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# Problem Based Learning for Distance Education Students of Engineering and Surveying.

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ABSTRACT

Reviews of engineering education have highlighted the need for an improvement in student's teamwork, communication, problem solving and life long learning skills. In addition, students need to learn the foundational skills of mathematics and science required to practice engineering. In particular, they need to apply this knowledge to solving complex engineering problems and reaching substantiated conclusions. To address these concerns many universities are moving, at least in part, to a Problem Based Learning (PBL) approach.

In 2001 the USQ Faculty of Engineering and Surveying introduced a strand of four PBL courses. The unique aspect of our courses is that 75% of our student cohort are distance education students, studying across Australia and the world. We have successfully delivered 8 offers of the course on-campus and 12 offers to distance students. Students work in multidisciplinary teams to solve open ended complex engineering problems, identifying and meeting individual learning goals in the process. The majority of these teams do not meet face to face but conduct all team communication, problem solving and assessments using electronic communication media.

This paper discusses the implementation of the course for a diverse cohort of students including assessment strategies. It gives the results of surveys investigating student learning and attitudes to the new teaching methodology. Results indicate that initially there is significant resistance to PBL from both staff and students. However, a majority of students believe it has significantly improved their communication, problem solving and teamwork skills.

## INTRODUCTION

The University of Southern Queensland (USQ) is a small regional university. It has gained an international reputation for distance education with approximately 75% of students studying by traditional distance education or in an 'online' mode. The University has 5 faculties – Business, Science, Arts, Education and Engineering and Surveying.

The Faculty of Engineering and Surveying (FOES) offers postgraduate courses and 4 articulated undergraduate programs – Associate Degree (AD - 2 years), Bachelor of Technology (BTech - 3 years), Bachelor of Engineering or Bachelor of Spatial Science (BEng - 4 years) and double degree programs (5 years) e.g. Bachelor Engineering and Business or Bachelor of Engineering and Science. These undergraduate programs can be based in one of 9 major areas of study – agricultural, electrical and electronic, mechanical, civil, spatial science, Geographic Information Systems (GIS), mechatronic, computer systems, and environmental.

The flexibility of our distance education programs combined with multiple entry paths to programs leads to a diverse student cohort. The majority of our students are mature age, working in industry, with a significant base of practical skills. They may not have the traditional base of physics and mathematics usually expected from engineering students. Traditionally this student diversity has been seen by academics as a disadvantage.

However the demographics of Australian universities are changing rapidly and regional universities in particular must adapt learning and teaching practices to engage a diverse student cohort. The challenge was to use this diversity to advantage. Our student group possesses a huge amount of prior knowledge and experience. This prior knowledge and experience, along with students who have the traditional academic skills (including maths, physics, computer and information literacy etc) forms a knowledge base from which to work from. The challenge now becomes not teaching a diverse student base but unlocking the potential of each student to share and learn from other students as well as the 'expert', the academic.

## REVIEW OF ENGINEERING EDUCATION

In 1999 the Institution of Engineers, Australia (IE AUST, now known as Engineers Australia) released its "Manual For The Accreditation of Professional Engineering Programs" which focused on a number of graduate attributes including teamwork, problem solving, communication and life long learning skills. These skills have also been highly valued by a number of other accreditation bodies worldwide (ABET, 2003, IEEE, 2002, Engineering Council UK (EC UK), 2003). These skills should preferably be learnt in the context of solving complex, open-ended problems and these problems should focus on the application of the science and engineering fundamentals. In short, the main focus of engineering higher education is now outcomes based.

This situation has been in response to criticisms that mainstream engineering programs have failed to equip graduates with the collaborative problem solving skills required for life long learning and the reality of the workplace (Wilkerson and Gijselaers, 1996, Boud and Feletti, 1997). Literature also goes on to suggest that desirable graduate attributes should be expanded to include working globally in a multicultural environment; working in interdisciplinary, multi-skill teams; sharing of work tasks on a global and around the clock basis; working with digital

communication tools and working in a virtual environment (Thoben K and Schwesig M, 2002; National Academy of Engineering, 2004).

