

Comparative study of project-based learning and traditional lecture-tutorial teaching approaches in undergraduate engineering courses

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***Abstract:** Project and/or problem based learning has been widely recognised as active, collaborative, cumulative and integrative learning approach that engages learners and centres on practical education. However, its widespread implementation in engineering curricula at Australian universities has not been realised due to a number of issues including resources required for large classes, teaching staff's reluctance to embrace it and students' learning styles, beliefs and expectations. On the other hand, traditional lecture-tutorial teaching approach is also criticised for being passive, surface learning and exam-focused. This study compares the data from students' actual performance, course evaluation and expectation in two large undergraduate courses over the last two years. This study is interesting in that both courses were taught by the same teaching staff using entirely two different learning and teaching approaches to the same cohort of students in the same semester within the same degree program. The analysis shows that there are significant differences between students' actual performance, course evaluation and expectation. Such conflicting differences might have negative impact on teaching staff who wish to adopt project and/or problem based learning in their undergraduate engineering courses.*

Introduction

Project and/or problem based learning has been widely recognised as active, collaborative, cumulative and integrative learning approach that engages learners and centres on practical education (Mills & Treagust 2003, Gibson 2003, Birch 1986,). In this paper, PBL refers to blended project-based and problem-based learning where a set of small-scale problems collectively form the components of a large scale project. Such PBL approach has at least two important advantages over standalone problem-based learning and project-based learning for engineering education. First, the project and its tasks (i.e., the problems) are closer to the engineering professional reality. Second, students learn both *the acquisition of knowledge* from problem-based approach and *the application of knowledge* from project-based approach (Mills and Treagust, 2003) as students have the opportunity to put together the jigsaw that is their learning from the apparently disparate pieces they have collected throughout the course (Johns-Boast and Patch, 2010). As a result many universities offering engineering programs across the globe are engaging with PBL as a preferred form of learning. In Australia, Engineers Australia (EA), accreditation body for Australian engineering programs, prefers engineering curricula to be designed around Stage 1 Competencies (Engineers Australia, 2011) for professional engineers and that the development of these competencies will dictate the type of delivery mode for course contents; PBL being an obvious choice to achieve such competencies at both the undergraduate and postgraduate levels (Ribeiro and Mizukami, 2005). However, widespread implementation of PBL approach in engineering programs at Australian universities has not been realised due to a number of issues including resources required for large classes, teaching staff's reluctance to embrace it and students' learning styles, beliefs and expectations. On the other hand, traditional lecture-tutorial teaching approach is also criticised for being passive, surface learning and exam-focused.

The benefits of PBL approach over traditional lecture-tutorial based approach for engineering education are well documented (e.g., Birch 1986, PBLE 2003, Gibson 2003) but the success of PBL approach and the strategies to make PBL successful in engineering classrooms are not clear-cut. It is because there are insufficient studies to clarify the underlying reasons and establish the interactions between teaching staffs and students. This study compares the data from students' actual performance, course evaluation and expectation in two large-sized (>61 students) undergraduate courses over the last two years. Note that Griffith University considers the class of more than 61 students as large class in its formal course and teaching evaluation and this study uses this classification. The comparative results are used to identify the likely impacts on teaching staffs while implementing PBL course compared to traditional lecture-tutorial course. This study is interesting in that both undergraduate civil engineering courses were taught by the same teaching staff using entirely two different learning and teaching approaches (PBL and traditional lecture-tutorial) to the third year students in the second semester of the Bachelor of Civil Engineering program.

