional alignment* (Biggs 2003).

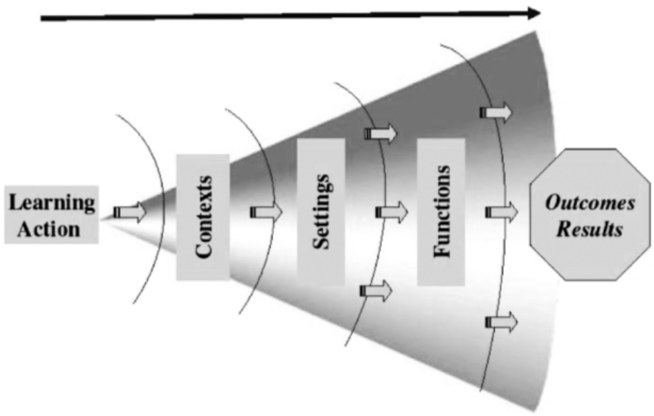

Figure 1.Autonomous learning model AQA/ECA08 (RUÉ, 2009)

According to the model used (AQA08, Rué *et al.*, 2009), the act of learning requires an alignment between certain settings and the corresponding functions expressed within it. These settings and functions are described in the following table (Table 1):

Table 1. Basic description of the settings and functions considered.

Settings	
DOCUMENTARY	Characteristics and properties of the information and resources available to students. The documentary setting not only includes the necessary

	information to accomplish a learning task but also guidance on the information given and the necessary steps and references for students to follow it. It can take different forms; a detailed hand out, or the basic explanations and generic guidance aimed at helping students find the information needed.
STRUCTURING AND GUIDING	Rules, guidelines, criteria, deadlines and assessment criteria, either given or requested, which are aimed at helping students understand and direct their learning tasks effectively.
PSYCHODYNAMIC	Successful social interactions and feedback that will keep students motivated, focused and inspired. Team-building, mentoring and discussion of the experiences involved in the learning processes are some of the social skills involved.
METACOGNITIVE	Knowledge, strategies and skills that allow for an active control over the learning process, planning and self-assessing tasks and self-monitoring comprehension.
Functions	
EXPLORING-RELATING	Activities aimed at associating theory and practice, developing skills, procedures and ways for preparing and articulating concepts.
COMMUNICATION	Feedback modalities on content and procedures.
PLANNING	Functions referring to the method of organising and managing the subject area and the learning tasks.
TUTORING	Coaching practices aimed at giving sustainability and meaning to learning processes.
REGULATING AND SELF-REGULATING	Evaluative or self-evaluative functions in relation to learning practices.

Main evidences found according to the settings defined

The body of evidence collected suggests important advantages of the application of PBL methodology into professionalising studies, such as law studies. The first advantage is that it encourages a deep learning approach. A second advantage is that the analysis contributes to the students' identification of relevant learning settings. Table 2 shows the settings sorted from highest to lowest percentages according to students' references.

	Interviews		*Journals*	
Learning settings	*nº*	*%*	*nº*	*%*
Metacognitive	102	33.7	244	62.72
Psychodynamic	105	34.7	137	35.22
Structuring and guiding	66	21.8	125	32.13
Other	29	9.6	33	8.48
TOTAL UNITS OF MEANING	**302**	**100**	**539**	**100**

Table 2. Assessment of the relevance of different settings by students, depending on the number and percentage of units of information identified.

The data in table 2 shows that a high relevance is attributed to self-regulation at work and in learning (metacognitive learning setting). As shall be argued later, this is a cross-cutting issue throughout the whole analysis. This evidence is observed in the percentages of positive references to a setting that favours self-regulation competence. Thus, students in their reflections, prioritise the need to know what they are doing, why and how. Statements such as "to know how to manage my own learning", "learning to acquire new knowledge, skills and competences", "to link what is studied with real world opportunities", all reflect a positive evaluation, which is shared by 45% of the students in their self-reflective journals, where they tend to express themselves more freely. The analysis also shows the importance assigned by students (psychodynamic setting) to the support received from peers and their tutor. This aspect, combined with the above, informs about the main concern of students: knowing how to solve their learning and having support from their peers and tutors to overcome the challenges of learning. When considering the cooperation with peers, 69.8% appreciate the positive cooperation and exchanges in the interaction. These concerns are supported by a third perception: to appreciate the fact of having an adequate *guiding orientation* (23.13% - 22%) is appreciated by a significant number of students.

Functions that have been shown to be necessary in the process of learning

According to the analysis model used, settings require complementary functions to obtain a positive perception from the student's point of view. Consequently, this section displays what functions have been demonstrated to be the most useful and the extent to which they were complementary with the previous settings. In the journals, students expressed their interest for certain functions that are crucial to their learning. For them "exploring and relating", is emerging as the dominant function (73% of ratings) within PBL methodology. This is a function that embraces the acquisition of theoretical knowledge, practical skills and competencies displayed in situations as plausible as the reality itself. The "communication" function, both by tutors and students – on the goals, procedures and content available – while engaging in the activity, is valued as positive by 14.7% of the students. The results are shown in Table 3.

Table 3. Assessment of the importance assigned by students to the functions identified in the PBL process.

	Journals	
Functions	*N*	*%*
Exploring-relating	263	73.26
Communication	53	14.76
Planning	27	7.52
Tutoring	16	4.46
TOTAL	**359**	**100**

Given the high percentage of reflection identified in students' journals, we aimed to take the analysis forward towards determining to what extent the function *exploring-relating* was oriented. One of the aspects recognised has been the learning levels shown by their reflections. For this reason, and adapting Bloom's learning levels approach (BLOOM 1956), we distinguished between three levels of learning, one of them (*understanding*) would be associated with a more "surface" level of learning; a second, located at an intermediate level (*application*); and two others linked to a more "deep" learning (*analysis and reflection*) (Table 4).

Table 4. Levels considered in exploring-relating function.

1 Understanding	*Aspects related with understanding (information, concepts) of the subject and content to be applied during the resolution of the cases.*
2 Application	*Aspects related with the application of different content in a specific situation / case study / simulation of real cases (includes procedures, sequences of decisions, etc.)*
3 1.Analysis	*Refers to issues related to the analysis of information and content, as well as the overall analysis of the proceedings and issues arising from it.*
3.2Assessment	*Knowledge activity related to the strategies and tools to assess the case or problem and the possibility to make a value judgment by students.*

According to table 4, the analysis of the units of meaning identified in the students' journals report the following results (Table 5).

Table 5. Levels of depth in learning reflected in the students' reflections.

Level of depth	*N*	*%*
2 Application	121	46.01
1 Understanding	70	26.62
3.1 Analysis	71	27.00
3.2 Assessment	1	0.38
TOTAL	**263**	**100**

The percentages in table 5 show that around 50% of the students develop a level of learning beyond the surface one. Application skills are likely to be developed through certain basic levels of analysis. The rest of the students are divided into almost two halves, which seem to show a basic understanding of the problem (26.62%) and those who show a level of deep learning (27%). However, the data above allows us to conclude that, from the students' perspective, 73% (46+27) estimate that they develop a learning approach beyond the surface and instrumental one. A complementary analysis has been adopted in order to analyse which is the object of students' reflection within the exploring-relating function. In Table 6 we can observe the data collected. This data suggests a strong consistency with the approach of learning identified in the previous section. It should be noted that approximately two-thirds of students welcome the fact of fully understanding the process of problem solving. In the same sense, the percentages of students who focus on the activity itself agree with those who show a more surface orientation, focusing on "understanding" what they are doing.

Table 6. Exploring-relating function and percentages of units of meaning identified.

Orientation	*Description*	*N*	*%*
Process	Refers to the process and procedures needed to follow the activity.	174	66.16
Activity	Refers to the activity or task performed.	78	29.66
Professional career / future career	Refers to the relationship between the task and the future professional practice/career.	11	4.18
TOTAL		**263**	**100**

CONCLUSIONS

In summary, it can be argued that the vast majority of students' valued positively all the aspects related to their own learning in the context of the module and the methodology used. Some of the reasons that may explain this are firstly, that the body of evidence expressed in the analysis encourages the implementation of the PBL approach to professionalising studies such as Law. In this sense, it appears that PBL is a useful approach to explore and relate the different content of the subject, and relate it with real world situations. PBL contribute to learn beyond the subject itself and to establish meaningful bridges between theory and practice. This confirms Boud's thesis (Boud 1985), where the link between theory and practice in PBL learning environments constitutes one of the most relevant features for learning. Secondly students attribute significant value to a 'deep' learning approach. This approach matches with the importance assigned by students to self-regulation during the learning process. This positive valuation highlights two important issues: the growing commitment that students have to their own learning and the strengthening of their ability to learn autonomously. The nature of this commitment and autonomy is reflected in the data, which is of great interest. This does not refer to autonomy in the sense of working on their own; on the contrary it is autonomy to work in a relevant way and based on the evaluation of what students attribute to the function of exploring-relating. This dominant function makes data more meaningful and it informs that a high percentage of students (around three quarters) develop a learning approach that would go beyond surface and instrumental learning. At the same time two-thirds of the students welcome a deep understanding of the process of developing the problem or scenario proposed.

However, the data collected reported that students' valuations are not only related to the introduction of a PBL approach. They are also related to the interactive dimension of learning. Thus, students find both very important and useful, to have a high support of peers and the PBL tutors. Such interaction is understood in terms of trade and cooperation. Furthermore, it is also supported by a third element which is having facilities for a clear action orientation. In this frame, it is not surprising that students in their ratings do not refer explicitly to the assessment and self-assessment of learning, or to their modalities, its timing and marking criteria. It may seem paradoxical but working from the projects/scenarios approach forces them to make continuous decisions about what to do, how to do it, to review the own work, to correct it, etc. and the students perceive and value this aspect of self-regulation in their learning as linked to the assessment.

To sum up, according to the aforementioned points it seems possible to establish some guidelines and hypotheses which appear to be relevant in the development of such approaches as PBL:

- When it is intended to promote deep learning and autonomy in its achievement, the teaching and learning methodological issues are being emphasised.
- In the PBL approach the tutors assume a key and more complex role than in traditional teaching styles. The tutor acquires a dynamic role and self-regulation catalyser, instead of being a transmitter of knowledge.
- A key role is to provide students the best scaffolding during the process of solving the challenges proposed.
- Students do not necessarily have autonomy, this is a *competency* that is learned and developed throughout the projects. Specific tutor intervention in this sense can foster the further development of such autonomy.
- It is important to assume that the principle of autonomy is to admit the diversity of personal learning styles, which consequently must be considered from activities of autonomy management and the assessment tools proposed.

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GROUP PERFORMANCE MODEL FOR AN ACTIVITY LED LEARNING APPROACH

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ABSTRACT

In order to enhance students' employability and future prospects it is necessary to develop their problem solving competences through an Activity-Led Learning (ALL) approach. There exist several models and theories on problem based learning as a tool. However there has been less research on group interpersonal processes and interaction, which can have significant impact on the successful realization of the approach. In this paper, we propose a Group Performance Model in order to deploy ALL successfully in a master-level module, Network Planning and Management. The model facilitates individual inter-action and group formation in a structured process. A key advantage of this model is that it allows students to focus on the activity/task, rather than be distracted by issues such as inter-personal conflicts, by developing their understanding of group processes.

INTRODUCTION

Traditional methods of learning focus upon didactic methods of content delivery i.e. lectures and assessment by means of assignments and or examinations to test knowledge.

Passive learning processes are rarely student-centred and are unlikely to equip students with transferrable skills, when they move from academic environments to work based employment. One of the key issues is a recognition that "Learning how to learn [skills] is of key importance." (French *et al,* 1999) In this respect introducing students to reflective learning and embracing it, was a critical element. An understanding of how highlighting and enhancing their level of self-awareness of their learning styles was similarly important. In assessing the effectiveness of teaching methods and focussing upon a student centred methodology, ALL offers a number of opportunities, in particular its "ambition to improve the learner experience [was] underpinned by a learning and teaching vision to build a community of learners, through employer and profession focussed activity led education" (Wilson-Medhurst 2008). In seeking to create this environment, there was a need for detailed preparatory work and structure. Debates concerning the nature of Problem Based Learning have focussed upon different interpretations of how it is facilitated. The student activities and learning may be tightly controlled or may be open-ended; the student's role may range from being an autonomous learner to being more directed as a member of a project team; the tutor's role can be that of a task setter and guide ranging through to a facilitator; and the learning activity can range from being very prescriptive (finding a specific solution to a given problem) to students working towards achieving their own individual goals (Savin-Baden et al 2004). There would appear to be less debate and concern however, relative to the process of how problems are addressed by students and the group dynamics that either assist or prevent effective group problem solving. There was an allied issue concerning how students approached a new style of learning, alien to them and how that related to their own reflective practices. It was determined that closer focus upon group development supported by tutor feedback and coaching was required. This was in order to enable students to recognise their individual learning styles as well as their self-awareness in a group context; issues such as conflict management and the achievement of group goals were integral to a learning experience that sought to acquaint students with "real world" problem solving strategies.

Methodology

The research methodology employed stemmed from student feedback and observations concerning their reflections upon their experiences in an activity led learning environment. A process of problem identification sought to detail any issues that had adversely impacted upon the ALL processes. It was clear that there were frustrations experienced by students that related to interpersonal issues as group members, rather than the tasks they were set. As entry level Masters students, they were unused to this particular university environment, to each other and to this style of learning. Additionally there was a high proportion of students for whom English was a second language. There was a need to deal with fundamental issues of group selection and formation, in order to address this problem. Additionally, students needed preparation for ALL as it was clear that it presented difficulties for them. (Uden & Beaumont 2006) This process was crucial to their realisation that they were developing essential skills pertinent to their eventual future employment. In essence, there was a need to understand the

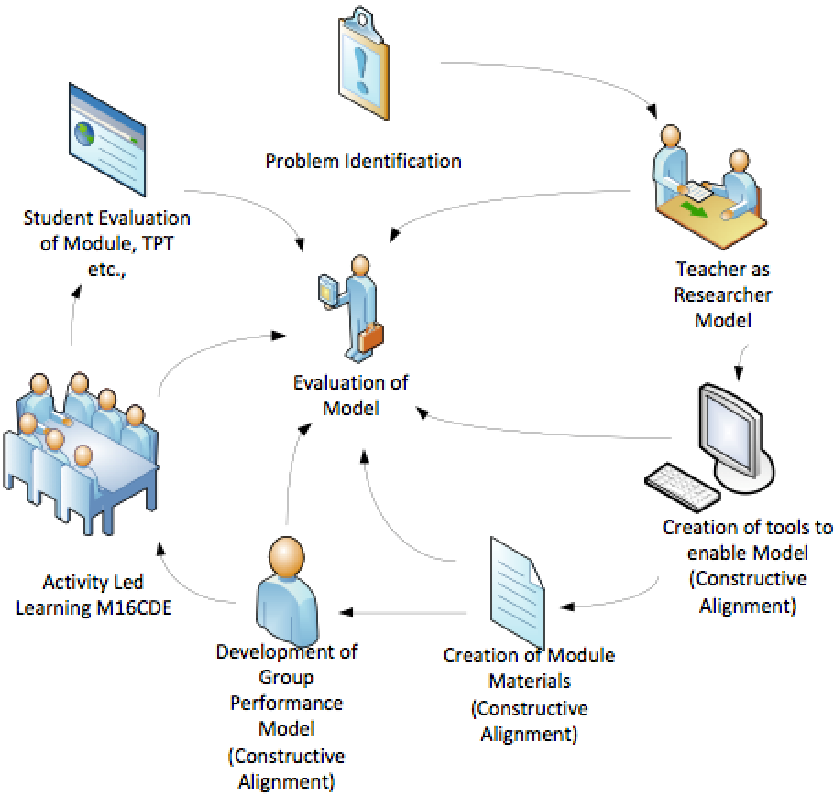


Figure 1 Methodology graphically represented

relevance of ALL in their approach to the solution of a "real world" problem by using appropriate skills. In seeking to develop a Module with "real world" relevance and application, we wanted it to be a stimulating and satisfying experience, not merely the completion of an academic exercise. In seeking to apply some rigour with respect to how the methodology employed could be audited, it followed an Action Research and 'teacher as researcher' model. Action Research defined by Cohen and Manion (1994) quoted in Bell (2000) is "essentially an on the spot procedure designed to deal with a concrete problem located in an immediate situation… As an essentially practical, problem-solving nature of action research make this approach attractive to practitioner-researchers who have identified a problem during the course of their work and see merit in investigating it." Figure 1 seeks to graphically represent the stages, undertaken in this process, with the cyclical process at each and every stage, subject to assessment and evaluation of this Model. This virtuous circle of improvement seeks to identify “what works” in order to build upon it and to address the perceived weaknesses or areas of development. The use of the concept detailed by Biggs (2005) “Constructive Alignment”, was a framework relative to which the methodology would be continually tested:” 'Constructive alignment' starts with the notion that the learner constructs his or her own learning through relevant learning activities. The teacher's job is to create a learning environment that supports the learning activities appropriate to achieving the desired learning outcomes. The key is that all components in the teaching system - the curriculum and its intended outcomes, the teaching methods used, the assessment tasks - are aligned to each other. All are tuned to learning activities addressed in the desired learning outcomes. The learner finds it difficult to escape without learning.”

Activity LED learning development

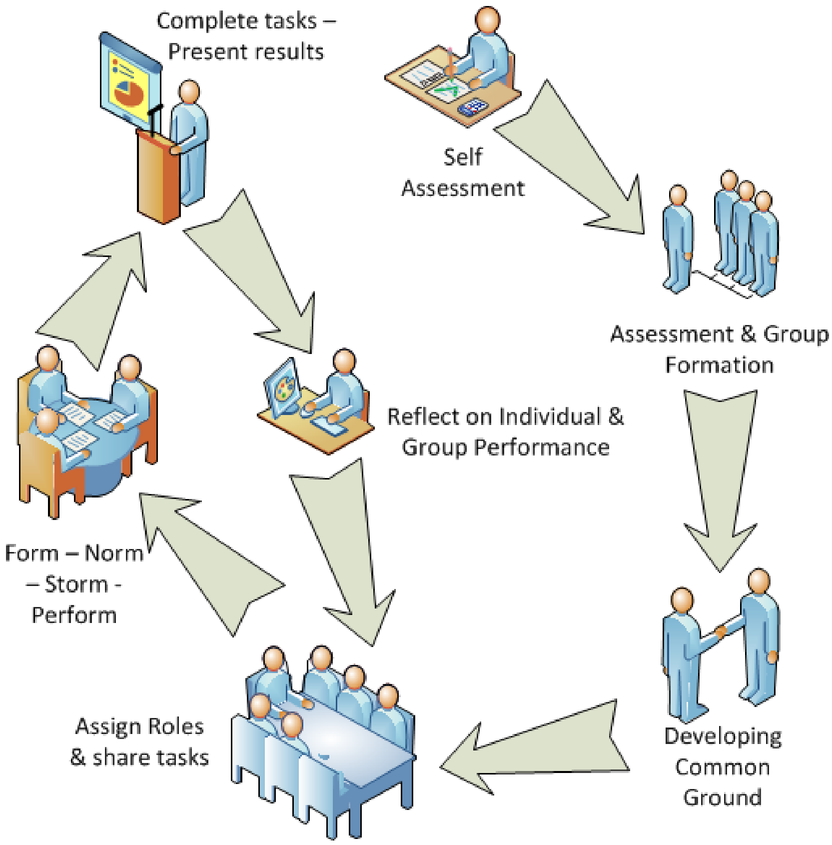
There were a number of identified objectives structured to develop ALL in this context:

a) To investigate the gap between students’ needs and the learning materials presented to them.
b) To develop a learning material that was relevant to the needs of students at this level.
c) To explore the theories relating to “Common Ground” and “Group Development” to identify their relevance to the teaching methodology adopted.
d) To develop a Group Performance Model that sought to identify the steps within group development that might maximise group interaction.
e) To improve the employability of Masters students by the identification of transferable skills and the acquisition of work related skills in the context of life-long learning.
f) To identify issues relating to the amount of time spent on relevant tasks by students to identify informative observations regarding any conclusions from this teaching methodology.
g) To assess the student’s reaction and views on the teaching methodology.

It is beyond the scope of this paper to address all of these, so we will concentrate on those relevant to the Group Performance Model. The first issue revolved around the group selection process and composition of the groups. The majority of group members were unknown to each other and the time constraints applied meant that the groups were directed towards task completion i.e. addressing the problem that the Case Study posed. There was, as a result a degree of confusion concerning individual roles and responsibilities, amongst a number of students. It appeared that unless an individual assuming the role of *Group Leader* was prescriptive in respect of task allocation and responsibilities, some groups inevitably floundered. Whilst documentation and guidance was provided for students concerning ALL, as a new style of learning, it was for many confusing. There were instances of lack of participation of behalf of some individuals and a sense that some students benefitted from the hard work of their colleagues, whilst offering minimal effort themselves. Kitchen (2010) noted with respect to groups of engineering students: "We cannot expect that it is enough to put eight random people into a group and tell them to solve a problem." In many ways this observation was central to my problem identification; there was a need for some planning and time to produce synergy in group formation to enhance ALL. Secondly, there was a statement that the Module would not teach the discipline of Network Planning and Management; there was guidance with respect to recommended materials with no formal lectures or instruction. This had been the subject of adverse comment from students who felt there was some "traditional" lectures. This was latterly addressed with some specific inputs following student feedback, but there was the belief that some guidance was required for student research to be fruitful. Thirdly, there was the observation that in submission of materials by groups, that some students habitually "cut and pasted" large amounts of material, rather than synthesising information. There was a need to engage students in more than regurgitation of researched works; the application of knowledge in a problem solving, decision-making process was required. There was an allied issue concerning how within a group submission and activity, individual contributions could be determined? Essentially, determining who did what within the context of their joint efforts? The core problem identified was that there was a requirement for a more managed process of group selection, formation and development. Structured exposure to Activity Led Learning was required and development amongst students of an understanding of what it was and what its potential benefits were. In particular the requirement to focus students upon their course of study, rather than be distracted with group issues, identified the need for greater tutor involvement and coaching.

Group performance model

The process model for this module was defined as a Group Performance Model. (see Fig. 2 ante) In essence this approach defined a structured process whereby students were guided through steps that defined their metamorphosis into a cohesive, functional and



productive group. This was formulated having regard to the theories of "Common Ground" and "Group Development" which are detailed at length ante. This model focussed on the elements of ALL that were potentially problematic and might hamper its effectiveness. The initial stage of the process was for the students to come together as a cohort. The students were given a self-assessment document where they were asked to assess and rate their own knowledge of computer networking disciplines, to grade themselves and to detail any relevant experience they had. This was a relatively initially simplistic means of assembling groups but was subject to change if necessary. The intention of a number of the questions was to establish what elements might constitute "Common Ground" for the students. These questionnaires were then given a weighted score and groups of 4 to 5 students selected on the basis of shared skills and abilities. The self-assessment process could of course produce disparate results i.e. if students either under estimated or over estimated their skills/relevant knowledge. Where any group was particularly unbalanced, individuals would be transferred to address any imbalance. The groups were formed with a developmental model of increasing "common ground" between students. Students were engaged in a process of "interviewing" each other with a questionnaire that built upon their first self-assessment. The inclusion of questions of a more personal nature (although it only focussed upon non invasive material) was designed to act as an "ice Breaker" in order to break down barriers and enable some effective communication. They were then to introduce their colleague(s) to their other group members; this process was designed to bring the individual students together in a group format in order that they would be able to gain knowledge of each other. The first Group task was to select a Group Leader for the first task; there was no prescription as to who was selected or volunteered, save that each group was required to have a leader.

Developing "Common Ground"

There is a good deal concerning ALL that requires interaction between students; the use of group meetings to examine a Case Study problem requiring their physical presence. A key element to the writers' belief in this teaching methodology relates to an appreciation of "Common Ground" theory in the facilitation of group processes. We briefly discussed below how it was used and the purpose of its use. In espousing Common Ground, H H Clark asserted, "individuals engaged in conversation must share knowledge in order to be understood and have a meaningful conversation." (Clark 1996) In this respect, facilitating "Common Ground: " between individuals who are collaboratively working upon a joint problem, remote from each other might be seen to be posing an insurmountable obstacle. In this respect a model for establishing "Common Ground" was proposed that focused upon initial team building with the object of moulding individuals into committed team members. It was further determined that in order for effective and continuing collaboration; the need to establish and build "Common Ground" was a structured process.

The learning materials required each team member to have assigned roles, in a Case Study context that required a skillset or was one that had to be acquired, over and above their involvement in the process as "students." Therefore initial student engagement was through facilitated exercises, where a group of students become a homogenous entity: a "Project Team or Board," was established. This enabled the group to engage in joint problem solving that was identified as a core process in order to address the task or Case Study. Studies have focussed, on "how the media [in this case web Technology] through which communication is conducted affect the ability of cooperating agents to accomplish a shared task." (Kutti *et al*, 2003) The need to achieve more meaningful initial exchanges between students was identified

as a requirement. "Common Ground" was partly addressed through the use of a common taxonomy and terminology. The student cohort was predominantly constituted from students for whom English was their 2nd language and the necessity to establish clear lines of communication was prioritised. This was initially facilitated through "ice breaking" exercises where individuals were required to complete self-assessment questionnaires in order to determine their level of knowledge and computer networking experience. Students were then assigned to groups on a basis of assessment of a skill and experience blend, and directed to undertake a joint interviewing and introduction exercise, where the group was able to become acquainted in a non threatening environment.

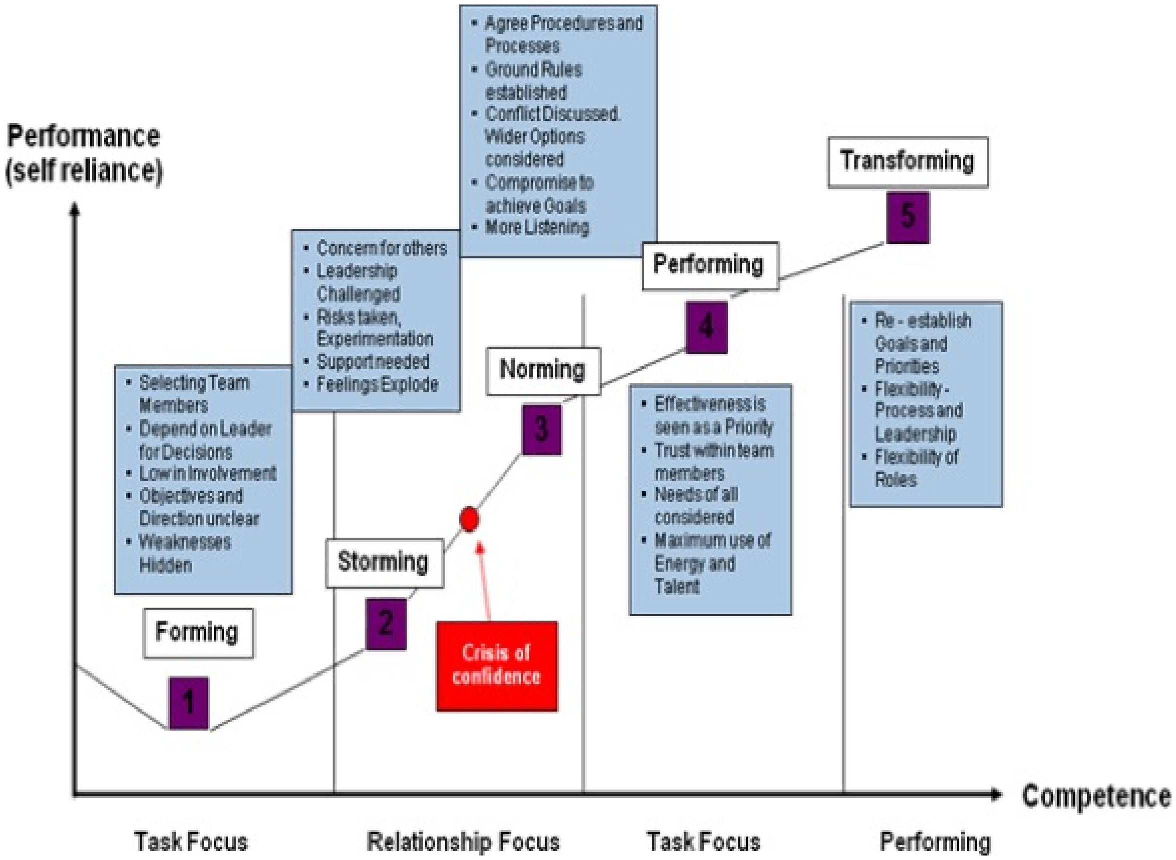


Figure 3 after Tuckman (1965) Group Development http://bpdassociates.com 2011

There was some time spent in explaining the mechanics of ALL as a discipline and an explanation of "group dynamics" in so much as they related to the module of study the students were to embark upon. The face-to-face establishment of "Common Ground" would then be consolidated by the use of team meetings that were to be held at times convenient to group members to reinforce its cohesive effect. This relied to an extent upon Tuckman's theory of group development and was explained in the context of the transferable work skills the module intended to facilitate. The process of **Forming – Storming – Norming – Performing** is a model of group development, first proposed by Bruce Tuckman in 1965, who maintained that these phases are all necessary and inevitable in order for the team to grow, to face up to challenges, to tackle problems, to find solutions, to plan work, and to deliver results. This was emphasised as a methodology to assess their own performance as individuals and to identify with respect to the process of group development. Essential to the understanding of group processes was an emphasis on the importance of maintaining a diary or journal in which students would record their experiences in a group context and relate it to their reflections upon their learning. This process is designed to:

- recognise their personal learning styles,
- reflect on how they address issues such as conflict, achieving consenus and in the context of "Common Ground," maximising the effectiveness of their communication, and
- identify how their individual personality traits contribute or otherwise, to collaborative work.

Integral to this is the belief that life-long learning can be achieved where self-awareness and assessment is embraced as a means of enhancing personal performance. This introduction to concepts that underpin Personal Performance Assessment criteria, as it relates to future student employment, seeks once again to acquaint students with their future work environments.

Tuckman and the group performance model (GPM)

In seeking to put the Group Performance Model in the context of Tuckman, the latter needs to be explained albeit briefly in this context. Fig. 3 details the stages within the processes of Form – Storm – Norm – Perform, detailing what happens in groups when they seek to jointly address tasks. This model has been enhanced with another element "Transform" and is explained ante. Tuckman and others sought to classify the stages in group development that bring about changes in the manner in which the group addresses a task.

Fundamentally, individual needs and perceptions are accommodated to a greater or lesser extent; the essential element, is that for a group to progress, it needs to move through the defined processes in order for them to become more cohesive as a group and achieve their potential.

In "Forming" the team is formed and is given a task. Initially group members behave like individuals; there are generally good feelings and relationships exist between them.

They will not know each other well enough for trust to be established and they will concern themselves with elements of the task that they feel most comfortable with. The "*Storming*" stage is where the group tackles the task suggesting different approaches and unless the team leader directs the process, there can be division and conflict if consensus cannot be achieved. It is a scenario where the interpersonal relationships between the group become tested and unless resolved may lead to long-term sense of grievance. If the group does not confront areas of disagreement, ultimately it may be the group cannot develop any further. If at this stage, group members feel slighted or believe that their opinion is not valued, they may become no more than passive members contributing little and diminishing the potential of the group.

The next stage is "*Norming*" but is dependent upon negotiating the "Storming" stage; it should be a period of more cohesive working relationships with group rules detailed or reinforced and the group identity firmly established. A key element is that all the group members' contributions are valued and as a result, their joint efforts contribute to their joint group efforts. As the group members confidence in each other increases any reliance on a Group Leader may diminish; it is also a stage where the group views itself as the "finished article" and complacency may set in reducing the group's efficiency. In "*Performing*" essentially the group processes are such that the group is at its most cohesive and productive. It is a stage that arguably not all groups achieve because high levels of motivation, responsibility and respect for their colleagues performing teams, will evidence the elements that characterise high. It is a "healthy" environment where self-criticism, intense debate and processes characterised by enjoyment and humour demonstrate the group's evolution into a cohesive and effective working entity. In respect of "Common Ground," this is the stage where its establishment is most evidenced and would indicate the highest levels of inter-communication and it being addressed at precisely the right level. Tuckman's original continuum of group development was later augmented by a further stage known alternatively as “Adjourning” or “*Transforming*.” The latter has been employed in this context and relates to the completion of the task and the break up of the group. The transforming element relates to the positive recognition of the skills and experiences gained within the successful addressing of a group task. Successful and effective Groups foster the achievement of like scenarios in future group or team environments.

Lessons learned

Tutor student relationships

There were various means utilised during to assess student experience and development during the module. In respect of the deployment of the GPM it should be recognised that groups and individuals within groups develop at a varying pace; the “storming” stage essential to group development may be experienced very early in the process or may be delayed. The level of inter-personal engagement and personal contribution from students will have highs and lows and this inevitably affects group performance. For the tutor the need to achieve effective communication with students is essential in order to be aware of the current stage of group development and any tensions that arise. Weekly tutorial sessions with groups was facilitated, as was monitoring of “on line” discussion groups and videos of group meetings recorded by students. The support offered to Group Leaders was crucial in respect of coaching concerning group issues and where necessary, individual group members whop were perceived as failing to effectively contribute. There was however an emphasis placed upon the students addressing these issues themselves wherever possible.

Student support

Students were provided with “on line” key texts, journals and associated materials via the University Virtual Learning Environment on a “Moodle” site and via “Twitter” feeds. This provision enabled the focussing of student effort upon applying this material and knowledge upon solving their set tasks and problems. This meant that students were able to dedicate time to problem solving, rather than the search for relevant knowledge and information.

Tutor workload

This approach places a focus upon the Tutor(s) in creating an environment where students have easy and regular access to them. This can be facilitated “on line” or remotely, but as the essence of the GPM identifies the need to establish “Common Ground” that process must be achieved in respect of the tutor- students to their mutual satiisfaction. This is a change or development in more traditional Lecturer type roles, but is essential in facilitating effective group development. It is not something that all individuals are necessarily equipped to do skills wise. Similarly, because of the level of engagement required it can be physically and mentally quite taxing.

Student – Tutor Feedback

There is a real need for a process of concurrent feedback on processes, materials and the student experience. In seeking to create reflective practitioners and group members, students must have the ability to freely discuss and comment on processes. Tutor feedback must similarly be timely and developmental in order that students can act upon it.

Creating the right environment

The energy and “buzz” generated in an ALL environment is fundamentally different to traditional learning environments. This is especially true where the GPM facilitates effective group development and student engagement.

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MASTERING PROJECTS AND PROCESSES IN THE AALBORG PBL MODEL

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ABSTRACT

The Aalborg PBL Model encourages experiential learning through group-projects. Supported by a course on PBL and project-management the groups develop process-competencies in order to achieve the required outcomes. The paper investigates factors significant for achieving an efficient process and an effective project as well as the logic behind groups' getting a grip of their project. It is recommended that in order to secure the quality of the required learning the facilitation should pay close attention to 1) the reflective practice of the groups; 2) the logic behind the groups' handling of their project; and 3) the decision-making processes of the groups in order to secure the quality of the required learning.

INTRODUCTION

The Aalborg PBL Model which Aalborg University (AAU) is practicing does not prescribe the use of specific or tight scaffolding for the student projects. Rather than focusing on scaffolding AAU focuses on research methodology as the general underlying structure for the projects. The methods for structuring the project as well as the process are therefore important learning outcomes of the first year at The Faculties of Engineering & Science (FE&S). Together with other process-competencies this learning is supported through a course and through the facilitation.

The course on PBL (incl. project-management – PM) is offered to all first-semester engineering students and provides general support for students' project-work and collaborative learning when planning and conducting a scientific problem-based project – as described in (Mosgaard and Spliid 2011). A facilitator is assigned to each project-group (first semester one facilitator, second semester two) who through regular meetings and additional communication (mails, text-messages, phone-calls) is available for consultancy regarding all project-related issues. As (Kolmos and Kofoed 2004) proposes reflection and experimentation as the method of developing the needed process-competencies the PBL-course supports this. Yet with a new study-structure project-facilitation has been eliminated from first semester and the coordinated effort to develop process-competencies is hampered.

Experience from teachers and facilitators consistently indicate that students have problems in acquiring the required learning outcomes regarding process-competencies during the first year. Feedback from the facilitators confirms that reports are lacking coherence and consistency as well as a reflective and critical perspective – the reports have structure, yet students lack overview and insight regarding the underlying logic. Process-competencies seldom reach the desired level of reflection although most groups appear to complete their projects through pragmatic, common-sense solutions.

Findings from surveying groups' perception of PBL and PM competencies confirm this (Mosgaard and Spliid 2011). A large majority of students do not acknowledge the importance of PM and about half of them feel ill equipped for performing PM with little change over the semester – as many groups also find PM more difficult than expected. The survey also shows that groups spend more of their project time on writing and structuring their reports than on anything else and a large majority of the groups identified this as an important activity. At the same time a majority feel ill equipped to write and structure the reports. One of the main aims of the PBL-course is to secure that the groups reflect upon their process and project-work several times during the semester – reflection on-action (Kolb 1984) – in order to secure that they learn from their own and other groups' experiences. Groups find evaluation and reflection important but spend little time and feel ill equipped for the performance (Mosgaard and Spliid 2011).

The scope of this paper is to explore further into the groups' difficulties acquiring the process competencies – specifically regarding the groups' structuring of process and report as this seemingly constitutes the principal pivot and thus an essential competence. The aim is to gain a deeper understanding of the groups' own perceptions of mastering their project. The initial research-question was:

Which factors do the groups identify as significant for an efficient process and an effective project?

Answering this should provide evidence of groups' own perception of significant factors – providing a useful foundation for later research into the learning and use of these factors. Therefore the groups' first-semester process-analysis reports (delivered at the end of the project-term) were regarded as a valid and reliable source of data. Furthermore, it was decided to select one program among the 20+ first year programs (as explained below in Methods) namely Global Business Engineering (GBE) with seven first-semester groups.

A thorough reading of the process-analysis reports (6-11 pages per group) generated themes which led to Table 1 showing that the groups as a whole report a broad range of factors significant for an "efficient process and effective project" (neither relative importance nor quality of the reported activities and PM-tools have been assessed). It should be noted however, that the groups use the term "project management" with different connotations – namely "steering", "handling" and "getting a grip". Verification by two experienced facilitators at AAU confirms that the themes in Table 1 constitute a valid and representative description of first-semester groups' recount of their ways of dealing with the realities of the Aalborg PBL Model.

