Revitalisation of a 2nd level Engineering and Spatial Science PBL course: Almost there but...

Steven Goh
University of Southern Queensland, Toowoomba, Australia
Steven.goh@usq.edu.au

John Worden
University of Southern Queensland, Toowoomba, Australia
John.worden@usq.edu.au

Hong Zhou
University of Southern Queensland, Toowoomba, Australia
hong.zhou@usq.edu.au

John Clewett
University of Southern Queensland, Toowoomba, Australia
rocksolidrocks@aapt.net.au

***Abstract**: This paper provides an interim report on the 3rd year of a 4 year study of the effects of curriculum reform on student learning outcome and experience in a 2nd level engineering and surveying PBL course which offers on-campus and off-campus modes of study. This investigation was initiated in 2007 which provided a list of recommendations and lead to structural changes in the course; these were implemented in 2008. Additional student feedback was collected in 2008 to further refine the model, and a list of recommendations resulted in modifications in the course model that was implemented in 2009. Data collected and lessons learnt in 2009 have been used to fine-tune the course design in 2010. The progressive findings noted that even though curriculum reform has resulted in enhanced student learning, it gave rise to a negative student experience in 2009. It can be argued that though the course design implementation process overall has been regarded as successful, academics' attitudes towards PBL, opportunities for training and orientation in PBL, and familiarity with the new course design were evidenced as weaknesses in the delivery of the course. This scenario also alludes to the dynamics of change management involving large teaching teams, in particular, difficulties relating to academics' buy-in and adherence to collective decisions.*

Introduction

A strand of four courses using the Problem Based Learning (PBL) paradigm was introduced into the Engineering and Surveying program in 2001. The PBL strand design and teaching philosophy intended that students were to take different team roles from project to project and from course to course. In the first problem-solving course students are encouraged to rotate team roles and meet personal learning goals through peer assistance and mentoring. This encourages students to take roles and responsibilities which are outside their areas of expertise and knowledge, such as a student with experience in formal report writing is encouraged to mentor an inexperienced team member. This is true for other roles and task allocations within the team, including leadership and technical tasks. As students progress through the strand, the problem complexity and technical difficulty of each problem-solving course theoretically increases as does the need for student independence and application of research skills. Teamwork, independent learning and management skills are developed in the early courses where the teams themselves provide peer support to the students (Brodie & Porter, 2008).

In the initial implementation of ENG2102 Engineering Problem Solving 2 (ENG2102 Synopsis 2009), a 2nd level PBL course in the engineering and surveying program, the focus on assessment was on process (leading to learning outcomes) not output, though there is a greater emphasis on the technical components of the project compared to the introductory course ENG1101. However, over time, the rotation of staff into and out of the ENG2102 staff team has been significant. The central concept for the course, with respect to assessment and teaching philosophy, has changed. At times, members of the staff team fall back into a traditional 'chalk and talk' mode during the facilitation which, far from helping the students, actually disengages them from the process of self-directed learning. Alternatively, if the technical content is esoteric to the student then they will disengage without appropriate intervention (dependent on the Zone of Proximal Development of the respective students). Appropriate scaffolding should result in students engaging as they use the knowledge to develop their skills. This project arose from an initial investigation in Semester 2 of 2007. This paper provides an interim report into the 3rd year of a 4 year study of the effects of curriculum reform on student learning outcome and experience in a 2nd level engineering and surveying PBL course which offers on-campus and off-campus modes of study.

The Ski Resort/ Lifts Problem

Having covered an alternate energy problem in 2008, the teaching team resolved to change to a recreational theme for 2009. The International ski lift/resort set problem for 2009 involved all engineering and surveying disciplines in a significant way for the first time. Surveying students had the challenge of "laying out" the different ski runs for all levels of skiing abilities and setting the ski lifts to service these runs. Eight separate sites drawn from both North and South Islands of New Zealand were proposed to the student teams for either green fields or redevelopment sites. Students were allocated a theoretical budget of NZ $80 million dollars to design ski lifts and supporting infrastructure that would support an international skiing facility capable of catering for 1000 visitors per day with a guaranteed maximum wait of 10 minutes between ski lift rides. They were provided with wind direction, snow depth and topographic data sets for locations and advised to check slope suitability for all levels of skiing ability. T The students were required to analyse the data set using statistics to select their preferred site with each student required to analyse one site and report back to his/her team on their findings. The team then had to rank and select the preferred site for the team's development. This involved assessing each student's analysed data as well as issues of site access, distance to an international airport, electricity supply, national parks, among other variables. These considerations formed the basis of the planning report assessment for the course.