Research method

Literature synthesis has confirmed that the student factors, such as students' self-directed learning readiness, willingness to study in a team, method used to allocate individual marks from a team mark etc., play an important role for implementing PBL approach in engineering courses successfully (Nepal & Stewart 2010, Nepal & Jenkins 2011, Nepal 2011). This study aims to look in broader terms whether there are discrepancies between students' actual performance, course evaluation and expectation that may affect the interests of teaching staff to favour PBL approach over traditional lecture-tutorial approach. For this, a controlled environment was set up by keeping teaching staff, classroom environment, class size, study program, year level and study semester constant. Data on students' actual performance, course evaluation and expectation were collected from two third year second semester Bachelor of Civil Engineering courses taught by a teaching staff to the same student cohort over the last two years (2009 and 2010). The actual course performance data was collected from university database, the course evaluation data was extracted from standard university online course evaluation database and students' expectation and preference of the courses were collected using a simple questionnaire survey. An ethical clearance was granted from Griffith University to conduct the questionnaire surveys. The data was analysed to identify the discrepancies between students' performance, course evaluation and expectation. The results are used to draw likely impacts on teaching staff's interests in adopting PBL approach in their undergraduate engineering courses.

Data analysis and results

Data Profile

PBL course offered to third year second semester Bachelor of Civil Engineering program had 118 students in year 2009 and 139 students in year 2010. This was the only PBL course in the whole program and the students had no prior PBL experience leading to this course. The course learning and teaching activities included 2 hours of brief lecture for the whole class, 2 hours of consultation workshop in a group of half the class and 2 hours of computer laboratory in a sub-group of 30 students every week in both 2009 and 2010. It makes the actual contact hours for the teaching staff of about 14-16 hrs/week and much more hours for outside classroom consultations. The assessment items included both team-based assessment items (3 items of 90% weight in 2009 and 2 items of 40% weight in 2010) and individual-based (1 item of 10% weight in 2009 and 3 items of 60% weight in 2010) assessment items. It is important to note here that there is a significant weight variation in team-based and individual-based assessment items in 2010 compared with those in 2009. This is an intentional variation to observe the impact of the amount of team-based assessment items in students' performance, course evaluation and expectation. Students were allowed to choose their study team of 4 members by themselves and all members of a team participated in the same lecture, workshop and computer laboratory classes. There were no supervised exams and all pieces of assessment items were parts of an overall civil engineering design project involving urban subdivision design and design of a connecting road including drainage structures. Fifty-nine (59) students completed the standard

university course evaluation questionnaire in 2009 (response rate of 50%) and 50 students completed in 2010 (response rate of 35.97%). Fifty-nine (59) students completed the additional voluntary in-class questionnaire regarding their preferences and expectations of courses in 2009 (response rate of 50%) and 40 students completed in 2010 (response rate of 28.78%).

Lecture-tutorial course offered to third year second semester Bachelor of Civil Engineering degree program had 81 students in year 2009 and 62 students in year 2010. Students were experienced with this type of course delivery method. As it was a discipline-based elective course, fewer students were enrolled in this course than in the PBL course. The weekly course learning and teaching activities included 2 hours of lectures and 2 hours of tutorial sessions for the whole class in both 2009 and 2010 amounting 4 hrs/week of direct contact time for teaching staff. The assessment items included only individual-based items including 1 assignment (20% weight) and two supervised exams (a mid-semester exam of 20% weight and a final exam of 60% weight) in both subsequent years. Forty-three (43) students completed the standard university course evaluation questionnaire in 2009 (response rate of 53.09%) and 25 students completed in 2010 (response rate of 40.32%). Since the course was offered in the tradition lecture-tutorial teaching approach, no further questionnaire survey was run for this course.

Course performance

Criteria-referenced assessment system was used for all assessment items of both PBL and lecture-tutorial courses in both 2009 and 2010. Figure 1 shows the students' actual performance in both the PBL course and the traditional lecture-tutorial course in 2009. It is clearly evident that the students' overall performance is comparatively better in PBL course (almost 63% of students received better than "P" grade) than in traditional lecture-tutorial course (only about 42% students received better than "P" grade). Similarly, only about 5% of the students did not pass the PBL course compared to 21% of those who did not pass the traditional lecture-tutorial course. To summarise, the overall result of the same cohort of students in the PBL course is better than that of the traditional lecture-tutorial course.