Goals	Activities	PM Tools	Personal issues
Structure	Planning Revisions	Time-schedule Planner Top-Tail Problem Statement Research Design	Discipline Motivation Engagement Attention
Efficiency	Decisions Task division Focus	Agenda Moderator Collaboration agreement	Trust Confidence Awareness
Learning	Discussions Writing Feedback (incl. facilitation)	Problem Learning outcomes Peer learning Log	Ambitions Preparation Sharing
Familiarity	Communication Social activities Evaluation	Collaboration agreement Tests on styles of learning & working	Openness Trust Confidence Attention

Table 1. Overview of factors the seven GBE-groups report in their first-semester process-analysis to be significant for an efficient and effective project.

Regarding process-competencies it is concluded that groups as a whole possess declarative knowledge ("know-what"), yet the process-analysis cannot give a full account of the procedural ("know-how"), conditional ("know-when-and-why") and functional knowledge. The presence of this, though, can be verified by the level of reflection and experimentation as explained by (Kolmos and Kofoed 2004). As regards reflection the first-semester process-analysis reports demonstrates common-sense and few comparative reflections but no vertical reflections conceptualizing the experiences. The level of experimentation is lower as move-testing – intentional experimentation as opposed to more explorative experimentation – appears to require more confident and more creative students and/or higher awareness of consequences and possibilities, which again suggests need for more experiential learning.

Concluding this preliminary analysis the data confirms that first-semester groups in the Aalborg PBL Model experience problems acquiring process-competencies at the required level, and the data also confirm that groups' striving towards efficiency and effectiveness aims for a more coherent and consistent approach to handling the complexity of the Aalborg PBL Model. The students are apparently adequately prepared for a longer second-semester project-term and a more complex project-problem. Consequently, the research to uncover by which means the groups master their second-semester projects will be guided by the following research question:

"What is the logic behind groups' getting a grip of their project?"

Following a short presentation of the concepts and theories underpinning the learning of process-competencies in the Aalborg PBL Model, the method of empirical data collection is explained, and findings are presented and discussed.

Development of process-competencies by reflection and experimentation

The literature points out a dilemma for the learning of process-competencies: learning by doing takes several iterations unless students apply an approach involving conscious and deliberate reflection and experimentation as concluded in (Kolmos and Kofoed 2004). Moreover, drawing on (Biggs 2003), evidence and experience points out that students at AAU initially have either declarative or procedural knowledge but no or limited conditional or functional knowledge. Students initially fail to acknowledge the extent of complexity of the Aalborg PBL Model. Developing functional knowledge (equivalent to operational process-competencies) involves a strong component of feedback from peers and/or facilitators. Besides, this development involves, as stated, conscious and deliberate reflection and experimentation – efforts which for many groups collide with their perception of efficiency, instead common-sense solutions are sought or majority rule dictates the decisions.

Students are cornered: they are trying to escape the "difficult learning" termed accommodative and/or transformative learning as opposed to the relatively "easier" assimilative and cumulative learning – see Table 2. The work by (Illeris 2007) describes how accommodative and transformative learning poses difficulties and threats to the students. Reconstructing understandings and insights is not an instructional issue – it is the result of conscious and deliberate reflection and experimentation by students supported by feedback from peers and facilitator. The inevitable resulting resistance is related to perceptions of identity, ambiguity and inconsistency.

Cumulative	Assimilative	Accommodative	Transformative
Establishing new schema	Adding to existing schema	Reconstructing existing schema	Reconstructing several schema simultaneously

Table 2. Four forms of learning, based on (Illeris 2007).

Empirical analysis

The goal of the following paragraphs is to present some of the findings from the additional data-collection among student-groups. The hypotheses to be tested were:

1. When groups are able to explain "what, how, when and why" the chosen methods and tools are applied – then they master their project;
2. When groups are able to relate their research design to other research designs and explain consequences of the divergence – then they master their project;

Method

The somewhat ambiguous findings in the initial surveys among first-semester groups (Mosgaard and Spliid 2011) indicated a need for further research, and for this the author selected one study-program, namely Global Business Engineering (GBE). The reasons for this were

- the author's previous experience with the program as teacher and facilitator;

- the complexity of second-semester project (open-ended; explorative; real business case);
- a sufficient number of project-groups (6 in second semester);
- the GBE first-year coordinator reported a general impression that the groups overall were not mastering their first-semester projects;
- observations by the author during GBE-groups' PBL-seminar and PBL-consultations in second half of first semester revealed that: 1) groups experiencing problems refrained from or were reluctant to apply PBL- and PM-tools; 2) reflection was predominantly common-sense; and 3) project- and report-structure posed a general and serious concern among groups.

The data-material was obtained through

1. Reading first-semester process-analysis reports (seven groups; 6-11 pages per report);
2. Observation of a full-day midway status-seminar with all 6 groups;
3. Observations of 1 group and reflection on facilitation of this group – 8 meetings and some mail-communication (reflections shared between the two facilitators);
4. Semi-structured interviews with 5 groups (excl. facilitated group) lasting 70-80 minutes;

Results

In the following paragraph the main results of the analysis will be presented.

Observation of midway status-seminar

The groups responded to a suggested formula for their project-presentation wherein facilitators asked for the groups' reasoning behind their choices of initiating problem-statement, theoretical framework, approach for problem-analysis, research-question, methods for data-collection and –analysis, and project-planning and –handling. Also groups were urged to present their doubts and difficulties concerning the project as well as the process. Yet, the groups primarily presented the contents and activities of the project so far ("the what's" and some "how's") while the reasoning behind ("the why's") were given little attention. The other groups and the facilitators acted as opponents questioning the choices made and gave suggestions. The doubts and difficulties presented mainly dealt with practicalities (i.e. "how to" improve data-collection and –analysis; "how to" perform the simulations and tests).

Despite similarity between projects, groups applied visually different research-designs, and generally groups reacted resistant when being criticized on their approaches and choices. It appeared that each group seemed content with their own understandings and rejected most suggestions from other groups and from facilitators – as if each group believed in their way being the truth. Obviously the perceived methodological logic should not be contested. When summing-up the status-seminar the parallels between a general research-design and a general process-flow were presented by the author but caused no reaction from groups. It was later (app. 2 weeks) confirmed during the interviews, that groups agreed to the contents of the summing-up but preferred to stick to the course they had already outlined.

Facilitation of one group

The group produced a time-schedule and a thorough research-design – of which the latter was abandoned despite consistent doubts and discussions over which alternative approach to follow. The relatively few meetings with the two facilitators were mainly initiated by the facilitators. The meetings predominantly addressed research-design and data-handling and little effort was directed towards feedback on written material. The problem statement changed several times resulting in recurrent and explicitly formulated doubts and de-motivation. The realization of inadequate data-collection and inadequate theoretical basis hampered the decision making in the group. Nevertheless, the group completed the project with a satisfactory result testifying to the perseverance and resilience established early and intensified through the semester.

Interviews with five groups

All interviews were opened with the question: "How do you get a grip of the project?" and the author took notes of the answers on the blackboard in the group-room in order to obtain transparency and validity. Later these notes were transferred to paper.

The interviews sought to provide evidence of the groups' "handling" efforts within the frame of the factors outlined in Table 1. Afterwards it appeared that the answers given fell in three distinct categories: steering, resources and disturbances. Findings will be presented accordingly.

Steering

The immediate answer to the opening question concerned "time-scheduling" (3 groups), "anchors" (1 group) and "discussion" as knowledge-sharing (1 group). The statements following to deepen these answers encircled a conglomerate of comprehension, planning-measures and research-design. Three groups had elaborated on their first-semester report-structure, while one group had established the research design after consulting with project-reports from previous years. The last group had established their research design on basis of the narrated project-description in the project-catalogue. No groups could give valid explanations of consequences if research designs were changed or reformulated. All groups reported that consultations with the contextual facilitator late in first semester turned out to be surprisingly helpful for the groups as the facilitator provided assistance with the research-design and report-structure. In second semester this contextual facilitator continued helping explain the meaning of methodology – as one student phrased it: "she explains what [the technical facilitator] says".

Steering thus appears to imply activities of decreasing uncertainty and decoding complexity – while simultaneously practicing and increasing process-competencies. The increased level of knowledge resulting from this is encompassed in this student statement: "we have a grip of the project when we know why".

Resources

This theme primarily involves group-members' agency (here defined as the capacity and will to make choices and to impose those choices on the world), the time available, and the facilitation – such that

- agency on group level is a consensus based state securing progression in accordance with the factors outlined in Table 1;
- time available dictates prioritizing and sequencing of goals and activities independent of research-design and report-structure ;
- facilitation as a resource varies in perception between "providing" and "governing" – meaning that the agency and the expertise of the facilitator are components that can be negotiated if this will not violate the facilitator's principles.

Disturbances

The factors disturbing (obstructing) the groups' "getting-a-grip" appears influenced by

- time available for project-work (one particular course is very demanding);
- facilitation (availability; style);
- decisiveness (inadequate subject knowledge; inadequate experience with this project complexity; fear of making incorrect decisions);
- social factors (non-productive socializing activities e.g. talk, games);

- lack of transparency of and agreement on project methods and goals;
- differing behavior concerning group-work (differing ambitions and seriousness).

Discussion

The status-seminar reveals that an approved (or not rejected) research-design is a tool and agent for an "efficient process and an effective project". When the recipe ("how to") is established with a clear structure and explicit procedures then the groups have a grip of their project (due to the many "grips" or "anchors" on their scaffolding). Follow-ups and tight coordination may be part of the agreed activities. This logic may be added as yet another factor essential for the groups as a visible sign of ownership implicitly supporting the groups' decisions and reasoning.

The facilitated group completed the project with a satisfactory result testifying to the perseverance and resilience established early and intensified through the semester. The decision-making was quite obviously influenced by the emotions within the group – following prolonged, two-sided discussions the group just wanted to get on with the urgent project-work and made choices to ease their frustration rather than basing their choices on well-argued cognitive and professional standards. The logic extracted from this set of data points towards reflection and experimentation as tool and agent for achieving "an efficient process and effective project". As unintentional the reflection and experimentation may have been – and from a facilitator perspective it was not "an efficient process and effective project" – the group certainly have achieved a more inquiring and critical approach to research methodology.

Despite the fact that the generic illustrations of research design and the associated project-management were made available to groups from the onset of second semester, the interviewed groups had no recollection of seeing these before and the designs had played no role for the groups' establishing of own project-structure or research design. Apparently no facilitators had directed the groups' attention to this material. Nevertheless, the groups were able to compare with their own processes and reason about the deviations. Explaining their reasons for ignoring reflection and planning during the process one group concluded that they "didn't think about it nor prioritized it". The logic emerging from this incident testifies that there should be a guided way into the research-process and the methodology (e.g. exemplified through a case or performed as role play) as simplified hand-outs without facilitative guidance and follow-up has no value for the group

Apparently the reflections applied by the groups are focused on the question "where do we go from here?" – a Schönian-type reflection-in-action (Schön 1983) approach with less intensity and impact in the groups' version, though. As the PBL-course has promoted a Kolbian-type reflection-on-action (Kolb 1984) intended to increase the quality of learning itself and of the learning-process groups have received no input with measures for reflection as decision-support. An everyday sense-making or way-finding that is familiar to the students – the art of muddling through while achieving some degree of success without much effort – would constitute a systematic and beneficial approach with lasting effects on achieving "an efficient process and an effective project".

Yet, reflection in-action sessions on questions like: "where are we? what are our goals and why are they important? what are possible activities and how to choose?" constitutes a sense-making or way-finding that is unfamiliar to the students. Likewise reflection on-action on the other hand is a procedure receiving little attention (though frequently presented and encouraged) as it is regarded a non-value adding activity until useful results repeatedly convince groups. Clearly incremental evolution of process-competencies is non-transparent for the groups unless adequately worded and acknowledged within the group, and preferably also recognized by the facilitator through appropriate feedback. The specific task of focusing on supporting reflection-in-action as well as reflection-on-action belongs primarily with facilitators but must be initiated through the PBL-course. Even facilitators' reflective practices may rely more on common sense than comparative or vertical reflections.

The logic behind the "where-do-we-go-from-here" attitude has close resemblance with the assimilative learning – that the process progresses mechanically step-by-step and predominantly without loops. The logic clearly depends on the type of project (explorative, explanatory, demonstrative, constructive, innovative or a mix). As second-semester groups has limited experience with scientific projects this logic can lead to coincidental success or failure – unless properly scrutinized through well founded scientific logic (guided by the facilitator) the "where-do-we-go-from-here" attitude may take too many iterations to complete the project within the time-frame. Common-sense approaches can turn into more commonalities than required sense-making.

Accommodative learning concerns whole or partial restructuring of already established mental schemes (Illeris 2007). Whether the establishing of these schemes is recent or more distant has less significance. What appears significant for the groups is whether there is a perceived consistency between first and second semester facilitation and a perceived compliance among the group of facilitators. When facilitators openly discuss their differing perceptions of problem statements and research methodology (as happened during the status seminar) groups react defensive and reject possible learning – a situation usually hampering agency either caused by increased uncertainty and frustration or caused by strengthened ownership to the project and to the research-design. As a consequence of this the facilitators should always explain the reasoning behind their perspective or suggestion – making it evident that the logic of scientific projects differs according to the intended outcome.

Achieving the competencies that comply with personal issues, diminish uncertainty, and lead to attaining the learning objectives (i.e. passing the exam with a good grade) bears evidence in itself of mastering the will to succeed. The logic of the group emerges from the negotiation between the aggregate wills within the project-process: there is a beginning and there is an end – the in-between sense-making is a game that relies on cognitive as well as affective approaches to ownership. The decision-making and the associated agency within the group should be regarded as high priority – it is a process with significant impact on group performance. An allegory expressed by a student exemplifies the challenge for the individual student as well as for the group: "It's like when you can dribble the ball with attentative eyes on the surroundings rather than with eyes fixed on the ball – that's what we're practicing."

Conclusion

Hypothesis 1:

- ✓ When groups are able to explain "what, how, when and why" the chosen methods and tools are applied – then they master their project.

Hypothesis confirmed – although groups differed in their readiness to clarify the full logic behind their research design or report-structure, this type of understanding clearly supports the mastering.

Hypothesis 2:

✓ When groups are able to relate their research design to other research designs and explain consequences of the divergence – then they master their project.

Hypothesis partly confirmed – groups can relate their research design to other research designs, yet the interviewed groups hold insufficient experience to elaborate on consequences of the divergence.

Answering the research question

"What is the logic behind groups' getting a grip of their project?"

depends upon the perspective. From students' perspective it is a matter of controlling the significant factors sufficiently. Still in second semester the level of agency and the logic applied differs considerably among students and between groups. It appears that the transparency and sustainability of the logics uncovered relies on the facilitators' competencies as regards relating the groups' choices to sound scientific practice and to the desired "efficient process and effective project".

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PEER-ASSESSMENT AND GROUP-COMPOSITION IN PBL: A CASE STUDY

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ABSTRACT

The Engineering Investigation project is a second year Civil Engineering PBL project at Coventry University that presents particular challenges due to the diversity of the cohort. The project has been run for two consecutive years. In the first year of implementation students freely formed their own groups, and they coalesced around commonality: part-timers worked with part-timers, international students worked with international students, etc. This led to a very large dispersion in the marks attained. In the second year of implementation, students were allocated groups. These groups mixed part-time with full-time students, UK/EU nationals with international students and so forth. This was introduced in order to promote peer-to-peer learning. Peer-assessment was used as a tool to differentiate individuals' contribution in both instances. A survey was carried out to investigate students' experience with allocated groups, gauge the benefits to the learning experience and assess the perceived fairness of peer-assessment as an individualising process.

INTRODUCTION

Project Management and Engineering Investigation is a second year Civil Engineering 20 credit module composed of two elements. Engineering Investigation (EI) is the 10 credit element that takes place in the first term of the year and consists of a Problem-Based Learning (PBL) group project. This module started in October 2009, and has therefore been running for only two consecutive years (2009-2010 and 2010-2011). The project has two main objectives: it aims to contextualise Civil Engineering concepts learnt in previous, concurrent, or indeed, future modules; and aims to develop and rehearse skills deemed of value in both in industry and academia, such as presentation, CAD draughting, teamwork, report writing, critical thinking and creativity.

About the courses and student diversity

The Department of The Built Environment at Coventry University runs some Civil Engineering courses that are accredited at Chartered Engineer (CEng) level and some courses that are accredited at Incorporated Engineer (IEng) level. According to UK-SPEC (Engineering Council, 2011) Chartered Engineers optimise, analyse, research, evaluate and lead in their field of engineering, whereas, Incorporated Engineers are more concerned with the application and management tasks of the profession. CEng courses have higher entry requirements than the IEng courses, especially in terms of mathematics. Students from the CEng and IEng courses come together for non-mathematical modules, such as 'Project Management and Engineering Investigation', but are streamed for the more mathematical modules such as 'Structural Mechanics' and 'Soil Mechanics'.

Another characteristic of the courses offered at Coventry University is the combination of part-time and full-time students into the same delivery sessions. Most part-time students work in the construction industry and are sponsored by their employers. Davies (2008) observed that part-time students at Coventry University in general out-perform full-time students. For the cohorts studied the average difference across all modules was 6.4 percentage marks.

Finally, Coventry University has a significant intake of international students, mainly from Africa and Asia. Though most international students arrive into the first year of the courses, some are direct entries into the second year of the course. In most instances investigated in this paper students were asked to define whether they were UK/EU or international students. When this information was not available, an international student was defined as the one paying an 'overseas' fee.

The EI project

'Engineering Investigation' has been the main Problem-Based Learning project Civil Engineering students undertake in the second level of the course, representing 10 credits (out of 120). The brief for the last 2 years has consisted of the sustainable regeneration of a brownfield site in Coventry city centre. The project has been used to contextualise, practice and learn Civil Engineering skills and concepts such as: 'Health and Safety' risk assessments; site investigation desk-studies; urban master planning; road, cycle-path and vehicle parking design; design of Sustainable Urban Drainage Systems (SUDs); land surveying; and sustainability concepts in general.

At the beginning of the project the students were presented with a brief (the problem) and it was contextualised within Coventry's master plan by a representative from Coventry City Council in a lecture. Students then received a lecture on aspects to look for on a site investigation. Subsequently they would rehearse these skills by visiting the site. Following the site visit students started preparing development proposals for the site in accordance to the brief and their observations. Their work was supported by lectures and tutorial sessions. In their own time students would meet to discuss and plan their work as a group. Students would also remain in contact during the week via email.

The early lecture and tutorial content was aimed at supporting the early tasks of the design and the global vision of the master planning. The subsequent lectures contained more technical aspects of the Civil Engineering design, and the latter lectures were focussed on professional presentation of drawings and academic report writing. The lectures were complemented by tutorial sessions. In order to increase the number of members of staff supporting the tutorial sessions, interns (post-graduate students employed by the university to provide academic support) were used in the first year of delivery (2009-2010). Feedback from the students regarding the value of the interns' guidance was quite negative. They felt it was limited (as some interns had less professional experience than the people they were trying to guide) and contradicted the expectations of the assessor. For 2010-2011 student proctors (Young *et al* 2011) were used instead. The chosen proctors were third year full-time students who had excelled in the previous year in the EI project. Though they were seemingly younger than the interns, they had greater clarity of the expectations of the assessors from their own experience. Their understanding of the brief and their professionalism much exceeded that of the interns, and this was reflected in the feedback given by the students.

Also, to avoid confusion about expectations in 2010-2011 different members of staff played different roles. The Senior Lecturers running and assessing the project played the role of Client representative, guest lecturers were external industry experts, and the proctors played the role of senior colleagues in their practice, therefore they could *only* provide guidance, but they could not interpret the intentions of the Client.

The cohort was split into groups of 5 students. In 2009-2010 groups were formed freely i.e. students chose their teams. In 2010-2011 students were allocated into mixed groups. The composition of the mixed groups aimed to be more balanced, consisting of at least 1 part-time student and 1 international student. In order to also achieve a more balanced distribution of skills, a questionnaire was distributed to the students in the first lecture asking them to identify their 2 greatest skills from drawing, writing, researching and organising. It was ensured that every group contained an even distribution of skills.

Assessment of the EI project

The project mark was made up of several components. In order to create an opportunity for constructive feedback, an interim assessment was carried out approximately half-way through the project. In 2009-2010 this consisted of an interim report. In 2010-2011 the interim assessment was a crit. This was deemed to provide more speedy and expedient form of feedback, and allowed students to rehearse a different presentation skill (oral presentation). The final submission consisted of a 4000-5000 word technical report and two working drawings (A2 size) outlining the proposed master plan and conceptual Civil Engineering design; both were assessed for style and content. The sum of the components (interim assessment(s), report and drawings) constituted the group mark.

With the aim to individualise the group mark blind peer-assessment (Russell *et al*, 2006) was used at the end of the project, but prior to publication of the group mark or return of feedback. The peer-assessment process was carried out through 'WebPA' software. The peer-assessment questionnaire focussed on the level of contribution and responsibility each student displayed throughout the project. The peer-assessment results were then used as factors to individualise the group marks. In the first occurrence of the project, 2009-2010, WebPA was set to allow a student's mark to be affected by up to 100%. In 2010-2011 it was agreed to cap the effect to 50% of the mark, as it was felt that allowing students to fail their peers was a contentious issue. This aspect is important to note, as it possibly had an effect on the final individualised results.

Feedback for the crits was provided immediately after these, but marks were released a couple of weeks later. Feedback for the reports was provided written on these and as an electronic audio recording. This method was implemented based on the experience presented by Moore (1979, cited in Nortcliffe and Middleton, 2008) for student preference and speed.

Experience from first occurrence of the EI project (2009-2010)

The first year EI was delivered (2009-2010) there were 130 students in the cohort, of which 29 were part-time students and 23 were international students. All part-time students were UK/EU nationals, and all international students were full-time students. For the purposes of this paper these two groups of students will not be further segregated between CEng and IEng students. However, the remaining group of full-time UK/EU students will be segregated for analysis purposes into CEng and IEng students, of which there were 44 on the Chartered Engineer course, and 32 in the Incorporated Engineer course (refer to table 1a). In the interest of simplicity full-time UK/EU CEng students will be referred to hereafter simply as CEng students, likewise for IEng students.

The average mark for EI was 62.2% with a standard deviation of 15.9%, prior to the peer-assessment factoring, increasing to 18.9%, after the peer-assessment factoring. When compared to the results for the other modules taken by this cohort during this period (Table 1b) it would seem that the average and standard deviation are slightly high. The best performers were the part-time students with an average of 72.8% and full-time, UK/EU, CEng students with an average of 68.7%. The worst performers were the international students with an average of 49.9% and full-time, UK/EU, IEng with an average of 57.2%. A similar pattern emerges for the other concurrent modules shown in Table 1b, though it is worth noting that part-time students are not the best performers in the more mathematical modules (Structural Mechanics and Soil Mechanics) and international students are no longer the worst performers in either Project Management or the mathematical modules.

	overall	part-time students	FT, UK/EU, CEng students	FT, UK/EU, IEng students	international students
Number of students	130	29	44	32	23
Average of group marks prior to peer-assessment	62.8%	73.9%	66.4%	57.9%	49.5%
Standard deviation for group marks prior to peer-assessment	15.9%	9.2%	15.0%	15.9%	12.8%
Average of individual marks after peer-assessment	62.2%	72.8%	68.7%	52.7%	49.9%
Standard deviation for individual marks after peer-assessment	18.9%	15.5%	16.8%	19.4%	12.5%

Table 1a – Constitution of cohort and Engineering Investigation project marks for the academic year 2009-2010

	overall	part-time students	FT, UK/EU, CEng students	FT, UK/EU, IEng students	international students
Average of individual marks – Project Management	60.3%	65.2%	63.8%	54.2%	58.3%
Standard deviation for individual marks – Project Management	13.5%	12.1%	12.1%	13.0%	11.1%
Average of individual marks – Soil Mechanics / Structural Mechanics	58.3%	59.0%	63.5%	49.6%	61.8%
Standard deviation for individual marks – Soil Mechanics / Structural Mechanics	18.1%	19.1%	16.0%	18.0%	14.1%

Table 1b – Marks attained by the cohort in other modules for the academic year 2009-2010

Responses in the university's official "Module Evaluation Questionnaire" at the end of the academic year indicated that students had liked the realistic project, but were critical of the organisation, support and assessment of the project. Amongst the criticisms made were those to the fairness of the assessment, the support provided by the interns and the composition of the groups (as expressed hereafter):

"*It is important to notice that some of the students are part timers, they have advantage over the full time students because they are making their living from designing, do not compare their work to the normal students.*"

"The interns gave varied and limited help."

"(...) I was left in a group that didn't contribute a lot. I feel all groups should be randomly chosen."

By the end of the first delivery of the module it was evident that the learning experience had been very different for part-time students immersed in industry to that of international students unfamiliar with the country, the language and the teaching and learning styles; this was evident from the huge spread of marks and the inconsistency with the results in other modules. It is worth noting too that during this first year of delivery, students were not provided with an opportunity to see the quality of work other groups had produced, so peer-to-peer learning opportunities were limited, other than within the group, but as groups had been formed freely this was limited too, as groups coalesced around commonality.

Mc Keachie et al (1986:63 quoted in Biggs 2000) states that *"there is no single best method of teaching, 'but the second best is students teaching other students'".* Davies (2008) identifies the untapped resource that part-time students are at Coventry University, and suggests creating mixed groups of part-time and full-time students; though the author does warn that this is likely to be unpopular with part-time students. It was therefore decided that greater opportunities should be introduced in the project for peer-to-peer learning. This would be done at three instances: mixed groups (containing at least 1 part-time and 1 international student), student proctors and crits. Through mixed groups and the student proctors peer-to-peer learning opportunities were created, crits were open to all students facilitating exchange of ideas and a greater appreciation of the quality of work other's produced.

Experience form second occurrence of the EI project (2010-2011)

The cohort of the second year of delivery (2010-2011) consisted of 155 students, of which 28 were part-time students, 40 were international students, 67 were full-time, UK/EU, CEng students and 18 were full-time, UK/EU, IEng students (refer to table 2a). The average for the EI project was 58.7%, which was slightly lower than the previous year, with a standard deviation of 9.8%, prior to peer-assessment factoring, increasing to 11.9%, after peer-assessment factoring, which was also lower than the previous year and lower than the other modules (table 2b). The lower project marks are consistent with the lower marks in the other modules taken by the cohort during this period (table 2b). The lower standard deviation prior to peer-assessment is likely to be a consequence of the introduction of mixed groups. The increment to the standard deviation after peer-assessment, though modest due to the capping explained before, indicates that some individualisation did take place. Mixed groups would not seem hugely detrimental to part-time students, as they obtained a project average of 61% prior to the peer-assessment, increasing to 65.6% after peer-assessment, giving them as the highest marks in the project, which is fairly consistent with their performance in other modules (table 2b). Interestingly, the improvement of part-timers' marks after peer-assessment indicates that full-time students are willing to acknowledge the contribution part-time students make to the project and reward them for it. International and IEng students' final results increased with respect to the prior year, despite their marks being reduced through peer-assessment. CEng students' results were closer to the group average than the previous year and were barely affected by peer-assessment.

Finally, it is important to note that there was one group constituted solely from late-starting international students that performed very poorly, the results for this group are deemed spurious as they were not representative of a 'mixed group' and have hence been removed from the data.

	Overall	part-time students	FT, UK/EU, CEng students	FT, UK/EU, IEng students	internationa l students (adjusted)
Number of students	155	28	67	18	35
Average of group marks prior to peer-assessment	58.8%	61.0%	58.9%	57.1%	60.4%
Standard deviation for group marks prior to peer-assessment	9.8%	8.3%	8.5%	12.2%	8.3%
Average of individual marks after peer-assessment	58.7%	65.6%	59.7%	56.1%	56.3%
Standard deviation for individual marks after peer-assessment	11.9%	11.3%	10.0%	12.5%	10.0%

Table 2a – Constitution of cohort and Engineering Investigation project marks for the academic year 2010-2011

	Overall	part-time students	FT, UK/EU, CEng students	FT, UK/EU, IEng students	internationa l students (adjusted)
Average of individual marks – Project Management	59.1%	72.5%	60.2%	51.8%	52.4%
Standard deviation for individual marks – Project Management	13.5%	12.4%	11.8%	17.2%	12.9%
Average of individual marks – Soil Mechanics / Structural Mechanics	50.4%	57.0%	50.1%	49.7%	47.6%
Standard deviation for individual marks – Soil Mechanics / Structural Mechanics	15.2%	18.4%	12.8%	14.5%	17.0%

Table 2b – Marks attained by the cohort in other modules for the academic year 2010-2011

The decision to constitute mixed groups for the academic year 2010-2011 was not taken lightly, though this was potentially a great educational opportunity, there was the risk that this would prove hugely unpopular amongst students, in particular part-time students who could see this as a burden. For this purpose a document was published and distributed to students explaining why this was deemed to be the fairest way to form groups. To complement this, a survey was carried out to investigate students' experience with allocated groups, gauge the benefits to the learning experience and assess the perceived fairness of peer-assessment as an individualising process.

Evaluation questionnaire

The evaluation questionnaire was distributed after the project was culminated and assessed. The questionnaire was anonymous, but required that students indicated whether they were part-time or full-time, UK/EU or international. It was also possible to infer if students were in the IEng or CEng course from the session in which the questionnaire was distributed. It contained 13 questions, of which 3 were multiple choice and 3 could be answered as simply 'yes' or 'no'. The subsequent analysis of the questionnaire refers only to the latter six questions. The questions, possible responses and number break-down per response per group type are presented in tables 4 to 7.

Total respondents	81
Segregation by mode	
Part-time students (UK/EU only, both CEng & IEng)	21
Full-time students ((UK/EU and international, both CEng & IEng)	49
Did not identify whether FT or PT	11
Segregation by nationality	
UK/EU students (FT & PT, CEng & IEng)	55
international students (FT only, CEng & IEng)	9
Did not identify whether UK/EU or international	17
Segregation by course	
student on CEng course (FT & PT, UK/EU and international)	71
student on IEng course (FT & PT, UK/EU and international)	10
student on CEng course (FT, UK/EU)	30
student on IEng course (FT, UK/EU)	9

Table 3 - Questionnaire Data Sheet

Possible Responses	overall	part-time students	FT, UK/EU, CEng students	FT, UK/EU, IEng students	international students
Total respondents	78	20	30	6	9
	Number of respondents per response option				
1 - Not at all	6	2	3	0	0
2 - Not very well	24	2	9	2	4
3 - Somewhat	15	6	2	3	2
4 - Mostly well	25	7	11	1	3
5 - Very well	8	3	5	0	0
Average response per category	3.06	3.35	3.20	2.83	2.89

Table 4 – Responses to Q6 – 'How well do you feel your group mark reflects the quality of the work your group produced overall?'

Possible Responses	overall	part-time students	FT, UK/EU, CEng students	FT, UK/EU, IEng students	international students
Total respondents	79	20	30	7	9
	Number of respondents per response option				
1 - Not at all	10	1	3	3	3
2 - Not very well	18	4	8	1	4
3 - Somewhat	16	5	4	0	2
4 - Mostly well	23	7	9	1	0
5 - Very well	12	3	6	2	0
Average response per category	3.11	3.35	3.23	2.71	1.89

Table 5 – Response to Q7 – 'Did the peer-assessment reflect effectively each person's individual contribution?'

Possible Responses	overall	part-time students	FT, UK/EU, CEng students	FT, UK/EU, IEng students	international students
Total respondents	75	21	30	5	7
	Number of respondents per response option				
1 - Not at all	17	2	3	4	6
2 - Not much	13	4	6	1	0
3 - Indifferent	8	3	2	0	1
4 - Slightly	25	6	15	0	0
5 - Very much	12	6	4	0	0
Average response per category	3.03	3.48	3.37	1.20	1.29

Table 6 – Response to Q8 – 'Did the peer-assessment make **your** mark fairer?'

Question	response	overall	part-time students	FT, UK/EU, CEng students	FT, UK/EU, IEng students	internati onal students
		Number of respondents per response option				
Q10 – 'Would you prefer to have all your group coursework peer-assessed?'	yes	40	11	22	1	1
	no	32	9	8	7	5
Q11 – 'Groups were created with a balance of part-time / full-time, UK/EU/international students and a balance of skills too. Was this good for your learning experience?'	yes	26	0	13	3	6
	no	29	16	8	2	1
Q12 – 'Would you prefer to choose your team members next time?'	yes	50	16	19	5	5
	no	7	2	2	1	1

Table 7 – Responses to questions 10 to 12

Discussion

From the data in Table 4 it is possible to observe that overall, with an average of 3.06 students in general felt that the group marks reflected 'somewhat' the quality of the work their group produced, with the part-time and CEng students showing greatest satisfaction with group marks, and the international and IEng students showing the greatest dissatisfaction. It is worth noting that part-time students obtained the highest average prior to peer-assessment, and that IEng students obtained the lowest, which reflects well students' attitudes, those obtaining the highest marks were the most satisfied, which seems obvious. Table 5 indicates a similar tendency to table 4, those who were favoured by the peer-assessment (part-time students) felt it was fairer than those who did poorly (IEng and international), but it is worth noting that the IEng students are quite split about this point. It is also interesting to note that IEng students seem particularly negative to peer-assessment when they only lost one percentage mark through the peer-assessment process, whereas CEng students gained less than one percentage mark, and still remained positive about the process. Attitudes towards peer-assessment seemed to be formed by perceived recognition, or lack of it, however small it might be.

Analysis into question 8 is limited, as it is the author's opinion that this question is flawed. The qualitative difference between level 2 'Not much' and level 3 'Indifferent' is vague and confusing. However, as similar trends to those shown in tables 4 and 5 are displayed, it is still possible to draw some conclusions, fundamentally yet again that the groups favoured by peer-assessment were more positive about peer-assessment. IEng responses seem particularly negative, but it is worth noting that there were fewer respondents for this question than for the previous, which had shown a split in the group. International students once again manifested dissatisfaction about peer-assessment.

Fewer students responded to questions 10 through to 12, than the previous questions. These were on the back side of the questionnaire and might have not been identified by all students. Question 10 clarifies the view of the tendencies observed so far, more than 70% of CEng students support further use of peer-assessment, whereas more than 80% of the IEng and international students would prefer not to have further peer-assessment. The most surprising result though, is that part-time students, the greatest beneficiaries of peer-assessment in this project and consistently the group most satisfied with the peer-assessment results, are split over its further implementation. The results for question 11 indicate that full-time students in general felt that the mixed group had been a productive learning experience, but it is worth noting that none of the part-time students felt that this had been a valuable learning experience. This would evidence that mixed groups are very unpopular with part-time students, and that they cannot see any benefit to them. The results for question 12 would seem to contradict the results for question 11, as all student groups, even those that felt that mixed groups had been a good experience, stated that they would prefer to choose their own groups in a future project.

International students also express an interesting, and seemingly contradictory, point of view with regards to mixed groups. They were quite emphatic that they found working in mixed groups beneficial, yet would prefer to choose their own group in the future. Mixed groups were introduced precisely to help weaker students integrate, and undoubtedly weaker student groups performed better in 2010-2011 than the previous year. Peer-assessment did lower their marks by 4 percentage marks with respect to the average, possibly making them feel chastised and maybe even marginalised.

Conclusions

The formation of mixed groups is one way to homogenise a diverse cohort, and is perceived by most students as an enriching learning experience, yet they would prefer to select their own group members. Possibly diversity within a group can be combined with free selection, and this should be considered in future instances. Part-time students are a valuable asset and can enrich the full-time student's learning experience considerably - full-time students acknowledge this - yet part-time students cannot see what they stand to gain in this form of peer-to-peer learning. Peer-assessment is a fair and reliable individualiser of students' contribution, but is not as popular as expected amongst part-time students, possibly because it does not provide sufficient academic reward. Had the cap on the effects of the peer-assessment not been placed, part-time students might have been more positive about its benefits, but of course this would have been detrimental to IEng and international students, who would have seen their marks lowered even further. The other form of peer-to-peer learning implemented in the module, student proctors as tutors, was quite successful, and it has a characteristic that mixed groups do not offer part-time students: proctors are paid to teach. If the use of mixed groups containing part-time students is to be continued in future deliveries of the EI project, the benefits to part-time students should be made more explicit.

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STAFF DEVELOPMENT AND STUDENT CENTRED LEARNING; THE STAFF DEVELOPMENT PROGRAMME FOR EXCELLENCE IN TEACHING AND LEARNING AT ISEL LISBON

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ABSTRACT

Problem and Project Based Learning (PBL) is one of the foremost student centred learning methodologies. For the teachers in higher education this implies a paradigm shift: from teaching to learning. To be able to work effectively with PBL the professors need to learn new skills, like how to share responsibilities across traditional discipline boundaries and to collaborate in interdisciplinary educational design teams, just like the students are expected to work together in their PBL teams.

In order to train the staff at ISEL in Lisbon a training course was set up. The objective of this training course is for participants to gain knowledge of the university's pedagogy in general and Problem and Project Based Learning in particular, while developing the ability to analyse and reflect on the teaching and learning processes. The paper evaluates the outcomes of this course plan.

INTRODUCTION

Traditionally, a teacher in higher education qualifies for the job on the basis of his / her achievements as a professional and / or as researcher, rather than on the grounds of teaching performance. As a consequence, the quality of university teaching is largely determined by the accidental occurrence of natural teaching aptitude. Following the increase of students in higher education, this method of securing teaching competence does not work anymore. In most European universities and colleges a freshman class nowadays consists of several hundreds of students. The professors, teaching in large lecture halls, need amplification simply in order to be heard by all students. Evidently, didactic skills play a different and more important role in such a large class than they did in the old model of private tutoring. Universities have to support students to acquire new knowledge and higher order cognitive skills to enable them to adapt to new contexts and pursue learning, whatever the conditions (Prosser & Trigwell, 1999).

Besides the changes in the participation in higher education, another factor increasing the need for didactic training is one that is in particular important in engineering education. It concerns the on-going diversification and specialization in science and the increasing speed of technological innovations (De Graaff, 2004). As a result of the rapid technological developments, teachers in higher engineering increasingly find themselves in a situation where they are unable to deal with questions from students directly, because their own experience has become obsolete. Moreover, the students will have easy access to the most recent information on line, and they will confront teachers with this knowledge. Consequently, the traditional teaching method of transferring knowledge from the experienced person to a layperson will fail more and more often.

The quality of learning depends on good teaching (Biggs, 1999). Teachers in higher education will have to learn to deal with new educational methods, which put a higher emphasis on the student's ability to direct their own learning process, like problem based learning (PBL), experiential learning and project organized learning (De Graaff & Kolmos, 2003). This means they will have to acquire competencies related to new teacher roles, like facilitator skills, advisory skills, etc. At the same time the teachers will have to acquaint themselves with new teaching technologies ranging from Internet software to simple presentation tools. As a consequence of the developments depicted above, professionals who become teachers need to develop their teaching skills much more systematically than before, and schools of engineering need to re-consider the kind of training they offer to their staff. The implementation of a faculty development programme presupposes an institutional culture where teaching activities are considered important. Academic leaders play a prominent role in this sense. Several authors stress the importance of institutional recognition of the quality and value of teaching in higher education by academic leaders at all levels (Wright, 1995; Knight & Trowler, 2001). All institutional policies and practices regarding teaching have to be fully supported by academic leaders from the lowest to the highest level. Demonstrating institutional commitment can take many forms from providing financial support to the organisation special events, initiating pilot programs, opening workshops and handing out certification at the end of programs, etcetera.

