Blending project-based learning and traditional lecture-tutorial-based teaching approaches in engineering design courses

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***Abstract**: Project based learning (PBL) has been widely recognised as a collaborative, progressive, student-centred, interactive, active and deep learning approach. The benefits of PBL have been well documented in the existing literature and the approach has been practised, to some extent, in most engineering schools in Australia. However, the majority of undergraduate engineering programs, except a few PBL-centred engineering schools, still use traditional lecture-tutorial approach. Both of these learning approaches have advantages and disadvantages. Some engineering students dislike the PBL approach as they need to adopt a self-directed learning strategy to complete often unclear and open-ended tasks. It may also not suit their individual learning styles and needs, which may be different than the team learning needs. Some teaching staff also criticise the PBL approach as it takes too much of their time and effort, especially for large classes. Academic institutions often hesitate to embrace the PBL approach as it demands more resources. This study investigates the use of a blended approach (mix of PBL and traditional) with the aim of eliciting the advantages of both approaches to enhance student learning outcomes. It formulates the strategies to combine both approaches, implements the strategies to an undergraduate engineering design course and relates the effectiveness of such strategies through a student survey. The results show that the blended approach, designed appropriately, helps to minimise the problems of both approaches.*

Introduction

Teaching in higher education is a complex activity that necessitates the emergence and development of approaches to instruction that are consistent with what we know about the way that learning happens (Ewell, 1997). Consequently, a number of learning and teaching approaches have been trialled, practised and modified extensively over the years. These methods can be grossly classified into two types- traditional method and modern methods.

Typical traditional method consists of giving lecture followed by tutorial and/or laboratory sessions predominately in isolated time segments. It often involves delivering as much information as possible and as quickly as possible. Traditional lecture halls are typically configured in rows with a lecturer's desk placed at a vantage point for watching students, and ensuring compliance with rules. It involves the direct flow of information from lecturer as sage to students as receptacle. How effective this transmission has been can then be tested by posing various exercises and exams to the students. The lecturer lectures, explains, asks students to copy and makes sure that the students paid attention and listened. Students are expected to be cognitively active but physically inactive, except for note taking. Most students of any age cannot maintain such behaviour for a long period of time (Cangelosi, 2003). The lecture hall, large classes and limited time prevent sufficient interactions between the students and the lecturer and among students to foster an active learning environment. The traditional method of teaching views students as passive learners (Steinhorst and Keeler, 1995) because it does not engage them actively.

Modern methods are based on cognitive science research about the nature of learning which views that students construct knowledge; they do not take it in as it is disseminated, but rather they build on knowledge they have gained previously (Cross 1998, Cross 1999). They include contemporary teaching and learning practices using project-based learning, problem-based learning, work-integrated learning, and integrative learning approaches. In a typical modern method, students use real world concepts, tools, experiences and technologies to engage in new roles as they pursue questions and share their combined knowledge in social situations. Students work in teams to identify and acquire knowledge required to solve realistic problems. Modern methods focus on creating student-centred learning environments where students are aware of their learning process. Students take charge of their own studies without depending 100% on their lecturers, effectively building student's expectation towards independence. However, students may become too independent where they think they don't need guidance from anybody because they think they can accomplish anything by themselves. Done unintelligently (or negligently), modern methods become a form of teacher-free learning. Of course, we cannot expect students to 'learn everything for themselves'. Out of these contemporary modern methods, project-based learning or PBL has been widely recognised as collaborative, progressive, student-centred, interactive, active and deep learning approach, particularly for engineering education. The PBL approach has been practised, to some extent, in most engineering schools in Australian universities and has been in some cases shown to enhance students' social skills, motivation, and interest in the subject matter. Benefits of PBL approach for engineering education are well documented in existing literature (e.g., Perrenet *et al.* 2003, Birch 1986, PBLE 2003, Gibson 2003, Mills and Treagust 2003, Ribeiro and Mizukami 2005). However, the majority of undergraduate engineering program structures, except few PBL-centred engineering schools, still use traditional lecture-tutorial approach.