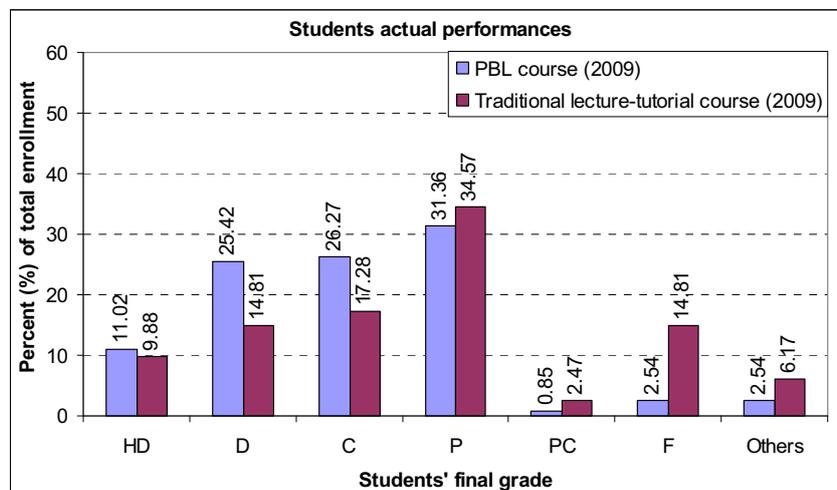


Figure 1 Students' actual performances in 2009

The performance results for the same courses in 2010 are plotted in Figure 2. Similar to those in 2009, the students performed better in the PBL course (about 50% students received better than "P" grade) than in the traditional lecture-tutorial course (only about 42% of students received better than "P" grade). More students failed the PBL course in 2010 than in 2009 (about 12% of the students did not pass PBL course in 2010 compared with only 5% in 2009). However, the traditional lecture-tutorial course recorded decreased failure rate in 2010 compared with 2009. Since both the PBL and the traditional lecture-tutorial courses had the same student cohort in a particular year, the higher failure rate in PBL course in 2010 than in 2009 can only be linked to the weight of team-based assessment items (90% in 2009 and only 40% in 2010). It is clearly evident from the results that the students who did not contribute to the team project (i.e., the free riders) benefited from the heavily weighted team-

based assessment items of the PBL course in 2009.

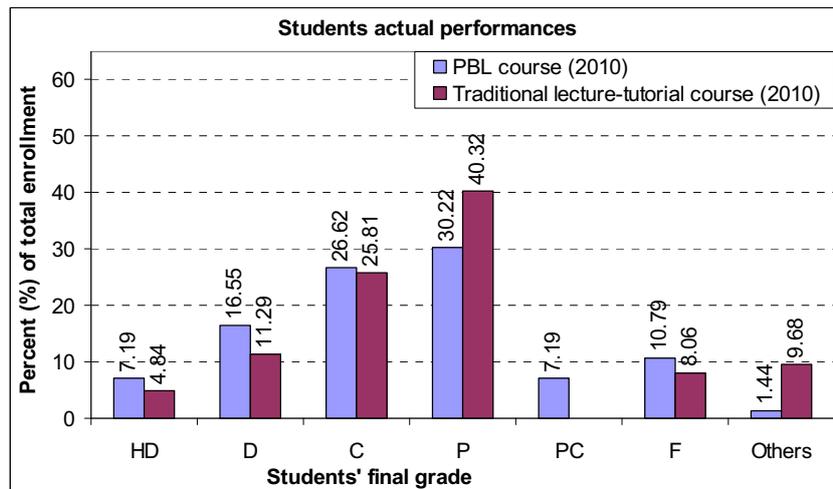


Figure 2 Students' actual performances in 2010

Course evaluation

Figure 3 shows the students' evaluation of both the PBL course and the traditional lecture-tutorial course in 2009. It shows that only about 36% of respondents evaluated the PBL course being better than average whereas about two-third (68%) of the respondents evaluated the traditional lecture-tutorial course being better than average. Similarly, about 22% of the respondents evaluated the PBL course being worse than average whereas only about 7% of the respondents evaluated the traditional lecture-tutorial course being blow average.