The summing up of possibilities indicates that in order to successfully implement a faculty development programme, it should be embedded in a "culture of teaching", and it should be part of a strategy. A qualification programme should include restructuring the teachers' knowledge, teachers' practice and the production of validated knowledge on teaching and learning. (Tillema & Imants, 1995). According to the Bologna process, student centred learning is an important component and Problem and Project Based Learning is one of the most applied student centred learning methodologies. The need for faculty development was recognized at ISEL (Instituto Superior de Engenharia de Lisboa) and the UNESCO chair in Problem Based learning at Aalborg University was invited to develop a training programme for excellence in teaching and learning (PETL). The objective of this training course was for participants to gain knowledge of the university's pedagogy in general and Problem and Project Based Learning in particular, while developing the ability to analyse and reflect on the teaching and learning processes. This paper describes the development of this programme and the experiences with two groups of participants.

The programme

The programme was developed by staff of the UNESCO Chair in Problem Based Learning in Engineering Education and consists of four main activities:

- An introduction workshop (on-site) of 4 days. Introducing tools and methods for design of curriculum to facilitate participants to work out a design of teaching experiment.
- A period for participants to work on experiments in their own class with possibilities of supervision from Aalborg University and individual work on a teaching portfolio. Materials will be available at the Internet and there will be a maximum of three facilitation sessions by using SKYPE or other online tools.
- A reflection workshop (on-site – 2 days) based on participants' documentation and reflection on their teaching experiments.
- Final assessment of participants' portfolio and reflection on and for practice.

The learning objectives state that after following the course the participants should be able to demonstrate the following learning outcomes:

- Ability to develop, plan, design, and analyse various types of student centred educational programs of both shorter and longer duration and in relation to various class sizes and types of students (e.g., lectures, seminars, study groups, project work).
- Ability to design cross-disciplinary projects.
- Ability to choose relevant pedagogic "tools" and methods for establishing student centred learning, especially problem based and project based learning.
- Ability to support the students learning process in relation to the students' group processes
- Ability to give relevant project-advice as a content expert.
- Ability to reflect own and others' teaching practice in a systematic teaching portfolio.
- Development of a vision for future teaching of students and a plan for concrete future student centred activities at ISEL.

The assessment is based on a teaching portfolio. The portfolio has to contain as a minimum: a vision on teaching and learning, design and documentation of the teaching experiment (assignment), students' evaluation and reflection on the learning outcome, design of cross disciplinary project, reflection on own development and plans for future student centred teaching and learning activities. The participants will be assessed in the categories: excellence achieved/non-achieved. If non-achieved, there will be recommendations for how to improve the portfolio/teaching practice. The UNESCO Chair issues a certificate to the excellence achievers.

Outcomes of the PETL programme

For the first run, starting in spring 2010 a total of 26 participants signed up. During the first 4-day workshop they were assigned to six groups so that each of the three trainers could supervise the members of two groups. At the second workshop in July 2010 14 people received a certificate. Three certificates were handed out a few weeks later after handing in extra assignments, bringing the total harvest of this group to 17 or 65%. The 8 people who did not finish in time to present their final portfolio in July had the opportunity to continue working on the portfolio and to present it together with the second group.

For the second group a total of 16 persons signed up, assigned to three workgroups. Two trainers who divided the supervision of these 15 candidates and the 6 remaining from the first run ran the course. At the second workshop in February 2011 eight participants presented a portfolio two of which were from the first group. At this point in time 19 participants of the first group have received a certificate, resulting in a success rate of 73%. A total of six certificates out of 15 participants comes down to a success rate for the second group of 40 %. There are a few participants who indicated they would like to present their portfolio at a later date. At this moment it is not clear whether such an opportunity can be provided.

At the end of the last sessions of the programme the participants were asked to evaluate the course by means of a questionnaire. The questionnaire contained a series of open-ended questions on the appreciation for various aspects of the programme and a checklist aiming to inventory the learning outcomes of the course in terms of the learning goals that were set at the start. The participants were asked to rate the degree to which they attained each learning goal on a five-point scale. Table 1. (below) displays the results of the learning outcomes checklist.

	Group 1 N	Mean	SD	Group 2 N	Mean	SD
1. To formulate operational educational objectives for a course	17	3,65	, 93	9	4,11	, 60
2. To choose the correct educational format given a set of objectives	17	3,71	, 58	9	3,67	, 50
3. To collaborate in the design of a project including assignments and student guide	17	3,88	, 48	9	3,89	, 60
4. To act as a facilitator to groups of students working on a project including giving feedback	17	3,88	, 69	9	3,67	, 50
5. To define the criteria for assessment of individual and group performance in project work	17	3,71	, 58	9	3,89	, 60
6 to assess individual learning outcomes for project work	13	3,77	, 59	9	3,89	, 33
7. To develop a practice assignments including student guide	17	4,35	, 49	9	4,89	, 33
8. To organise and supervise a practice assignment	17	4,71	, 46	9	4,44	, 72
9. To define the criteria for assessment of performance of a practice assignment	17	4,29	, 68	9	4,44	, 52
10. To assess individual learning outcomes for a practice assignment	17	4,18	, 52	9	4,22	, 66
Table 1 continued	Group 1 N	Mean	SD	Group 2 N	Mean	SD
11. To develop a plan for lecture course including detailing the contents and the writing of a student guide	17	4,0000	, 79	9	3,78	, 97
12. To prepare running develop a lecture course including the preparation of presentation slides and homework assignments	17	4,35	, 70	9	4,22	, 66
13. To give a lecture course including an interactive exchange with the students (questions and answers)	16	4,56	, 51	9	4,00	, 70
14. To construct a test to assess the individual learning	16	4,25	, 57	9	4,11	, 60
15. To make a plan for supervision of an individual project	17	3,71	, 58	9	3,78	1,20
16. To give feedback on the performance on an individual project	17	3,88	, 48	9	3,67	, 86
17. To define the criteria for assessment of the performance on an individual project	17	3,82	, 72	9	4,00	, 50
18. To assess learning outcomes for an individual performance	17	3,82	, 63	9	4,00	, 70
19. To develop an online learning environment including a digital student guide	16	3,19	, 83	9	2,22	, 83
20. To manage an online learning environment including interaction and feedback	16	3,19	1,16	9	2,56	, 88
21. To construct an online test for assessment of learning outcomes	16	2,81	1,04	9	2,33	1,00
22. To motivate the choice for an assessment format in relation to the learning objectives	17	3,76	, 56	9	3,89	, 78
23. To construct items for a multiple-choice examination	16	3,81	, 75	9	4,00	1,00

24 to construct open-ended questions including an answer model	17	3,59	, 87	9	4,333 3	, 70
25. To conduct an oral examination	16	3,75	, 44	9	4,00	, 86
26. To teach in English	17	3,12	, 60	9	3,44	1,13
27. To produce study materials in the English language	17	3,71	, 46	9	3,67	, 86
28. To construct an examination in the English language	16	3,50	, 51	9	3,67	, 86
29. To report on the educational quality of a course or curriculum, including a plan for the improvement of weak elements	17	3,59	, 71	9	3,33	, 50
30. To reflect on my own competencies as a teacher in all different facets (design, construction, delivering and management of education)	17	3,94	, 55	9	3,56	, 52
31. To give feedback to other colleagues at ISEL	17	4,12	, 48	9	3,89	, 92
32. To develop a vision for future teaching and learning at ISEL	17	3,88	, 60	9	3,89	, 60

Table 1. Results of the learning outcomes checklist for the first two PETL groups

The results in table clearly indicate that most learning goals were realized in both groups. It can be seen that competences in the domain of practice teaching is most developed among the participants. With respect to on-line teaching, big discrepancies can be observed, in particular in the second group.

In a series of open-ended questions the participants were asked to comment on the PETL programme. A selection of the answers to these questions is given below, following the categories presented in the questionnaire.

A. Expectations

A.1 In what respect did this course meet your expectations for this course?

"This course helped me a lot to reflect on my teaching methods in order to improve students' knowledge, as well as my own knowledge."

"I enjoyed the course because a number of issues about the learning methodologies were cleared on my mind. I can now implement some learning techniques in a more secure attitude."

"It was surprising to me, both the approach and the outcome.
I found this course very interesting and useful. So, it exceeded my initial expectations."

A.2 In what respect did this course not meet your expectations for this course?

"I think the only problem was the time I had to expend as well as the difficulties of Implementing something new without the permission of my superiors."

"None"

"The first part of the programme was very interesting but it was too short. I would like to have had the first part more developed."

B. Learning outcomes

B.1 Can you outline the three most important learning outcomes?

"I learn that is very important to reflect about my job and the way of doing it.
Be aware if students are learning and if I'm able to reach them.
Be auto critical and aware of my own development and always think of students as the Centre of the learning process."

"*1. I'm surely a richer person intellectually because I've learned so much. 2. Working in a group: with the students, but also with the teachers; we all have so much to learn with each other. 3.To reflect and try to improve always."*

"Student centred learning activities. Some theories about pedagogical skills.
To learn how to write a portfolio and it's importance to me and other colleagues or co-workers (for example)."

C. PBL and student centred learning

C.1 Have you practised PBL or other student centred learning methodologies before this course?

"Yes, but without knowing it. Nevertheless, I missed some points. For example, the clarification of the learning goals and my role as a facilitator"

"No"

"I already try a student cantered learning during the laboratorial classes (practice assignment). In a very small scale I tried to implement the PBL philosophy in the laboratorial assignments"

D.2 What is your experience practising this?

“I think this kind of problems develops the capacity of students to think and search using the strategies of the trial and error.” “Is good, but I have a long way to go” “Graduated Projects and Final course projects”

D.3 Do you want to try it again?

“Yes, as I said in my teaching portfolio, next semester, I'm thinking of framing the PBL in the evaluation system of the course module and create a class to monitor the problem-solving research”

“I would like to do it with students that approved. That could be made and I intend to do it.”

“Yes. I will try to improve my skills on that.”

“Yes. Definitely”

E. Ideas for continues improvement

E.1 Are you planning a new teaching experiment for next semester?

“Yes, I’m development some practical chemical problems that student’s must resolve by themselves. They will need to do the research and the development of the best technique.”

“Yes. I will analyse the possibilities to extend the inter-disciplinary approach on CAD course, and I will, also, try to figure out the best way to implement our PBL proposal (proposal to be presented to the Mech. Eng. Dep. of ISEL, in conjunction with my colleagues.”

“Yes, I’m planning to introduce more practical contents in my classes and less teaching exposure.”

E.2 Which ideas did you get for improving your teaching next semester?

“To be more organized; to plan practical classes intermixed with theoretical contents; to be more reflective; to talk more with the students and to tell more jokes (to make a pause)”

“I think that project assignments can be done with several inputs of the department of chemical engineering. For example, I can propose a problem to solve with input of chemical

analysis, biology, analytical methods, pollution, etc. Like I did and explain in my teaching portfolio"

"Begin with applied examples and only after lecture about contents. Use more group work in classes. Try to get a problem that can be used throughout the semester for illustrating different contents."

Summarizing the outcomes of the selection of answers to the questionnaire cited above, it is clear that the participants display a highly positive attitude towards the course, even indicating it exceeds their expectations. The participants report useful learning experiences that will have impact on their teaching practice. The most serious criticism is that the course is too short. The participants will definitely need time to let it sink in and to be able to apply the newly learned educational methods with full effectiveness and they may be in need of guidance how to do that. Of course we have to realize that the questionnaire was filled in by the participants that concluded the course successfully and not by the participants who dropped out. In particular with the last group there were a substantial number of participants who never really started to work on the portfolio.

Summary and conclusions

The UNESCO Chair on PBL has developed a faculty development programme for ISEL to train a group of teachers that can become the leaders of educational change in the institute. The PETL programme that was developed aimed to embed experience with Problem Based Learning in a wider context of teaching competences. The programme applied the principles of PBL providing the participants with the opportunity to work together and to share experiences in small groups. A four-day workshop at the start aimed to introduce some basic principles of didactics. Most important in this workshop was the explanation of the importance of competence oriented learning goals as a tool for planning and development in education. Applied to their own situation, this was operationalized by means of an inventory of relevant competences. The inventory – the matrix of educational competences – was also the backbone of the assignment after the workshop. The main assignment for each participant to work on during the course was to document his/ her teaching experiences in a teaching portfolio.

At first it was difficult for the participants to understanding the purpose of the teaching portfolio. In the first group the explanation during the course was not clear enough. The explanation had to be repeated in several on-line supervision sessions. In particular the concept of “reflection on your teaching competences” proved difficult to understand. However, working with examples of their own work during the online supervision sessions made it much clearer and in the end most were able to use the reflections as a starting point for their personal development plan.

A serious problem during the whole course programme was lack of time. For starters it was not possible to find a timeslot where all participants could be present the whole time. More serious was the lack of time for working on the assignments. Several participants of the first group who were unable to present their portfolio reported that they simply did not have the time to work on it, due to other teaching or research obligations. Somehow this problem seems to have increased during the time the programme has been running. Of the 26 participants that started in the first group nine were not able to present a final portfolio in July 2010. However four of them did present a development portfolio indicating their commitment. Still only two of these participants were able to present their portfolio in February 2011. Despite several attempts it proved to be impossible to contact the others, so it is not clear what the reason is for their dropping out.

The second group proved to be less successful than the first. Only 6 out of 15 participants presented a portfolio. Three to four participants reported they were going to continue working on the portfolio and they hoped there would be an opportunity for them to present the results of their work. Several others never ever bothered to answer any calls or emails asking about their progress. Apparently there has been a change in national policy in Portugal during this period. At first participants had the impression, that a teaching certificate would be an important asset, essential for promoting ones career. Later, it turned out that this was not going to be a formal requirement. Therefore the performance in research would remain more important for ones career than any kind of teaching qualification. We can only appreciate the fact that teachers are quite capable of understanding the consequences of such policy measures and will act according to their best interest.

As for ISEL at least the result of this programme is that there is a group of 25 teachers who are certified as excellent in teaching and learning. Looking into the content of the portfolios we have seen some truly excellent developments. It is up to the management of ISEL to support this group in their future development.

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USE OF CRITICAL INCIDENTS IN A PBL APPROACH TO GENERATE CREATIVITY IN HIGHER EDUCATION LECTURER TRAINING

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ABSTRACT

Tutors engaged in training university lecturers commonly find lecturers questioning the practical relevance of underpinning pedagogical content knowledge (PCK) and continuing to use teaching methods experienced as their own learning habits. We found lecturer's becoming willingly motivated to change and integrate PCK, when anxious classroom moments that challenged teaching habits were explored and their feasibility 'accepted/approved' among a peer-mentor discipline community, and learning issues were only then explicated inductively using underpinning PCK. It was evident that the motivation in integrating the learnt PCK to their pratice had been extended beyond the course when these lecturers integreted the PCK to produce peer reviewed work at pedagogy-related conferences. We explain the design and successful implementation of a PBL process bringing about lecturer's creative habit changes, scaffolding several learning sets of differing compositions of tutors, peers, seniors. These commenced with identifying, sifting and evaluating ill-structured 'anxious moments' and collaboratively moving them to become solvable Critical Incidents through self-directed and peer-facilitated discovery-learning and process-evaluation, harnessing explanatory PCK within lecturer's own disciplines, taking responsibility for their own learning and bestowing value through their own real-world of classroom teaching practice.

Key words: Training, Lecturers, Course, Staff Development, Educational Development, PBL, PGCert Course, Critical Incidents

INTRODUCTION

The traning of lecturers

The training of lecturers in Higher Education to make them better teachers has been a challenge that faces many countries and attracts considerable debate. Some countries such as Sri Lanka have made such training mandatory for joining staff on a country-wide basis, while it has been the universities in some countries that have made such courses mandatory for their own staff. Thus, courses for such training abound, along with units or centres for delivering them, but their effectiveness has been a matter for concern and research (Gibbs and Coffey, 2004; Trowler, and Cooper, 2002). Various reasons have been advanced why these courses have not been as effective as first envisioned, and have served to show that teaching, and the training for effective teaching, to be a complex issue. Among these reasons, the resistance to change has been seen as a major aspect (Trowler and Bamber, 2005), though both resistance and change are complex aspects by themselves.

Resistance to chance and their loci

Resistance to change occurs at multiple levels, as for example from the individual level to the organisational levels. Within the individual also, there could be several aspects that interact to bring about such resistance. The failure of courses to bring about the necessary changes in individual lecturers has also been adduced to the failure of courses to take into account and address the multiple loci that are at work within the social structure of a university to resist change (McGuinness, 1997). This is because learning is a social process (Rowland *et al*, 1998), and because it can be the variables in the social organisational structure, including leadership, that interact to bring about, or stymie, effective change practices. It is considered that individual learning must take place within the lecturer's social context to change the 'Ways of Thinking and Practice' (*sensu* McCune and Reimann, 2002) and that the loci from where the resistance may be generated should be made to feel part of the process of the individual, through organisational change and the stewardship of competent leaders.

Context od this paper

In Sri Lanka, the Staff Development Centre at the University of Colombo conducts courses for lecturer training. These courses have been conducted since 1997. The courses were put in place as the result of a student-led violent insurrection that was quelled, but with the death of thousands of youth. The insurrection was triggered by youth feeling compelled to mount a rebellion at perceiving a socially unjust university education that did not impart transferable skills but led to mass graduate unemployment. Both of us have been tutors in this lecturer training course, with one of us being associated from course inception. This harrowing backdrop has pushed us to find a practically meaningful and a workable operational mechanism for this course, and the length of time that the course has run has afforded us the space to develop it with advice from leading educational developers from many countries so that we have been able to modify practices and to evolve them reflectively, having first struggled with several versions of course delivery. Over the last five years, lecturers following the course have not only brought about a change in university culture through changed ways of teaching their university courses, but also started reporting their changes through pedagogy-related conferences, showing a scholarly development in the thinking and practice of their teaching pedagogy, and in owning and advancing their changed Pedagogical Content Knowledge (PCK - Shulman, 1986) in relation to their own subject disciplines. We report here the process we used for bringing about such change, and believe that the principles of PBL can be evidenced and ascribed to the effectiveness of that process.

Skills and principles considered

Throughout the years in the conduct of this course, we have observed, discoursed and recorded the resistances that course participants have related to us, as aspects of practice that made them unable to make the necessary changes in their teaching practice. To enable them to make the changes, we reviewed practices and realised that they needed to develop certain skills and so targeted the development of the following skills;

- Self-directed learning skills
- Team skills
- Problem-solving skills

- Resource-based learning skills
- Oral and written presentation skills

Based on the above, we considered the principles outlined below to integrate into the course delivery, and it was based on these that we adopted the PBL approach that these observations had made us consider in our course delivery, incorporating them into the PBL approach that we used.

Principle 1. *Collaboration at different integral levels in the social life of the lecturer, with self and multi-level assessment, including peer assessment, and actionable feedback.* This would bring in the 'community of practice' aspect into their work so that their department peers and their seniors would accept their work. This was also to make them perceive and internalise teaching as a social activity and adopt/accept 'situated facilitation' (Lave and Wenger, 1991; Kolmos *et al*, 2008; Boud and Walker, 1998, Rowland *et al*, 1998).

Principle 2. *Responsibility for their own learning based on problems valued in their own real world of their disciplines and classroom contexts.* This was to incorporate andragogic principles to bring in motivation in their change and learning process, including the adoption of the inductive reasoning approach (Knowles *et al*, 1998)

Principle 3. *Problems being ill-structured to allow for flexibility, free inquiry and integrated from a wide range of disciplines or subjects*. This also allowed ownership of the change process through self-discovery.

Principle 4. *Availability, through provision, of resources for exploring solutions from best-practise models*. This enabled them to identify resources that they could use even after course completion so as to sustain their change practices.

Principle 5. *Use self-directed learning as a process by revisiting the solution and reanalysing how they found a solution, and concluding as to what transferable concepts / principles and PCK* (Shulman, 1986) *have been learned from the specific problem-solving narrative account*. This was to bring in and develop Reflective Practice as an internalised habit.

Principle 6. *Use 'Permitted' Reflective Practice within the constraints of their practice.* This was to allow them to realise that professional-social contexts would delimit certain practices at different stages of their careers and that was an acceptable reality.

Principle 7. *Inquiry-based, inductive, divergent learning as the pedagogic base* in the curriculum and not a convergent, deductive, didactic curriculum. This approach made them see the advantages of, and get used to, student-centred and active learning approaches that were transferable to their teaching practice for developing generic skills in their students.

Principle 8. *Summative assessment through a portfolio phenomenographic narrative account.* This showed them a progress measure of a developmental 'process' rather than a 'product' that could be used towards the skill outcomes, such as in problem-based learning. This allowed each lecturer the learning of a 'process', and the freedom to feel that each of them had been able to identify, puzzle over and fit together one's own jisaw of classroom problems, that could also be taken apart and reconfigured as and when the need arose.

PBL process adopted

Pre-PBL Facilitation reorienting step

Getting a job in a university in Sri Lanka, like in most countries, is very competitive, and so all participants in the course had performed as excellent and effective academic-oriented learners but not as effective teachers. We thought that the first step was a need to reorient their thinking before the PBL process. So we brought about a session for tutors and participants to brainstorm why teaching may be more difficult than learning so that course participants would open their minds to perceiving that they may indeed have to think of change as a practical reality for them to become effective in teaching as against learning, based on the quote;

'*Teaching is more difficult than learning; for only he (sic) who can truly learn—and only as long as he can do it—can truly teach.'* (Martin Heidegger)

PBL Process

The course attracted around eighty to a hundred trainee-lecturers each year, and were divided into two equal-sized classes. Each class was divided into several 'permanent' peer-groups, with up to five individuals per group, with each individual coming from a different subject-discipline. Each class met over seventeen tutor-facilitated full-day workshops. Throughout the 9-month course, trainee-lecturers worked in these peer-groups and so interacted closely with their group members. Among peer-groups, interaction occurred only at plenary sessions of the workshops. For purposes of describing the PBL process that we conducted, it is the activities within a peer group that will be described, considering each peer group as the unit of PBL activity. For designing the PBL activities, we adopted elements from Maastricht "seven jump" process (Wood, 2003) and factors considered in Graaff and Kolmos (2003) and Kolmos et al (2008).

The PBL 'meetings', with the constituent dialogic process, were central to reorienting the trainee lecturer to become a change agent having the necessary skills. At these meetings, the trainee lecturer remained the central figure, to whom collaborative support was given by those who participated in these meetings. We created at least four of these meetings, for each trainee lecturer, which served as Learning Sets or Learning Spaces, and structured as follows;

- two peer group meetings facilitated by one group-designated member from that group, to first identify and then discuss 'anxious moments' of teaching experienced in their teaching class or learning experiences. The first of these meetings reviewed their 'anxious moments' and gathered the views of peers for selecting a given 'anxious moment' as a Critical Incident (CI) that merited to be addressed and resolved by the trainee lecturers. That CI then became the trigger to find out Learning Issues and Outcomes needed to examine its possible resolution. At the end of this meeting, each trainee lecturer would then go and, over a week to two weeks, use the library and other resources, including workshop handouts, to read and find information on the identified Learning Issues. The findings would be written down and discussed at the second meeting, being focussed around questions or statements from a template that was given as part of the course (see Appendix: Learning Agreement Form). The Learning Agreement Form would be provisionally filled as a concluding document of this meeting and serves to link reflections derived from the past 'anxious' experience/s with future activities that are provisionally proposed in the Learning Agreement Form for resolving the identified past anxiety/ies.

- the next meeting would be to discuss the findings, that were proposed in the Learning Agreement Form, as to their wider practicality with respect to the department and subject discipline. This meeting took place with a more experienced senior subject-academic in the lecturer's department. This discussion-meeting would normally involve some modifications to the problem solution proposed in the Learning Agreement Form.

- the final meeting would be with the course tutor who would go through the inclusions in the Learning Agreement Form and finalise it. The tutor would check mainly whether the proposed activities aimed at solving the 'anxious problem' would be satisfactory to meet the course assessment criteria. If not, then the tutor would give written feedback so that the Learning Agreement Form could be refilled and resubmitted. This meeting would sometimes be preceded by another meeting in the peer group, if the trainee- lecturer wished.

At each of the above meetings there was multi-source formative feedback and written records of contributions from self and others made by the participant owning the CI. It also differed from typical PBL in that the triggers for outcomes were not externally facilitated but self-provided by a sorting of the 'anxious moments' to become CIs. Also, the entire peer-group did not focus on a common problem scenario but each was at liberty to focus on self-selected scenarios, and meetings were at three incremental 'expertise levels', *i.e.,* peer, senior academic and course tutor. The introduction of 'approval' from a senior academic from the participant's own subject department lent strength to give confidence to the trainee lecturer that the 'pedagogic theory' or PCK that underpinned the teaching change was acceptable within the subject-discipline and helped to bridge the gap with the participant's disciplinary practice.

It was possible for the CIs to be internally-facilitated triggers as the trainees were already 'initial' practitioner-lecturers, having some teaching experience that they could use to identify and sort 'anxious moments'. Although the entire peer group did not address the same problem, participants were prevented from coming up with widely divergent problem-scenarios by keeping problems within defined course-module areas, as the course was modular.

What usually happened within a course iteration was that, at the start, most of the peer group members would each adopt the same or similar teaching ‘problem’ to address, even though they were lecturers coming from different subject-disciplines. This was not discouraged as it was this that allowed them to perceive and appreciate that PCK components were relevant across different disciplines and thus, raised their interest in PCK. Gradually, as the course proceeded, their confidence in the use of PCK components would develop and peer group members would increasingly address different ‘problems’. In this way, by the end of the course, even though each lecturer had attempted to address a limited number of PBL based solutions due to time limitations, as a group they acquired insight into solving a wide range of problems utilising a range of PCK applications.

Conclusions

The above process that we described was helped by the Learning Agreement Form as it provided a template, in the form of questions, for the participants to model how to narrow down a multiplicity of the ill-structured ‘anxious moments’. It enabled them to collaboratively sift through the ‘anxious moments’ and to move selected ‘anxious moments’ to become solvable Critical Incidents through self-directed and peer-facilitated discovery-learning and evaluation. Once the peers ‘approved’ a selected ‘anxious moment’, the pressure was on the participant to harness the PCK that would furnish the explanatory account to justify its use to solve that CI in the lecturer’s own discipline, and so finding the relevant PCK became motivational. This resulted in the lecturer taking responsibility for his/her own learning and taking ownership to bestowing value through his/her own real-world of classroom related teaching practice.

In conversations with the participants, it was observed that the incorporation of PCK as dictated by a course tutor was not readily acceptable as having high relevance to the participant’s discipline teaching because the course tutor conceptually stood outside the participant’s subject discipline, and as this would involve accepting it by ‘deductive’ reasoning. In contrast, facilitating them to self-discover solutions through an ‘inductive approach’ and acknowledging its acceptability by a shared discourse across their cognate subject community was found to facilitate them to take ownership of that PCK self-discovered by the participant and approved by subject mentors.

A questionaire survey at course commencement revealed that almost all participating lecturers were unaware of the PCK elements that they subsequently used. As the course progressed, trainees recorded a diversity of teaching problem-situations in which they effectively applied PCK components that they learnt and then used to change their lecturing practices. Such changes done by all group members were documented in a 'group file' and made available to the entire peer group. It was only after they had seen this recorded validation of their own changes in lecturer performance, the extent to which learning was enhanced in their students by the PCK principles they had used, as well as how widely PCK principles could become shared in teaching improvements across divergent disciplines, that the lecturers really realised that they had become creative as agents of change. Another factor supporting the validity of their changes could be established from the fact that around 30% of the lecturers of these courses went on to report their PCK-related teaching improvements in pedogogy related peer-reviewed activities such as teaching conferences. They also reported instances where students taught by them would question and bring pressure on other lecturers to adopt thier PCK-related teaching practices, particularly in humanities disciplines that experienced high graduate unemployability, as the students perceived the underpinning beneficial empowerment of the changed teaching practices. Although this was surprising, it was not out of place, given the backdrop of student perceptions with regard to the need to make their university education meaningful towards career prospects, which had been the original driving force behind the establishment of these lecturer training courses.

The feedback for this course has been exemplary with participants expressing that they had changed not only their pedagogy and teaching practice but have also extended this reflective PBL process to personal aspects in their lives. A number of participants had gone on to disseminate their PCK based teaching changes in pedagogic teaching conferences so that they feel the course has empowered them to become part of the pedagogic community of scholarly practitioners to change and improve teaching practice. Thus, this CI-based inductive PBL approach has mediated to induce participants to change their teaching habits and so they have become creative by 'defeat of habit by originality' (Koestler, 1964), bringing change to the lectures' own experiences, practices and classroom settings.

One of us now teach another similar HE lecturer training course but which is taught using a theory-based, deductive, didactic approach. The feedback on this course is not favourable and participants complain, and university leadership have commented, that the methods advised in the course for changing their teaching practices are not related to their discipline practices. This shows the difference that a PBL based course can contribute to changing practices, in contrast to an instruction based course that generates resistance to change. This is further evedenced by the Colombo course External Examiners, who are Professors of HE from UK and who meet with and interview course participants, as they have consistently commented that the changes they have seen participants undergo to be unique and empowering, in contrast to many courses that they know of in the UK.

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Submission Serial #	
Resubmission Serial #	
Peer reviewed by	

APPENDIX University of Colombo, CTHE

Learning Agreement Form 2007 ***(to be submitted with 'Script')***

To be used for making CHANGES to your teaching-related practice/s

The purpose of this form is to allow you to describe the changes that you wish to make in your teaching and/or other aspects of your professional life. For further information, please see overleaf.

L.A. Number:…………… Area of work to be improved: **Teaching / Learning / Assessment** ……………

Name: ……………………………………………….. Seminar Room Group: ………….. F / M

University: ……………………………… **Dept: ……………………**

Course / class(es) where the change/s are to be practiced: . No. of Students: ..

When will you implement this change (date & Month):

After completion, where in portfolio (i.e. section/page):have you reviewed further improvements:

Identify the PRESENT PRACTICE (the present context) that needs to be improved / changed **(for instance, what were the prevailing circumstances that stimulated you to consider change)**

Describe WHY do you want to CHANGE (improve) the present practice:

What OUTCOME do you EXPECT (TO HAPPEN)- by this proposed change?

What underlying 'theory' (*e.g.* from literature) supports the likelihood of your expectation/s happening?

Describe the plan of what you will DO, as your change:

How are you going to assess / monitor that the change took place?

Write down concisely;

-which SEDA specialist outcome/s you are demonstrating:

-which SEDA value/s underpin this change:

What supporting documents are attached (e.g. script is essential, class handouts ,…)

Signed (Participant): Date:

Signed (Peer): Date:

Signed (Mentor): Date:

Signed (Tutor): Date::

Additional comments / Action Comments on this change could be included on an attached sheet

DESIGNING AN EDUCATIONAL PROGRAM FOR HE TEACHERS – A DEVELOPMENTAL PROCESS IN AUTHENTIC PBL SETTINGS

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ABSTRACT

Universities are supposed to offer the highest education, but do they also guarantee the highest learning? The two universities in Oulu started a pedagogical education program for university researchers and teachers. The aim was to develop their teacher identities and make them understand how to help their students to attain better learning outcomes.

The planning of a 1-3- year program availed of the PBL method and was carried out in 2006. It was put into practise in 2007 and again in 2008 with slight alterations. It was allocated 60 ECTS credits associated with 1600 hours of study. The program was planned by a joint expert team which followed a slightly prolonged PBL method with 10 "steps".

Key words: problem-based learning, authentic learning, higher education

INTRODUCTION: SHOULD *HE* TEACHERS HAVE PEDAGOGICAL TRAINING?

Regardless of cultural or national specialities, the educational implications of higher education teaching are a very special task. Higher education organisation is not just an ordinary school. It is also a research oriented scientific community, being responsible for global knowledge development. The purpose of a higher education system is to foster and encourage scientific competencies and promote progress in science. In terms of creativity and expertise this is the hardest challenge. How can anyone be allowed to undertake teaching activities in higher education without preparing him/herself for the task?

Educational literature presents arguments for and against higher education teachers´ pedagogical training. Trowler & Bamber (2005) review this discussion in their article and ponder pros and cons for compulsory pedagogical education. Their view is that: "… from a purely rational-purposive perspective, compulsory training is self-evidently a good idea: train higher education teachers to teach and they will do a better job than untrained ones. However the rational-purposive view... is unrealistic – the political processes add complexity". (Trowler et al., 2005, 80.) The authors would prefer seeing more research based evidence about the effects of compulsory teacher training courses. (ibid. 89, 90.)

Nothing speaks for the divinity of a teacher's pedagogical ignorance. Competence to teach is neither an inborn talent nor a pure result from the development of research ability. Teaching and learning situations are an overriding source of complexity. To introduce the continuous complexity of teaching and learning processes is to ask the question "How does the knowledge of a teacher transform into the knowledge of a student?" and use the pedagogical arrow model below to analyze the answers:

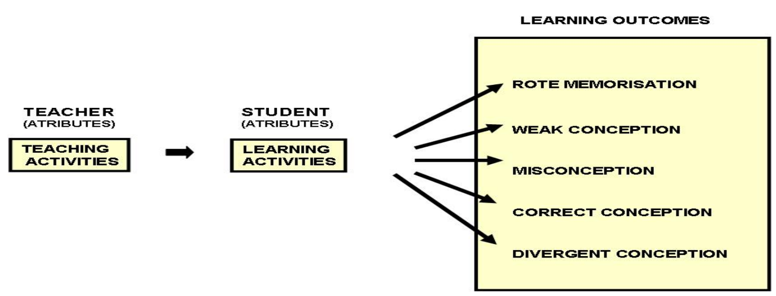

Figure 1. The pedagogical arrow (Karjalainen & Nissilä 2008a).

An untrained teacher in most cases seems to think that teaching implies learning. The arrow shows that although teaching causes differences in students´ learning activities, it does not cause learning. A competent teacher is able to help the student to study more efficiently than would be the case if the student had to learn the subject matter by him/herself alone.

The second source of complexity comes from the concept of learning. The level of learning always varies and the teacher should be able to reflect on the variations. How to teach in such a way that the students´ learning outcomes surpass the knowledge of the teacher? This conception may be the eventual aim of higher education. The central mission of teacher education for all-level schools in Finland has over the past 30 years been research-based professionalism. (Westbury, Hansen, Kansanen & Björkvist, 2005.)

Reflection is aimed at helping students and teachers to develop multiple goals and encourage transformative development. Transformation is not one significant emotional event; rather it is a series of experiences which teach critical thinking. Reciprocal processes enable the students and teachers to construct meanings.

Autonomy and pedagogy may be seen as interrelated and interdependent concepts, if their meanings are deeply analyzed and interpreted. There are two assumptions: first, that there cannot be any ´real´, genuine pedagogy, in the proper sense of the word, without the autonomy of the teacher, without his/her freedom in decision-making and action; and second, autonomy of a teacher does not lead to what is educationally worthwhile or educative, unless it is backed by pedagogy, by a teacher´s pedagogical consideration and tactfulness. (Lauriala 2002, 131-132; Nissilä 2002; Korpinen 1996.)

Theoretical framework

Bridges (1992) emphasized three conditions created within the PBL environment. They are linked to subsequent retrieval and appropriate use of new information: 1. activation of prior knowledge, 2. encoding of knowledge in a specific context and 3. opportunity to elaborate on that information (ibid 9).

In addition to cognitive rationale, social-psychological theory also provides conceptual support for inquiry links between modes of instruction and the learning of various skills.

Social comparison of ability is prevalent in and central to group members´ assessment of self and the others.

There is an ethical perspective in the use of PBL in administration. Ethics is about our relationships with others (Singer 1994). It can also be viewed as a ´philosophy of morality´ as it deals with ought and ought not (Mahony, 2009, 983). It can be seen as prescriptive rather than descriptive, since ethics is concerned with what we ought to do. According to a research (Helton & Ray, 2005) ethical dilemmas can arise from administrative decisions conflicting with personal and professional ethics.

Because of the responsibility of the administration to give attention also to ethical dilemmas included in university teachers´ daily work, careful preparation for a new program design is necessary. PBL is expected to provide also for this aspect in its cognitive, social-psychological, open and group-oriented approach.

Research questions

To make joint planning possible the framework was to be designed carefully. The problem based approach seemed to offer the best way to manage the joint planning, since it appeared to be systematic, group-oriented, autonomous and favoured negotiation and research. The explicit research questions were: 1. How can a real problem be solved in education? 2. How does a real PBL process differ from the traditional one? 3. Can PBL be used as an administrative tool?

Context and participants

The real life problem which led to this study was to plan an educational program for HE teachers in pedagogy. We were interested in the differences and similarities between the traditional 7-step procedure and a real life problem solving process. Basically, the question is also about the nature of the problem situation in itself. Can real life settings avail of this approach?

A new program was to be put into practise as a pilot project in 2007. It attracted 50 participants and was repeated in 2008 with 40 participants. The Program was allocated 60 ECTS credits associated with 1600 hours of study. It was to span a three-year period but might be completed in one year as a full time study program. The approach to planning was needs-oriented. The planners were the staff and teachers of the two universities in Oulu. The size of the planning team varied from 10 to 20, the core group consisting of about 12 persons.

Shared planning and material collection

1. The members of the joint team were both teachers and administrative staff. Protocols were written throughout the process to make the various phases transparent. After each phase/ step the planning group participants wrote down their ideas or suggestions and sketched various solution models which were all saved. The teachers testing the pilot program wrote down their observations about the implementation of the program and gave their notes to be used by the researchers. The approach was phenomenographic including some statistical data.

2. When piloting the program the student teachers wrote essays throughout their education and were interviewed as well. Together with reflection diaries and feedback forms they became the sources of several other mainly phenomenographic research projects (Karjalainen & Nissilä, 2008a, 2008 b; Nissilä 2009a, 2009b; Erkkilä 2009a, 2009b).

3. The phases/ steps of the planning process were: 1. Setting general aims for the program, 2. Defining the concepts to be used in planning, 3. Brain storming: making a list of competences for the competence analysis, 4. Autonomous work: suggesting and defining core competences, core courses, core contents, learning objectives as well as teaching and assessment methods, 5. Combining the data, 6. Making decisions on the plan, 7. Designing quality assurance policy, follow up study procedures, and the admission criteria, 8. Experimenting with the solution of the problem (the plan put into practice), 9. Evaluation of the outcomes and proceeding to the second cycle, and 10. Marketing the "product".