## COURSE DESIGN

In 2000, the Faculty prepared for accreditation by Engineers Australia. One of the tasks was to review the curriculum in light of the requirements to embed core graduate attributes within the course. The conclusion of the review determined that these requirements could best be met by an integrated strand of engineering problem solving courses that employed a problem based learning (PBL) approach. This would have the added benefit of introducing first year students to 'real' engineering; more effectively engaging our diverse student cohort and reducing the early attrition from the programs (Dowling, 2001b, Dowling, 2001a).

Four core courses, Computers in Engineering, Physics and Instrumentation, Numerical Computing and Data Analysis were replaced with four PBL courses (Porter M and Brodie L, 2001). Each PBL course developed specific course specifications and implementation strategies to meet the required 'academic' content and to also cater for the increasing skill set of the students (Brodie. L and Porter. M, 2004). This paper will deal specifically with the first of the PBL courses, ENG1101 Engineering Problem Solving 1.

Whilst the introduction of PBL is not unique to engineering education, our student cohort did provide some challenges. To begin with approximately 75% of our students study by distance education i.e. off campus. They are located across Australia and the world. In a literature review conducted prior to implementation, the teaching team could find no references to PBL being undertaken in a true virtual environment. Where PBL was undertaken in an 'off campus' mode, it still relied on students meeting face to face at least several times during the course or it was more likely that the students were simply located away from the main campus at a satellite campus. Thus the introduction of 'virtual PBL' was something untried.

In moving to a virtual environment the teaching team realised they would have to spend considerable effort establishing a learning community for the students to engage with their team, their facilitator and other students in the course. However, initially the effort required in establishing a true 'team' for the students was underestimated particularly for the distance students.

All students are allocated to a team of eight. Whilst this is larger than the current literature advises, the larger team size allowed for students to drop the course and not affect the viability of the team. This meant that teams did not have to spend time and effort reforming during semester. Initially the allocation of team members was somewhat random, simply ensuring that each team had a mixture of AD, BTech and BEng students of all majors, as numbers allowed. This semester (Semester 1, 2007) the teaching team is trialing a 'skills audit' of student prior knowledge an abilities for team formation to ensure teams have a solid basis for mentoring and peer learning within each team (Gibbings P and Brodie L, 2006, Gibbings D and Brodie L, in press).

USQ uses a standard learning management system (LMS) for all distance and online courses – WebCT Vista 4.0. This LMS offers facilities such as links to URLs, chat, discussion boards and electronic submission of both team and individual assessment items. The teaching team has shown that the LMS along with a carefully planned and implemented pedagogy can successfully and effectively develop a learning community for the students to work in and supports the construction of knowledge (Brodie. L and Gibbings P, 2007, Brodie L and Gibbings P, 2007). Figure 1 shows the average number of postings on discussion boards for distance and on-campus teams. The average number of postings per student was equally shared between on-campus and distance students. This is an interesting result as it was assumed that on-campus students would make significantly less use of the 'virtual' communication methods, however these statistics indicate that on-campus students appreciate the flexibility offered by electronic communications and virtual teamwork (Brodie L, 2006).

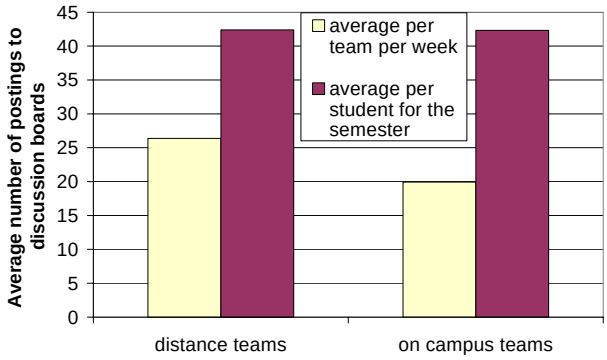


Fig. 1. Discussion board activity for off-campus and on-campus students teamwork (Brodie L, 2006).

The formation of a learning community and the construction of knowledge for students is supported by team facilitators. Each team is allocated a USQ staff member to act as mentor to the team. The facilitator guides not only the solution of a technical problem but also helps teams through the process of team formation, conflict resolution and problem solving methods This role of *facilitating* or guiding student learning as apposed to lecturing is often a large change for staff and staff attitude and uneasiness with this change is a major barrier (McNamara C, 1999).