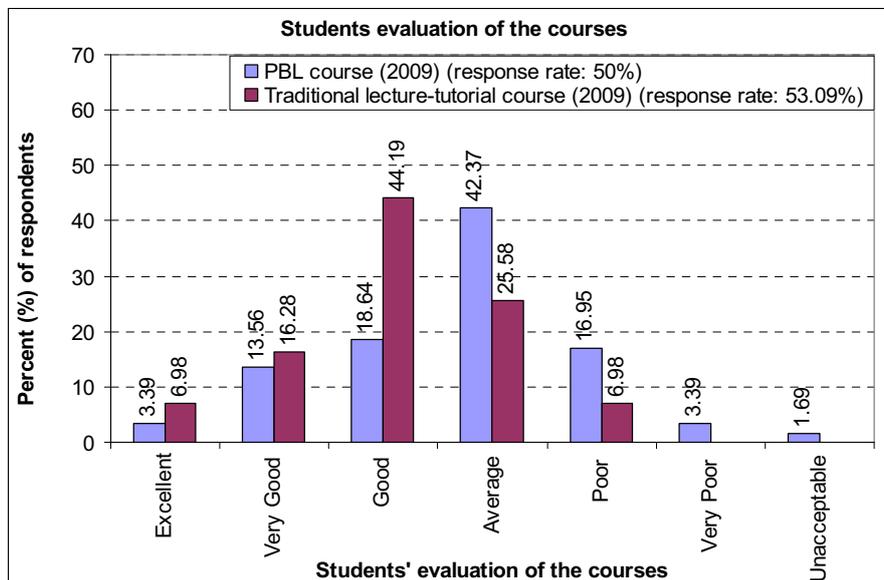


Figure 3 Students' evaluation of the courses in 2009

There are significant improvements in student evaluation in 2010 compared with in 2009 for both courses as shown in Figure 4. Still, the traditional lecture-tutorial course is comparatively better preferred by respondents (80% respondents evaluated the traditional lecture-tutorial course being better than average where as only 60% respondents evaluated the PBL course being better than average). Similarly, only 4% of the respondents evaluated the traditional lecture-tutorial course being worse than average whereas 22% respondents evaluated PBL course being worse than average.

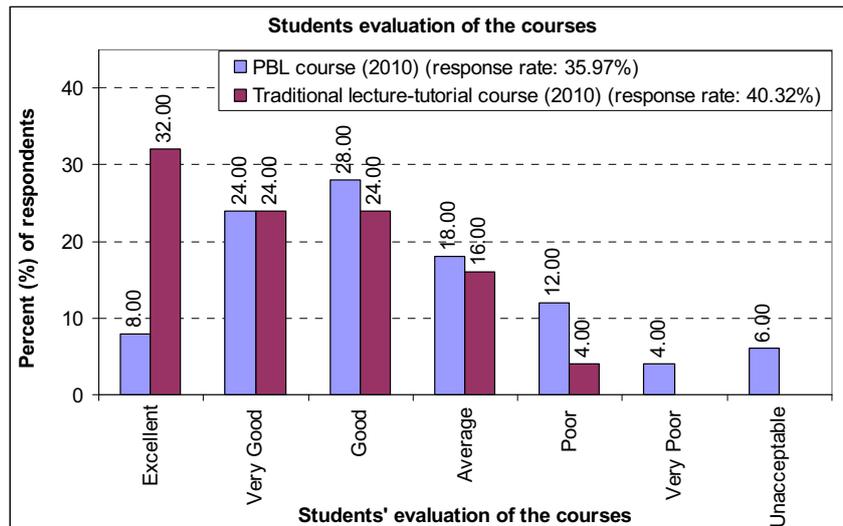


Figure 4 Students' evaluation of the courses in 2010

Expectation and preference

Further, to compare the PBL course with the traditional lecture-tutorial course, the students were asked whether they would prefer lecture-tutorial course over PBL course. The majority of the students preferred the PBL approach (72.9% in 2009 and 70% in 2010) and remaining (27.1% in 2009 and 30% in 2010) preferred traditional lecture-tutorial approach (Figure 5). Whilst about one-third of respondents preferred a traditional assessment approach, more than 80% respondents have admitted that PBL approach has improved their job readiness. It shows that at least 1 in 10 respondents would prefer to go for the traditional-lecture tutorial course in spite of their beliefs that PBL course would help them to get a job.