Steps 1-3 and 5-7 were carried out in open and flexible workshops. All ideas and suggestions were documented and shared by the participants. They were also dealt with by both organizations in charge. The matters could be returned to, if necessary. As is notable, seven steps covered only the actual problem solution. The continuance was to be constructed, since on one hand we thought we could repeat the implementation stage for possible improvement as the PBL method seemed flexible enough to allow data gathering in repeated phases.

Outcoms: PBL model in planning and in real life

After the PBL **steps 1 and 2**, the planning proceded according to the steps model (see Kolmos et al 2004; Nummenmaa et al 2001; Boud & al 1999). Competence definitions and analyses (**step 3**) were started by a brainstorming session in which over 100 basic skills of a good higher education teacher were specified.

During **step 4** these raw items were reduced, combined and classified to form 8 core competencies first through individual study and thereafter through negotiation. They were formulated so that the overall learning outcomes of the program could be established. According to the analysis and classifications a competent teacher in any academic discipline in a higher education institution:

1. should be committed to scholarship of the teaching and learning in his/her discipline and in the interdisciplinary scientific community;

2. should demonstrate research-based and reflective practice;

3.should possess a creative approach towards challenges;

4. should show and promote active participation in national and international networks;

5. should be able to use modern and applicable learning centred teaching and assessment methods;

6. should show positive attitudes and possess skills for carrying out responsible tasks as a leader and supervisor in his/her organisation;

7. should be an interactive and communicative agent (of change) in the academic community;

8. should be able and willing to facilitate profitable cooperation with life outside the academy

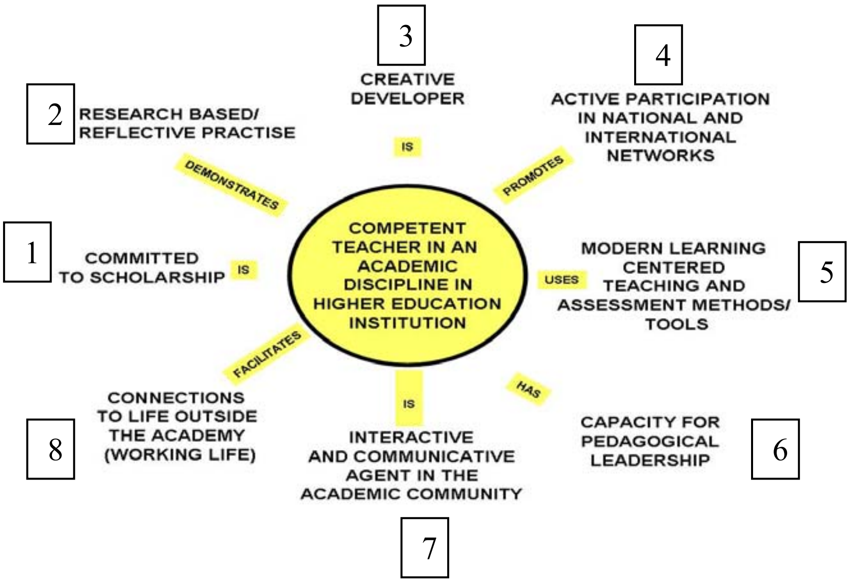

Figure 2. Higher education teachers´ core competencies (Karjalainen et al 2008b)

During **step 5** the data were combined to form the framework of 7 modules. They were formed so that all competencies could be included in them and that their scope should correspond to their contents. The general framework follows the law of vocational education in Finland decreeing the following modules 1, 2, 3, and 6 to be included in the education.

1. teaching and learning in higher education (the core module, 11 ects)
2. introduction to educational sciences (10 ects)
3. practical training periods I (11ects) and II (3 ects)
4. higher education institutions – codes of laws, statutes and practises (3 ects)
5. promoting a student´s scientific thinking (3 ects)
6. special studies based on personal study plan (15 ects)
7. higher education as a profession (4 ects)

In **step 6** the accepted contents were distributed into modules, the recommended placing in the program was defined, and recommendations were given about the order of passing the modules as well as compulsory and optional solutions, as expressed in figure 3:

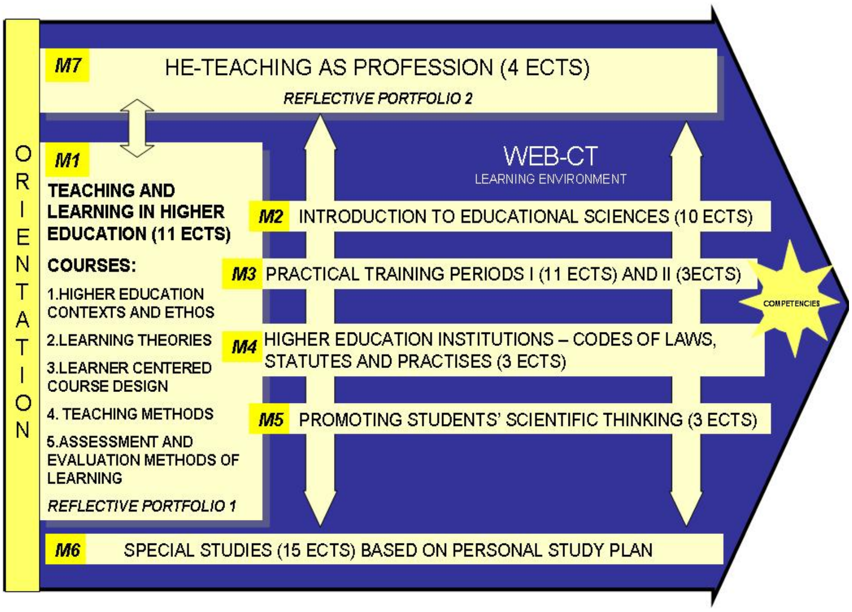

Figure 3. Program structure (Karjalainen et al. 2008b)

Modules M1-M5 and M7 are compulsory for the student teachers. M6 is based on their free choice from a large supply for specialized items. Module 1 (M1) serves as an introduction to the studies. It summarizes both theoretical and practical contents of the program. The module is delivered by six intensive one-day workshops at the beginning of the studies. M2 gives introduction to scientific pedagogical concepts. M4 guides student teachers to become aware of the institutional and organizational context of the higher education. It helps to interpret the meanings of organizational cultures and studies both formal and informal as well as internal and external codes and regulations. M6 promotes student teachers´ competence to guide the development of students´ scientific thinking and writing skills. Special weight is laid on the supervised periods of teaching practice (M3).

Practice period 1 takes place in the student teacher's own department, where he/she plans and delivers one academic course to ordinary students. Each student teacher has an academic mentor from his/her own department and also a pedagogical tutor from Oulu School of Vocational Teacher Education.

Practice period 2 is carried out in some other higher education institution than the home institution. Thus the program offers chances to get experience of teaching in both a traditional university and an applied sciences university.

In every module the teacher student has to demonstrate his/her development by reflective written work. All assignments and tasks given during the modules or courses are meant to be accumulated within the professional portfolio (reflective portfolio 2), which is also assessed as a final examination to complete the program. All course assignments are given, completed and assessed via an electronic learning platform. Written feedback is given after every assignment, with the exception of Portfolio 1 which is evaluated both numerically and in writing (Karjalainen 2001). Before final decision making, the modules of the program were compared to the core competences to check if they were covered by the modules as the table below presents (step 6 continued).

MODULES	COMPETENCES *							
	1	2	3	4	5	6	7	8
TEACHING AND LEARNING IN HIGHER EDUCATION (THE CORE MODULE 11 ECTS)	x	x	x	x	x	x	x	x
INTRODUCTION TO EDUCATIONAL SCIENCES (10 ECTS)	x	x						
PRACTICAL TRAINING PERIODS I (11ECTS) AND II (3 ECTS)	x	x	x	x	x		x	
HIGHER EDUCATION INSTITUTIONS – CODES OF LAWS, STATUTES AND PRACTISES (3ECTS)			x			x		
PROMOTING STUDENTS SCIENTIFIC THINKING (3ECTS)		x			x			
SPECIAL STUDIES BASED ON PERSONAL STUDY PLAN (15 ECTS)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)
HIGHER EDUCATION AS PROFESSION (4ECTS)	x	x	x	x	x	x	x	x

* The pre-designed competencies are: 1. Should be committed to scholarship of the teaching and learning in his/her discipline and in the interdisciplinary scientific community, 2. Should demonstrate research-based and reflective practise, 3. Should possess creative approach towards challenges, 4. Should show and promote active participation in national and international networks, 5. Should be able to use modern and applicable learning centred teaching and assessment methods, 6. Should show positive attitude and possess skills towards taking responsible tasks as a leader and supervisor in his/her organisation, 7. Should be an interactive and communicative agent (of change) in the academic community and 8. Should be able and willing to facilitate profitable cooperation with life outside the academy.

Table 1. Modules and core competences

Step 7. Alignments between both theory and practise and course activities (assignments, teaching methods, planning, evaluation and teaching practises) are the mission for the teacher educators throughout the program. For instance, HE student teachers expect to be taught in the methods they are supposed to use in their teaching. They expect to be evaluated in a way relevant to their context in university, and they are evaluated, given feedback and directed to peer evaluation in a way which will be applicable in their teaching work. They are also guided to use reflection and self-assessment as their tools in their professional growth. These practical measures bring the pedagogical thinking of a HE teacher visible. For that reason it is important to study the theoretical bases of practice first.

Step 8 expected the solution of the problem to be realized in practice. To implement the plan, two groups of 25 participants started, one in June, another in September in 2007 and again 23 and 17 in 2008. The experiences surpassed all the expectations: the program worked well, and after doubts at the start a general enthusiasm was present. The participants stated that the program contents were just what they needed. (Nissilä 2009a & b; Erkkilä 2009a & b.) They were also happy to be able choose the fast track, the slow track or the medium speed track.

Step 9 included the evaluation of the program. Since the idea was to repeat the implementation of the PBL solution, several study projects were created around the results of the PBL design work. After the first data collection in 2007 slight alterations were made for the second cycle of program implementation. All the results show that besides adopting a wide picture of a teacher´s profession, the participants experienced that their identities as academic teachers had arisen, they felt enthusiastic about the teaching profession and their self-efficacy beliefs as teachers were high. (Nissilä 2009a & b; Erkkilä 2009a & b; Karjalainen & Nissilä 2008, 2011.)

Step 10 suggests measures to be found for marketing the designed study program. The future prospects will be in education export and in the projects of other universities.

The research questions will now be answered on the basis of the observations, note taking, reflection diaries, assignments, essays and a huge amount of collected feedback from the students (qualitative contents and discourse analyses.

1. How can a real problem be solved in education? Since there were two times two groups participating in the PBL-oriented programs and since they had their counterparts in ordinary programs, the observations appear interesting. First, a PBL model is splendid as a joint planning work because of flexibility, autonomy, cooperation and responsibility, not to forget collective creativity. It appeared to be concise and targeted. Tailoring is what makes the PBL designs unique.

2. How does a real PBL process differ from the traditional way? The process was flexible and undefined in the beginning. Only after successive workshops the later phases began to be realised. This led to a flexible and unhurried timetable in planning. In this PBL process nothing was accidental, since all decisions were made together, with reasons given. Dealing with a real problem situation is complex in nature (Karjalainen 2001). A special feature is that PBL could offer a way of authentic teaching and evaluation. The follow-up was also collective, since the persons responsible for teaching had to cooperate closely. It made teaching the contents concise. The feedback was also dealt with collectively, so all participants could share the experiences. In a traditional program, though planned together, the implementation is often more individual, and each teacher studies the feedback alone. Collective reflection will thus be lost. Now the teachers were willing to develop their teaching throughout the program and they felt that they had the support of the learning community.

3. Can PBL be used as an administrative tool? There is an ethical perspective in the use of PBL in administration. Since ethics deals with our relationships with others, joint program design will see to the equity of participants and the whole community in planning. In universities, administration tends to be seen as an organ with exclusive authority blamed for rigidity and unwillingness to carry out changes (Karjalainen & Nissilä 2011). Joint planning might make pedagogical voices and those of the staff in general heard. In negotiations and avoiding conflicts, PBL design, though painstaking, might serve its place.

Discussion

A freely constructed PBL-method proved to be functional, applicable and recommendable in education. Enthusiasm and positive atmosphere are a highly important factor in real life, leading to collective responsibility and caretaking. The support of learning communities and individuals´ willingness in professional growth are the prerequisites of empowerment.

What we have found out is that teachers do not want to be simple technicians who have to put into practice what the politicians and educational authorities ask them to do. (Estola, Lauriala, Nissilä & Syrjälä 2007.) Teachers want to be involved in the work with their whole personalities using their understanding and skills for the best of the learners. As reflective practitioners and professionals, they should be given enough autonomy over their work. The results of the present study provide evidence that the quality of education depends on the ability to take seriously the scholarship of practice and on a new kind of interaction between educational research and practice.

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IF YOU BUILD IT WILL THEY COME? SUPPORTING FACULTY IN ASSESSING PROBLEM-BASED LEARNING

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ABSTRACT

Problem-based learning (PBL) curricula involve students in acquiring skills and knowledge needed to succeed in the world of work, but assessment is still needed to signal to students what is valuable to learn, provide evidence of student learning, and supply both students and instructors with feedback for continuous improvement of instruction. This paper describes an effort to develop a process to support community college and university faculty in learning to design and use assessments with one model of PBL—problem-based learning with scenarios (SBL). The findings indicate challenges to bringing SBL assessment professional development activities to scale. The paper recommends improvements that can assist SBL faculty in designing and implementing an assessment design.

INTRODUCTION

The Scenario-Based Learning (SBL) projects (2003-2013) were funded by the National Science Foundation to work with community college and university faculty to create and implement scenario-based learning and assessment in their science, technology, engineering, and mathematic (STEM) classrooms. In the SBL approach to PBL (Schank, 1997), students are engaged in a loosely constructed, industry-inspired scenario intended to teach technical knowledge and meta-cognitive and professional skills. SBL curricula offer a solution to persistent complaints that U.S. graduates of technician programs lack skills to apply knowledge flexibly (Kolmos & Holgaard, 2010; Levy & Murnane, 2005; Lynch, 2000). Efficacy studies focused on cognitive learning outcomes show that PBL is comparable and sometimes superior to traditional instruction in facilitating content learning and supports learning flexible problem solving, application of knowledge, hypothesis generation, and coherent explanation (Dochy, Segers, Van Den Bossche, & Gijbels, 2003; Hmelo, 1998; Schmidt et al. 1996). In a study of the range of knowledge and skills that students learn from SBL curricula, researchers found such curricula provided an opportunity to acquire technical problem solving as well as a range of social skills around teamwork and social-technical skills (Yarnall & Ostrander, in press). Accordingly, to assess such learning, an assessment needs to target more than a student's capacity for factual recall. This paper will describe the development and implementation of a process to support U.S. community college and university STEM educators in creating such assessments.

The design problem: Building faculty assessment literacy

Facilitating and assessing PBL demands greater understanding of teaching and learning from faculty (Kolmos, Du, Holgaard, & Jensen, 2008). Yet, in the U.S., community college faculty are typically hired for their technical content knowledge and industry experience—not their pedagogical or andragogical training. Few educators receive any formal training in assessment (Guskey, 2006). Indeed, even K-12 educators with extensive credentialing requirements for pedagogy lack extensive experience in the art and science of assessment design and use (Shavelson, 2003). Stefani (2004-2005) has recommended increased professional development for assessment to help higher education faculty teach students more sophisticated skills, such as analysis and evaluating information. Past work in cultivating teachers' assessment literacy has encountered numerous barriers, including: resistance based on fears of accountability, lack of time, and little clear vision on what to do with assessment results beyond entering a grade in a grade book. Fostering change in assessment requires time to reflect and integrate ideas into one's own work (Sato & Atkin, 2006/2007). In a review of 14 post-secondary institutions' effort to improve assessment on their campuses, Maki (2010) describes "challenges to gain faculty momentum in assessment" and "patterns of faculty resistance that range from initial mild discomfort to outright denial based on the enduring belief that grades themselves are the best documentation of student learning" (p. 3).

The design for the SBL project's assessment process has passed through two phases. In Phase 1 (2006-2008) researchers with assessment expertise co-designed assessments with faculty developing new SBL tasks. The next phase (2008-2010) involved researchers and instructors collaborating to develop and implement an evidence-based assessment reflection (EC-AR) process and tools to help faculty prepare effective task assessments during professional development workshops (Yarnall & Ostrander, in press). The current faculty-led phase (2011-2013) will create online tools to guide faculty assessment design and implementation.

Research questions

This paper will address the following research questions:

1. How have faculty resisted assessment design and use during the SBL project?
2. How have faculty endorsed assessment design and use during the SBL project?
3. What quality of assessment materials have been designed during these two phases of the SBL project?
4. When examining these patterns of faculty resistance and endorsement and the quality of assessment materials over the two phases, what are the core elements of the SBL assessment approach that must be maintained when bringing the professional development system to scale?

Methodology/analysis

In analyzing results from the SBL project, the team leaders reviewed several key documents, including annual evaluation reports; annual and final project reports; and SBL assessment materials produced during the project. From these data sources, researchers focused on specific evidence of resistance and endorsement, and on actual assessment materials produced. They tracked the following data: a) evidence of faculty resistance, as indicated by alternative interpretations of a workshop assignment in the online community discussion threads and direct email feedback to workshop leaders; b) evidence of faculty endorsement, as indicated by consistent interpretations of a workshop assignment in online discussion threads and direct email feedback to workshop leaders; and c) evidence of differences in assessment materials produced in each phase of the project, as indicated by an *assessment comprehensiveness* coding system.

This analysis involved reviewing SBL assessment documentation created through an evidence-centered design approach (Mislevy & Risconcente, 2006), which captured the knowledge and skills to be learned—and measured—in a fine-grained manner to improve the assessment validity argument. A coding system was applied to the assessment documentation that is based on (1) the literature that indicates the potential of PBL curricula to teach a range of technical problem-solving, teamwork, and communication skills (Downing, Kwong, Chan, Lam, & Downing, 2009; Hmelo, 1998; Hmelo-Silver, 2004; Reynolds & Hancock, 2010) and (2) prior project research that characterized the core learning outcomes of SBL modules developed by faculty as: technical problem solving skills and social and social-technical forms of knowledge and skill. The following activities in the modules and assessments were classified as technical problem solving: research and analysis, framing a problem, generating a product, using tools, and making inferences (Yarnall & Ostrander, in press). Activities around presenting or justifying solutions to technical problems were classified as social-technical, and activities involving teamwork were classified as social. Accordingly, assessment materials produced during each phase were rated according to a 3-level scale (low to high) that characterized how *comprehensively* the assessment materials targeted the technical, social-technical, and social skills. Materials received "high" ratings if they included at least one social and social-technical skill type and two phases of technical problem solving, which, by its nature, should be multi-step or multi-phase (Jonassen, 2000). Materials received "moderate" ratings if they included at least one social and social-technical skill and one phase of technical problem solving. Materials received a "low" rating if they included one type of social and social-technical skill or one phase of technical problem solving.

Findings phase 1: Researcher-faculty assessment co-design

In the initial phase, researchers from SRI International engaged in assessment co-design with faculty who were designing SBL tasks. SRI researchers interviewed faculty about learning goals, evidence of learning in student behavior and work products, rubrics, teamwork and project management, and complexity of problem solving. These findings were documented in "design patterns," a template based on an ECD-inspired assessment system called PADI, or Principled Assessments for Design in Inquiry (Mislevy & Haertel, 2006). The design pattern includes several attributes of an assessment: rationale for teaching the knowledge/skills to be assessed, lists of the knowledge/skills to be assessed, prerequisite knowledge/skills, work products, observations, characteristic features of an assessment of the knowledge/skills, and variable features that will make assessments easier/harder. Design patterns may be used repeatedly to create formative or summative assessments.

Elements that Faculty Endorsed

Some faculty used the design patterns to create a set of assessments to use with their SBL tasks. Below are the six findings from the work of five participating faculty:

Team work assessment (Social). Faculty conducted informal progress checks with teams, identifying problems around project management and team dynamics. Few faculty actually graded team participation, but those who did employed a "peer assessment" technique where students rated all team members by how much they contributed.

Presentation assessment (Social-technical). Faculty focused on aspects such as content accuracy and thoroughness, presentation organization, professional appearance, and eye contact.

Some brought in an outside professional to view the presentations to provide a more authentic experience.

Technical assessment (Technical problem solving). Faculty reported SBL let them observe aspects of student processes not seen before. They engaged in more nuanced coaching of student technical processes as a result.

Types of assessments. Faculty members preferred to focus on the *type* of assessment task they were using (e.g., presentation, final exam, or log book); these were specific artifacts they were accustomed to using in their classrooms.

Grading procedures. Grading procedures varied widely. Some faculty provided a holistic grade with broad feedback about student performance; Some used detailed checklists of performance features assigned weighted numeric scores; Some faculty graded students on whether they handed in an assignment on time or not.

Rubrics. When asked to supply researchers with existing assessments, none of the faculty shared any rubric. When working with researchers to develop assessments, however, faculty members share good ideas for how to specify rubrics.

Faculty Resistance to Assessment

During the initial interview, resistance took the form of complaints about the length of the interview and non-responsive answers to interview questions, such as providing descriptions of the knowledge and skills (learning objectives) that were too vague or too complicated to be useful for developing assessments. During SBL development, resistance took the form of refusals to create or implement assessments, usually because of lack of time or a perception that the assessment process might alienate students.

The review of the comprehensiveness of formative and summative assessments in Phase 1 are presented in Table 1. As the data indicate, researchers could usually assure that the SBL assessments covered multiple phases of the technical problem-solving process and different types of social and social-technical knowledge. Researchers could also ensure that different modes of assessment were designed (formative and summative). The moderate ratings occurred when faculty designers declined to include specific assessment rubrics around teamwork or presentation skills or declined to assess more than one type of technical problem solving skill.

Specification

SBL Tasks	SBL Assessments		Comprehensiveness of Learning Outcomes Specification in Assessment Materials
	Formative	Summative	
Computer programming			
Ajax	Yes	Yes	High
Python	Yes	Yes	High
Network security	Yes	Yes	High
Environmental studies	Yes	Yes	Moderate
Engineering			
Structural collapse	Yes	Yes	High
Rescue robot	Yes	Yes	High
Bioinformatics			
Databases	Yes	Yes	Moderate
Search/Data Use	Yes	Yes	Moderate
Data Use/Analysis	Yes	Yes	Moderate
Full Analysis	Yes	Yes	Moderate

Table 1. Phase 1 SBL Tasks and Assessments Produced, and Quality of Learning Outcomes

Adjustments Made

Most of the adjustments in this phase occurred around the information collection process. Researchers refined the interview process to link to faculty members' existing assessment vocabulary and to take less time. Researchers also developed systems to document faculty input to ensure each SBL task assessed the core SBL knowledge and skills.

Findings phase 2: Assessment design in SBL development workshops

To scale up SBL usage, the project team offered six different workshops that educators could attend from June 2008 to May 2010. Since the focus of this paper is on faculty design of assessments using the EC-AR approach, only the two workshops including assessment design in their agenda will be discussed. These workshops devoted the initial three assignments to defining student learning outcomes (SLOs) and creating SBL tasks, and then the fourth to creating assessments. To make the process manageable, faculty were asked to create a formative and summative assessment for each of their top two SLOs. The process engaged faculty in a paired peer interview to select SLOs for their SBL task and identify relevant knowledge and skills, and a series of interactive assessment design worksheets.

Elements that Faculty Endorsed

In the workshops faculty endorsed certain activities and tools. Faculty filled out the SLO and assessment sections of the Task Development form, sometimes putting a high level of detail into the assessment plans, and, in one case, showing considerable assessment literacy. Faculty also endorsed the Project-Based Task Interview activity. They liked talking with each other about respective SBL tasks and how to prioritize skills or characterize them according to SBL categories relating to technical problem solving or social and social-technical skills. Those who endorsed the Assessment Menu and the Design Pattern Template said they liked considering how different assessments revealed different aspects of what students were learning. They also liked having a structure to understand what and how to measure the various skills students were learning in an SBL task. Some faculty members found it easy to discern the two distinct levels of granularity in the assessement design process, from defining high-level SLOs in the Task Development Form to specifying finer-grained attributes of the assessments in the assessment design pattern templates.

Faculty Resistance to Assessment

When faculty resisted the Assessment Menu and Design Pattern Template, they complained that it felt redundant. In reviewing their work, it appeared that some faculty members had determined that writing high-level SLOs in the Task Development Form led directly into assessment design, usually using the same approaches they had used for non-SBL lessons. The results were problematic in the following ways:

Central skills to be learned in an SBL task were not identified for assessment. Students doing an SBL task on survey creation were to be graded on how well they wrote a survey report and worked on a team—but criteria for quality around the process skills of survey creation were never specified. In another case, students creating online courses were to be graded on how well them completed a Seven Components Model, but criteria for rating the seven components were never specified.

Critical forms of process knowledge and skills to be learned in an SBL task were not differentiated for assessment. In another workshop, it was clear that few of the 6 out of 12 workshop participants who turned in assessment work differentiated among the high-level categories of SBL learning outcomes: technical problem solving, social skills, and social-technical skills. As a result, faculty did not use the design patterns as intended to create distinct assessments for these specific SBL learning categories. Instead, they put all kinds of skills into one design pattern. The final assessments often focused narrowly on the quality of a final product. It was not clear that students' process skills were being assessed. The assessment comprehensiveness analysis of the assessment materials produced during the workshops appears in Table 2.

SBL Tasks	**SBL Assessments**		**Comprehensiveness of Learning Outcomes Specification in Assessment Materials**
	Formative	**Summative**	
Consumer Report Surveys	No	Yes	Moderate
Financial Report	Yes	Yes	Low
Creating an Online Class	No	No	Low
Public Health Presentation	Yes	No	Moderate
Create Flier on Agricultural Industry with Data	No	Yes	Moderate
Blog Reviews of Browsers	No	Yes	Low
Accounting Spreadsheets	No	No	Low
Updating Websites	No	Yes	Low
Report on Novel	Yes	Yes	Moderate

Table 2. Comprehensiveness of Phase 2 SBL Assessments

Adjustments Recommended

A review of the data from Phase 2 indicates that there was a decline in the comprehensiveness of SBL skills assessed and the use of both formative and summative assessment modes. Recommended adjustments include the following:

- Provide faculty with a clear understanding that SBL employs multiple forms of assessment, both formative and summative, which focus on different phases of technical problem solving and different types of social or social-technical skill.
- Clarify that assessment design does not flow directly from identification of SLOs.
- Clarify that the SBL assessment specification process expands faculty ideas about the range of assessments to use and the process skills involved in producing specific products.

Conclusion and discussion

In any effort to bring an innovation to scale, designers make adjustments to their original approach to support wider dissemination (Coburn, 2003; Dede & Rockman, 2007). As the SBL project team continues its work, it will be important to foster faculty buy-in without undermining the central justifications for using the SBL curriculum. In this paper, we have identified the core categories of learning outcomes that need to be assessed in SBL tasks: a) process skills of technical problem solving and b) process skills of a social or social-technical nature. The data indicate variation in the assessment literacy of faculty. Those with lower assessment literacy may have problems orchestrating the multiplicity of SBL learning outcomes. A common response is to toss together a mix of familiar assessment approaches, particularly those focused on holistic ratings of final products, without sufficient reflection on whether the assessments target the most important process learning outcomes of the SBL task. In future work, faculty will be engaged in using EC-AR online tools to develop SBL assessments. Our findings suggest that a clear framework defining the range of SBL task knowledge and skills needs to be incorporated into these tools to support faculty understanding and assessment development needs.

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A STRATEGIC FRAMEWORK: ASSESSING INDIVIDUAL STUDENT LEARNING IN TEAM-BASED SUBJECTS

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ABSTRACT

The assessment of individual students' learning in team-based subjects can be problematic for academic staff and students alike, unless these stakeholders work toward a shared understanding of the basic elements of the assessment process. This paper describes both the background of an ongoing five-university research project investigating effective assessment of individual student learning in PBL-based subjects as well as the current framing of our findings – a strategic assessment framework.

This assessment framework is described as *strategic* because it is founded on the principle that academic staff must engage students in a progressive knowledge construction process guided by the subject's learning outcomes while also preparing individual students to demonstrate their learning within a team environment.

INTRODUCTION

Grading individual students in teams has always been problematic. To accurately gauge individual learning outcomes, students' grades need to be based on what they have learned as an individual within the team context. However, within engineering team-based projects, individuals have traditionally been assigned a grade heavily influenced by the team's project outcomes. Consequently, a poor project outcome for a team results in poor grades for its individual members, even if significant individual learning occurs. As assessment drives behavior, the desire for higher grades influences the team dynamics resulting in an emphasis on project outcomes rather than individual learning, potentially degrading collaborative learning (Johnson and Johnson, 1998; Johnson, Johnson, and Smith, 1998). While some research has been conducted on team formation and monitoring to help reduce these effects, such as the 2007 Carrick project "Developing and disseminating TEAM SKILLS capacities using interactive online tools for team formation, learning, assessment and mentoring" (Kavanagh, 2007), existing research does not address the assessment of individual learning in teams.

An Australian Learning and Teaching Council (ALTC) - supported project "Engineers for the Future" (King, 2008) recommends the development of best-practice engineering education to promote student learning and deliver intended graduate outcomes. That project was founded upon a previous report entitled "Changing the Culture" (IEAustralia, 1996), which first highlighted the need for change to an outcomes-based engineering education system in Australia. Implementing changes to student learning and graduate outcomes have since resulted in a greater emphasis on team-based projects. This has required a dramatic change to the traditional methods of assessing individual students' learning in engineering programs as these methods alone do not currently meet the assessment needs of practice-based education, such as project-based learning (PBL).

Qualitative assessment methods are more suited than quantitative methods in assessing graduate attributes in PBL in terms of the broader, professional, context-dependent skills required of an engineering student. These methods contrast with the quantitative assessment methods generally used in engineering courses which assess specific, technical content knowledge and tend to require right or wrong processes and answers. The majority of engineering academics and industry professionals, however, understand and are more comfortable with quantitative assessment methods.

Experience with accreditation panels shows their mistrust of qualitative assessment, with panels often commenting that qualitative assessment is subjective and is therefore not a valid or reliable method of assessment in engineering. Currently, the engineering discipline does not have a valid method for qualitatively assessing individual learning in a team environment recognized by the accreditation body for engineering programs (Engineers

Australia), as well as engineering academics and industry. This is a major challenge to the recognition, accreditation and implementation of PBL-based assessment of individuals in teams. However, it is also an issue for all engineering programs, which must demonstrate graduate outcomes from complex tasks such as final-year design and research projects.

This paper will describe an ongoing research project, supported by funding from ALTC, in which investigators have constructed the initial version of a strategic framework to assess individual students' learning in team-based courses. This assessment framework is described as *strategic* because it is founded on an understanding that quality assessment in team-based subjects involves a progressive knowledge construction process throughout the term. Guided by the subject's learning outcomes, this ongoing effort to clarify the various foci of learning can also prepare individual students to demonstrate their learning within a team environment.

First, the background of the research is described, including epistemology, methods, and preliminary results. Then the strategic assessment framework is described as well as efforts to pilot the framework at four Australian universities in Term 2 2011. The paper will conclude with a general discussion of the implications of the framework and a discussion of our next steps.

Background of the study

In this project, researchers from five tertiary institutions are investigating current practices for assessing individual student learning in team-based engineering coursework and from this investigation have constructed a strategic framework which effectively reveals and evaluates individual student learning in the team context. The questions driving this research are:

1. What methods are currently in place at member institutions for assessing individual students' learning in team-based coursework?
2. What connotes the effective assessment of an individual student's learning in a team-based course?
3. What challenges and opportunities do individual instructors (as well as teaching teams) face when first implementing the first iteration of our strategic assessment framework?

4. How can these opportunities and challenges shed further light on the complex context of assessing individual student learning in the team-based learning environment and on the efficacy of our new-formed strategic assessment framework?

This research and development project is founded on a synthesis of design research (Brown, 1992; Collins, Joseph, and Bielaczyc, 2004) and Grounded Theory inquiry (Strauss and Corbin, 1998; Charmaz, 2006). Design research offers an epistemological approach to investigating theoretical constructions of learning and teaching in the "real world" context of the working classroom. Grounded Theory, a research paradigm founded in the social science context, offers the opportunity to explore participants' lived experience for the purposes of generating theory – in our case, a theory of effective assessment of individual students' learning in team-based pedagogies such as PBL.

The research team first obtained ethical clearance and conducted open-ended interviews with academic staff and students at each of the member institutions about their experiences with assessment in the team-based setting. These transcripts were analysed for recurrent themes and outlying data points (Boyatzis, 1998), revealing a range of considerations that participants employed when designing and implementing assessment of both individuals and teams. These considerations included contextual considerations for assessment (such as the number of students in the subject), considerations about assessing types of learning (such as design thinking or technical knowledge), and considerations about the team context (such as determining an individual student's level of engagement in team products).

The research team met in November 2010 with the task of constructing a conceptual model for effective assessment of individual students' learning in team-based subjects. To this end, the research team reviewed the thematic analysis findings, reviewed key assessment literature sources, and compared these with their own professional experiences teaching PBL courses and mentoring others in doing so. Using these elements, the research team constructed a broad conceptual model capturing key processes which work together to support effective and fair assessment in team-based subjects. This model is illustrated in Figure 1 below.

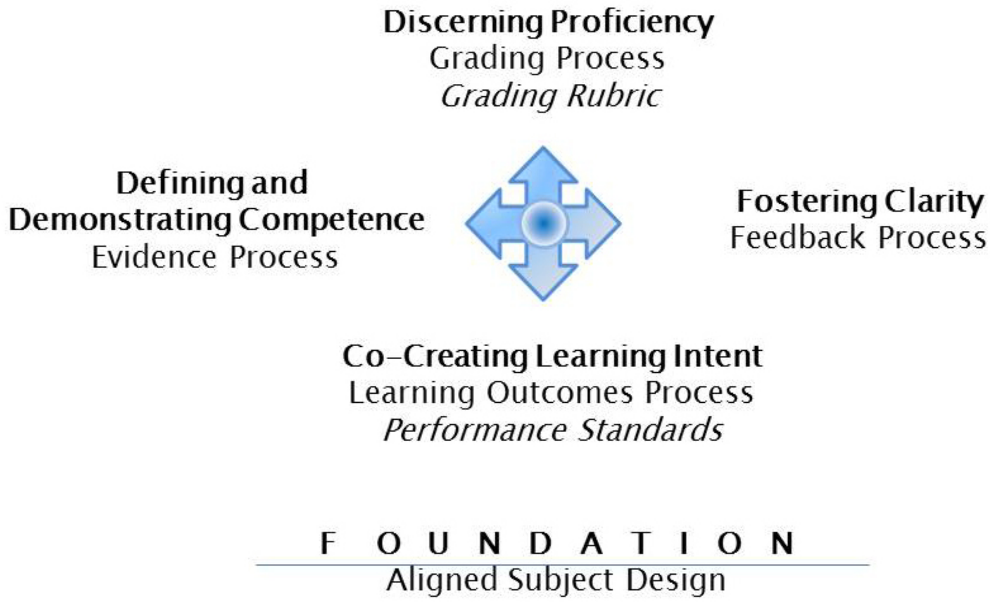

Figure 1. Strategic Assessment Conceptual Model

The conceptual model describes a group of processes that are all necessary for an effective assessment framework. This model was then used to create a generic assessment strategy that could be adapted for specific team-based courses at the Australian member institutions for implementation in Term 2 2011. Elements of the conceptual model will be explained more completely in the "Strategic Assessment Framework" section of this paper.

Founding Principles

During the process of moving from the conceptual model to the strategic assessment framework, we derived a number of founding principles to guide the implementation of the framework in varying institutional contexts. As a group, we understood that assessment is a significant 'driver' of student learning as a student's perception of the importance of a given course activity can be directly related to the weighting the activity is given in the assessment process (Black and Wiliam, 1998). At the same time, our experience suggests team-based pedagogies, such as project- and problem-based learning, offer a new and perhaps confusing context for students because opportunities for individual students to demonstrate their own learning are often limited when team products form the basis for final grades. In addition, the complexity of team products and the team focus on receiving the highest grade can both limit individual students' input into and control over final version of the product

Reflecting on these and similar observations, as well as the preliminary data analysis findings, the research team developed the following principles to support the adaptation and implementation of the strategic assessment framework at multiple institutions for the Term 2 2011 pilots:

1. Assessment is a significant 'driver' of student learning as students' perception of the importance of a given course activity can be directly related to the weighting the activity is given in the assessment process.
2. Quality of assessment depends on the alignment of learning outcomes, teaching and learning activities, assessment items, and the professional skills.
3. Students' understanding of the connection between learning outcomes, teaching and learning activities, and evidence of learning is developed through ongoing dialogue between students and staff. This ongoing dialogue is vital for optimal student learning and performance,
4. Learning outcomes are the intellectual contract between staff and students and act as the organizing structure for assessment.
5. Learning outcomes within a single subject vary in importance and impact, especially when considered within the larger stream of degree-related subjects.
6. Learning activities must provide multiple opportunities for individuals to gather personal evidence of learning against the subject learning outcomes.
7. Team products, such as reports and presentations, are not evidence of individual student learning.
8. Learning teams at the university should differ significantly from working teams in industry in relation to values, practices, and expected outcomes.
9. An individual students' final grade should represent their final state of learning as opposed to indications of learning at various points during the term.

These principles will serve to help adapt the strategic assessment framework to the varying pilot conditions on the four Australian campuses. In the next section of this paper, the strategic framework is described in light of the conceptual model and the founding principles.

Strategic assessment framework

The Strategic Assessment Framework employed in this study is implemented as five on-going processes that occur before and during the term for a particular subject:

1. Foundation Process: Aligned Subject Design
2. Learning Outcomes Process: Co-Creating Learning Intent
3. Evidence Process: Defining and Demonstrating Competence
4. Feedback Process: Fostering Clarity
5. Grading Process: Discerning Proficiency

Each of these processes is an exercise in social knowledge construction where the instructor interacts with her teaching team (if applicable) and her students to build mutual understanding of the learning goals of the subject (as exemplified in the learning outcomes), to construct guidelines for evidence of varying levels of achieving these goals, to craft feedback to students that helps orient them in terms of their achievement for each learning goal, and to determine a final grade which reflects the scope and the depth of an individual student's learning.

Foundation Process: Aligned Subject Design

The term *constructive alignment* (Biggs and Tang, 2007) describes a pedagogical design paradigm in which the professional skills and knowledge that form the heart of the course content are described as a series of learning outcomes. From these outcomes, the instructor/designer creates teaching and learning activities that will offer students the opportunity to learn the scope and the depth of the subject's knowledge and skills. These learning and teaching activities include tasks which are designed to both assess the student's learning in relation to a specific subset of learning outcomes while also offering the opportunity to deepen that learning and connect that learning to other contexts.