Once the team had chosen its preferred site, they then had to design the ski lifts to accommodate the number of visitors scoping the mechanical engineering aspects of the "bull wheel" and civil engineering needs for the support towers, along with any other additional infrastructure they thought was required in a ski-field environment. Electrical engineering aspects were important in powering the lifts and supporting the necessary site facilities for the visitors. Environmental concerns required ensuring water supplies, sewerage and waste removal from the ski resort site. All these considerations as well as site and development costing were to be included in the final tender report.

The change of topic was not as warmly welcomed by students as the teaching team anticipated particularly with the somewhat heavier emphasis on mechanical engineering concepts involved, such as the examination of stresses and braking on the ski-lift. This became the source of complaint as is evident in Figure 1 for 2009 when student satisfaction reversed the earlier trend of 2007 to 2008. While they were less satisfied, they acknowledged that their overall learning may have marginally increased (Figure 2).

Course Data Analysis

Intensive student surveys have been conducted on the ENG2102 course since 2007 (Goh et al 2009). The survey questions cover almost every aspect of the course from the course content to technical guidance and staff support. From the experiences of 2007 and 2008, the changes made to the course were encouraging in terms of learning outcomes and student experience (Goh et al 2009). There were issues with the implementation of the restructured course content, assessment, support and pedagogy

which the teaching team hoped to address in the semester 2 of 2009 (Goh et al 2009). Key elements included 1) More explicit in expressing the expectation for the course and reinforcement of PBL in the course, 2) greater discipline mix within the student teams, 3) greater monitoring and authority from the team facilitators, 4) stability and training of teaching staff, 5) further refine the assessment structure, and if possible 6) smaller student teams. The feedback from the students on selected survey questions are illustrated in the following figures in the *Survey Results and Analysis* section.

The course details in terms of student numbers and structure for 2007 and 2008 were reported in Goh et al (2009). In Semester 2 of 2009, 427 students were enrolled in this course comprising of 56 teams, made up of 118 on-campus and 309 external students. This compared to a 2008 student population of 131 on-campus and 297 external students and 54 teams. The problem was based on development of an international ski field and resort facilities in the Southern Island of New Zealand. Again it was a fairly highly technical problem and the requirements were demanding, but the content was well spread over the respective disciplines (as opposed to 2007 offering). A single integrated problem was introduced for students to solve in the form of a planning report (30%) and a final report (30%) (versus 2008 of three team-based reports consisting of a planning, progress and final tender report representing 70% of the assessment). The elimination of the need for a 'progress report' aided the teaching team to introduce another individualised online test specifically for *Statistics* content (with the change in the course name and emphasis) held early in the semester to ensure students had the capacity to manipulate and present statistical data. The weighting of the *Statistics Online Test* was 10% and it was scheduled around 4-5 weeks into the semester. This is in addition to the 20% *Course Online Test* due a few weeks before the final report to ensure students are able to exercise the necessary engineering skills for the problem. Assessment culminates towards the end of the semester with a 10% individual *Reflection* report. This is a re-adoption of the 60/40 split between team-based and individualised assessment weighting (against the 70/30 in 2008) recommended post 2007. A set of assessment criteria in the form of a marking rubric was also introduced in 2009. There were 13 group facilitators overseeing the teams averaging about 4.5 teams per facilitator which did stretch the teaching team resources. Student teams were also larger as per 2008. There were 5 technical facilitators covering the respective disciplines. A Surveying and GIS component was re-introduced after it was removed in 2008, hence the additional technical facilitator. An official prescribed textbook, Moaveni (2008) was also introduced for the first time to provide a consistent template from which technical facilitators could prepare course materials. Almost all communication with students was performed through the Moodle (learning management system) and all assessments were submitted through Moodle. From this cohort, 205 students participated in the end of semester survey (243 students participated in 2008).

Survey Results and Analysis

Survey data confirms that in 2008 55% of students were satisfied with the course, whereas 23% students were not satisfied (Figure 1). In 2009, there was a decrease in student satisfaction, 33% students were satisfied with the course and 38% students were dissatisfied. The percentage of satisfied students increased dramatically from 2007 to 2008, but a declined from 2008 to 2009. This decreasing trend is not replicated in Figure 2 on overall learning experience, where students were acknowledging that the learning outcomes were achieved; 55% students believe they learned a lot in this course while there was 56% in 2008 and 41% students in 2007. On other survey questions such as timely assessment feedback (Figure 3), the differences between 2007 and 2008 years are not very significant, whereas a significant increase in satisfaction occurred in 2009. This observation reflects the introduction and use of specific assessment criteria for each of the assessment tasks. Our students remain committed to being directed in assessment items rather than adopting the PBL paradigm.