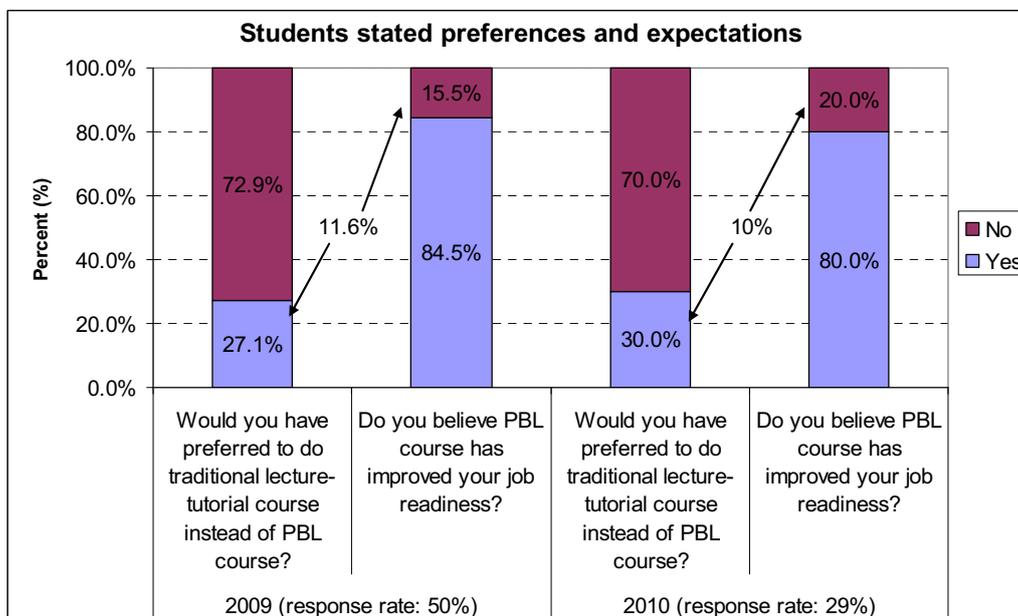


Figure 5 Students' stated preferences and expectations

Discussions

The results of the previous section seem to clearly show that students' actual course performance and course evaluation do not align in the same direction. Since the students' actual performance and their

course evaluation were similar in both 2010 and 2009, it can be concluded that the majority of students do not consider their final grades or results in their evaluations. This may be because students evaluate course based on (i) the amount of efforts they need to put into it to successfully complete the course rather than the final marks or grades they receive, and (ii) the difficulties they may face while working in teams and following a self-directed learning approach. Unfamiliarity and the lack of prior experience with such a large scale open-ended PBL project where the requirements, processes and outcomes are not fixed may be feared by some engineering students who prefer structured approaches to achieving solutions. Another possible reason for such results can be the timing of the course evaluation surveys. Since the confidential student evaluation surveys were conducted during the final weeks of study semester (Week 11- Week 13) when students had heavy workload to complete the PBL projects, students might have felt that the traditional lecture-tutorial course that had final exam in weeks' time was not in their minds. However, opposite to their course evaluation, the majority of students seem to prefer PBL approach to study engineering design courses in line with their course performance. They also believe that PBL approach can better prepare them for future engineering jobs.

To summarise, the results of this study clearly show that there are significant differences among students' actual performance, course evaluation and expectation. In spite of investing more time and effort, these differences may adversely affect the teaching staff's motivation to introduce and to strengthen PBL approach in engineering curricula. Since many universities in Australia consider student evaluation of the course as one of the key performance criteria for promoting and awarding academic staffs, it is difficult for teaching staffs to stick with PBL approach and to help student engage in deep and active learning. To make PBL approach a part of undergraduate engineering program, it may be required to change the current student evaluation practice. It can be done by either by treating course evaluation separately or by adjusting the timing of the evaluation surveys.

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