We call this foundational process "Aligned Subject Design" because the quality of the alignment between learning outcomes, teaching and learning activities, and assessment can have a powerful impact on the assessment process. When the alignment between these elements is tenuous, or that alignment is poorly understood by staff and students, the recognition and characterizing of student learning can be severely compromised.

This process begins in the subject design phase prior to the start of the term and can continue across the life of the subject as the instructor learns to better understand and articulate the alignment of the various elements.

Learning Outcomes Process: Co-Creating Learning Intent

While learning outcomes can guide the design of an effective course, staff and students may have limited ability to interpret the wording of these outcomes and to understand them in concrete and demonstrable ways. In this process, teaching staff work directly with students to both develop better understanding of the learning outcomes as a whole and to understand how a particular activity is built upon and demonstrates a subset of the subject's learning outcomes.

One important tool in this process is the performance standards sheet. This sheet contains guidelines for a student's demonstration of engagement with a particular learning outcome at each grading or marking level. These sheets are best prepared prior to the beginning of the term and introduced to students within the first week, offering an opportunity to engage students with the learning outcomes early and to help them interpret the learning outcomes in terms of their own performance.

This process is called "Co-Creating Learning Intent" because the unpacking of each learning outcome in terms of levels of performance begins to strengthen a hallmark outcome of this framework: helping students to make informed choices about their own engagement with the goals and activities of the subject.

Evidence Process: Defining and Demonstrating Competence

The academic staff interviewed for this study used a variety of methods to assess the learning of both teams and individuals in their subjects: ranging from final written examinations to reflective journals to team meeting minutes to team presentations. Some participants relied primarily on team products while others combined individual and group assessment methods.

While team products have great value in terms of focusing group activity, they are poor indicators of the scope and depth of each student's learning in a team. Based on the founding principle that individual students need multiple opportunities to demonstrate their learning within a single team-based subject, the evidence process is an on-going dialogue between staff and students to help students understand how to produce evidence that speaks to the specific learning outcomes underlying a particular learning activity. Using the performance standard sheet, staff members help students determine the level of competence they are seeking to demonstrate and to compile evidence that clearly reflects that level of competence.

Feedback Process: Fostering Clarity

One can imagine that a student's understanding of a particular learning outcome is most complete at the end of the subject, after having completed the subject's learning and teaching activities. Not only are these activities vital to understanding an individual learning outcome, the learning and teaching activities also demonstrate how the learning outcomes interact with one another to build understanding and attainment of the professional knowledge and skills at the heart of the subject.

Given this complexity, it is no wonder that students (both individually and in teams) can feel confused and unsure as they work to complete a project. While the research team understands the value of ambiguity at certain points of the learning process, there is one area which deserves elucidation at nearly every point: the alignment between the current activity and the learning outcomes underlying that activity. This is especially true in terms of the students' demonstration of their learning. Most students can benefit by continual reorienting to both the learning outcomes and the performance standards for these learning outcomes – delivered through feedback from both instructors and peers. This continual course correction can take within an on-going "conversational framework," which is at the heart of the teaching and learning process (Laurillard, 1993).

Grading Process: Discerning Proficiency

As can be seen from the preceding processes, this assessment framework takes a strategic approach. It makes both the learning goals and the criteria for expected levels of performance in relation to those goals transparent to students throughout the subject. It also offers support to students in terms of crafting targeted evidence and clarifying their learning intent in the midst of the complex team-learning environment.

One additional tool in helping students take ownership of their learning is the grading rubric. This rubric is related to the founding principle that learning outcomes within a single subject can vary in their importance. Some learning outcomes are vital and students must demonstrate significant levels of competence for them at the end of term. Other learning outcomes need only be demonstrated with basic levels of familiarity. The grading rubric is a tool for helping students to understand the prioritization of the learning outcomes as related to levels of the final grade. Offered to students at the beginning of the term, the grading rubric again makes transparent the underlying logic of both the subject's contents and assessment framework, allowing students to make informed choices in terms of where they want to focus their efforts and affording academic staff the opportunity to make more effective grading decisions about individual students working in teams.

Conclusions and next steps

The goal of this study is to create an empirically derived approach to assessment in team-based subjects that more effectively assesses an individual student's learning. Four of the Australian research partner universities are piloting this framework during Term 2 of 2011. Pilot participants are teaching Engineering subjects which involve a significant team project. At this point in our process, we are beginning to train participant academic staff for the Term 2 pilots. While the strategic assessment framework makes sense to the research team, the pilot will shed light on "naïve" participant's ability to engage with the framework, and integrate the processes within their individual contexts. Contexts are varied even within an individual institution, where some participants are offering totally project-based and hence team-based subjects, while others are delivering team-based projects as a part of a subject. For this reason, the research team members are taking a mentoring role during these pilots.

The evaluation of these pilots will include surveys and interviews with both participant staff members and students. It is expected that the evaluation will indicate the value of the framework in assessing the learning of an individual who does their learning in a team environment, as well as the transferability of the framework to a range of contexts.

Many questions are present as we move forward. What impact will workload issues have on this approach? Will familiarity with the project-based learning paradigm be a deciding factor in academic staff's ability to apply the framework successfully? What advantages do academic staff report using this framework and what challenges do they face? These and other questions will hopefully be answered within the coming months, helping to refine our understanding of effective assessment of individual students' learning in team-based subjects.

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QUANTIFYING REFLECTION – DEVELOPING REFLECTIVE COMPETENCIES BY PROFILLING STUDENT REFLECTION ON THEIR LEARNING GAINS IN THE INITIAL STAGES OF COLLABORATIVE PBL LEARNING

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ABSTRACT

This paper looks at 1st semester student reflections on "learning to learn" in a team-based PBL environment. It documents data from 60 student portfolios and graphically illustrates their class, group and individual learning gains as perceived by the students, over a range of specific skills and process competencies involved in initial phases of an Architectural Technology and Construction Management degree. These include both 'product and process competencies'.

In effect it is a Student SOLO taxonomic approach – Structuring Student Observations of Learning Outcomes - based on Bloom's cognitive taxonomy. It develops students' reflective competencies and graphically 'documents' both individual and collective learning gains that help plan future learning aims and strategies. It accelerates students' development through the structural phases of a SOLO taxonomy and increases their understanding of the complexity of PBL – defining, comparing and contrasting their cognitive, intrapersonal and interpersonal gains.

INTRODUCTION

Over 40% of our Architectural Technology and Construction Management students are international students - over 40 nationalities - with widely varying educational and cultural backgrounds. They work in collaborative project teams in a Project/Problem Based Learning Environment – with great diversity in their knowledge, competencies and attitudes to learning. Their degree is designated as a ‘professional’ bachelor degree which stresses:

> *“The importance of active participation in the practice of communities and of constructing identities in relation to these communities”* (Wenger 1991)

Developing a random group of widely diverse students into highly motivated and effective PBL community is a constant challenge. No two classes are the same and a crowded curriculum puts pressure on developing good ‘communities of practice’ Most international students have little or no experience of working in a collaborative PBL environment which requires competencies and attitudes that they may not have developed in more traditional individual- based courses. Inspiration and motivation for the study partly came from previous work done by the authors Alcock & Blyt (2010) and from a study by Kolmos & Kofoed (2002) that suggested *“students use Bloom’s taxonomy to state their own learning aims related to their different learning goals*.” Their study however indicated the problem of combining theory with practice - “*the students did not really use the course content for their process analysis”*. The papers authors decided to study how students could use Bloom as a useful personal and process analytical tool.

Reflection on, in and for learning

Assimilating the skills needed to make their learning as effective as possible requires reflection and insight into what is a highly complex process. Such reflection is both individual and collective. Students reflect on what they have already learnt to help define their learning aims and strategies. Many report that they have never actually reflected on what they had learned, but only about what they had to do – what was demanded by the teachers. Raising their awareness of learning is emphasized in the first two semesters (of 7) which are designated as the *'learning to learn'* phase of their education.

VIA University College's PBL model is based on 3 criteria

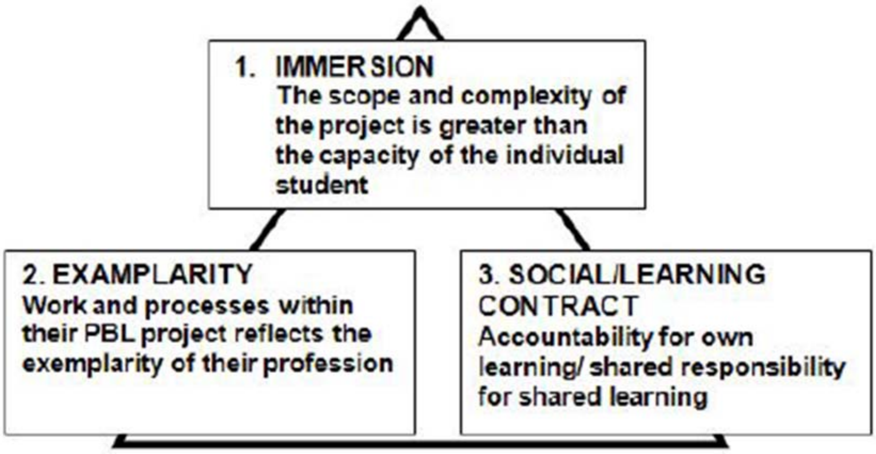

Fig 1 3 criteria for VIA university Colleges PBL model

In an initial introduction to PBL the students are introduced to Bloom's taxonomy; theories of developing competence; Tuckmann's team development models; Kolb's, Schön's and Cowan's views on reflection and Knowles philosophy regarding adult or andragogical learning to help define what they have already learned – in terms of their knowledge, skills, competencies and attitudes to learning. For - as Biggs states -

> *"The role of building on students previous experience is becoming increasingly' recognized. "Before they can build on it they have to define it – define both what they have learned and how they learnt it best"* (Biggs 1995)

Their 'Learning Portfolio' documents the development of their learning – both quantitatively and qualitatively – throughout the semesters. This study contrasts the students' self-evaluation in a range of 'product' skills such as *Revit, Structural Design*, *Mathematics of construction, Technical Installations*; and 'process' competencies such as '*Working in a team', Sharing knowledge, Maintaining a portfolio* and *Reflection on, in and for learning.*

Such documentation helps them take responsibility or be '*accountable for their own learning',* while also *'sharing responsibility for shared or 'common' learning'* –becoming:-

> *"Self-directed learners who take the initiative to "diagnose their learning needs, formulate learning goals identify human and material resources; choose and implement appropriate strategies and evaluating learning outcomes"* (Knowles 1987)

In taking such initiative they have to develop their abilities to evaluate both their own and others learning – in other words self and peer assessment. In terms of an actual problem statement our study asks – "**How can students define and illustrate their learning gains in a wide range of PBL competencies?"** Collaborative Team-based PBL requires students to have an insight into their own (*Intrapersona*l) and other's (*Interpersonal*) learning. If they are to exploit the full potential of the human and material resources, such insights must made available to all members of any PBL team and their facilitator(s). This analysis forms a major part of their own individual and group learning portfolios.

The results document improvement in student appreciation of the complexity of Project Based Learning and how the individual components – cognitive or subject- related knowledge and skills and process related competencies – integrate. The students are introduced to the theories of reflection – aiming to move them on from mainly Kolbian reflection on what they have learnt and experienced to more Schönian and Cowanesque reflection 'in' and 'for' future actions. For most students this is a major development in terms of developing their capacity to be conscious of and responsible for their own learning – both individual and group aims and strategies. For many – if not most – their learning profiles help them reflect on and access the resources:

> *"necessary to learn what they need to learn in order to take actions and make decisions that fully engage their own knowledge ability*" (Wenger 1991)

As the learning profiles are public and involve both self and peer assessment, they are encouraged to be open and honest about their learning.

> *"Good learning takes place in a climate of openness where politics is minimized."*
> *(*Argyris and Schön - 1992)

The learning profiles also encourage what Biggs – quoting Glassner - saw as the 3 most effective means of learning

> "*People learn 10% by what they read; 20 % by what they hear; 30% by what they see; 50% by what they see and hear;* ***70% by what they talk over with others; 80% by what they use and do in real life; 95% by what they 'teach' someone else"***

The survey

The student learning profiles are based on Bloom's taxonomic levels which are explained and discussed in class. They are also related to developing competence – from initial 'Unconscious incompetence' - where people '*don't know what they don't know*', through 'Conscious incompetence' – where '*you know that there is something you don't know'*, through 'Conscious competence' - where '*you concentrate in doing or learning what you want to learn'* to the final stage 'Unconscious competence' where '*you do what you set out to learn without having to think about how you actually do it'*. Alan Chapman (2003) lists a 5th dimension which he refers to as 'Conscious, unconscious competence' This reflects the rationalization behind the process of profiling learning – getting the students to be aware of what exactly is involved in their learning. Even when they begin to do things 'automatically' they should still to reflect on and integrate what they have learned as on-going life-learning process – both on an individual and group basis.

This helps students to document, verbalize and communicate their learning competencies and learning needs and is a vital factor in accelerating personal and group development. It helps students reflect on and assimilate their own and others understanding of learning and accommodate such reflection into future learning strategies and encourages teaching staff / facilitators to**.**

> *"trust that students are capable of learning - by themselves and that they have to organize students learning processes without telling them what they have to learn – or even that students are able to learn the fundamental knowledge by student centered learning methodologies"* (Savin Baden 2003)

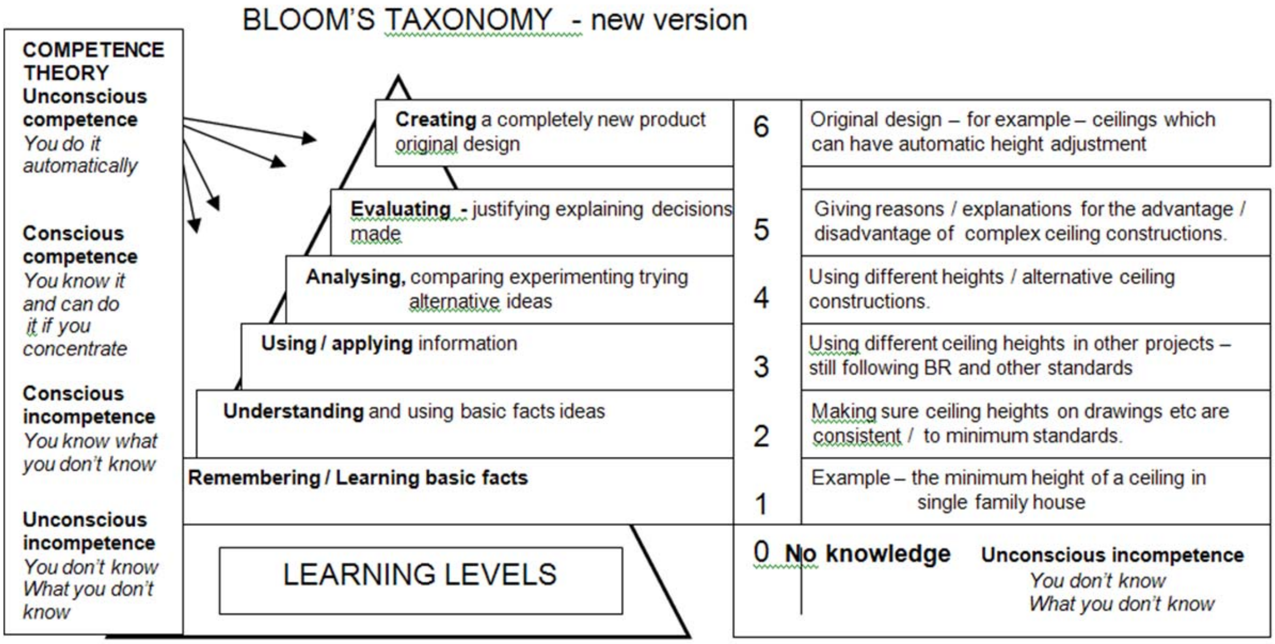

Fig 2 Bloom's cognitive taxonomy – as the basis for defining competencies.

Individual student reflections

At the start of the semester students were asked to define their level of competence in a range of 16 cognitive, affective, self-perceptive and social competencies. of specific skills / process competencies involved in initial phase of the Architectural Technology and Construction Management degree.

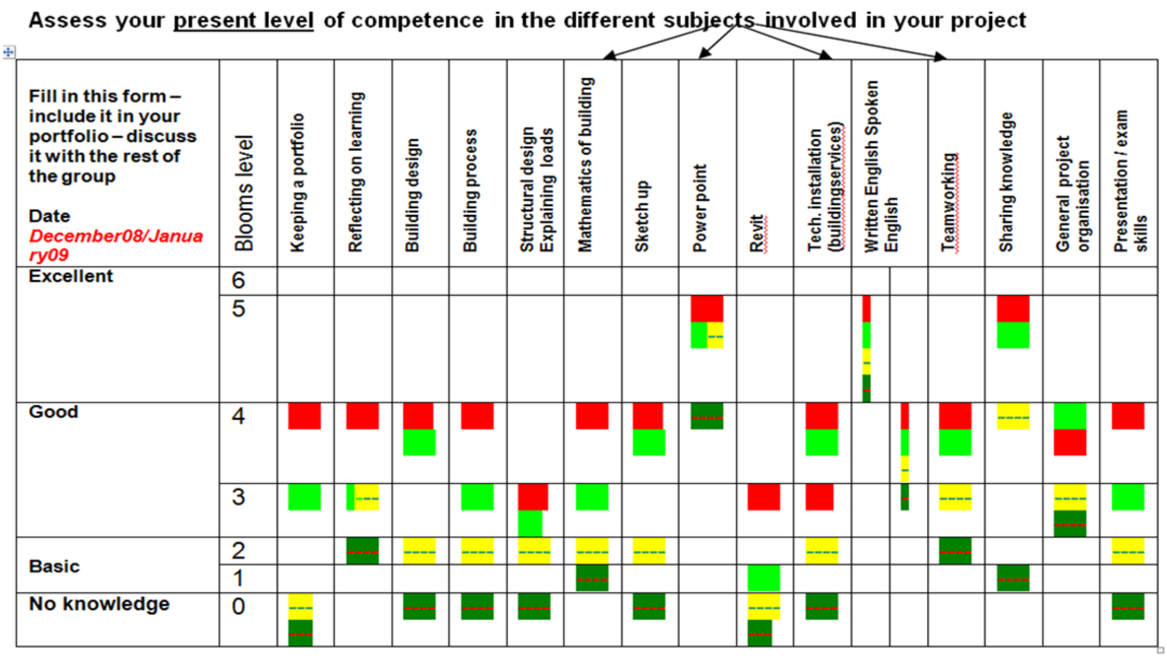

Fig 3 – Example of one student's reflections in documenting their learning gains.

The four colours represent one student's assessment of her learning throughout a semester. Dark green is on entry to the education in August. Yellow, light green and red represent her reflections in October, November and January.

Quantitative and qualitative reflection

The profile in Fig 2 documents a student's quantitative assessment of learning development and earning gains. They also reflect on and document their reflections on a written qualitative basis and write a final summary of their overall evaluation of their development.

The following are examples of such qualitative reflection taken from the same 1st sem student's portfolio

Reflecting on learning: *I have learned a lot about my own way of learning and working and have really begun to see why the others work in a different way. This has helped a lot in the way we work – we do talk a lot about how we are doing what we are doing" Before I came here I used to only think about what I had to do – what the teachers told me to do - now I am really thinking more about what I am really learning.*

Sharing Knowledge: *We really do have an excellent class environment. It is very motivating, relaxed and flexible. The idea that there is only one team in the class works brilliantly. We watch what the others are doing and have ended up working very closely with two other groups. Some people are very good at teaching. If you ask for help they always do. We have found out who is good at different things and use them as teachers.*

From Summary. *Looking back I can't believe how much I have really learned over the last 5 months – not just what I have done , but what I have really learned and that is a lot about myself and how I work best with other people. Before I came here VIA a student who was here told me that I would either love it or hate it – well I really love it".*

Both the quantitative and qualitative reflections form an essential part of individual and group facilitation meetings with a teacher acting as their facilitator/ consultant. Teachers also read the students' portfolios before the final examination – which are based on student presentations of their project. The students also have to document and present the most important aspects of their learning gains. At the start of the examination – where they introduce themselves – the students use their profiles and portfolios to describe rationalization behind their projects and their learning development. In defining their learning gains students use a 'sensibly interpret' their performance. All in the group are involved in this process and the common framework involved helps promote

> 'f*ace-to-face interaction, group processing, social skills* and *positive interdependence* without detracting from *individual accountability'*–

Five basic elements of cooperative learning identified by Johnson and Johnson's (1999) summary of 40 years research on collaborative learning. The profiles are taken on to the next semester – where the students have to work in new PBL teams. The results help verbalize and accelerate the initial group 'Forming' process (Tuckmann 1965) After that it hopefully becomes an unconscious competence - with students doing it automatically. It also promotes greater understanding of the increasing complexity of PBL models – students show better understanding of Savin Baden's 5 Models of Problem-Based learning - students quickly learn *to solve real problems in order to solve undertake practical action, integrate across competence boundaries; become independent thinkers with a critical stance* and – hopefully – *go on explore underlying structures and beliefs* and *develop new hypotheses and knowledge.*

Analysis of 60 student profiles

To document overall learning gains 60 students profiles and portfolios were analysed to assess student evaluation of their competencies at the start and at the end of the semester. Students are asked to provide a 3 profiles and reflections in their portfolio – normally at the start, half-way through and at the end of the semester. They could do more if they wished. The levels of competence defined by each of the 60 students were collected together – The total learning assessment was reached by multiplying the number of students on each Bloom level and totalling the results. In 'Keeping a Portfolio', for example, five students defined their competence as being at level 5 – this gave 25 points. Four students at level 4, 13 at level 3, five at level 2 and 19 at level 1 gave a further 74 points which when added to the 25 from level 5 resulted in a total of 109 points. This was repeated for each of the 16 defined competencies which resulted in a ranking of the students perceptions of their competence levels at the start of the semester - 'Keeping a portfolio' being ranked at number 14. Spoken

English, Team working, Written English and Sharing knowledge were perceived as being in 1st, 2nd, 3rd and 4th place by the students.

Fill in this form – include it in your portfolio – discuss it with the rest of the group Date START	Blooms level	Keeping a portfolio	Reflecting on learning	Building Design	Building process	Structural design Explaining loads	Mathematics of building	Sketch up	Power point	Revit	Tech. installation (buildingservices)	Written English	Spoken English	Team working	Sharing knowledge	General project organisation	Presentation / exam skills	Students asked to appraise and set a value on their existing knowledge/ skills / competencies for each of the semester components on entry to semester
Excellent	6						2	3				2	3	5	6			
	5	5		5	9	5	6	7	12	2	1	10	5	7	6	6	3	Number or respondents in each category
Good	4	4	15	9	12	3	12	10	13	5	4	14	17	10	12	14	19	
	3	13	16	14	12	7	18	13	12	7	7	14	20	21	18	14	14	
Basic	2	5	12	12	10	17	15	11	12	7	21	14	12	12	9	12	11	
	1	19	12	13	11	18	7	12	9	15	16	6	3	5	7	11	11	
No knowledge	0	14	5	7	6	8		4	2	24	11				2	3	2	
Totals		109	135	140	160	110	154	150	171	80	100	194	198	197	193	163	166	Number of respondents x Blooms level results in total response on entry to semester
Rank order at start of sem		14	12	11	8	13	9	10	5	16	15	3	1	2	4	7	6	

Fig 4. Ranking of student reflection on their defined competencies at the start of the semester

This process was repeated when the students defined competence levels at the end of the semester (3 weeks before the final examination) The resultant ranking show **'Keeping a portfolio'** being ranked at number 14. **Spoken English, Team working, Written English and Sharing knowledge** were perceived as being in 1st,6th, 5th and 4th place by the students

Fill in this form – include it in your portfolio – discuss it with the rest of the group Date END	Blooms level	Keeping a portfolio	Reflecting on learning	Building Design	Building process	Structural design Explaining loads	Mathematics of building	Sketch up	Power point	Revit	Tech. installation (buildingservices)	Written English	Spoken English	Team working	Sharing knowledge	General project organisation	Presentation / exam skills	Students asked to appraise and set a value on their existing knowledge/ skills / competencies for each of the semester components at end of the semester
Excellent	6	5	3	16	13	3	3	6	4	4	1	4	10	7	9	3	8	Number or respondents in each category
	5	11	10	11	14	5	8	14	11	11	7	18	15	16	18	22	15	
Good	4	15	23	13	12	17	24	17	21	21	13	22	18	20	12	12	16	
	3	22	22	11	14	20	12	21	16	15	31	10	15	12	13	12	14	
Basic	2	7	2	9	7	12	11	2	8	9	6	4	2	3	7	9	5	
	1					3	2				2	2		2	1	2	2	
No knowledge	0																	
Totals		225	230	244	252	178	190	251	227	226	200	242	256	245	246	232	241	Number of respondents x Blooms level results in total response at end of semester
Rank order at end of sem		13	10	7	2	16	15	3	11	12	14	6	1	5	4	9	8	

Fig 5. Ranking of student reflection on their competencies at the end of the semester

Finally the difference between the scores recorded at the start and at the end of the semester was calculated and the student 'learning gains' calculated as a percentage of the levels of competence they defined at the start of the semester.

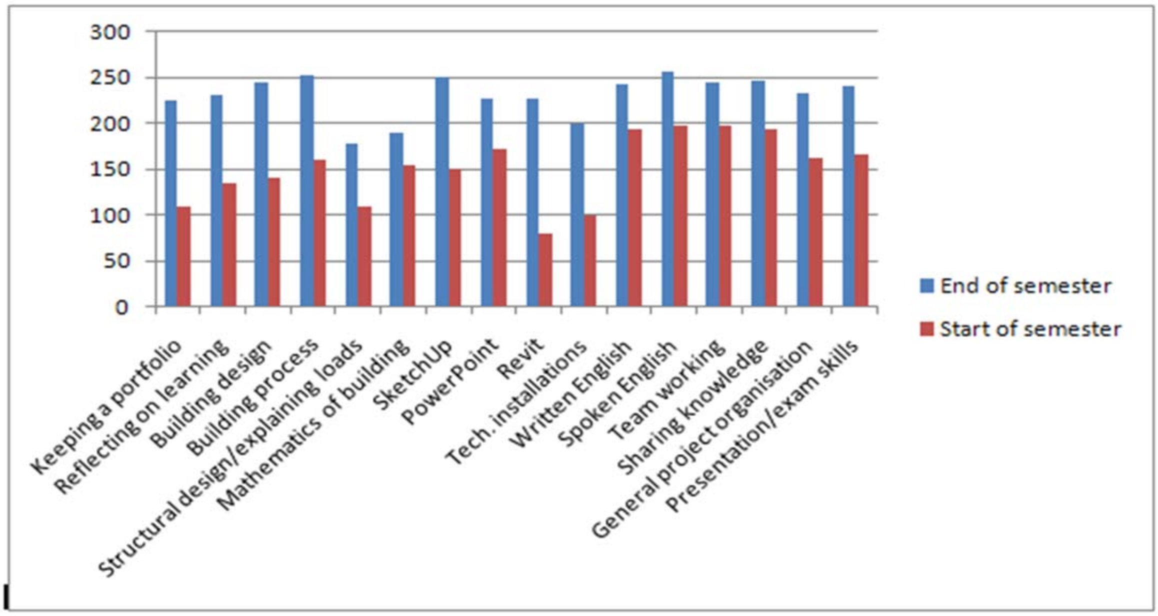

Fig 6 Learning gains calculated as a percentage of the original defined competence levels

FINAL RESULTS	Keeping a portfolio	Reflecting on learning	Building Design	Building process	Structural design Explaining loads	Mathematics of building	Sketch up	Power point	Revit	Tech. installation (buildingservices	Written English	Spoken English	Team working	Sharing knowledge	General project organisation	Presentation / exam skills
Rank order at start of semester	14	12	11	8	13	9	10	5	16	15	3	1	2	4	7	6
Rank order of % learning gain	2	6	5	4	9	16	7	11	1	3	14	12	15	13	10	8

Fig 7. Final ranking of perceived learning gains from analysis of 60 portfolios

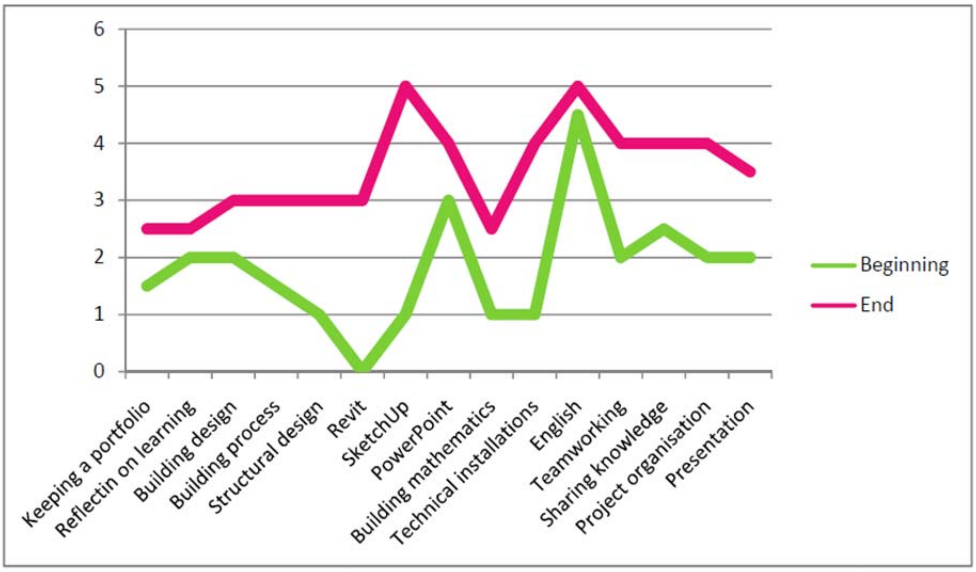

Fig 8 Example of a group of 4 x 1st year students ranking their group's learning gains over the semester

(Their documentation)

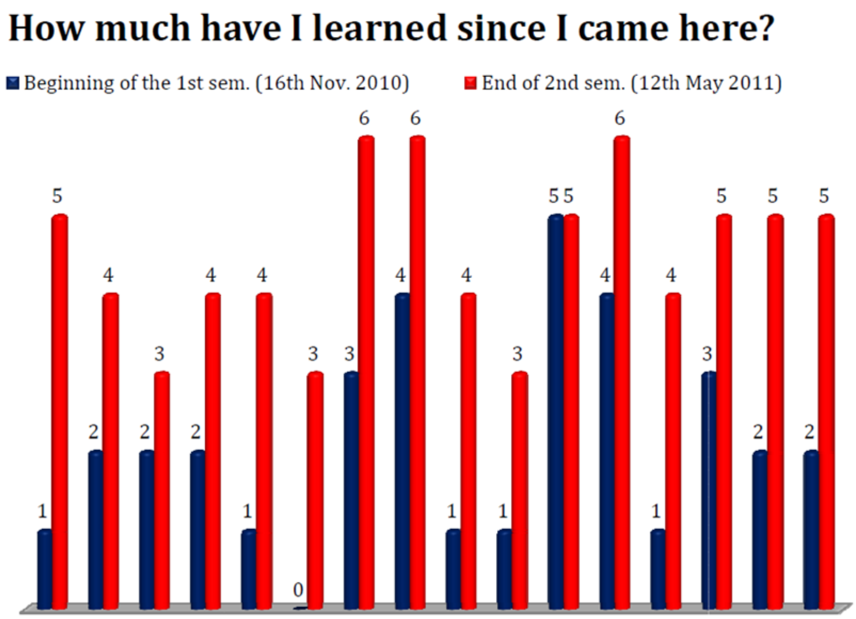

Fig 9. Example of a 1st year student's ranking her own perceived learning gains over the semester – related to subject's in Blooms taxonomy (refer to Fig's 67 and 8 for subjects)

Results

In terms of awareness or consciousness of their learning gains the Revit program went from 16th to 1st place. Levels 6 and 5 are seen as being at Unconscious Competence level and only 5 students felt that they were at that level at the start of the semester – with 15 feeling that they had reached that level by the end.

The student in the individual example in Fig 2 felt that they had reached level 3 – conscious competence –having to consciously think about what they were doing when using the program. This analysis can be repeated for all the defined competencies.

The learning profile is an excellent tool in developing both student awareness of their learning – raising their consciousness considerably of both product and process competencies. It also helps them and their teachers raise the effectiveness of dialogue both in the PBL teams and facilitation meetings.

Students became more able to verbalise many of the factors and competencies involved in the complexity inherent in collaborative PBL and 'professionalise' their approach to learning. The 1st and 2nd semesters of VIA University college's Bachelor of Architectural Technology and Construction Management degree are defined as **"learning to learn"**. The 3rd, 4th and 5th semesters are referred to as **"professional student"** semesters and students are expected to demonstrate both increased professional subject or 'product' competencies traditionally associated with the work of Architectural Technologists and those competencies specifically linked to becoming a highly efficient learner. The final two semesters – 6th and 7th – are referred to as **"professional professional"** semesters, which stresses the Wenger's view of '*joining a community of professionals'*.

Developing reflective competencies reflecting On action, IN action and FOR action is important for efficient / effective learning and greatly improves communication between students themselves and teacher / facilitators. It may also help the team really understand that while the size and complexity of the project is defined as being '*beyond the capacity of the individual student*' assessing it and the range of competencies required to solve it effectively may actually be beyond the capacity of the individual teacher! Any 'tool' that helps identify the students learning gain can only add to their ability to assess the quality of the students' final results – the project that the students present and the teachers assess at the end of every semester.

Conclusion

This study examines and illustrates student assessment of their learning gains and development in a wide range of competencies involved in the Bachelor of Architectural Technology and Construction Management degree. The graphic results of the analysis of 60 student profiles illustrates student reflections on their learning – both collectively and individually. It also documents group and individual assessment of learning gains.

The paper finds that the profiles resulting from this 'quantification' of their learning gains are reflected in the qualitative reflection that forms a major part of student learning portfolios. Students report far higher levels of understanding of both what and how they have learned as well as increased consciousness of the complexity of their learning processes – both on an individual and team basis – in a PBL environment which greatly facilitate guidance or process meetings with their consultants.

The authors' conclude that the results encourage students' to view learning from their own perspective – gaining greater understanding of the complexity of their education. It helps students move away from superficial 'survival learning' strategies - doing what they have to do 'to keep the teachers happy' – to an increased sensitivity and deeper realization of what they are actually learning or constructing when 'immersed' in their collaborative PBL project teams. The result, hopefully will enable the 'scope and complexity of the project to become to a greater extent - within the capacities of the individual students' It should also help project supervisors to a greater understanding of the scope and complexity of the PBL project and the students development within a wider range of product and process competencies.

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HOW WE IMPLEMENT PBL IN A UNIVERSITY: TWO CASE STDIES

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ABSTRACT

As an innovative and promising educational approach, PBL (problem based learning) gradually draws increasing attention due to its effectiveness in promoting students' learning motivation and learning outcomes during the past four decades. Therefore, PBL is now expanding to and implemented by a large number of higher educational institutions. However, current studies about the implementation of PBL tend to reduce PBL practice to merely a pedagogical matter, and thus relatively neglect the organizational aspect when discussing PBL implementation. In this study, we attempt to explore in depth the implementation of PBL at two universities, particularly concentrating on the major issues emerging in the change process while highlighting both curriculum aspect and organizational dimension. Four major issues are further discussed: curriculum, resource, existent organizational system, as well as the attitude of staff members and students towards PBL.

INTRODUCTION

As an innovative educational approach, PBL (Problem Based Learning) possesses a set of principles differing from traditional lectures. Firstly, the problem should be served as the learning departure, and dominate the whole learning process. Secondly, PBL encourages interdisciplinary study, drawing contents and methods from different disciplines to solve real problems. Finally, PBL emphasizes a social approach in terms of teamwork and collaboration (De Graaff, and Kolmos, 2003). With a history of more than four decades, PBL has already successfully proved to be a promising education model in showing instrumental values in terms of enhancing students learning motivation and teaching and learning quality (Dochy, etc., 2003; Strobel and van Barneveld, 2009; Savin-Baden, 2000:26), and thus has been expanding to a number of different disciplinary fields, higher education institutions and countries. Through a meta-synthesis (Bair, 1999) of existing PBL meta-analyses, it can be noted that there is no doubt about PBL strength in terms of long term knowledge retention, skill performance, and mixed knowledge and skill; therefore, it is suggested that research attention should be shifted to understand the factors, drivers, and challenges of the implementation of PBL (Strobel and van Barneveld, 2009), which implies a relatively lack of knowledge of the implementation of PBL in current research field. Concerning the implementation of PBL, many concerns are focusing on the didactic dimension of PBL in terms of learning content, curriculum design, teaching and learning method, assessment, etc. For instance, Hung et al. (2003) mentions tensions with PBL context such as depth versus breadth of the curriculum, higher order versus factual knowledge, long term versus immediate learning outcomes, etc.. The role of teacher and student equally intrigues many research concerns (Ribeiro, 2008; Savin-Baden, 2008). The teacher needs to change their role from a wisdom authority, a knowledge imparter, a class controller, to a learning facilitator. The student also needs to be fully responsible for their learning and preparing for all the challenges, rather than being protected by teachers' shield. In addition to these theoretical discussions on the implementation of PBL, we may also notice a series of case reports about the implementation of PBL at higher education institutions addressing major issues arising in the change process. These issues include staff training (Alarcao, 2007), role confusion of teacher, remain of conventional approach (De Graaff and Cowdroy, 1997), staff attitude towards PBL (Wang etc., 2008), tutor (Lin etc., 2009), contradictory educational objectives, student background (Carrera, Tellez, and D' Ottavio,2003), etc. These pedagogical debates, although to a large extent, shed light on the understanding in the implementation of PBL; there is a significant drawback of these arguments reducing the implementation of PBL to merely a pedagogical matter. In other words, the implementation of PBL requires a more systematic or holistic approach. Given this, Kolmos and de Graaff (2009) propose that the change to PBL is not just a didactical change; rather, it involves the whole organization in terms of the organization culture, the value and concept, as well as the physical space and resources. Without the change of the organization, the implementation of PBL, only constraining to didactical change, would not be complete and successful. Similarly, Moesby (2004) argues that the ideal of PBL is indicative of a radical change occurring at the institutional level. The implementation of PBL would therefore entail the curriculum design, institutional planning, organization, organizational culture, assessment methods and objectives. These arguments point to a crucial aspect for the implementation of PBL which has not gained sufficient research concern: the organization aspect.