On the questions relating to facilitation, interestingly the staff were perceived as more helpful and supportive in 2007 than in 2008, and even more so than in 2009 (See Figure 4). This observation may be attributed to the experience levels of the facilitators, in that in 2008 and 2009, a large proportion of the staff team members were new to the course and in most cases new to PBL. This observation is also accentuated by the fact that a large proportion of course and support materials such as quizzes and marking criteria were not made readily available to students at the relevant stages of the semester (Figure 5). (In the figures below, the legends used are: SA - Strongly Agree, A – Agree, N -Neutral, SD - Strongly Disagree, and NA – Not Applicable or not answered.)

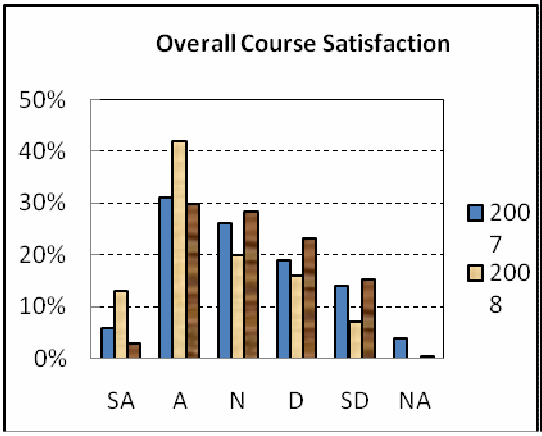

Figure 1. Overall satisfaction

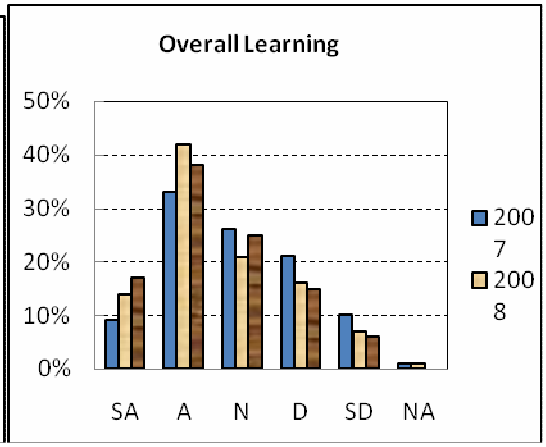

Figure 2. Overall Learning

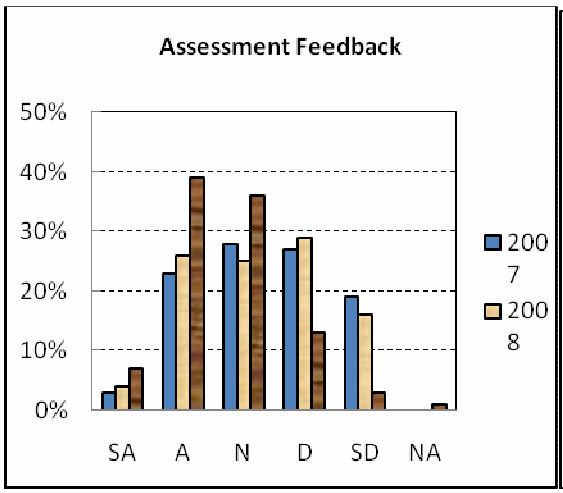

Figure 3. Assessment Feedback

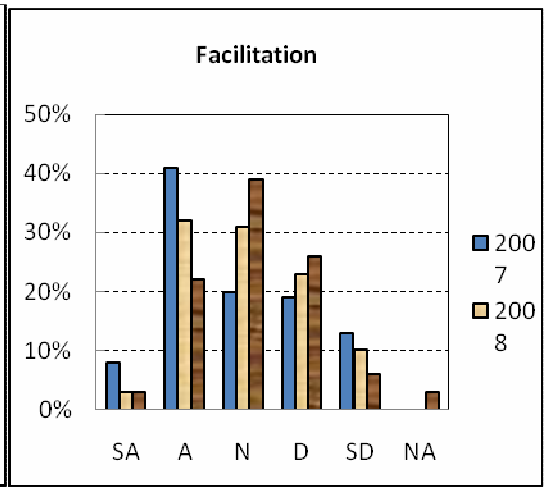

Figure 4. The facilitator effectiveness

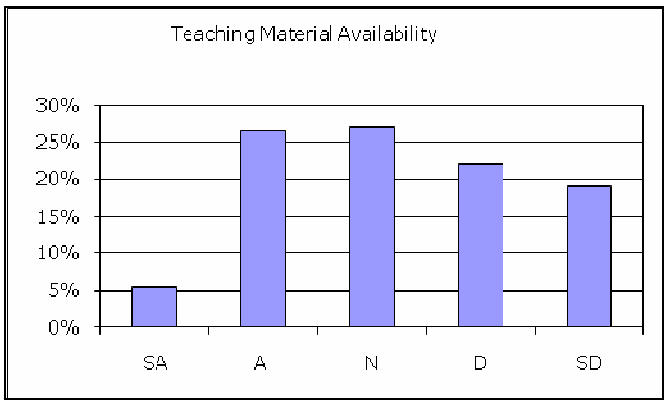

Figure 5. Teaching Material Availability for 2009

In the 2009 offering, there were an increase in dissatisfaction with the course as compared to 2008; in particular there were 15% from this group who were strongly dissatisfied with the course content, facilitation and delivery of the course (slightly worse than 2007 year as the baseline measurement).

A more in-depth analysis of their comments reveals the reasons for their dissatisfaction, which were mainly attributed to the following issues:

1. **The perceived level of technical content**: Most students struggled with their inability to search, evaluate, digest, and synthesise the course materials that were required. The open-ended nature of the content proved difficult for students to explore in solving the problem. The wide variety of concepts and multi-disciplinary context also lead to students complaining that technical content required was of an advanced level and had not been taught prior to this course. There were calls from some students for more compartmentalisation of course content (like traditional courses) which is counter to the purpose of PBL. Our students are too heavily conditioned by years of didactic teaching in our secondary schools and/or a lack of knowledge in fundamental science and mathematics.
2. **Timeliness and availability of course materials**: The significant increase in student numbers in the faculty dramatically affected the workloads of teaching team members. This was very evident when demands in terms of providing effort were placed on them to develop course materials for the 2009 problem. Also, the addition of new staff members and the inexperience of existing staff in PBL led to delays in providing course materials to students. The availability of the assessment criteria was also delayed. As a result, students were floundering and did limited work towards self-directed learning and solving the problem in anticipation to being guided by the assessment criteria.
3. **Technical and staff support**: Students were still expecting direct answers to their questions from their facilitators; both group and technical. The inexperience of the teaching staff in facilitating and guiding the teams may have attributed to the perception that staff 'don't care' or 'don't do their job' as the students were still expecting to be 'taught'. Stronger explicit outline of course expectations and reinforcement of PBL is still required.