The change in role can be seen as moving from a supervisory role which has responsibility for the end product to that of a facilitator which guides the team through processes which will help the team reach their desired goal (Brodie L and Borch O, 2004). To support this change in role requires considerable institutional support for staff training. It is a role which often does not come easily to traditional academics and the PBL team at USQ implements regular in house training of facilitators (Brodie L et al., 2006).

To evaluate the success of the learning community, team and individual student learning has to be appropriately assessed. The assessment strategy involves individual reflective portfolios, team solutions to the problems (submissions of both draft and final versions) and self and

peer assessment. In addition it also includes providing evidence of mentoring within the team, team reflections and strategies for improvement and research methodologies.

An initial team assessment begins by having teams discuss and formulate a Code of Conduct and Responsibilities detailing roles within the team including the facilitator; rules the team will work by; team meeting strategies (not only times and but methods of ensuring meetings are effective and efficient given they may not be meeting face to face) and problem solving strategies. Making this an assessment item ensures teams place sufficient emphasis on thinking through the issues. Throughout the semester, teams are encouraged to revisit these items, particularly the Code of Conduct, as the team matures and moves through the stages of team development. Initially students find this a tiresome exercise but in student evaluation surveys they acknowledge it was one of the most important and helpful exercises, as illustrated by the following student comment:

> *I thought the code of conduct was a waste of time. I really wanted to get into the problem. However by the end of semester I realised the coc [sic] was one of the most important things we did as a team. It helped us solve many nasty situations and by the end of the semester it looked like a formal legal document. It will certainly be the first thing I get the team to do in the following prob solve[sic] course*

In the reflective portfolio, which is an individual assessment item, students must initially set individual learning goals and plan to meet these goals. These goals must be based on the course specifications. They must also consider and analyse their prior knowledge, experience and skills in setting these goals. At the end of the semester in the final portfolio submission students must re-examine these goals, discuss and self assess their levels of achievement and what assisted or hindered the meeting of these goals.

> *The goals I have set for myself are more than just something to make the facilitators happy, they are not just to be seen to be making an effort. Instead I see them as ongoing and applicable outside the realm of this subject and extending even beyond the completion of it…..They have been designed to challenge me in areas I perceive as personal weaknesses or lacking in applied experience.* **– (Student comment)**

## RESULTS

Since the inception of the course, a longitudinal study has been conducted. This study has monitored student's perceptions of their learning, particularly with respect to the key graduate attributes of problem solving, communication and team work. Students have shown that they believe that these skills have increased significantly in these three areas. This has been supported not only by quantitative results but also qualitative information from student portfolios.

Figure 2 shows the result of the student surveys. It indicates that:

- 84% of students agree or strongly agree that the course increased their appreciation of how prior knowledge and skills of their colleagues and themselves can be used to effectively solve problems
- 85% of students believe the course improved their problem solving skills
- 81% of students agreed that the course increased their ability to work in a team
- 73% of students agreed that the ability to learn independently increased
- 79% believed their communication skills had increased

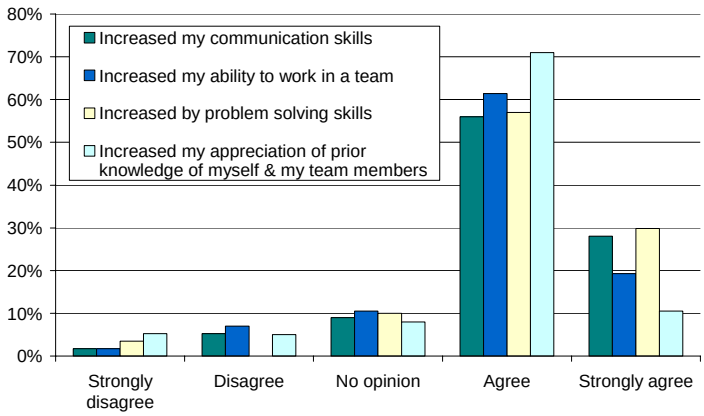


Fig. 2. Results of the longitudinal survey on student learning.

In addition to these results the course also had other positive impacts. Figure 3 demonstrates that ENG1101 provides an opportunity for social interaction to occur, an opportunity which most external students might not have had if it were not for this course using group work and being offered in virtual space through a reliable LMS (Brodie. L and Gibbings P, 2007).