In this study, we explore in depth two recent cases of international institutions introducing PBL into their education system. The two universities have different disciplinary and cultural contexts. Both have a long history of traditional teaching and learning, and the process of transforming their educational paradigm is not free of tension and challenges. This study starts with describing two change stories respectively, and later discusses the issues that emerge in the implementation process while highlighting both pedagogical dimension and the organizational dimension.

Research framework and data collection

Inspired by Kolmos and de Graaff' model of curriculum development (2009), this study develops a research framework that covers four dimensions (see figure 1): curriculum, resource, organizational system, and attitude of staff and students towards PBL. The curriculum change is crucial for the implementation of PBL since PBL first and foremost infers to a new type of instructional method as well as an educational philosophy guiding the curriculum design process. The organizational system refers to both external and internal organized institution that guides the behavior of the organization and the members in it and achieve the goals of the organization. To put it in another way, it refers to the rules, regulations, and laws of the university and those ones imposed by the externals. It is crucial to an organization since organizational system defines how an organization works, and "*converts the input into output*" (Birnbaum, 1988). Any educational change at the university is conditioned by the existent system of the organization, and is unlikely to be successful if there is no change to the organizational system. In addition to organizational system, the implementation of PBL is also resource intensive and significantly subjected to the attitude of staff and students. This framework is of significant benefit for us to understand the change process to PBL at a university, not because it directly contributes to the design of an action plan, but in that it can relatively serve as a guidance to understand the important issues arising in the change process which might reveal the tensions, the challenges as well as the obstacles for the implementation of PBL.

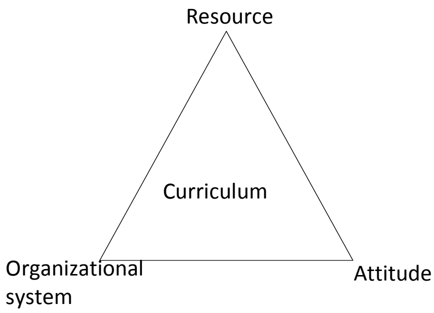

Figure 1: four dimensions for the implementation of PBL

Case study is adopted in this study as the main study strategy, because it is advantageous for researchers to explore the process of a phenomenon (Merriam, 2001, p.33), or to investigate "a complex social unit consisting of multiple variables of potential importance" (Merriam, 2001, p.41). Due to our interest in the process of implementing PBL, and the complexity of the university system, a case study strategy was quite suitable for this study. In order to offer a thick and deep account of the change history, we used a variety of data resources: official documents relating to the educational reform in the selected universities (e.g. policy statement, curriculum plan, and evaluation report), interview transcripts (from administrative staff, teaching and researching staff as well as student), observation notes, and other materials.

Case 1: Victoria University, Australia

Victoria University (abbreviated as VU) is located in the west suburb of Melbourne in Australia. Traditionally, it is an engineering education institute, aiming at cultivating engineers with high competence. Prior to 2005, the dominant educational paradigm at VU was traditional lectures where teachers delivered the prescribed body of information to students. In 2005, after several rounds of internal discussions and external meetings with industrial partners, the vice chancellor of VU decided to transform its educational paradigm into PBL in its two engineering schools: School of Electronic and Electrical Engineering, and the School of Architecture, Civil and Mechanical Engineering. The whole curriculum system was restructured. School of Electronic and Electrical Engineering restructured its four segmented subjects (Maths, Physics, Circuit Theory and Electronics, and Computer Engineering) of the first year program into two integrated units: "Enabling Science" and "Electrical Fundamentals", and "PBL and Engineering Practice". The two units differed in delivery but were closely linked to each other. "Enabling Science" and "Electrical Fundamentals" took the form of traditional lectures aiming at imparting fundamental science and engineering knowledge for problem solving to students. The second part was conducted in the form of group work on project tasks. In addition, the university established a new way to assess students' learning outcomes, rather than evaluating students merely by a final individual written exam. This included writing portfolio, project evaluation, group report and presentation, and individual performance. Meanwhile, in order to create an appropriate and comfortable learning environment, the university invested a large amount of financial resource in improving its basic infrastructure, such as building PBL studios and group rooms, providing facilities, as well as offering new equipment. All through the change process, there were intensive training programs in order to increase staff's awareness of implementing PBL and promoting their practical skills regarding PBL.

The change to PBL followed a phased roll out procedure. In 2006, PBL was firstly introduced into its first year program, then in 2007 into second year program. In 2009, all the four years' program of its undergraduate curriculum was completed transformed into PBL paradigm. Later, the organization restructuring led to a new change to PBL at VU. Initially, VU had two different PBL approaches because two engineering schools introduced PBL separately and differently. School of Electronic and Electrical Engineering favored large PBL project lasting for one semester, whereas School of Architecture, Civil and Mechanical Engineering adopted a combination of several relatively small projects in one semester. In 2008, however, the merging of these two schools stimulated a reconsideration of the necessity of two PBL approaches existing in one single school. Eventually, a new PBL model was designed to replace the two separate PBL models in 2010.

The change to PBL at VU obtained a significant amount of support from the management level since the change was primarily driven by the top manager. The middle level administrative staff was quite enthusiastic about PBL implementation. Moreover, many staff showed great interest in practicing PBL because they saw the benefits they could get from PBL. The champions regarded PBL as a powerful model in engaging students in learning and addressing the graduate competence (e.g. teamwork, communication, problem solving) expected by the labour market and the professional body, Engineers Australia. Some staff noted "*higher attendance, higher attention, higher participation*" of students in PBL class than in normal lectures. PBL also benefited staff themselves, in terms of a better understanding in teaching and learning principles. The response from students to PBL seemed optimistic, as a school wide survey of first year students' response to their learning experience in industry and community noted "*nothing but positive feedback from students*" (Simcock, Shi, Thorn ,2009). The activity of PBL at engineering schools also attracted great attention from other departments at VU and the external labor market. The Faculty of Business and Law was quite impressed by the PBL studios and small group rooms in engineering schools. Meanwhile, external employers also commented the students at VU in a positive way, "*I have gained a great deal from this experience and I am really looking forward to working with you and more students again next year.*" (Simcock, Shi, and Thorn, 2009) Currently, it is widely recognized that PBL paradigm has firmed institutionalized into the university practice. The curriculum system based on PBL rationale has officially established at VU. However, noticeable internal resistance to PBL and tension could be found at the university. Staff resistance, accompanied by staff fluctuation and the change of university agenda, creates significant challenge for PBL implementation in the future.

Case 2: China Medical University, China

China Medical University (abbreviated as CMU), located in the northeastern part of China, is a typical medical university in China. Most disciplines in this university are centered on medical areas, intending to cultivate basic medical awareness, knowledge and skills for the students. Traditionally, the educational paradigm of CMU strongly favours the priority of knowledge and the dominant role of the teacher. The curriculum is basically designed on the base of a set of prescribed knowledge and skills, teachers impart the knowledge to students in the form of big lectures, and students memorize the knowledge in order to obtain a better score in their test at the end of each semester.

Prior to introducing PBL in 2004, CMU had accumulated many years' experience of conducting pedagogical reforming experiments since early 1990s. In 2004, the vice president for teaching and learning affairs at the university launched a project to introduce PBL elements into its education structure. The project was actually a particular funding program available for all departments to apply. The successful applicant would be granted 20,000 RMB to experiment PBL elements in their own courses (group work, case analysis, design new medical cases, etc.). In this sense, the incentive for CMU staff to implement PBL was a result of a combination of both economic stimulus and bureaucratic encouragement.

Since there was little systematic and rigid redesign of the whole curriculum system from the top management level, as had happened in VU, each department at CMU had the freedom to develop its own PBL approach. As a manager recalled, it was an "*all flowers booming together but differently*" strategy for change. Consequently, at the micro level, such as the departmental or the course level, the PBL approaches were quite diversified, although at the macro level, there was no significant change to the entire curriculum system. The portion of PBL in the course varied among different departments, ranging from 10 percent to 100 percent. The Cell Biology course developed a clinical case analysis model in the form of small group discussion. In the course of Medical Ethics, it was a combination of small group discussion on ethical issues in the student dormitory and group presentation in big class. For some departments, like the Department of General Surgical, due to the lack of space and time, they sought alternative learning space and time and thus developed dormitory PBL (the group work takes place in students' on campus dormitories) and online PBL model (students participate in online medical case discussion). The size of the group ranged from 8 to 20, depending on number and energy of staff. Some departments introduced a diversity of innovative assessment methods, adopting elements such as literature review, report writing, oral presentation and defense, group work participation performance, etc. However, as a whole, due to practical reasons (which will be discussed later), the dominant assessment at CMU remained the traditionally individual written test.

It can be noted that the change at CMU was a huge success in terms of several aspects: firstly, a large number of staff and students showed great recognition and interest in PBL, they regarded PBL as an "*enlightening*" experience which was beneficial to both teaching and learning. Students thought that they became much more involved in the learning process and thus their ability of self-learning and communication skills were better developed within a PBL environment. Secondly, a few PBL courses are institutionally established at CMU which indicates that PBL is more or less embedded in the institution and becomes a university routine. In other words, PBL has gained stable institutional guarantee for further development, at least for some courses. Last but not least, PBL at CMU has attracted attention both nationally and internationally. CMU has already won several national awards from the Ministry of Education for its excellent performance in PBL implementation. In 2008, CMU hosted an international symposium for PBL which attracted a great many participants across Asian-Pacific area. As many staff stated, the hosting of this conference marked that CMU PBL model has more or less obtained global attention.

Issues arising in the change process

Curriculum

The didactic discussion regarding learning content, teaching and learning method, the assessment, students' prerequisite for learning, etc., is ongoing and impacts the implementation at both universities. At VU the approach by which PBL was implemented required students to work on a large project lasting for half semester. Conversely, realizing that freshers were not well prepared for PBL learning context due to their inexperience in group work and problem solving, CMU came out with a "buffering" phase which led to a reduction of PBL to only 25 percent of the curriculum system for 1st year students, compared with its original plan of 50 percent PBL elements. At CMU, although it is generally accepted that the skills development (problem solving, critical thinking, communication, etc.) is essential for students, the knowledge centeredness tradition still dominates the university education philosophy, which can be noted from its daily practice. Both teachers and students are eager to summarize the main knowledge points after the completion of PBL learning, which is indicative of a strong emphasis on knowledge memorization. The assessment method, though there are notable innovations towards examining students' skill development, in the whole, still focuses on knowledge retention of students.

Resource

Any education agenda and activity are resource intensive; since universities have only a limited amount of budget for education reform activities, the change to PBL is to a large extent resource confined. PBL favors group learning rather than individual work; therefore there is a significant need for the support about basic infrastructure, such as PBL studios and small classrooms. Within PBL environment, students have to spend much more time than the traditional educational model in searching academic material, and this calls for longer opening hours of library, more available seats and books in the library, and more convenient access to internet and university library database. At both universities, it can be noticed that the university allocates a huge amount of resource in PBL issues. In VU, we may notice the construction of PBL studios and small group rooms. In CMU, the funding for the PBL reform is encouraging. Nevertheless, compared to the huge need of PBL, the resource so far allocated for PBL is not sufficient. For instance, CMU students living in off campus dormitories are still not able to access the electronic database in the university library. There are not enough small classrooms for CMU students, so they are forced to discuss the learning problems in their dormitory as an alternative. The lack in staff is also a major concern because PBL needs more staff to facilitate students than traditional education model does. The lack of staff accounts for the huge size of the groups (some groups have up to 20 students) at CMU. At VU a paradox emerges: there has been a reduction in staff members due to the university agenda, but PBL is quite "staff intensive". The decrease in staff poses significant challenge for the advancement of PBL in the future.

Organizational system

The organizational system determines how an organization works and what kind of outcome it produces. Therefore, the implementation of PBL is to a large extent conditioned by the existent organizational system. It is clear that the organizational restructuring at CMU has affected the implementation of PBL, notably the merging of schools resulted in a single PBL approach replacing the two separate PBL models. At CMU, challenges from the organizational system come from various sources. The time and energy spent in PBL course study for students is quite limited because the general education curriculum subjects, such as English, Computer

Science, Humanity and Social Science course, consume a large amount of time and energy. These general education curricula are nationally designed, and usually occupy one third of the whole curriculum system. In addition to the national curriculum, students have to pass a set of national examinations such as national English test and national computer test, because the passing of these examinations is the prerequisite for graduation. Therefore, it is understandable that students are quite conservative about spending too much time and energy in PBL because the national curriculum and the national examination distract them largely from PBL to facing the reality. The staff in the university affiliated hospital serves double roles: a doctor at the hospital and a teacher at the university. The role of the teacher was more or less weakened because they have to fulfill their responsibility as a doctor and complete a large number of clinical tasks for the hospital. Therefore, their time and energy for the teaching is quite limited, let alone PBL reform. The change of the assessment method is another major challenge. Although a huge body of the curriculum has introduced PBL elements, the majority of the curriculum system still adopts the traditional assessment method. Also, teachers and students are much more comfortable with the traditional assessment because it is easy, reliable and viewed as fair for the students who have to compete for scholarships, opportunities of master study and job opportunities in the labour force market, most of which are based upon traditional assessment. It is almost unheard of to change the assessment method for a course if no change occurs to the other elements, i.e. scholarship competing mechanism, admission assessment to master study and recruitment in labour force market.

Attitude

The attitude of the staff and the students towards PBL is another major concern at both two universities. On one hand, there are a significant number of staff and students who are quite enthusiastic about PBL. They have seen the benefits brought about by PBL: increasing attention in the classroom, high motivation and involvement in learning, better teaching and learning quality. For staff members, PBL provides them with more opportunities to rethink and reflect their traditional thoughts of teaching and learning. Students are more likely to better develop their self-learning ability, problem formulating and solving skills, as well as communication skills. Nevertheless, the negative attitude towards PBL from both staff and students can be noticed.

Firstly, the pedagogical debate on PBL is continuously going on. At VU, some staff members are still worried about the knowledge coverage within PBL environment although other may argue that the essence of PBL is not about learning detail. It seems that some staff lack the confidence of PBL in skill development of students. Therefore, they still prefer traditional lectures rather than a PBL project. At CMU, staff from the Medical Fundamentals argue that clinical courses are much more suitable to implement PBL because they are closely linked to real medical cases, while clinical teachers think the other way around. Both universities have the debates on the size of the problem, the project or the case.

Moreover, there are some practical reasons for being reluctant to do PBL. Both staff and students have a limited amount of time and energy which is often occupied by a variety of university agendas. Currently, since the evaluation for the staff at the university is centred on researching rather than teaching, staff members are more likely to concentrate on research activities such as applying research project, publishing, etc., rather than teaching. For the teachers working in the hospital at CMU, their major responsibility is to accomplish clinical tasks, and thus they are not treating teaching mission as a high priority. Students are often complaining about the extra burden resulting from PBL. While several PBL courses or projects are running simultaneously, students are likely to become exhausted due to the overwhelming academic burden. In addition to the heavy workload brought by PBL, students have already suffered a lot from learning general education curricula and preparing for national examinations such as English and Computing.

Last but not least, implementing the policy might not have enough support from the more junior staff. Both universities adopted a top down approach to initiate PBL, and this strategy was theoretically and partially against the will of the staff members. Also, since the time for the change is quite short, many staff members were not well prepared for it both in terms of knowledge and emotion. Sometimes, there can be too many university agendas at the same time (some of them might be conflicting with each other), and staff are likely to “drown” while struggling among competing agendas.

Conclusion

This study depicts two stories of educational change to PBL happened at two universities in different countries. Through the use of multiple data resource, this study tries to explore in depth four essential issues when higher education institutions implementing PBL: curriculum, resource, organizational system, as well as the attitude of both staff and students towards PBL. The pedagogical concern and debate somehow formulates the conception of PBL at the university and thus affects the implementation of PBL. Education practitioners should be aware of the resource issue since the resource in a higher education institution is always limited. The change to PBL could not go too far without the support of sufficient resource. A university, especially one with a long history, usually has firmly established organizational systems regarding bureaucratic structure, university rules and regulations, evaluation and assessment systems. Therefore the introduction of PBL into the university is likely to cause tension with the existing system. Sometimes, the power of the old system is so strong that it assimilates or even distorts the new thought and practice. For instance, our empirical work noted that some staff members translated "student centred" learning into "student lectured" learning when conducting PBL. In these cases, students (instead of teachers) were chosen to give lectures to others which unconsciously misses the essence of PBL. And finally, the attitude of staff members and students towards PBL should never be neglected. Without the recognition, willingness, and support of them, the practice of PBL would have no solid base from the bottom. It also should be aware that the four dimensions are always intertwined with each other. A problematic situation in one dimension can usually find its reasons in the other three dimensions. For instance, the difficulty for CMU to change its assessment method is due to its knowledge centred recognition of staff member; however, it is equally conditioned by the existent organizational system and the resource limitation. Therefore, the implementation of PBL requires a holistic approach caring for all four dimensions.

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APPLYING PROBLEM-BASED PROJECT-ORGANIZED LEARNING IN A TRADITIONAL SYSTEM

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ABSTRACT

Nowadays, PBL is considered a suitable methodology for engineering education. But making the most of this methodology requires some features, such as multidisciplinary, ill-structured teamwork and autonomous research that sometimes are not easy to achieve. In fact, traditional university systems, including curricula, teaching methodologies, assessment and regulation, do not help the implementation of these features. Firstly, we look through the main differences found between a traditional system and the Aalborg model, considered a reference point in PBL. Then, this work is aimed at detecting the main obstacles that a standing traditional system presents to PBL implementation. A multifaceted PBL experience, covering three different disciplines, brings us to analyse these difficulties, order them according to its importance and decide which should be the first changes. Finally, we propose a straightforward introduction of generic competences in the curricula aimed at supporting the use of Problem-Based Project-Organized Learning.

INTRODUCTION

The Aalborg Model (Barge 2010) describes a context where PBL in the central means of teaching-learning. It specifies the features that an organization should take into account to follow an approach to problem and project based learning similar to Aalborg University. This specification is divided into nine areas which cover the key dimensions of any university. This paper is based on experience at the Universidad Politecnica de Madrid (UPM). This university has a strong academic tradition. It is made up of 18 schools, it offers 41 degrees and has around 3300 teachers and more than 37000 students. It is a point of reference in architecture and engineering studies in Spain and around 5000 students graduate every year. Among the schools of the UPM, the Escuela Universitaria de Informatica (EUI) was chosen for including this experience. Recently, the EUI has started off two new degrees: Computer Engineering and Software Engineering. Both curricula are organized by semesters that contain around 5 subjects. EUI is composed by 6 departments which are in charge of designing and organizing a subset of the curricula subjects. Its main characteristics are: curricula organization by subjects, predominance of traditional lectures, use of traditional written assessment and predominance of individual student work against teamwork. Although we carried out several works to apply PBL in the academic curricula of the EUI, these experiences have been restricted to individual courses (Garcia *et al.* 2009). Consequently, the achievements obtained have been quite limited. During the year 2010, we have set out a new experience, where PBL is applied to a multidisciplinary context. More specifically, students carry out an ill-structured project that covers knowledge about three subjects: Requirement Engineering and Modelling (REM), Operating Systems (OS) and Statistics (St). These are three mandatory subjects out of five that constitute the third semester of the Software Engineering degree. The purpose of this experience was to achieve a larger number of PBL benefits than in previous experiences. In particular, we want our PBL course to be Multifaceted, Ill-Structured and based on Teamwork and Autonomy.

This study, applying the above mentioned methodology in a traditional frame, is aimed at detecting the main obstacles that a standing traditional system presents to PBL implementation. Then, these difficulties are analysed and ordered according to importance and this leads us to decide which should be the first changes to be introduced in our system. In next section, we highlight the main differences that we find between the Aalborg model and the UPM traditional model. Following this, the multidisciplinary PBL experience provided in the year 2010-2011 will be described. Then, we present some results obtained in reference to academic performance and students´ response. In addition to this, we point out the most important deficiencies that have been detected in the traditional structure when an active learning methodology such as PBL is implemented. Finally, we deal with the issue of introducing PBL into an educative system with strong standing traditions.

Traditional system vs. Aalborg PBL model

The UPM establishes some general academic regulations. It has recently published the Modelo Educativo UPM (UPM 2009), an extent document which describes the challenges and changes that this University should carry out in order to adapt it to the new European university context. It gives a large number of proposals to foster these changes. On the other hand, departments are in charge of organizing the teaching activities and evaluation of a subset of subjects. This way, each department decides the teaching and assessment regulations. In some cases, subjects have a great autonomy to organize contents and methodologies, although continuous efforts are made to improve coordination among subjects. Table 1a highlights some relevant aspects of the Aalborg model related to 6 of the areas included in this model. In contrast, Table 1b describes the main characteristics of the traditional EUI Model related to the same areas.

Educational Vision
Systematic framework for PBL approach. Ongoing commitment to its central principles
Problem/wonderings orientation
Multifaceted projects
Students make relevant decisions to complete the project
Integration of theory and practice
The institution has adopted learning objectives specific to the PBL approach
Team-work based
Students demonstrate understanding of framework and are prepared to identify and articulate the strengths
Curriculum
Credit-bearing academic work that introduces students to PBL and scaffold skills
Balance of orientation courses, study courses and project-related courses. Project supported by specific courses
Students´ project work comprise at least 50 percent of their academic credits
Assessment
Students´ group project work stands as the main assessment method
Forms of both formative and summative assessment are used
Students´ academic work is assessed according to clearly documented policies and

procedures and learning objectives
Students receive appropriately differentiated individual grades for their contribution to the project
Faculty
Faculty member demonstrate a clear understanding of and commitment to the PBL model
Faculty members have been introduced to the theoretical framework
Faculty are directly involved in the development and maintenance of program curricula
Faculty members demonstrate ability to incorporate best practices in supervising and advising student project groups
The institution has established the maximum of groups one faculty member is able to effectively serve as primary supervisor for in one team
Students
Students are able to identify the way in which the PBL approach shapes their academic work
Students demonstrate strong project management skills and collaborative work
Students play a meaningful role in the administration of degree programs. They participate in curricular development and implementation, term themes, course offering
Resources
The institution deploys resources in ways that consistently support the PBL educational approach
Each group is provided with its own private or semi-private work space
Classroom and laboratory space are provided as required by study courses and project courses
Materials required for completion of project work are provided for groups
The institution maintains an appropriate array of operational and modern technological resources. Resources which facilitate the collaborative work of project groups are central

Table 1a. Aalborg Model Abstract

Educational Vision
Students follow a number of independent subjects during the term
Each subject consists of a number of theoretical credits (50%) and practical credits (50%)
Traditional lectures predominate over other teaching methods, although new methodologies, such as oral presentations or case study have been incorporated to complete teaching activities.
Topics of practical tasks usually consist of well-defined tasks and are restricted to those matters studied in the subject
Individual student work has more weight than teamwork in the final mark
15 generic competences are specified in Software Engineering degree. Nevertheless, there is not a specific plan to reach them. Each subject chooses a subset of generic competences and tries to promote them
Students do not receive specific information or explanation about teaching-learning methodologies
Curriculum
There are not specific credits for teaching about generic competences
All courses are matter oriented and students register for them independently
The subject work is focused on reaching objectives related to a particular discipline
Assessment
Individual assessment predominates over group work

Teachers are not in the habit of using formative evaluation
Subject assessment is aligned to subject specific learning objectives
When group work is used, specific method to assign individual grades according to their contribution are not used
Continuous evaluation has been incorporated in the new curricula over the last years.
The assessment method is based on written tests.
Faculty
UPM foster the setting-up of educational innovation groups to engage teachers in new methodologies
UPM supports educational innovation projects to introduce the use of new methodologies
Some crash courses about educational methodologies are organized
Teachers are members of executive organisms where important decisions about curriculum are taken
Every teacher is in charge of one or several classes in which academic activities are carried out. This way, a teacher is responsible for teaching and assessing every student in those activities related with a subject
In the case of compulsory subjects, there is an average number of 40 students per class.
Students
There is a representation of students in each executive institution. This way, they participate in academic organization
Students are not introduced in teaching-learning methodologies
Regarding project development, students take a course about Project Management in the Software Engineering degree, where they acquire knowledge about project development. However, we cannot assert that they acquire long experience about this ability until the final semester, when they have to develop a final degree project
Resources
There is a Computational Centre where students can use some rooms at their convenience. Other rooms are dedicated to teacher-leaded sessions.
Departments have specialized laboratories to carry out practical sessions. In this case, laboratories have restricted opening hours, and there is no habit of using them at student convenience
Library has rooms dedicated to teamwork, student teams have not semiprivate spaces
Most of the subjects have Moodle platforms which offer learning material and some basic collaborative tools

Table 1b. Traditional EUI Model Abstract

All in all, we could conclude that the adaptation to the European Space of Higher Education points out the need of introducing new methodologies and it has produced the incorporation of some new practices. Nevertheless, there is still a predominance of traditional education and assessment. These features are widespread among most schools in the UPM.

Method: The multidisciplinary PBL experience

As we have previously described, we carried out several projects to apply PBL in individual courses. In this experience, PBL is applied into a multidisciplinary context where students carry out an ill-structured project that covers knowledge about three subjects: REM, OS and St. Our purpose was to achieve a larger number of PBL benefits than in previous experiences, covering the main characteristics of problem-based learning (de Graaff *et al.* 2003). In particular, we established four specific goals: to make students: a) deal with ill-structured problems, b) develop a multifaceted project, c) improve their teamwork skills, and d) reach more autonomous work. REM, OS and St are three mandatory subjects out of five that constitute the third semester of the Software Engineering degree. Students registered independently in each one of these subjects, therefore, only students who were registered simultaneously in the three subjects could participate in the development of the project. These students attended a special theory class in OS and REM, where lessons were aimed at supporting the project. On the other hand, St followed the usual lessons. The topic given to the students was related to an ill-structured problem. More specifically, students had to develop a study to compare two operating systems, Linux and Windows, from the performance point of view. To reach this goal, they had to specify formally the system requirements, carry out a software benchmark and develop a statistical analysis to explain the results. Before starting the project, students followed a two-session seminar about team-working, project development and problem solving. The project was carried out by groups of four students for fifteen weeks. Students of the three disciplines were required to implement a solution. The project was divided into three phases. Each subject has one two-hour laboratory session per week. REM and OS sessions were dedicated to project development. This way, teachers of both subjects have a close monitoring of student work. Statistics laboratory sessions were dedicated to practical tasks related to subject disciplines. In this case, students attended teacher office hours to consult about project technical doubts. Also, the OS teacher had a twenty-minute individual meeting with every group every fifteen days. These meetings were focused on helping students to solve problems related to general orientation and scheduling of the project. As far as assessment is concerned, each phase had a preliminary evaluation in order to give feedback to the students prior to the final submission. Each project phase gave three grades corresponding to each one of the three subjects. The project had different value in the final grade of every subject: 60% in REM, 50% in OS and 20% in St. The complementing grades were evaluated individually in every subject through written tests.

Now we describe the sources of information that have been used in the study to gather information.

(1) At the end of the term we did a five-point Likert scale survey to obtain the students' opinion on the usefulness of different aspects such as subject organization, kind of project developed, assessment and resources.

(2) The report that students should hand in at the end of every project phase included several questions about the procedure. Among them, we have analyzed the number of work hours and a description of the main difficulties that students had found.

(3) Teachers took advantage of individual meetings with every student team to take directly their opinion and explanation about their decisions.

(4) Two tests were used in order to measure generic competences: the Team Work Behaviour Questionnaire (TWBQ) (Tasa *et al.* 2007) and the Problem Solving Inventory (Heppner 1988), which were filled in by the students at the beginning and at the end of the term. TWBQ test has two parts: one in which students have to assess their own ability, TWBQ (Self), and another in which they assess the ability of the group as a whole, TWBQ (Others). In each item (statement), participants have to evaluate the statements on a 7 points Likert-type scale (1= not at all; 7 = very much). The purpose of the PSI test is to assess the students´ perception of their own problem-solving behaviours and attitudes. Participants have to evaluate each item (statement) following a 6-point Likert-type scale (1= Strongly Agree; 6 = Strongly Disagree).

(5) At the end of the term, students have to fill a survey elaborated by the UPM, which consists of 17 questions about the teachers and the subject. For this study we have analysed 4 questions: "I have improved my starting level, regarding the competences established in the course", "The teacher assistance is effective to learn", "The volume of contents and tasks included in the learning activities is proportional to the credits attached to this subject", "The assessment method shows relationship with the kind of tasks that are developed". This survey follows a Likert scale of 6 points (1=strongly disagree, 6=absolutely agree).

(6) Figures related to participation of EUI teachers in Innovative Education Groups and Innovative Education Projects.

(7) Opinion and conclusions of the teachers that have participated in this experience, which were gathered in a meeting at the end of the term.

Results

First of all, we would like to highlight some administrative issues that directly affected this experience. The first intention was to have all students who participated in this experience included in a specific group. Nevertheless, as we have described previously, REM, OS and St are individual subjects in the curriculum, and students register for each one independently. Students are free to choose the group according to their time-table preferences. These facts, along with some problems with registration software did not allow us to include all students who were going to participate in this experience in the same group. Eventually, the student participation in the PBL experience was voluntary.

Students: Regarding the information described in point (1), students who followed the PBL course gave a good opinion about learning by development a project, obtaining an average mark of 5.5 over 7 points. Although the best valued aspects were the continuous evaluation system against the traditional final exam (6.3) and the lectures used to support the project (6.2). On the other hand, the difficulties described by the students in the information included in the reports, point (2), were arranged in the four categories displayed in Table 2. This table shows the percentage distribution of these kinds of difficulties related with the two first phases of the project. These data have been complemented with the same measures taken during the year 2009-2010 in an Operating System course based on PBL as well. The figures show that students find more difficulties that are linked to dealing with unknown information at the beginning. On the other hand, in subsequent phases their attention is mainly focused on technical problems.

Kind of difficulties	2010-2011		2009-2010	
	Phase 1	Phase 2	Phase 1	Phase 2
a- Scheduling and approaching the problem	16.6%	11%	4%	10.1%
b- Looking for and dealing with unknown topics	58.3%	9%	68%	40.5%
c- Technical and specific problems	8.3%	70%	28%	48.6%
d- Lack of resources	16.6%	10%	0%	0%

Table 2. Kind of difficulties found by students

As far as UPM survey is concerned (5), Table 3 displays the results of the four questions selected for this study. First column shows the appraisal related to OS group that followed the Multifaceted PBL course, whereas the second and third columns correspond to the average range of the remaining OS groups (which followed traditional lectures) and all the subjects of the school. Whereas there are not significant differences in questions c and d, PBL shows better scores in questions related to student improvement and teacher assistance.

	PBL OS group	Not PBL OS groups	School
a- I have improved my starting level, regarding the competences established in the course	4.60	4.12	4.32
b- The teacher assistance is effective to learn	4.85	4.14	4.28
c- The volume of contents and tasks included in the learning activities is proportional to the credits attached to this subject	4.08	3.83	4.13
d- The assessment method shows relationship with the kind of tasks that are developed	4.28	4.34	4.35

Table 3. UPM survey

Teachers could gather some interesting opinions of students during the individual meetings (3). Among them, students showed some initial doubts about the convenience of following the multifaceted PBL alternative. The main reasons seemed to be that they do not feel sure about the difficulty of the work that they had to carry out and the low weight of the project in Statistics. Moreover, they perceived the lack of organization described above. These facts, along with the voluntary participation above mentioned, resulted in a high dropout rate in the multifaceted project experience. Initially, there were 30 students who could participate in the PBL experience, but a half of them decided not to participate due to administrative issues. 17 students were organized into 4 groups that started the project. Nevertheless, 2 groups gave up the multifaceted project because of insecurity and convenience. Eventually, only 2 groups took part in the experience. Related to this, we highlight that all OS and REM students should develop a team project in any case, although only these 2 groups carried out the multifaceted project. Finally, the PSI and TWQ tests (4) indicate that there is not significant improvement in the problem solving and teamwork skills during the semester (Table 4). An analysis of the items included in both tests, along with the information obtained from the individual meeting, reveal some deficiencies regarding both skills.

Generic Competence	Mean (SD) beginning	Mean (SD) end
TWBQ (Self)	4.98 (1.095)	5.14 (1.169)
TWBQ (Others)	4.50 (0.864)	4.70 (1.322)
PSI	85.38 (20.250)	87.43 (23.329)

Table 4. Mean and Standard Deviation (SD) in generic competences in OS PBL group

Curriculum: Although the analysis of the information included in the reports and the surveys shows us that students spent a number of hours similar to the number of hours that were foreseen in the PBL course, students complained about the overall workload that they had to tackle taking into account the five compulsory subjects. Continuous evaluation has been incorporated recently in both degrees with limited experience, especially in those aspects related with the work load. Consequently, some work overload was detected in several weeks during the term.

Assessment: Subject regulations determined that students who developed the multifaceted project had to reach the same specific objectives as students who did not participate in the project, and they were evaluated with the same written test. This fact had a special importance in the Statistics´ case, since the project value was merely 20% of the final grade. The third semester of Software Engineering degree consists of five subjects. As we know, deadlines in the development of a project are more flexible than in short practical tasks and written tests, and consequently students tended to give the project a secondary role, paying more attention to written tests and shorter deadlines of other practical tasks. As a result, students had some delays in the project implementation. Table 3 displays that students do not appraise the assessment method used in PBL course better than in other courses.

Faculty and Educational Vision: In general, there is some resistance to the use of new educational methodologies among the EUI teachers and a limited number of them participate in seminars and courses about this topic. Regarding the point (6), 20 EUI teachers out of 130 are involved in 2 educational innovation groups. The number of educational innovation projects developed in 2010 was 3 and in 2011 it has been 5. These figures are lower than the average rate in the UPM. The final conclusions of the three teachers (7) who participated voluntarily in this experience point out some failings. Although they showed a keen interest in the PBL course, the lack of previous experience in this kind of multifaceted project pointed to some aspects that should be improved in future experiences. In particular, there were two aspects that were detrimental to REM subject. Firstly, teachers decided to give the project specifications in an incremental way to facilitate the project planning. This fact did not allow students to tackle conveniently some matters related to REM, where a global view of the project would have been more appropriate. Secondly, teachers perceived that matters related to each subject were too much differentiated in the project requirements, so we will need the specification of a global project that combines better the different areas as a whole.

Discussion

This experience has been part of an educational innovation project with limited institutional support. Problems in the registration process produced some organizational troubles that have made the experience more difficult. Moreover, due to the perceived resistance to the introduction of new teaching methodologies, in some cases there was a significant lack of support from some teachers involved in related subjects and departments. These facts point to the need of a change of mentality and a direct involvement of the institution, which represent one the most important drawbacks.

EUI students are not used to dealing with ill-structured problems and they show some insecurity when they have to tackle some important decisions. Moreover, teachers perceived some inefficiency related to team-work and problem solving strategies. Nevertheless, surveys described in points (1) and (5) indicate that, despite the initial doubts, the PBL methodology is well received by students. Results of Table 2 indicate that they assimilate satisfactorily the new methodology. So, this lack of experience does not represent a strong drawback, but points to the need of specific training. Besides, some instruction about learning in PBL could be really helpful for student performance.

The curriculum structure establishes strict technical objectives for every subject and a large part of subjects are evaluated according to these objectives. This fact constitutes an important drawback when students have to deal with an ill-structured problem, since they tend to pay more attention to written tests than researching activities. Therefore, some changes are needed in assessment methods and regulation, as they seem to be quite strict and not adapted to active learning. Related to this, the uncoordinated working of the subjects that make up a semester, their strict technical objectives and their established assessment rules do not help at all the development of multifaceted projects. These drawbacks related to the curriculum, along with the resistance to the new methodologies make us conclude that changes related to new methodologies should be introduced in a straightforward and gradual.

To sum up, students, despite their lack of experience, have shown enough ability to adapt to new challenges and they do not represent the main obstacle. Changes in teacher´s mentality seem to be more difficult and they would be necessary to overcome the current resistance. On the other hand, the strict structure of the curriculum and the assessment regulations represent the strongest drawbacks to implement the multifaceted PBL course. These aspects should become more flexible according to active learning methodologies. Related to this, more institutional support seems to be central to achieving better results in the application of methodologies such as PBL.

Conclusions and future work

In conclusion, we highlight the changes that, from our point of view, should be made to overcome the main difficulties found in the introduction of a methodology as PBL. In the first place, some changes in teacher and student mentality about learning methodologies should be introduced. This will allow subsequent changes in academic regulation and practices. At the same time, some credits should be spent on teaching general competences, since currently there is no specific training about them and they are central to achieve success in PBL methodology. Moreover, students seem to have some important deficiencies in basic skills. Secondly, we propose the introduction of new assessment methods in tune with active learning, since traditional ones mean an important barrier to PBL success most of the time. Changes in the curriculum could come later, once the institution and a majority of teachers are in favour of supporting these methodologies.

Certainly, the best situation to introduce the PBL model is the inception of a new school or at least a new curriculum, since it affects the key dimensions of the university. Unfortunately, this is not the real situation of most schools, where the only choice is to apply this methodology to already existing structures. In these cases, a short-term application of the Aalborg model is not viable. Therefore, based on our experience, we outline some proposals to start a gradual introduction of Problem and Project based learning in our school. In future years we will suggest the integration of some general competences in current curricula. This integration will be done such a way that it affects the current organization as little as possible. The proposal will consist in developing a map that distributes general competences among semesters in a balanced way. Subjects which make up a semester will spend some practical credits in order to teach about the general competences selected for this semester. Then, subjects will require the students to show enough ability related to these skills according to the training they have received. Related to this, some new assessment methods will be suggested. The first term will deal with basic competences, among them teamwork, problem solving, written expression or time management. Once students have acquired some basic competences, Project Based Learning will be introduced in subsequent semesters.

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PROBLEM-BASED LEARNING: A SOLUTION FOR MINORITY GIFTED STUDENTS AND THEIR TEACHERS

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ABSTRACT

Gifted minority children are underrepresented in gifted and advanced placement programs. To reach their full potential, these learners require culturally relevant, rigorous, student-centered curriculum that emphasizes critical thinking. Problem-based learning (PBL) offers meaningful learning opportunities for bright students of diverse populations via a constructivist strategy that is authentically engaging. Teachers of minority gifted students benefited from participation in a PBL scenario in which they investigated obstacles to the identification and retention of minority gifted learners in advanced educational placements. They constructed understandings of the learning styles, characteristics, and needs of minority gifted students; became more aware that in order to retain bright minority students, the development and provision of appropriate, culturally relevant, student-centered curriculum was essential; and, more ready and able to facilitate problem-based learning as a cornerstone instructional strategy in the education of minority gifted students. Facilitation of the PBL experience by the author of this report in combination with a review and analysis of the participant reflections and team artifacts led to the construction of matrices that align minority gifted students' learner characteristics and program recommendations with PBL outcomes.