In summary, a majority of the hurdles and barriers were related to the three themes above. In comparison with 2007 and 2008, the assessment structure was less dependent on team-based reporting measuring their output (or artefacts) and individual performance was recognised or rewarded. There were now only isolated cases where students were passing without actually meeting any of the course objectives. Students were somewhat satisfied with the requirement to achieve a pseudo real-world problem in a learning environment with some authority and accountability provided by the facilitators. This along with a well designed assessment structure, led to an increase in perceived learning outcomes (correlates well with the increase in the quality of assessment feedback).

Some students again (as in 2007 and 2008) felt that the some assessments contained irrelevant technical content with respect to their individual discipline, and thus were not engaged in some of the learning process. This is confirmed by quotes such as *'it not relevant to my discipline… we had to learn it just to pass the course'*. Staff commented that they were contributing significant amounts of time to help students and guide them in the right direction, but this was often under appreciated. This may be attributed to the expectation from students that the technical facilitators were a source of "answers' rather than for the purpose of guidance and advice. Similarly, the equivalence of on-campus tutorial sessions was inconsistent with some facilitators going out of their way to be very helpful, while others did not. PBL training workshops are scheduled before Semester 2, 2010 to address this perceived deficiency in facilitation abilities of the teaching team.

Student comments again conveyed the message that the time required for team meetings and reading discussion boards was excessive, though most students did not exceed the 10 hours per week expected for this course. A major proportion of our students have external part-time employment and family commitments, and at times are less inclined to commit time to learning beyond that necessary to pass a course. Self-directed learning in PBL presents unwelcome challenges to these students and staff expressed the view that there is a need to actively advise students to be good time managers in response to this comment. Also, staff desired more control over the grading of student contributions to the team assessments to minimise 'hitch-hiking' behaviours. Overall, semester 2, 2009 was productive and interesting, barring the hiccups in the timeliness and availability of course materials and assessment criteria. This influenced negatively in the students' feedback on satisfaction for the course

and facilitators. These issues surrounding staffing, timeliness, and facilitation were targeted to be addressed in 2010. It is worth noting that change management strategies were not considered as part of the revitalisation of this course. One could suggest that if there is one, the 'growing pain' experienced as far may not have eventuated from both student and staff perspectives.