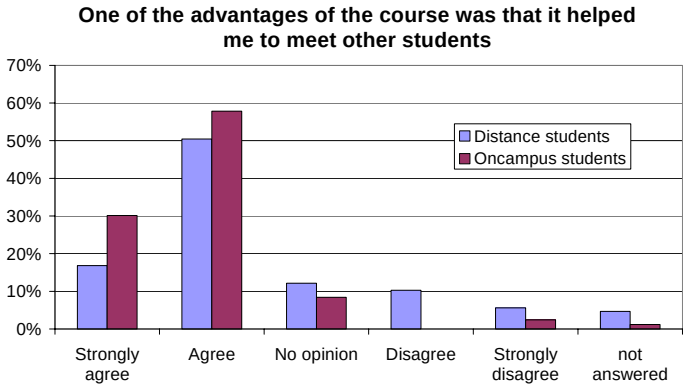


Fig. 3. Course provided opportunity to meet other students (Brodie. L and Gibbings P, 2007)

Qualitative evidence in the form of student quotes from portfolios and evaluation forms also indicates that we are meeting many objectives of the course, in addition to the listed graduate attributes. These include an appreciation of diversity within a team; peer mentoring; individual learning goals; life long learning and helping students' transition to university as shown by the following student comments:

*"The diversity of the team is one of its greatest strengths; subsequently suggestions and comments always vary due to our different backgrounds, experience and individual viewpoints. This should result in a wide range of alternatives for us to always consider and be advantageous to us all."* ***– (Student comment)***

*"This reflection really started me thinking. It is helping me to examine not only what and how the course is teaching but how I am performing, my shortcomings and what I need to work on."* ***– (Student comment)***

*"Our entire team was 'green' to universities… and at first we did not know what was going on. Throughout the course we learnt a lot about our team and ourselves, and really got a feel for group work. We gained a much better understanding of how to work together and how to use the resources of our entire team. The course also gave us invaluable knowledge about ourselves. We discovered that although we had never seen some of the problems before, we were able to work together as a team to find the solution.…This has been a very rewarding course. Although it was challenging and quite different to what I expected, it was very enjoyable and I personally have gained a lot from the experience."* – **(Student comment)**

*"This course has challenged my ideas of learning, … [and] has taught me what no other subject has before…. As such, I feel confident in my basic knowledge of all the areas covered in this course, and I am confident in my ability to learn what I don't already understand"* **– (Student comment)**

The longitudinal study has also informed our problem development and assessment strategies. Sabburg et al (2006) reported on the success of teaching physics concepts through a PBL methodology in ENG1101. This investigation concluded that the problems offered by ENG1101 had most benefit for students with less than one year of physics in year 11 and 12. This is a significant proportion of our distance cohort, however we also need to cater for the students with a more traditional entry route to the course i.e. year 12 physics. Whilst these students can play a mentoring role within teams, we also perhaps need to cater more specifically for their learning goals. The investigation also shows that the problems are pitched at the physics concepts in which student have the greatest prior knowledge. This process of monitoring student learning and engagement has directly informed the development of the course.

## CONCLUSION

In 2001 the Faculty of Engineering and Surveying embarked on an ambitious plan to deliver a PBL course to students working entirely in virtual space. These students would communicate entirely via email, chat and discussion board and would have no face to face contact either with other students or the team facilitator. Not only was this successful but our research now shows that traditional on-campus students are embracing the flexibility offered by virtual teamwork (Brodie L and Gibbings P, 2007).

The teaching team has successfully developed a learning community which engages the student and supports the construction of their own knowledge. The aim of developing graduate attributes of teamwork, communication and problem solving skills has been successfully met. In addition key academic content is being delivered along with other desirable attributes such as life long learning; appreciation of cultural and educational diversity within a team; working electronically and an appreciation of prior knowledge and experience held by the individual students and as seen in others.

*"All of these skills [covered in the course] will be applied in my future study and career, as they relate to the area of work that I wish to be a part of. I have already found that these skills have helped in other areas of study and that I have a more professional attitude towards the tasks I carry out. I have been complimented on my quality of work from my employer and since been promoted."* **– (Student comment)**

The continued development of the course, associated staff training and investigation and evaluation of results is providing significant support for student learning.

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