AN ILL-STRUCTURED PROBLEM

The number of potentially gifted minority students who are either unidentified or are not included in gifted and/or other advanced placement program options may reach as high as seventy percent in some school districts… (Ross, et.al., 1993).

This was the problem statement that greeted thirty-one teachers and school counselors as they arrived at the first class meeting of ESE 651 "The Minority Gifted Student", a three credit graduate level university course offered in a large, mostly rural southwestern border community in the U.S. The group of thirty-one teachers included those responsible for the identification of gifted students at their various school districts and for delivery of curriculum to students identified as gifted. The problem statement was intriguing to teachers who were frustrated with school districts' inadequate identification processes, with the lack of connection to the traditional curriculum shown by their bright minority learners, and with their own inability to find and use the kinds of teaching methods that would critically and authentically engage these able learners. Compounding the issue for these teachers were current district approaches that emphasize lower level knowledge acquisition and test preparation, and that drastically limit teacher autonomy and decision making through scripted lessons and direct instruction.

A Persistent Dilemma

The underrepresentation of gifted minorities in gifted and/or other advanced-placement program options is so well documented that it is practically indisputable (Blanning, 1980; Ford & Thomas, 2008). As reported in *A Nation at Risk* (Ross, et.al., 1993), African American, Hispanic American, and Native American students may be underrepresented in advanced placement courses to a degree of 30% to 70% with an average of 50%. Recent data from the U. S. Department of Education's Office for Civil Rights (2009) reveals that representation in gifted programs is disproportionate by race and ethnicity, and that African American, Hispanic/Latino, and American Indian students remain poorly represented in gifted education. The continuing underrepresentation of culturally and linguistically diverse students in gifted programs is a "persistent dilemma at all levels of education" (Ford, et.al. 2008, p.1).

Methods

Over the next three weeks, the teachers immersed themselves in a problem-based learning scenario in which they acted as a taskforce charged to explore the complicated issues that confront teachers of minority gifted students and to find solutions to the problems. A full class discussion served as the introduction to the problem after which the group re-defined and re-framed the original problem. The guiding question for the teachers would be: How can we more effectively identify our gifted minority students **and** ensure their retention and success in gifted and other advanced placement options? The teachers accessed prior knowledge by constructing their first list of "What we know" statements. Those statements were subsequently utilized as an informal assessment of pre-knowledge. During the first week of the investigation, the teachers cycled repeatedly through the "What do we know?", "What do we need to know?", and "What do we do?" PBL process. After three weeks of intensive inquiry, analysis and collaborative problem solving, the teachers reported their findings and their recommendations at a gathering of interested educational stakeholders.

As the facilitator of the PBL experience, the author of this report had immediate and authentic access into the culture of master teachers investigating a problem about which they were deeply concerned. To document the experience, the author drew upon ethnographic field methods such as observation and theoretical note-taking across the three week investigation. Class artifacts from group brainstorming and questioning sessions, a video recording of the culminating presentations of the teacher "taskforce", and teacher reflections as captured in a class survey following the final debriefing were utilized by the researcher as data sources to illuminate connections and meanings made by the participants. Of particular relevance to the researcher was the participants' recognition of learner intensities in the intellectual, emotional, and imaginational domains, program recommendations for minority gifted students based on learning styles and characteristics, and connections to the PBL instructional strategy as an appropriate match to meet the learning needs of minority gifted students.

The PBL experience: Participants perspectives

To start, the teachers self-selected into five working groups. They generated questions to re-frame and focus their inquiry and they developed plans for investigation. As the groups researched and collected initial data and information, their discussions and actions were somewhat scattered and unfocused. “The team building and collaboration in our group was very positive but,” a teacher stated, “I think we all felt frustrated at the beginning of this open-ended problem.” As the inquiry continued, the teachers’ quest for knowledge and understanding grew. A member of one team stated, “The problem was examined and defined at various levels and from multiple perspectives. I saw what it takes to take a problem from ground level and ‘create’ a workable solution. I found my team taking a personal interest in creating this program that we would be proud of.” Another teacher describes her group, “Our group was extremely committed. So much so, that we often got into debates. I view this as a positive thing. Each one of us cared about this project and wanted the best possible end result.” At each meeting, the participants de-briefed, discussed, re-defined the original problem, rewrote their plan, and re-directed their energies.

Questioning Drives the Investigative Process

The questions posed by the teacher/participants accessed their own prior knowledge and pushed the investigations forward. Discoveries led to new and divergent questions: “Is there bias in the referral process?” “What other barriers are faced by minority gifted students?” “How do the learning styles of minority gifted students differ from their more average peers and from their gifted peers?” “What factors affect them after they are placed in gifted programs?” “What would make the learning more relevant to them?” Of the questioning that emerged in her team a teacher commented: “At all levels of problem solving, we continued to question.” Another teacher stated, “Our questions became more flexible and more focused.” Questions led the teachers to research and research led the teachers to reflect. The questions and teacher reflections resulted in the atmosphere of critical examination that developed. “The level of complexity was directly related to the depth of the questioning by my group members,” a teacher stated.

The Professor as Facilitator

All the while, the university professor acted as a resource and facilitator to the groups of teachers. "I would say we had two facilitators: Kerry (a group member) and Dr. Stutler. Kerry really kept us on track and focused. Dr. Stutler boggled and challenged us throughout!" Another participant wrote of the facilitator, "The professor was there to support us and sometimes provoke us, but she did not limit us." Of particular note to the professor was the heightened excitement with which the teacher-investigators infused their search, their discussions, and their planning. "PBL added to the relevance of the learning because we were able to research our area of interest - what we felt was important to us, our students, our school, and our district." The professor noted that the teacher/participants were making connections with the PBL process in which they were deeply engaged and with the teaching pedagogies they were investigating to provide authentic, culturally relevant learning opportunities for their minority gifted students.

Immerging themes: Focus on intensity

As the course continued, the various investigations achieved focus and purpose. Three themes emerged: 1) the need to adapt and/or expand the identification process in order to find hidden strengths and talents of minority gifted students; 2) the need for teachers, administrators, and parents to better understand the learning characteristics and needs of gifted students; and 3) the need to develop curricular opportunities that would challenge and engage these learners. In the initial participant discussions, "intensity" as a characteristic of gifted and minority gifted learners immerged as a connective thread in and among the three themes. The professor provided information regarding Dabrowski's (1997) Theory of Overexcitabilities. His descriptions of the intensities and intelligences of gifted individuals in the intellectual, emotional, and imaginational domains resonated with the participants as they collaborated to re-construct a broader conception of giftedness and to understand the learning characteristics and needs of their students. Also utilized by the teachers were Blanning's (1980) program recommendations for minority gifted students that emphasized student-centered, student-led investigations to foster questioning and meaning making through interest based investigations and problem solving.

Aligning Learner Characteristics and Needs with Appropriate Curricular Options

Teams used their developing understandings of the intelligences and intensities of gifted children to define and refine methods for teaching in ways that would not only foster academic growth and achievement, but would nurture natural talent and abilities, and result in vibrant gifted programs that could retain minority gifted students. Given appropriate opportunities, minority gifted learners are apt to soak up knowledge and make connections in and across disciplines. Because minority gifted students are often highly curious and relish intellectually challenging learning experiences that allow for the construction of personally and culturally meaningful connections, the teams considered constructivist approaches to facilitate student examinations of issues and systems from multiple perspectives. They decided that PBL would engage minority gifted students in the kind of complex, generative learning most suited to their intellectual intensity; a characteristic of minority gifted learners of which the teachers had first hand knowledge. Table 1 illustrates the alignment between the learning characteristics of minority gifted students in the intellectual domain, program recommendations for minority gifted students, and related outcomes often associated with the use of PBL as an instructional strategy.

Intellectual Domain		
Characteristics of Gifted Minority and CLD Learners	**Program and Curricular Recommendations**	**Outcomes from Problem Based Learning Experience**
Intellectually intense – seem to soak up knowledge – may or may not demonstrate advanced mastery of skills.	Student centered curriculum that affords opportunities to pursue topics of interest in depth.	Utilizes student interest as a springboard that elicits meaning making in multiple domains of learning. Promotes acquisition and mastery of skills.
Highly curious – ask many questions, divergent and convergent– use questions to expand and focus inquiry – may be persistent in quest for answers.	Opportunities to ask open-ended and focusing questions that guide intellectual investigation.	Questioning is fostered to guide the investigation. Students must refine and focus questions to find answers.
Enjoy challenging work and play in the intellectual domain.	Opportunities to find and frame complex, multi-faceted problems.	Student centered exploration of compelling real world problems leads to personally challenging intellectual work.
Relish exploration of issues such as justice, truth, power, beauty. Ability to locate patterns and find connections.	Opportunities for integrated, issues oriented, thematic learning in and across disciplines; Promotes exploration, analysis, and evaluation of important social issues in experiential formats.	Integrative investigation of complex issues provides opportunities to make unexpected connections and broaden understandings. Social issues and/or service learning experiences may drive learning.
Enjoy challenging materials that allow for critical examination of meaningful issues in depth.	Opportunities to engage in critical investigation of personally and culturally meaningful issues.	Challenges learners to examine issues and systems from multiple perspectives; engages learners in complex, generative learning.

Require relevancy in learning – bored by repetition and drill – may become apathetic or openly rebellious.	Opportunities for student directed learning at correct level of difficulty. Focus on higher levels of Bloom's Taxonomy: analysis, synthesis, evaluation.	Student choice and decision making in problem finding, framing, result in authentic rigor. Students analyze data and patterns, make connections, synthesize & evaluate in order to solve relevant social and other authentic problems.
Are independent – require open-endedness and ambiguity – delights in intellectual discovery.	Chance to explore, follow intellectual pursuits down unforeseen pathways. Strategies that value inquiry, exploration, and investigation of issues and themes.	Inquiry through exploration promotes the construction of knowledge; planning and decision making are based on discoveries and growing understandings.
Verbally advanced – may display expanded vocabulary – accelerated acquisition of 2nd language – enjoy word play.	Chance to explore and use words and language in authentic settings and among various domains of knowledge.	Exposure to and practice of the professional languages of many disciplines encountered through investigation.
May or may not be early readers in either first or second language; communication skills may be advanced.	Opportunities to engage in challenging, personally and culturally relevant reading, writing, speaking, and listening experiences.	Student-student and student- teacher discussion as well as wide reading and sharing of results; fosters literacy development and communication skills.
Learning and development may be asynchronous.	Curriculum differentiated by interest, pace, depth, and product to meet individual learning needs.	Provides opportunities to work at advanced levels in areas of talent and authentic skill building to support problem solving.

Table 1. Alignment of Intellectual Intensities with Program Recommendations and PBL Outcomes

Focusing on the intellectual and the emotional intensities of minority gifted students, another team was interested in infusing the PBL method for teaching the gifted with the kinds of transformative and social action opportunities advocated by Banks (2009). The group worked to develop a student-centered, issues oriented, critical curriculum with opportunities for service and community involvement. Emotionally intelligent, these students are often highly empathetic; able to view issues from multiple perspectives, and likely to think long and deeply about issues of social injustice. Another team of teachers compared and contrasted cooperative learning strategies commonly utilized in classrooms with the collaboration that is fostered through PBL. Cooperative learning typically involves a heterogeneous group of students that includes one high achieving student, one low achieving student and two students of more average ability in a learning task designed and assigned by the teacher for which the students take responsibility as a group. "I've found that cooperative learning creates mediocre results," a teacher commented, "everyone puts in the minimum, as opposed to problem-based learning where the students are in control, and interest and novelty promote buy-in by the students, real collaboration and personal accountability."

The teams also noted that minority gifted students often do not respond to extrinsic motivations, but are intrinsically motivated to learn when there are opportunities for student decision-making. Further, bright minority students connect with curriculum that taps their emotional intensity and intelligence. The teachers discussed the benefits of authentic assessments associated with problem-based explorations. In all of the discussions, the professor noted the teachers' excitement as they worked to construct curricular experiences that were more student-centered, likely to engage the emotional intelligence of the students, and designed to promote life-long learning dispositions. Table 2 illustrates how learning characteristics in the social/emotional domain align with program recommendations for minority gifted students and PBL outcomes.

Social/Emotional Domain		
Characteristics of Gifted Minority and CLD Learners	**Program and Curricular Recommendations**	**Outcomes from Problem Based Learning Experience**
May be adverse to highly competitive learning environments – may not respond to extrinsic motivations.	Emphasize collaborative teaching and learning strategies. Embed opportunities for meaningful student decision making. De-emphasize high stakes tests and grade acquisition.	Exploration of meaningful, student initiated problems nurtures love of the learning processes. Emphasizes and accesses student strengths and multiple learning styles. Evaluation is continuous and authentic.
May experience feelings of separateness and isolation.	Requires understanding of learner characteristics from adults in their life. Learning environment should be affirmative, empowering, challenging, and fun.	Teacher as facilitator, mentor allows collaborative learning process to develop between teacher and learner, fosters interaction among interested learners.
Feelings of being different from more average peers and from gifted peers, but may be unusually empathetic to the feelings of others.	Opportunities to work and learn with diverse students of like ability and intensity.	Collaborative problem finding and framing promotes appreciation of diverse talents and empathy for the experience of others.
May have a need to achieve at high levels – often intrinsically motivated to learn for learning's sake.	Value achievement as discovery and growth across domains rather than as test scores and/or grades.	Equally values contributions of a cognitive, affective, or aesthetic nature.
May actively seek growth – likely to embark on a path of self study, but will resist conformity and conventional approaches.	Strategies designed to support student interest and purpose without extraneous and confining structure. Opportunities for experiential learning.	Flexible, least restrictive learning environment supports students as they seek purposeful learning. Student decision making on social issues and service learning.
Is independent – requires self direction, choice – may not conform to unnecessarily restrictive and/or punitive rules.	Embed opportunities for student choice, direction, and decision making in learning. Facilitate and guide learning.	Student problem finding, questioning, planning ensures authentic engagement in the learning process.
Due to lack of rigorous, meaningful curricular experience, may become easily frustrated when challenged at correct level of difficulty.	Give students room to experiment with alternate methods and pathways to achieve learning goals. Consistent, constructive feedback.	More than one method for problem solving fosters academic risk taking. Teacher as guide/facilitator provides continuous constructive feedback.
Will invest in challenging learning when intrinsically motivated.	Nurture intrinsic motivation with student choice, appropriate differentiation and challenge. Provide responsive and culturally relevant curriculum; Focus on Transformative and Social Action levels of Bank's (2009) multicultural model.	Affords students the opportunity to work at appropriate level of difficulty on challenging tasks that are valued by themselves and their communities.
May have conflicted sense of self – may experience low self esteem, and uncertain self efficacy.	Provide materials to nurture self reflection, examination, resiliency, flexible thinking and persistence in problem solving. Structure curriculum to enable students to view themes and events from multiple perspectives. Offer rich literacy opportunities such as biography, story, and histories. Provide mentorships/ role models.	Involvement in social action experiences supports the growth of self efficacy. Students interact and collaborate with community members with expertise in diverse fields to solve problems. Resources for research and enrichment are provided. Students empowered through decision making and self examination.

Table 2. Alignment of Emotional Intensities with Program Recommendations and PBL Outcomes

Many of the teams also took note of minority gifted students' talent for intuitive and imaginational thinking. One team focused on the development of several simulations and scenarios in which students would take on roles as they worked to solve problems. The team was eager to scaffold the students' creative abilities and create a learning environment that valued the unusual solutions that are quite often the result of imaginative thinking. PBL was seen by the teacher/participants as an appropriate curricular approach to nurture and support imaginative and creative problem solving abilities. (See table 3) A teacher commented, "At first I was not comfortable with what I perceived as a lack of structure. I wanted a lecture, note-taking, a map of some kind. But at some point, I realized we were structuring the learning, we were designing the map. We had to collaborate to do it yes, but we also had to use our imaginations."

Imaginational Domain		
Characteristics of Gifted Minority and CLD Learners	**Program and Curricular Recommendations**	**Outcomes from Problem Based Learning Experience**
Imaginational intensities. Enjoy work and play in the imaginational domain.	Opportunities to pursue topics that engage the imagination.	Involvement in variety of problem based scenarios provide chance to use imaginational thinking.
Likely to possess great capacity for make-believe and fantasy. Enjoy using imaginative thinking through playacting and pretending.	Enthusiastic teachers, open to new ideas, understand and value imagination as a thinking tool. Opportunities for role-playing and other forms of dramatic play.	Students participate in role-playing and other simulations. Students take on role of community members, scientists, lawyers and others.
May create imaginary friends, scenarios, worlds. May organize world, express self through story, develop rich and/or mythic story action. Likely to daydream.	Time and space for thinking, imagining, reflecting, storytelling, creating play scenarios. Teacher recognizes and models methods to organize experience through story.	Supports the development of narrative, story as problem and solution. Opportunities for students to envision alternative "plots", scenarios, outcomes, solutions.
Use of imagery, fantasy, and visualization. Create and use images to make meaning among interconnected concepts and ideas.	Responsive classroom with opportunities for imaging and imagining in integrative, issues oriented curriculum.	Encourages use of visualization and imagination to make connections, imaging to construct and communicate creative solutions.
Utilize imagination to engage in future thinking; make connections in and among seemingly unrelated concepts and ideas and make inferences and predictions.	Inquiries that deal with uncertainty, foster self expression, require divergent solutions. Alternative thinking strategies to develop rich, optimistic future images.	Ill structured and incomplete problems promote alternative thinking strategies, foster inference and prediction, and allow for divergent, imaginative solutions.
Use images to play with complex concepts and ideas; to see problems in ways that others do not.	Complex inquiries that afford depth and breadth in which students find, explore, frame problems. Allow for differences and disagreements.	Messy, intriguing issues foster exploration, experimentation, defining, refining, construction and reconstruction of the problem.
Capacity for intuitive thinking. Ability to combine what is known and unknown with "hunches", and to develop unusual solutions.	Safe, affirmative environment. Teacher models respect for different ways of knowing and values intuitive insight.	Ill structured problems afford use of intuitive guesses and hunches in positive, accepting environment.
Intuitive way of knowing may include an immediate, complete awareness and understanding of a situation or problem.	Guide students as they try out intuitive behaviors; facilitate as they develop systems, standards to evaluate their understandings.	Intuitive ways of knowing are validated as are other ways of knowing. Students continuously reflect and self evaluate progress.
Often attracted to the unknown and/or mysterious, and to complex, puzzling, unconventional phenomena and ideas.	Provide access to wide range of diverse, challenging materials, resources for research. Questioning, exploration, experimentation, illumination, communication.	Use of diverse, interesting, illuminating resources and materials aids in exploration of issue from multiple and novel perspectives.
Nonconformist behavior may disturb or disrupt the traditional classroom. May exhibit energy and exceptional focus when engaged in creative problem solving.	Opportunities for choice and self management. Environment responsive to diverse learner characteristics, styles, interests. Flexible grouping as needed.	Conformity is not the expectation. Unusual vision and solutions are valued. Student directed inquiry promotes development of autonomy and responsibility.
Challenging intellectual, emotional, and imaginational thinking may lead to "peak" and/or "optimal" experiences and growth toward self actualization.	Rich, complex investigations that involve interdisciplinary inquiries that challenge intellectual, emotional, and imaginational thinking and provoke growth.	Involved in complex, meaningful creative problem solving, students marshal strengths, intelligences to meet challenges. Opportunities for optimal experience and growth.

Table 3. Alignment of Imaginational Intensities with Program Recommendations and PBL Outcomes

Findings

As a culminating event, the teacher taskforce presented a report of their findings and recommendations to local educational stakeholders. A teacher stated, “Boy, did we investigate every area. We knew if we were asked specific questions, we needed to be able to back it up. Personally, I believe we gave one of the best presentations I’ve ever been involved in.” Taskforce recommendations included broader conceptions of giftedness, multiple avenues to identification, and differentiated program options that included PBL opportunities as the cornerstone of curriculum for minority gifted learners. The taskforce presented options that would engage gifted learners in the kinds of educational experiences that would ignite interest, build skills and knowledge base, and encourage critical thinking. A team member stated, “I definitely think PBL can and should be used in elementary classrooms, especially with integrated social studies and science problems – water issues, recycling, extinction of a particular plant or animal. If we embed PBL in our classrooms we will see a rise in student motivation and achievement.”

In the words of one participant, “The level of complexity of this task was so high. We had to construct our own learning – there was no ‘best’ way or cookie-cutter formula to use. I believe the depth of learning was greater because we did have to construct our own learning from the ground up. I did internalize the characteristics and needs of minority gifted students more using PBL versus traditional learning. The instructor never gave a single lecture or assigned any readings, and I never worked so hard for a class.” Regarding giftedness and intensity a teacher commented, “When I think of how I used to define giftedness I feel it was narrow. It is like a window has been opened.”

Discussion

Solutions for Students and Their Teachers

Active participation in the PBL simulation not only caused the teachers to gain insight to the many ways in which the kinds of critical and collaborative investigations inherent in PBL meet the learning needs of minority gifted students; their participation caused them to believe that they could be successful facilitators of PBL experiences for their gifted and minority gifted students. “It must be hard at times to allow your students to ‘run’ with a project without adding all of your input, to allow students to explore a concept without limits,” a teacher wrote. “This is what I am learning to do. Really, I think that is what this whole experience is leading to. Now that I have experienced it, I want my students to have the opportunity for these kinds of learning experiences. I think I am ready to be a facilitator, a guide for my students as they really explore issues that are important to them. I think I am ready…”

Intensities, Program Recommendations, and PBL Outcomes

For most of the teacher/participants, the discovery of Dabrowski’s (1977) hierarchy of development which highlights emotional, imaginational, and intellectual areas of intensity and potential, was exciting and relevant new learning that deepened their understandings of “giftedness” and led to plans for broader identification pathways and more relevant curricula for minority gifted students; even now components of the teachers’ recommendations are being adopted and implemented in local schools and districts. Given the opportunity to investigate an issue about which they cared immensely, supported as they took responsibility for their learning and decision-making, the group of teacher participants grew in confidence and self-efficacy.

With the support of administrators who were in attendance when the taskforce presented to the community, PBL scenarios are being constructed and piloted in the classrooms of more than one excited teacher. For example, a teacher involved her third grade gifted students in a PBL scenario that integrated geography, history and science to determine a new list of the seven natural wonders of the world and a sixth grade teacher has his students designing and testing filtration systems to determine a cost effective way to remove salt from water. Anecdotal reports indicate that the learning scenarios are messy and fun and that minority gifted students are highly engaged. Further research, both qualitative and quantitative in nature, needs to be conducted in order to determine if and how these types of learning opportunities effectively challenge and engage minority gifted students… and their teachers.

PBL is a learning strategy particularly suited to provide the kinds of student choice, intensity, and critical inquiry necessary to engage minority gifted children in the processes of learning. As the teachers constructed understandings of Dabrowski's (1977) theory and envisioned curricular options to engage these able students, the professor/facilitator, and author of this report unexpectedly found that she, too, was making connections that ultimately led to the construction of tables to illuminate the relationships between the characteristics of gifted and minority gifted students in three domains of human development (the intellectual, the emotional, and the imaginational), program recommendations for gifted minority students, and the match with PBL outcomes. Those tables are included in this report. To find solutions for fuzzy problems, learners utilize intellectual, emotional, and imaginational intelligences in collaborative problem solving ventures. Involved in finding, framing, and solving messy, meaningful problems, supported as they move through the inquiry processes, learners are likely to become more motivated, to grow in autonomy, and to gain self-efficacy as they develop solutions and evaluate their decisions. And so are their teachers.

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CASE STUDY: ISSUES IN MAKING A TRANSITION TO PBL

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ABSTRACT

In PBL, the role of the teacher shifts from the *sage on the stage* lecturer to the *guide on the side* facilitator. The transition sounds simple, but for traditional instructors, this is not as easy as simply walking from the familiar spot in the front of the class to a new position at the side. For instructors accustomed to teacher-centered approaches of classroom management, the transition to PBL is a daunting task. Moreover, such instructors tend to view PBL dubiously for a variety of reasons.

This case study was an attempt to understand some of the factors that facilitate or impede transition to PBL at the level of the individual teacher. The purpose of the study was to provide some insight into the resolution of difficulties in making a change to this student-centered approach, as I followed one instructor in his classroom over the course of two years.

INTRODUCTION

One important aspect of science education reform, as suggested by the American Association for the Advancement of Science, is the transition from the traditional lecture-based style of teaching to more student-centered forms of instruction (AAAS, 1989). One such learner-centered approach is that of Problem-Based Learning, or "PBL". Briefly stated, PBL begins with the presentation of a real-world problem. Students are encouraged to direct their own learning in small tutorial groups, using their own independent study, as well as collaboration skills, in solving the problem. It is the role of the expert facilitator to guide student collaboration and learning during group discussions (Barrows, 1996).

Ideally, successful transition to PBL occurs at three levels simultaneously, including the level of the individual, the culture, and the organization (Kolmos, 2002). However, in the less-than ideal world, it may be possible for teachers to utilize some key principles of PBL within their own classes, providing they come to have an understanding of the factors that are necessary for successful transition (Barrows, 1996).

Background

According to Howard Barrows, the founder of PBL at McMaster's Medical School, the original model of PBL includes six defining characteristics. These characteristics include: learning that is 1) student-centered and 2) takes place in small groups, 3) change in the teacher's role to that of facilitator or guide, 4) the use of real-world problems as focus, 5) development of students' problem-solving skills; and 6) acquisition of new information by way of students' self-directed learning.

While many take the hard-line view that a transition to PBL must be 100% (Savery, 2006), Barrows has admitted that varying degrees of PBL are often necessary, given the wide variety of contexts in which the method is attempted (Barrows, 1996). Additionally, the entrenched habits associated with traditional lecture style pedagogy are difficult to change, for both instructors and for students. Two of the major obstacles for teachers who are willing to try are: lack of knowledge on how to make the change, and lack of time to prepare for the changes (Silverthorn, D.U., Thorn, P.M., and Svinicki M.D., 2006).

Theoretical framework

The learning theory that provides justification of the PBL approach is Constructivist Learning Theory, which is based on the belief that an individual's knowledge is constructed upon his or her prior knowledge (Bransford, Brown and Cocking, 1999; Dochy, F., Segers, M., Van den Bossche, P., and Struyven, K., 2005). Therefore, the role of the teacher in the constructivist paradigm is to support student learning by building on students' previous knowledge (Hmelo-Silver, C.E., and Barrows, H.S., 2006). Taking on this support role is a challenge to teachers whose orientation has been toward covering course content by way of a pre-designed presentation of facts: otherwise known as the traditional lecture (Silverthorn, D.U., Thorn, P.M., and Svinicki M.D., 2006). Additionally, the use of computer technology to scaffold or support student learning has been shown to be compatible with project and problem-based learning and an aid to making this transition (Hoffman, B., and Ritchie, D., 1997; Hung, D., 2002; Petrosino, 2004).

The study

The setting of this study was a traditional classroom, maximum seating capacity 50 students, at a mid-sized, Mid-Western, state-run university in the United States. The two-year case study was conducted over two different fall semesters (2009 and 2010). The purpose of the study was to observe one instructor's attempt to change his strictly lecture-based delivery to one that would incorporate some of the student-based features of PBL.

The participants in this study were students enrolled in either of these two consecutive sessions of a 400-500 level forensic science seminar on Death Investigation. The instructor was a practising board certified forensic pathologist, director of a hospital laboratory, and county coroner, who taught one class as an adjunct professor. He had been teaching the class every autumn for the past twenty years. I acted as participant observer in this mostly qualitative study.

The reason for the study was rooted in the instructor's initial concern that his students' test scores of recent years had shown erratic trends. He frequently expressed his perception that students today lack the motivation found in students of previous decades. A secondary concern of the instructor's was in reference to a recent study that had indicated a need for improved education among practitioners in the field of forensic science (National Academy of Sciences, 2009). One of the general failings of forensic practitioners has been to address issues of human bias. "The most obvious danger in forensic science is that an examiner's observations and conclusions will be influenced by extraneous, potentially biasing information" (Risinger, M., Saks, M.J., Thompson, W.C., and Rosenthal, R., 2002, p. 9). Therefore, it would appear that explicit instruction in regard to the sources of human bias would be appropriate for this course. We agreed that one possible source of bias is an inability to distinguish between observation and inference, which are key components of the Nature of Science (Lederman, N.G., 1999). Another failure within the field of forensic science appeared to be failure to collaborate. One of the recurring themes of this instructor's lectures had been the way in which the lack of collaboration between law enforcement agencies has led to the miscarriage of justice, time and time again.

With all of these shortcomings in mind, we wondered if PBL could benefit the science education of students in this context. The idea was that PBL could prove useful in addressing the shortcomings in the training of practitioners of forensic science, just as PBL has proved useful in addressing the shortcomings of traditional teaching methods in providing adequate student preparation for the field of medicine. The incorporation of the PBL-style approach to this class was intended to give students multiple opportunities to deal with the issues of observation, inference, and human bias while applying course content to problems of real-world scenarios. Students were to be afforded the opportunity to collaborate while working through actual case-based simulations, as well as through a student-generated hypothetical death scene simulation.

Methods

I was a participant observer in this case study (DeWalt & DeWalt, 2002). The data was in the form of surveys, questionnaires, recorded and transcribed interviews with the instructor and students, classroom observations (audio recordings and field notes), and student artifacts including computer-based discussion board, summative tests, and PBL presentations. Data analysis was made primarily through triangulation of field notes, student questionnaires, surveys, artifacts and interviews (Merriam, 2009). Although it was used, quantitative evidence, such as exam scores, revealed little in regard to PBL. The exams given in the class were identical to those given in previous years, and were geared toward assessing lecture-based content, rather than assessment of critical features of PBL, which include the development of collaboration and student self-directed learning. Therefore, qualitative and semi-quantitative data was favored.

Plans for year one

The research questions for year one included: 1) What are the key understandings of science concepts that need to be improved in this class? 2) What are the teacher's concerns about making a transition to PBL? and 3) What are the students' backgrounds and capabilities with regard to this class and the potential use of computer supported PBL? The first year of the study was an attempt to observe the instructor's existing teaching practices, gauge student willingness to utilize online and other support activities, and to collect recordings of the in-class lectures, in order to move the lectures online, thus freeing up class time for collaborative work and discussion. By studying the structure of the course, including the order of topics and type of information presented, we planned to incorporate student learning support techniques that, hopefully, would aid in the transformation of the class from a strictly lecture-based format to one that included elements of PBL.

The existing format of this class was strictly lecture-based, with no textbook or other outside materials provided or suggested to students. Autopsy photographs were shown during the last twenty minutes of the pertinent lecture, and were not shown again until the exam, at which time the slide photographs would be projected onto a screen for students to identify in a time-controlled sequence.

One of the experimental activities planned for the first year was designed to help students understand how collaboration relies on competent documentation of evidence, and was called, *The Penny Evidence Exercise*. As pointed out by Dolmans and Schmidt (2006): "collaboration is not a matter of division of labor among learners, but involves mutual interaction and shared understanding of a problem" (p. 322). This type of warm-up activity is what Ertmer and Simons (2005) refer to as a "post hole" activity that is used to support students as they move into the PBL environment.

Year one results

In answering the first question, interviews seemed to indicate that students needed to gain a better understanding of observation and inference, as well as a better understanding of sources of human bias. Student responses on the discussion board to the *Penny Evidence* activity revealed that, after participating in this exercise, they understood the interdependent nature of collaborative work more clearly. I had led the activity at the request of the instructor, since he was out of town that day, but that meant he would not observe, nor learn how to conduct the activity in a classroom context. This had repercussions in the next year.

In reference to the second research question, multiple interviews revealed the persistence of the instructor's attitude that students in this particular major area are generally "lazy". He believed they were not sufficiently self-motivated to participate in a learner-driven environment of PBL in the way that medical students do. He also felt that the students' lack of content knowledge and relatively limited science background would hinder the transition to PBL. Finally, he believed that problem solving in real-world contexts is an ideal approach to learning and he had very little faith in his students. Although he clearly recognized the need for productive collaboration in the field of forensic science, he was nevertheless reticent to support collaborative activity among the students. For his reason, he cited difficulty in assessment, particularly of "slackers" whom he anticipated would leave the work to others within the group, while receiving full credit for work not performed.

The third research question was in regard to students and the use of computer based collaboration. The instructor had provided his own case-based scenarios, taken from his autopsy practice, to be used via web-based activities. I had incorporated these cases into the class web site, but he failed to utilize these in small group discussions, as planned. In spite of providing the cases for PBL, he continued to lecture, exclusively. Participation on the discussion board was consistently ill supported by the instructor, and so student participation, which was initially strong, fell off sharply after the first couple of summative exams. Although thirty-eight of the thirty-nine had reported being comfortable using computers and the Internet, only nine of the original thirty-nine students in Year One had reported having any experience with on-line collaboration. However, in providing the class with a discussion board for use with planned activities, I had inadvertently opened an opportunity for students to voice their concerns about the class in general. This unexpected student use of the website came after the first exam, when students began requesting that the instructor use the site to post content support materials, in the absence of a textbook. In response to the students' requests, the instructor provided edited versions of his power point presentations, as well as external links to a web site with information about death investigation. Students were pleased that support was now being offered in an online format, but they were disappointed that the autopsy photos were still being handled in the same way as before. This student action demonstrated, at least to me, that the students were not inherently as passive as the instructor had believed.

From the beginning, the instructor had voiced dissatisfaction with the status quo of his class, and yet he seemed to think that, somehow, I could make the change happen for him, without his having to address the changes that he, himself, would have to make. The year one experience showed me that the instructor's attitudes toward students, as well as toward educational innovations such as PBL, and his reluctance to invest adequate time in making the necessary changes to classroom practices had been the critical obstacles to the move toward PBL. Feeling discouraged, I had decided to stop the project at the end of the first year. However, to my surprise, he voiced an interest in continuing, and at that point I told him that I would do so only if he made more of an effort to give the project a reasonable chance of success. "My efforts cannot be marginalized; otherwise, you're wasting everyone's time," I told him. "A superficial interest on the part of the instructor will not facilitate real change." He agreed to give points to students for utilizing the discussion board, and also to take the time to read key articles describing the role of a PBL facilitator, in order to become more aware of his role in making the change.

Plans for year two

The research questions for the second year of the study included: 1) Do computer based activities help students understand the underlying science concepts of this class? 2) Which elements of the traditional presentation of this course's content can be adapted to the PBL approach so that course content is not compromised? and, 3) Do students gain a better understanding of a real-world problem related to Death Investigation by participating in a PBL-style project? Keeping in mind the continuing goal of using the PBL-style approach to improve students' understanding of science concepts as related to better training in forensic science, we set about building transitional supports into existing class practices. In order to maintain essential content, all of the traditional lectures that had been recorded during the first year were edited and put into podcast form for the second year. The idea behind this move was that students would access the podcast lectures on the university-supported online Blackboard, according to the posted lecture schedule. After doing that, they would come to class prepared to engage in small-group mini-cases. These mini-cases would be selected by the instructor to highlight key concepts of the podcast lectures, and provide students with the needed support to make the transition to group work.

In the final interview of the first year, the instructor had spoken of his annual Mass Disaster lecture, and of what he was trying to accomplish in terms of student understanding. He had indicated that students were failing to grasp the enormity of the task of investigating the scene of a mass disaster. During the summer between years one and two, we decided that the instructor's annual lecture/discussion on Mass Disaster would be the most amenable to a PBL style project. This was the one presentation in his collection of lectures that he felt was the most like problem-based learning. For the Mass Disaster, he typically presented students with the scenario of an actual plane crash that had occurred in Northern Indiana in 1994. After giving a brief verbal description of the plane crash scene, his habit was to choose a student to put into the role of deputy sheriff, *First at the Scene,* and then ask the student, "What do you do?" as the opening question of the discussion. It was the only lecture presentation in which he called upon students to reason through a problem, and so he had referred to this as his, "problem based lesson."

Transcription of this annual lecture/discussion, as presented in its original form during the first year, shows a repeating pattern of: a) Instructor's initial question, b) Student's response, c) Instructor's repetition of student response, and d) Instructor's challenge of student response with a probing question. Whereas this pattern does not really represent PBL—in which students, rather than the instructor, generate the questions—it does show that the instructor is trying to provoke deep thinking in students, which is a goal of PBL facilitation (Hmelo-Silvers and Barrows, 2006). Therefore, I agreed that this topic had potential as the source of a PBL-style project.

At mid-semester during the second year, the instructor presented his annual Mass Disaster lecture/discussion, as usual. However, this time, students were assigned to one of four study groups following the presentation. Each group, comprised of four to six students, was to invent a hypothetical mass disaster and explain how they would go about doing the investigation. The four aspects to be demonstrated in the student-generated scenarios included: 1) Plausibility (had to be within the local county and be an event that could believably take place in present time, given the local environs), 2) Application to death investigation (must involve more than sixty fatalities and show realistic application of death investigation concepts presented in class), 3) Students' self-guided research (the location and the hypothetical occurrence were both thoroughly described, including the list of agencies to be involved in working the scene), and 4) Proposed strategy.

Year two results

Student collaboration was supported via the online discussion board; however, the instructor was still reluctant to afford class time for group discussion. Therefore, student reflection on observation/inference and human bias was less than expected. The instructor did not monitor the discussion board, but relied on me to forward to him any points made by students that he should address. Furthermore, the lack of instructor participation in the *Penny Evidence* activity the first year proved a disadvantage in the second year, because the instructor failed to grasp what had actually occurred during the activity, in spite of lengthy explanations after-the-fact. He was unable to reproduce its results with the next year's class, and then minimized its relevance by referring to it as "finger painting". Continued participation in collaboration warm-up activities would have helped to develop the much-needed collaboration skills, but these activities were not fostered by the instructor as planned in the second year, in spite of the positive results from the first year's warm-up *Penny Evidence* activity that had indicated students' heightened awareness of the need for collaboration.

Student interviews at the end of the semester revealed that lack of in-class meeting time ("even just ten or fifteen minutes at the end of class!" was one student's comment) and the instructor's failure to guide students' initial focus were the main stumbling blocks to the PBL mass disaster activity. Groups attempted to meet face-to-face on their own time in the library, but scheduling conflicts between work, other classes, and family obligations (several were parents of small children), as well as long commuter treks discouraged and prevented many from participating in out-of-class group meetings.

Unfortunately, during the implementation phase of the plan to move the traditional lectures online, technical difficulties with the university-supported Blackboard prevented the students from accessing the first two weeks of podcasts, and so the instructor fell into the old habit of presenting the lectures in class, as he had always done before. Once the Blackboard was functional, the students began using the podcasts as review for the traditional short-answer and multiple-choice tests that the instructor continued to give over the lecture-based content material, instead of listening to the podcasts as background material for group discussions concerning cases. Therefore, the use of the podcasts as prompt to in-class discussions was thwarted by lack of technical support, as well as the instructor's reluctance to let go of his familiar ways, even after the technical difficulty was overcome.