ENG2102- Operation during 2009

A significant change introduced during 2009 was that of marking rubrics to increase both grading transparency for students and to enforce greater marking consistency between teaching team members. Their introduction was also intended to provide a subtle level of guidance for students in relation to report content while being not too prescriptive and leading and thereby defeating PBL concepts.

A further positive benefit was that it clearly distinguished between areas for teaching team members to individually mark and grade. In prior years there was always a degree of confusion between markers on which criteria a student was addressing in the submitted team report due to student's "jumbled and mixed" responses to general instructions.

Highly prescriptive marking rubrics have undoubtedly reduced the pure PBL strategy behind the course design; however, the trade off between these two factors appears to have been beneficial in terms of student and staff time on task. The only downside effect noted has been a decrease in facilitator feedback to student teams due to rubric use.

Course Assessment in 2009

Retention of the on-line exams, their weighting and need for a Project Management Plan (PMP) combined with the advent of marking rubrics to actually increase student acknowledgement of feedback that is markedly evident in figure 3. This has reinforced for the teaching team the desirability of using marking rubrics and ensured their presence in future course offerings.

The large student cohort of more than 500 students meant that there are always a certain number of students who have planned weddings, overseas trips or encounter issues arising from their employment needs who are unable to take the on-line exams within the three day window during which the exam is offered. These factors as well as interrupted on-line access issues due to computer maintenance, etc, necessitate a second chance for a group of students for which these factors can be documented. We had to offer the on-line exams over three periods to accommodate equitable opportunities for all students. Fortunately all on-line exam questions have multiple answers, or where numeric, have computer values randomly selected from a range of variable values such that each student receives an individual exam. Final results for these later exam runs did not significantly differ from the original exam sessions.

ENG2102 in 2010

The course team has agreed to return to the vital issues of energy generation in 2010 and chosen to set a problem on Coal Seam Gas (CSG) for power generation in the Bowen Basin, Queensland. The topic is both local and timely with the foreshadowed developments in the Surat and Bowen Basins, major coal-producing and exporting provinces of Queensland.

Students will be required to analyse data generated for about 50 drill holes, 30-40 of which actually contain Coal Seam Gas, on each of 10 prospects for a theoretical company interested in investing in CSG as a cleaner energy source for generating power for the Eastern Australia electricity grid. Individual students will have to statistically assess the CSG potential of a prospect, take that analysis back to their team and then jointly select their preferred prospects to generate and satisfy a certain power need for 20 years. Furthermore they have to decide on the most appropriate style of power generation from their prospects, either a central power station or a number of smaller gas turbines.

Assessment means will be kept the same as in 2009 and rubrics will be generated to guide students and their assessors.

One area that will receive priority attention is the training of facilitators in PBL and effective facilitation techniques in a workshop scheduled for mid July 2010. With many new staff to problem-based learning and problem-solving, there is a considerable challenge for the staff teaching team to

maintain its standards of delivery to our students. The disappointing data in figure 4 emphasizing the decline in student satisfaction with facilitation has been mentioned previously, but with a combination of training and the ability to select staffing for problem-solving strand courses ahead of staffing of other Faculty courses, this decline should be arrested and hopefully reversed in later years.

Conclusion

Curriculum reform in this course is often performed in isolation of pedagogical consideration, mainly because of the rotation and experience of the staffing team; particularly in PBL philosophy and teaching techniques. The progressive findings noted that even though curriculum reform has resulted in enhanced student learning, it gave rise to a negative student experience in 2009 as compared with 2008. It can be argued that though the course design implementation process overall has been regarded as successful, academics' attitudes towards PBL, opportunities for training and orientation in PBL, familiarity with the new course design, and timeliness in providing course materials and assessment criteria were evidenced as weaknesses in the delivery of the course. This scenario also alludes to the dynamics of change management involving large teaching teams, in particular, difficulties relating not only to student but also for academics' buy-in and adherence to collective decisions. This presents an opportunity for further qualitative study to investigate change management at the course level during the 2010 delivery. The following salient points are worth summarizing:

- On-going strong and explicit outline of course expectations and reinforcement of the underlying PBL philosophy in the course.
- Staff training in PBL is not only vital but an essential component of a successful the problem solving strand.
- Adoption of a set text ensures consistency in the course teaching team and required course content (Moaveni 2008). This establishes a year-to-year operational efficiency.
- Active participation by facilitators in student team management assists with individual student contributions in team assessments.
- Stabilisation of assessment structure with the view for refinement.
- Ensure timeliness in providing course materials and assessment criteria.

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