Our academic and professional community these days are divided into two different ways of thinking on the instructional approach in engineering classrooms. Both the traditional and PBL approaches of learning and teaching have their own merits and demerits. Some engineering students dislike PBL approach as they need to adopt a self-directed learning strategy to complete often unclear and open-ended tasks. It may also not suit their individual learning styles and needs, which may be different than the team learning needs. Some teaching staff also criticise the PBL approach as it takes too much of their time and effort, especially for large classes. There are some emerging evidences that students evaluate the PBL approach lower than the traditional approach in spite of their improved learning and course performance (Nepal & Stewart 2010, Nepal & Panuwatwanich 2011). Academic institutions often hesitate to embrace PBL approach because it is resource intensive. This study investigates the use of blended approach (mix of PBL and traditional) with the aim of eliciting the advantages of both approaches to enhance student learning outcomes. It formulates the strategies to combine both approaches, implements a set of the strategies to an undergraduate engineering design course and relates the effectiveness of such strategies through a student survey.

Research method

As previously mentioned, the primary objective of this study is to capture students' preferences on a range of strategies that help develop a blended learning (mix of PBL and traditional) and shape blended learning and teaching activities. Nine strategies selected include, (i) level of information, (ii) amount of learning resources, (iii) degree of freedom when setting the direction, scope and timing of activities, (iv) provision of learning resources and materials, (v) activities that help manage the project progress, (vi) amount of team-based summative assessment items, (vii) process of team formation, (viii) type of summative assessment items, and (ix) methods to allocate individual marks from a team mark. Often teaching staffs have dilemma regarding these strategies while setting up of the PBL course. For this, Civil Engineering Design Project, a third year core course in Bachelor of Civil Engineering program at Griffith University, is selected as a case study blended learning course.

The blended learning environment was designed taking into account the abovementioned strategies. In its 2010 delivery, the following strategies were adopted. Controlled information was provided with brief outline of the project and its requirements. The information was provided in the form of brief lecture notes, example tutorial exercises and computer lab guides. A list of learning resources was provided and students were asked to search out required information in them by themselves. These resources were provided electronically online through Learning@Griffith only. Students were encouraged to freely set out the direction, scope and timing of activities that help them to achieve the best learning outcomes. The progress was monitored through regular class-room based workshops. The assessment items included both team-based (40%) and individual-based (60%) items. Students were allowed to choose their study team of 4 mates by themselves. All assessment items were summative and included three intermediate tasks, a final project report and an individual learning folio. An individual mark allocation method proposed by Nepal (2011) was implemented that allocates individual marks based on their individual contributions but at a diminishing rate for those who contribute more than average.

At the end of the semester, a survey questionnaire was developed taking into account the variability of these strategies. At one end, these strategies resemble with a typical PBL course and at the other end they are close to a typical traditional lecture-tutorial course. It helps to simulate the students' preferences regarding these strategies. In total, 50 responses were completed by the class cohort of 139 representing a response rate of 35.97%. The questionnaire survey contained ten (10) distinct questions. Question 1 was related to the respondent's background that enabled to establish a comprehensive respondent profile (i.e. gender, age, industry experience, English language ability, previous years' academic achievements, i.e., GPA, etc.). Question 2 to Question 10 included nine (9) strategies that help build a PBL course and its learning environment. These questions requested respondents to provide their honest opinions by choosing an option from a set of options about the strategies. The data were then analysed and plotted to see what students think of the strategies.

Data analysis and results

Respondent profile: Only a fraction of the respondents were female (13.7%). The majority of respondents were in their early twenties (more than 70%) with only a small fraction being over thirty years of age (2%). The majority of the respondents (56.3%) had progressed straight from secondary school and another 27.1% had less than 6 months of work experience. Only 8.3% of the respondents had more than 1 year of work experience. The majority of respondents' grade point average (GPA) before commencing this course was more than 6.0 (22.4%) with 20.4% for both between 5.5 to 6.0 and between 4.0 to 4.5. A significant number of respondents (36.7%) stated English as second language.