Students who had listened to the podcasts prior to coming to class reported that they found the podcasts to be redundant, since the instructor was continuing to present the same material as an in-class lecture, so they quickly ceased the practice of prior listening, in spite of the instructor's attempts to verbally prod them into discussions of the podcasts during his in-class lectures. The instructor interpreted this as a lack of student self-motivation to prepare for class. He failed to recognize that his own action of continuing to lecture was contributing to the classroom culture that kept students in the passive-learner role, typically fostered by traditional teaching.

Still, we continued with other planned, web-based activities, including two case-based scenarios, during which students were to be introduced to in-class collaboration. These were solved cases that the instructor had pulled from his own experiences and case-files. We provided students with the redacted evidence of the cases, but not the results of the original investigations, via the web page that I had developed specifically for the class. Both cases involved death by gunshot wound, and so the cause of death in each case was known. However, manner of death was in question. Provided with all pertinent information, student groups were given time to discuss the cases and then determine manner of death: homicide, suicide, natural, accidental or undetermined. These activities were moderately successful in guiding students toward the use of online resources, but less successful at building collaboration, as the instructor still failed to follow through with small group facilitation, and returned, instead to traditional lectures. It was not until after the group presentations of the mass disaster exercise, near the end of the semester, that the instructor facilitated a day of case-based group work in class.

The results of the Mass Disaster exercise were encouraging in that all of the twelve students who were interviewed (63% of the class) reported having a greater appreciation for the intricacies involved with investigating a scene of mass disaster by using the PBL-style approach than they would have had through the lecture/discussion alone.

Summary

This study provided insight into the issues involved with making such a transition, when given an expert instructor who lacks pedagogical training. The instructor was an expert in his field. However, although he had taught the class for nearly twenty years, he lacked formal training as an educator and was, therefore, unaccustomed to teaching by any way other than the traditional methods with which he had been taught. Having received his medical degree prior to the widespread use of PBL in medical schools, he was unaware of the specific theories and methods of PBL. My role as participant observer was to design custom-made computer based support, to provide information regarding the use of scaffolding, and to facilitate the culminating attempt at Problem-Based Learning at the end of the two-years.

This study revealed that the instructor needed to realize that relinquishing the role of lecturer does not imply that the instructor is no longer involved in student learning. I discovered that, in spite of his belief that he knew how to direct problem-based learning, he needed specific guidance in how to facilitate group work in true PBL form. Immediately following the second year's presentations of the PBL projects, the instructor finally took the time to read the material on PBL and the facilitation of small group discussion that had been provided to him the previous spring. After becoming aware of the role of facilitator, he introduced several case-based scenarios in class, to each of the four groups that previously had been defined by the Mass Disaster problem, and attempted to facilitate discussion of these cases in class. To my surprise, further interviews revealed the instructor's interest in expanding the use of case-based activities to build toward PBL scenarios in future classes, and to revisit the Mass Disaster problem. The only revision would be that he, not the students, would describe the mass disasters to be investigated. Clearly, he was influenced by the fact that students who had participated in the 2010 PBL project succeeded in grasping the enormity of the task of investigating the scene of a mass disaster, as compared with their predecessors, who had heard only the lecture, and had failed to grasp this concept.

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A "PASSPORT" TO LEARNING: AN INTERNATIONAL STUDENT PERSPECTIVE

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ABSTRACT

This study details the evaluation of a postgraduate module, from an international students' perspective, which introduced a focus on student activity. A passport-based concept was implemented in which the students conducted research, investigation and analysis prior to the class, the results of which were required in order to gain entry to the classroom and were also the focus for in-class activities. A qualitative survey was conducted to determine how this approach compared to the students' previous educational experience; whether they found it helpful; if it influenced the way they studied or prepared for class; and the challenges they encountered. Analysis revealed this learning approach was different for the majority of international students. They enjoyed the in-class interactions, group work and presentations and found the passport focused their studies outside of the classroom. Students suggested enforcing the passport process and extending the in-class activities.

INTRODUCTION

Over the last three years we have been developing our pedagogic approach on the postgraduate quality management module to incorporate the use of Activity Led Learning (ALL, Wilson-Medhurst, 2008) and to better support and engage our large cohort of international students. This paper documents the evolution of the module and is based on our reflections and investigations, in collaboration with an academic development colleague. In particular we are reporting the outcome of an evaluation of the current pedagogic practice based on student feedback.

This is a 15 credit mandatory module contained within the suite of MSc programmes in manufacturing and engineering management disciplines and runs 3-4 times in a semester. Only a small percentage of the student cohort originates from the United Kingdom. Approximately 92% of our participants are international students with 74% coming from outside Europe. The University expects that postgraduate students will have an English Language qualification equivalent to level 6.5 of IELTS insisting that they do an introductory course otherwise, but we find that levels of English are variable.

> *"Initially language and communication difficulties may be prevalent among international students, occasionally compounded by regional UK accents among staff."* (Dales *et al.*, 2011, p1)

However, the issues we are dealing with, lack of preparation or engagement and plagiarism, will be recognised by colleagues for whom the added complexity of supporting students operating in an additional language is not an issue, and adding weight to the argument that better support for international student can have a positive impact on all students (Carroll & Ryan, 2005).

Context

For over ten years the postgraduate modules were delivered using a "short block" system, normally comprising an intensive taught week followed by three weeks of student self study dedicated to assignment completion. Three years ago the delivery format was restructured to a semester system. At this time Activity Led Learning was introduced as a key pedagogic approach in the Faculty of Engineering and Computing.

> *"ALL (as defined by the Faculty) is a pedagogic approach in which the activity is the focal point of the learning experience and the tutor acts as a facilitator. An activity is a problem, project, scenario, case study, research question or similar in a classroom, work-based, laboratory-based or other appropriate setting and for which a range of solutions or responses are appropriate."* (Wilson-Medhurst, 2008, p. 2)

These type of approaches can encourage the development of the employability skills such as problem solving, communication, team working and self-directed learning (Boud, 1985; Reynolds, 1997) therefore we decided to use ALL in the module redesign and build our new approach around activities that the students would plan, research and carry out before, during and after the contact time.

Redesigning the module – mark I

The semester version of the module was designed around the consecutive delivery of a one hour lecture and one hour seminar. The seminars were designed to be student activity focused (in accordance with ALL philosophy) and were based upon a task (such as evaluating a journal article, data collection) that the students would have completed prior to the lecture and brought with them to class. The problem-based in-class activities were designed to align with the assessments, to encourage engagement with the subject and to provide opportunity for formative feedback and assignment advice.

Initial reactions

When we first introduced this approach we were dismayed to observe:

- Typically less than half the students brought the requested seminar material to class.
- Consequently students were in very large seminar groups as they worked with the student who had prepared, which led to a number of students not fully participating.
- This impacted in their ability to do the assessments: they could not ask questions or receive formative feedback in the seminar.
- A proportion of the students had a very poor English comprehension.

We spoke informally to the students, asking why they were not preparing for the seminars as requested. They told us they were adopting a strategic approach, in which they only focused on work which had marks directly attributable, rather than as was intended, broadening and deepening their knowledge. In addition we found that:

- Students spent considerable time contacting the academics for further explanations of the assessment at the end of seminars and outside formal contact sessions.
- The module grades were low compared to the higher education expectations.
- An increase in assessments which contained some form of plagiarism.
- Some students had never or rarely accessed the online learning environment.

The formal plagiarism procedure investigation revealed a significant proportion had produced neither long academic pieces of work nor short industry focused assignments; their experience was limited to examination type assessments. There is a good deal of literature about precisely these issues with assessment and dealing with different ways of learning (for example Carroll, 2008; Dolan & Macias, 2009; Foster, 2008), including the need to

> *"help students to prepare for seminars, by suggesting that they produce summaries of short prior readings or lists of questions based on the lecture, providing prompt questions which you will use to start discussion in the seminar/tutorial, or setting preparatory tasks based on students' prior experience (e.g. in their country of origin);"* (Universities Scotland, 2010)

We noted that students who had engaged asked meaningful, relevant questions, obtained formative feedback and achieved good grades. This suggested that the underpinning philosophy was sound but prompted the question: How can we better facilitate the engagement of all students in seminar work?

Redesigning the module – mark II

We did some more development and decided to adopt a high risk strategy in order to address the engagement issue. We opted to make completion of the pre-lecture activity mandatory. We were nervous as Master's students are considered mature and able to manage their own learning and an enforced approach contradicts this belief. The assessments would still be linked to the seminars and have an employability focus.

The demographics of the student cohort gave us the idea of using a passport metaphor. The "passport" into the seminar would be the required preparation: at the end of the previous week's seminar the academic would tell the students the requirements for the passport. Then at the start of the next lecture the academic staff would arrive early to the lecture and check that each student had bought their "passport". If the student had done the preparation they were allowed entry but if they had not they were turned away from the session until they could bring the passport material to class. We hoped that by being quite strict at first we would encourage the required behaviour and that this would have a subsequent impact on their assignment outcomes as they engaged more effectively with the material. An example of a "passport" was to read and summarise two journal articles on Quality Function Deployment (QFD) then complete a QFD chart and bring this information to class. This information was the cornerstone of the seminar problem-based activity which in turn initiated the assessment of this topic and provided formative feedback on some of the questions.

While the new approach appeared to be effective in encouraging students to prepare for contact time in producing the "passport", we wanted to understand more about their experience, how different this way of learning was for them and what elements of the new approach worked for them particularly as we felt this was a high risk approach. One of the first things we noticed was that our metaphor use proved problematic for some students: a group of four students arrived at the classroom with their actual passports. This firmly reiterated the need to ensure that objectives and directions are clearly explained and instructions are understood (Bond & Scudamore, 2010), of being explicit (Carroll, 2005). It also underlined our concern about potential issues with the poor level of English of some students.

Research method: Investigating the mark II redesign

We explained that we wanted to investigate the effect of using the "passport" on the students approach to study to an academic development colleague. We had limited access to the students as we were not convinced that we would be able to persuade students to attend a focus group or individual interviews, so we decided to conduct a short survey at the start of class and asked the academic development colleague to carry this out to ensure anonymity. The questionnaire comprised a couple of closed questions in order to establish facts about the students and "open questions to allow the possibility of asking deeper questions and obtaining unanticipated perspectives" (Easterby-Smith *et al.* 2002). Our colleague drew up a list of open ended questions seeking to explore this issues we identified, these are shown below

(Figure 1). We used mostly open ended questions as we did not want to prejudge any of the responses students may have given, but we wanted to explore some of the issues they had raised with us such as the unfamiliarity of the active and independent learning elements, so that we can further develop the support we offer.

We wanted to find out if students from any particular cultural background found this active approach more difficult than others, hence the focus of the first questions.

1. Which country did you do the majority of your education in before Coventry?
2. Did you do your undergraduate degree in the UK? YES / NO
3. When you started M29EKM classes at Coventry in what way were the face-to-face sessions different to those you were used to?
4. In what way are the assessment requirements for M29EKM different to those you are used to?

We wanted students to focus of the positive aspects of the new approach, to identify any changes in their own approach and to help us understand what it is they find difficult.

5. What do you find helpful about the way you are taught and expected to learn on M29EKM?
6. In what way has doing M29EKM changed the way you study and the way you prepare for class?
7. What do you find challenging or difficult about the way you are taught and expected to learn on M29EKM?

Figure 1: Questions used on the survey with annotations giving rationale

We complied with institutional ethical procedures and, as is expected, each student was provided with an information sheet and informed that they did not need to take part (Denscombe, 2003; Oliver, 2003) and that this would have no impact on their grades. Our colleague reported that only one student appeared to take this option (based on a discrepancy between number of returns and to number in attendance). We informed the students that this information was going to be used to help evaluate and further develop the course. Once the introduction was made the course team member withdrew from the room so that the survey could be administered and completed.

Research method: Data analysis

Content analysis is a "classical procedure for analysing textual material" (Flick 1998 p192) and is an objective, deductive approach which searches for content (based on prior hypotheses) in order to determine clarity and it usually involves examining frequencies within the qualitative data which in turn are translated into numeric form (Easterby-Smith *et al.*

2002). The data analysis process followed the recommendations of Miles and Huberman (1994) and consisted of three concurrent phases: "data reduction, data display and conclusion drawing/verification" (Miles and Huberman 1994 p10). The data reduction process consisted of firstly transposing the questionnaire response data into a data display, and this was followed by coding using a summarising approach (Flick 1998) to simplify the data before displaying in further matrices. Codes (Figure 2) were created by starting with a provisional

NC	=	Either not classified(did not answer question) or no comment
LBD	=	Learning by doing, practical, in class exercises
IN	=	Interactive, participation, group work
GL	=	Passport, guided learning, self study
LR	=	Lecturer responsiveness, lecturer support, answering questions
CR	=	Critical thinking, challenging, independent learning
IU	=	Improved knowledge, understanding, learning
PSI	=	Presentation skills improved
TMW	=	Too much work, time consuming
CA	=	Coursework, assessments
FO	=	Forced, pressure to work
P	=	Positive, must be explicitly stated, otherwise neutral response
N	=	Negative, must be explicitly stated, otherwise neutral response

Figure 2: Codes

list of pattern codes linked to the research questions, which then evolved as the text was analysed reflecting an interpretative approach to coding (Miles and Huberman 1994). Finally the reduced data was evaluated to draw and verify conclusions. This evaluation stage of analysis comprised within case analysis (the individual student) and cross case analysis (at the module occurrence and cohort level) in order to establish themes and results which cut across the cases.

Data analysis and discussions: The student experience – what did the data tell us?

The cohort comprised students from 17 different countries however only 14 countries were specified in the responses concerning prior educational experience (question 1) since 9 students did not complete the question. These students were clearly concerned about confidentiality with responses such as "Europe – to keep it anonymous". Therefore this data was simplified and the responses grouped into regions (Middle East, Africa, Asia South, Asia

East and Europe). It was found that 28% had completed an undergraduate degree in the UK whereas the majority (72%) previous educational experience was international.

Although the survey had a high response rate which represented 75% of the total cohort, the analysis found that a number of questions had either been answered incorrectly and could not be classified or had not been answered at all. These were coded as NC and were analysed (summary in Figure 3) by question, cohort and nationality to establish whether there were any trends evident which would affect the reliability of the data.

	Question 1	Question 3	Question 5	Question 6	Question 7
% Average NC	10	38	17	17	34
Highest % NC (and Region)	N/A	55 Asia South Not Known	37 Middle East	33 Not Known	55 Asia South Not Known
Lowest % NC (and Region	N/A	17 Africa	0 Asia South	8 Europe Africa	8 Middle East

Figure 3: Summary of NC responses

This shows that students from Asia South or those who did not specify a country were more likely to NC on other questions, although the lowest NC rates were from mixed regions and varied according to the questions. It is uncertain whether the high NC rate was due to the students' lack of comprehension of the question or they simply did not want to answer it.

Firstly the research intended to establish how the face to face classroom sessions were different to those the students had previously experienced. Almost 77% of the responses identified that the sessions were different. The pattern code analysis found 71 code-able comments (quantity shown in brackets) with 4 themes emerging strongly: IN (18), GL (17), LBD (12) and LR (9). There was little difference in the frequency of the responses across the module occurrences, however analysis by region revealed that students with European background focused on IN more strongly; African background focused more on LR and IN whilst the Asia East students mostly identified GL and IN. These regional variations emphasise the differences in the previous educational experience. There were 22 positive comments such as "the interactive activities … improves the learning process", "helpful … understanding the course" and only 1 negative comment concerning the classroom experience. Therefore whatever the reason for the different classroom experience the students viewed it favourably.

Next we wanted to establish what the students found most helpful about the way they were taught and expected to learn. Three themes emerged strongly from the cohort analysis: almost one third of the students identified GL as helpful followed by LBD with 16% and 13% IN. GL appeared strong in each occurrence and had the strongest response from all students regardless of region. LBD was the strongest category from one particular occurrence (with the most EU students) and joint strongest (with GL) from EU students across the whole cohort. This suggests a difference between EU and other international student perceptions. From the 92 useful comments 34 were positive with just 4 negative. The positive comments covered a range of topics including "developing a range of skills", "in class activities really good" and "enables me to learn". However the negative comments included a request for "more teaching and less group work time" and two students comments suggested that they had not learnt anything.

We also wanted to establish if the introduction of the "passport" had changed the way students prepared for class. Over 70% of the responses identified guided learning had affected the way they had prepared for class with only a handful of comments categorised into each of the other codes. This finding was strong across all occurrences and nationalities. Whilst 36% of the responses were positive (and echoed those already presented) there were 4% negative comments which related to the fact the passports were perceived as too much work ("too time consuming") or students felt "forced to prepare for the course". Yet one student explicitly stated "the module has enhanced my time management skills" which contrasts those who identify with the TMW theme.

In order to improve the module delivery we wanted to establish what the students found challenging/difficult about the way they learnt. Whilst the questionnaire was created to investigate teaching and learning methods the students perceived this question as trying to identify the difficult topics within the module which resulted in 26 NC's. When the remaining responses were analysed 40% were found to refer to coursework/assessment with comments such as "not open book exam". Ignoring these responses TMW accounted for 20% of the responses suggesting students found time management and balancing time demands difficult. In total 19% of responses identified either LBD or GL as challenging. It is worth noting that 10% responses (predominately from the EU occurrence) identified “nothing” as difficult/challenging and also there was only 1 positive comment and no negative ones.

Examination of the textual responses in addition to the coding analysis found a range of contradictions. These were sometimes from an individual such as “they expect too much, they forget we are here to study” and between individuals across the cohort “lecturers do not cover the topics at all” compared to “thoroughly explained by lecturers”. Some unexpected and noteworthy comments from the students include them suggesting that the passport should enforced even more strongly, increasing the amount of work required for the passport and making the passport more activity based and extend the concept even further into the classroom.

Conclusions and recommendations

Conducting a survey to investigate students’ perceptions to different approaches to teaching and learning has provided a valuable insight into the similarities and difference which exist between different international student groups. Although the open questions provided rich textual data there were a couple of questions which were misinterpreted by the students or not completed. Despite a transparent ethical process being followed and a completely independent academic conducting the survey some students were still concerned about confidentiality. Therefore modification to the survey to include some more closed questions which could be used to obtain regional nationality facts and also guide the responses to open questions by leading students along the correct thought process. This may also facilitate student understanding and overcome any comprehension issues.

It was apparent that the approach to teaching and learning was significantly different for the majority of students, yet the reasons for this difference varied across the different international regions. The fact that a small proportion of students found the learning by doing and guided learning challenging means that not only should this be considered when adopting these approaches but also when taken in conjunction with the fact that the different approaches were preferred by different nationality regions, class sessions should be designed accordingly. The passport approach combined with ALL in the classroom environment was found to be a positive method for use in class sessions at a master’s degree level. In particular the benefits were identified as: the in-class interactions and group work (linking to the presentations and the improvement of these skills); lecturer responsiveness to student queries; and learning by doing (the in class activities). Similarly the students found the passport approach to guided learning outside the classroom helpful and it had affected a significant majority in the way they prepare for class no matter which region their prior educational experience was in. The negative comments and particularly the emergence of the theme "too much work" suggests a lack of student awareness and knowledge concerning postgraduate level teaching and learning expectations. It has been recently noted (Universities Scotland, 2010) that "the appreciation of cultural differences need to be reciprocal from the outset and, if adopted can form a positive basis for the benefit of all".

As a result of these conclusions the module academics will continue to use the passports (and review their effectiveness) but consider improving teaching and learning practices to include an explicit link between ALL and teaching which the students can identify, and use a range of approaches within this pedagogic approach to meet the differing student preferences. In addition, further investigation into preparing the students for masters' study at a module level and course level is required particularly concerning equipping the students with suitable time management skills.

We would like to recommend further research in the form of refining the survey questions in order to reduce the NC's and occurrence of contradictory statements. It would also increase confidence in the findings since they are limited to the experience of students during one semester. We also believe that further investigations into the differences which exist in educational experiences between the different international regions would be beneficial, as this research found that "international students are not all the same".

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THE NEW AALBORG PBL MODEL – THE FIRST PART OF THE STORY FROM A MANAGEMENT PERSPECTIVE

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ABSTRACT

Over the last five years there has been a change in the Aalborg PBL model as practiced within the Engineering and Science Faculty. The change has been so considerable that it can be considered a "new" Aalborg PBL model. Tremendous changes have taken place in the coherence between traditional course work and project work as well as a change in the assessment system from a group-based assessment to individual assessment without the presence of peers. The newly established research project "Assessment of the new PBL model for engineering education at Aalborg University" will consider the arguments for, and the impacts of, these changes. This paper will present results from the phase of the research based on an analysis of the arguments made by the Faculty management to change the PBL model. The conclusion is that the changes in the Aalborg PBL model were primarily initiated as a response to external factors – mainly a decrease in financial support and accreditation

demands. However, the overall enhancement of PBL has not been one of the main drivers of change; instead the need for change has been seen as an opportunity to un-freeze pedagogical norms and create a new platform for pedagogical innovation. The actual impact of the new model on student learning, however, is yet to be explored.

INTRODUCTION

No engineering education should be static. Technical content as well as pedagogical methods should be in constant debate and reflection and resources should be allocated to set up new experiments and evaluate their effect on students' learning. These considerations should also be applied to PBL education. Even educational models, which have been proven to be effective for engineering education, should be constantly reflected upon and developed in order to achieve continuous improvements. There is no unique choice in the development of problem based and project oriented curricula since advantages and disadvantages of an educational model depend on the particular educational context. The point of departure for discussing the innovative and contextual nature of education is the PBL model applied to engineering educations at Aalborg University (AAU). Throughout the paper this will be referred to as the Aalborg PBL model.

The question is how we sustain and develop previously implemented PBL models to provide effective student learning on the one hand and adjust to societal changes on the other. We know from many places that once implemented an established PBL model will not last forever. New educational models need regular energizers in order to keep the change process going. Educational designs have to be adjusted to new trends in youth culture, employee demands and political strategies at the national as well as the international level. Aalborg University has been one of a few universities that were established as a PBL university. However, even at PBL universities, there is a need for continual PBL development to adjust to societal needs and developments. The challenge is sustaining the uniqueness of PBL in this process of change.

Recently, there has been a re-formulation of pedagogical PBL learning principles (see Barge, 2010), which have been used as a common reference for reflection for the various study programmes. At the same time, the Aalborg PBL model has undergone considerable changes, in only a five years period, in terms of framework conditions, how teaching is organised and practical teaching models. Such changes are due to both internal and external circumstances, but regardless of their origin have considerably influenced the PBL practice experienced by the students.

Due to the considerable changes in the Aalborg PBL model within the Faculty of Engineering and Science, a research project on the impact of the new model has been established and supported by the faculty. The overall research question of the project is:

What are the impacts of the Aalborg PBL model on students' learning; and have the objectives of the changes been met?

To address this question, we have taken a mixed-methods approach, including interviews with the head of faculty, schools within the faculty and study boards as well as surveys of students and staff. This paper deals with the first phase of the research project including interviews with the top management to identify the drivers of the change process, the actions taken to change the PBL model and their possible impacts on PBL practice. Two interviews have been conducted with the top management who had the overall responsibility of deciding to change the PBL model at the faculty level. In order to maintain the anonymity of the two interviewees, we will refer to them as Management One and Management Two.

Before we turn to the drivers for change of the Aalborg PBL model, we will give a short outline of the two versions of the Aalborg PBL model.

Description of the old and new Aalborg PBL model

In the following paragraphs, the primary changes in the framework conditions and teaching organisation at the Faculty of Engineering and Science, Aalborg University, are accounted for as well as structural changes in the pedagogic model. In general, the framework conditions for educational planning at Danish universities moved towards increased harmonisation despite considerable contextual differences at the institutional level.

In both the "old" and the "new" model, the Aalborg PBL model is characterized by problem-based project work. Furthermore, the students work on a project each semester, and all projects are carried out in project teams of typically 6-7 students in the first year, reduced to a maximum of 2-3 students in the final semester. Most of the projects start out with open-ended problems formulated within the framework of a given theme and related to the overall educational objective.

Description of the "old" Aalborg PBL model

In the "old" Aalborg PBL model used in the Faculty of Engineering and Science, the project-unit constituted approximately 75% of the ECTS in a semester (approx. 23 ECTS per semester). Embedded in this project-unit were 50% project work and 25% project-unit courses. The assessment of the project-unit courses was integrated into the project assessment and the project report was used as the point of departure in evaluating both the project work and the project-unit courses. The remaining 25% of the time was allocated to the so-called study-unit courses which were evaluated individually since they were not necessarily relevant to the project that particular semester. The old Aalborg PBL model is illustrated in Figure 1.

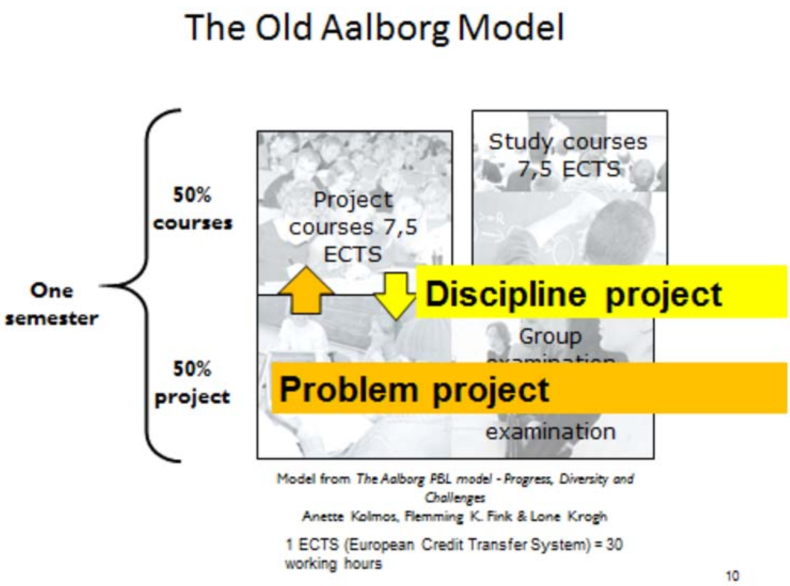

Figure 1. Illustration of the Old Aalborg PBL model (based on Kolmos et al, 2004).

In principle, there could be various types of connections between the project-unit courses and the project. For example, the project could take point of departure in the project-unit courses, thus giving the students additional learning within the determined goals of the project-unit courses. This type of project can be referred to as a discipline project. Another type of project can be referred to as an innovation project. These projects rely on courses that are designed to support the project, meaning the courses are determined by the themes and goals of the project.

Through the years, many initiatives have been taken to improve the assessment of project-unit courses and different solutions have been tested. One effective but very expensive solution was having course lecturers participate in the project assessment. Another solution was having the course lecturers compose a catalogue of questions for the project groups' supervisors to ask at the assessment session, however while this solution is less costly, it comes at the expense of the quality of the project-unit course assessment.

In the old PBL model, the project was assessed in a team setting, even though students were graded individually. A typical project assessment of seven students took five hours to complete. It started with the students giving an oral presentation of the project and was followed by questions by examiners and a general discussion of the project.

Description of the "new" Aalborg PBL model

In the new Aalborg PBL model used by the Faculty of Engineering and Science, the project-unit courses have been eliminated, making the project unit meaningless as a concept. Furthermore, the size of the project unit has been reduced from 75% of the ECTS in a semester to 50%. Now, however, the project unit consists exclusively of project work. In addition to the project work, there are three courses worth 5 ECTS each, which require individual examinations for each course. The new Aalborg PBL model is depicted in Figure 2.

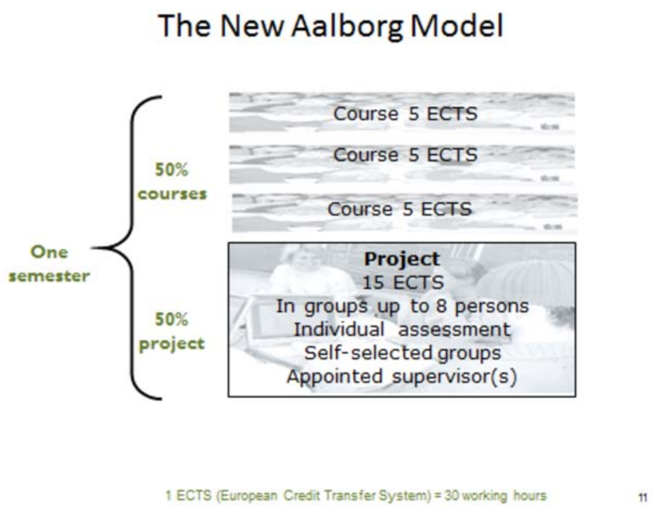

Figure 2. Illustration of the New Aalborg PBL model

The new Aalborg PBL model thus has four parallel modules with a corresponding assessment for each (consisting of 5, 5, 5 and 15 ECTS, respectively). Previously the project-unit assessment covered up to 23 ECTS by including the assessment of the project-unit courses (typically between one and four ECTS). Now it has been divided into a project assessment of 15 ECTS supported by three course exams (using all types of methodologies, but mostly written individual tests) of larger course modules. Therefore, the model no longer explicitly calls for integration between the courses and the project. The transition to the new Aalborg PBL model is still in progress, so how the courses and the project are integrated has not yet been evaluated.

Furthermore, in 2007 Danish law banned group-based assessment making it mandatory for students to be assessed individually. This meant that the opportunity to argue and discuss the project as a team does not now exist, and the discussion of the project phases is broken up in short sessions. The views from employees, students and examiners can be seen, e.g. in Kolmos & Holgaard (2010); and Holgaard & Kolmos (2009). These views will not be discussed further in this paper, but there is no doubt that the change in assessment procedures has had consequences for the students' learning processes.

To evaluate the success of the new Aalborg PBL model experiences from study boards, supervisors, and students are relevant in order to gain the full picture of the impact of the changes. However, the matter of success seems to be in the eyes of the beholder. This first paper starts the story of the new PBL model by clarifying the faculty's intensions and visions of the new Aalborg PBL model.

Drivers of change to the Aalborg PBL model

Management's challenge is to respond to changes in both external and internal conditions. The interviews conducted with the two managers from the Faculty of Engineering and Science point to the following external drivers of change: research indicators, decreased financial support, accreditation and the prohibition of group-based assessment. Each of these drivers is potentially influential at the institutional level (see figure 3). In addition to the external drivers of change, there was a wish to "un-freeze" the educational practice, to use the Lewinian notion and to provide a new base for innovation.

External drivers	Implication at institutional level
Research indicators	A change in the academic culture
Economy	Efficiency improvement is neccessary
Accreditation	Flexibility in the curriculum design
Group assessment	Learning methodology

Figure 3. External drivers for change in Danish Higher Education Institutions

A process was initiated to investigate what could be done to meet external demands and at the same time fulfil internal requests and visions. Part of the process included two committees which focused on: 1) the reorganisation of education; and 2) the organisational structure needed to obtain and maintain this reorganisation. The two committees worked in parallel to provide input to one another (Management One, 2011; Management Two, 2011). As a result of the two committees' investigation of the reorganisation process, both a new school structure was introduced at Aalborg University and the Faculty of Engineering and Science adapted the new Aalborg PBL model.

The main focus of the remaining paper is on the reorganisation of education based on a report from the committee (Andersen et al, 2009) and interviews with management (Manager One, 2011; Manager Two, 2011). The following drivers of change to the Aalborg PBL model will be considered one by one: decreasing financial support, research indicators, prohibition of group-based assessment, accreditation of educations, and a new platform for innovative thinking.

Decreasing financial support

Many factors created a need for change in the educational structure, but the primary driver was a lack of finances (Manager One, 2011). More and smaller study programmes that had no overlapping courses with other similar programmes created a poor economic situation in the departments. One way of optimising the economic effectiveness of education is to ensure a high degree of joint courses, which a larger number of students can attend (Manager Two, 2011). This problem called for a larger coordinating unit and a more robust organisational structure (Manager One & Two, 2011). To make matters worse, the hourly wage rate per student received from the state was continually decreasing. The wage rate per student had reached a level where it was difficult to obtain consistency between the actual time staff could afford to spend and the amount of time actually needed to sustain the educational model (Manager Two, 2011). Overall, these factors led to a financial state that created a need for change (Manager One, 2011).

Research indicators

One alternative to coping with the financial problems on the educational bottom-line is to re-allocate some time set aside for research to teaching activities. This, however, was not seen as a realistic option to the management team. Instead, they expressed their concern for giving enough research time to employees so the university would stand out as having highly qualified researchers. This emphasis on research is seen as a necessity in order to create a financially sustainable university in the long-term, enabling the university to compete with other universities (Management One, 2011).

This concern for research should be seen in light of the increased political focus on research indicators. Starting in 2010 the state began distributing resources to universities based on a model which besides educational performance also includes research performance in terms of publications and the ability to raise external funding.

The prohibition of group-based assessment

The prohibition of group-based assessment was also mentioned as a driver of change in the course structure. The individual assessment made it difficult to capture the range of learning objectives in a project-unit consisting of up to 23 ECTS, as the 5-6 hours of continuous group assessment was now broken into pieces (Manager Two, 2011). Students on the managing advisory board also supported the decision to change the assessment structure and requested that the assessment of the project-unit be divided into more manageable parts (Manager One, 2011). The students also desired that all courses should be explicitly written on the diploma (Manger Two, 2011). The students' wishes supported the decision of three 5 ECTS courses assessed separate from the project.

Accreditation

In 2007 the law for accreditation of higher education was adopted (Ministry for Science, Technology and Innovation, 2007). The law has meant an increased demand for documentation of the: 1) study programme's relationship to research, 2) academic profile of staff, 3) learning outcomes, 4) structure and organisation, 5) quality assurance, and 6) need for the field of study in the job market.

The accreditation body highlighted that in some study programmes at the Engineering Faculty at Aalborg University, students covered too much material for too few ECTS (Manager One, 2011; Manager Two, 2011). In some cases, the number of ECTS given for a course was 2-3 times less than the number of ECTS given at other universities (Manager One, 2011).

This was problematic for several reasons. First of all, it made transferring credits to and from Aalborg University difficult. Secondly, students at Aalborg Universities obviously had to cope with more material than other students at other universities within the same period of time. Thirdly, since staff used considerable time on teaching activities compared to other universities, management found a possible explanation for the lack of economic effectiveness of the existing educational design. Therefore, the reform was implemented to meet the demand of the accreditation board, but at the same time, there was also a desire to create better working conditions for the employees (Manager Two, 2010). The better working conditions could be obtained by allocating less time to teaching and more time to research and administrative purposes given the increased pressure on research performance and reporting.

A new platform for innovative thinking

Both managers consider external conditions, most importantly decreased financial support and demands from accreditation bodies, to be the main drivers of change. However, the need for change was also seen as an opportunity to create a platform for innovative thinking. Prior to the changes, pedagogical practice had to some extent become stiffened as the existing educational model and the established practices had stopped being continuously questioned. This solidified way of thinking seemed to limit new thinking and innovative activities (Manager One, 2011). Therefore, the external pressure was also seen as an opportunity to rethink PBL in engineering education.

One of the visions with the standardised 5 ECTS courses was that the students should have the opportunity to "shop" around to find courses that fit their project and future career plans, may they be in business, research or entrepreneurship (Manager One, 2011). This change was supported by a demand from the accreditation bodies for voluntary courses and not just voluntary projects (Manager Two, 2011). In some cases, the allocation of resources for increased course supply could be considered (Manager One, 2011). What the educational designer then might experience as increased standardisation, the students could experience as increased flexibility.

The vision of the project was that it should maintain its independent value and be more than just an application of course material (Manager Two, 2011). If the project and the courses had separate assessments, then the learning objectives of the project work were thought to be more clearly stressed as an independent activity that challenged students to search for knowledge themselves. Nevertheless, it was still the intention of the management to keep the course content and project work closely interrelated (Manger Two, 2011). Furthermore, as the project-unit courses were assessed individually, it was also expected that these subjects would receive more student attention (Manager Two, 2011). In the recommendations for reorganisation of the study programmes it was suggested to differentiate between three kinds of modules: basic modules (e.g. mathematics), specialisation modules, and voluntary modules (Andersen et al, 2009). It is yet to be investigated whether these intentions have actually been put into practice.

Furthermore, management wanted to emphasise that active learning methods were not to be reserved only for the project work, and thus they wanted to motivate a higher degree of active learning methods in the courses. In the recommendations for reorganisation of the study programmes it was recommended that:

"…teachers, as well as educational designers, include a variety of teaching methods, so students experience a broad range of educational methods throughout their studies through lectures, study groups, symposia, workshops, excursions etc., and those activities are then supported by exercises, mini-projects, weekly assignments, cases, questioning sessions and alike which include a high degree of student involvement." (Andersen et al, 2009: 24; authors translation)

Likewise, it is recommended to rethink the choice of assessment methods to include a broader spectre of methods (Andersen et al, 2009).

However, it is still important that these kinds of activities are carried out within the accredited amount of time (Manager Two, 2011). This highlights that the risk of an overloaded curriculum is not only related to the amount of the material presented, but also to the number of activities the students are able to be actively involved in, thus leaving them less time for preparation and reflection.

Conclusion

The so-called Aalborg PBL model has undergone considerable changes in the last five years. First of all, the assessment of students' learning went from group-based assessments to individual assessments (without the presence of peers) due to changes in the statutory framework in Denmark. Furthermore, the university management at the Faculty of Engineering and Science decided to change the Aalborg PBL model and provide larger course units assessed independently from the project modules.

The change in the Aalborg PBL model was initiated as a response to the considerable changes in the framework conditions for higher education in Denmark; meanwhile a decrease in financial support, accreditation demands and increased pressure to document research performance were main factors in the changes made.

These challenges are not limited to the Danish context. They are a sign of the times for universities on the European and even to some extent on the international level. The more general question to be discussed is: How can we sustain the philosophy of PBL under these circumstances; and in doing so, how can we take into consideration the challenges of the 21st century including globalisation, increased complexity of techno-systems and the call for sustainable development? We believe that the new Aalborg experiment to develop the PBL model can contribute to develop PBL 2.0 for the 21st century, both on the conceptual and the practical level.

Although the main driving factor in changing the Aalborg PBL model has not been to enhance PBL, as such, efforts have been made to sustain and develop the uniqueness of PBL under the new conditions. Visions of more active learning methods in courses as well as project modules containing a variety of assessment methods have been thought into the change process. Thus, the external changes have been used as an opportunity to question and rethink existing structures and practices. Furthermore, the change in the educational model has also been seen as an opportunity to reduce the stress of both students and staff.

Nevertheless, arguments in the name of harmonisation, economic efficiency and research performances are challenging the PBL virtue of a flexible and integrative curriculum. Undoubtedly the strength of these arguments also has an impact on staff and students' learning – but that is still an untold story.

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