Strategy 1 Level of information: Figure 1 seems to clearly show that 66% of the respondents agreed that the amount of information that was provided was appropriate to their prior knowledge. In contrast only 18% of them felt this was not the case. This would appear to suggest that the students were ready for the project and that the information provided by the teaching staff was in a form that allowed them to develop their learning through the project. However, it may be a bit disconcerting that 16% could not decide one way or the other on this point. Assuming a worst case scenario, it could be said that up to 34% felt that some of the information was not appropriate for their level of prior knowledge. This indicates that there may be scope to provide more background information from the courses they completed previously.

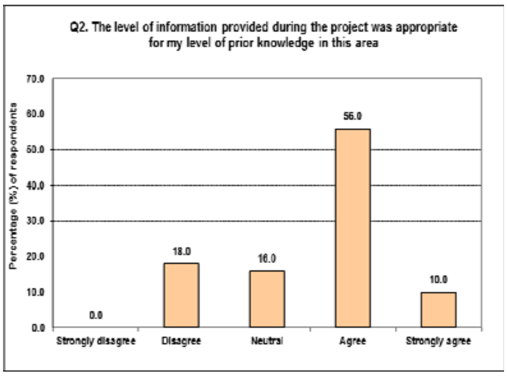

Figure 1 Level of information provided

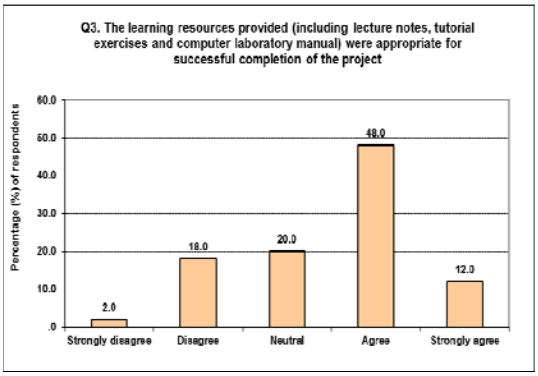

Figure 2 Amount of learning resources provided

Strategy 2 Amount of learning resources: Figure 2 shows that 60% of the respondents agreed that the learning resources provided were appropriate for the students to complete the project. In contrast only 20% felt this was not the case. This would appear to suggest that the learning resources provided by the teaching staff were in a form that allowed them to develop their learning through the project. However, it may be a bit disconcerting that 20% could not decide one way or the other on this point. Assuming a worst case scenario, it could be said that up to 40% felt that some of the learning resources were not appropriate for the students. This indicates that there will be some students who will benefit from the more rigorous learning resources.

Strategy 3 Degree of freedom: Figure 3 clearly identifies that an overwhelming majority of the respondents (94%) believe that the lecturer should play a significant role in defining the direction, scope and timing of activities for the project. However, 50% of the respondents also feel that students should play some role in setting the direction, scope and timing of these activities. Therefore, it would appear that students clearly see themselves as an integral part in defining the learning contract that is set up between the student and the teaching staff. However, they also feel that the lecturer still has a significant role to play when setting activities that are designed to achieve learning outcomes for the students. It is important to note that no students identified that either the lecturer or the student on their own should define the direction, scope and timing of these activities.

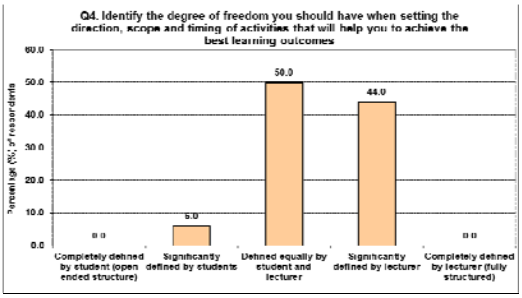

Figure 3 Degree of freedom

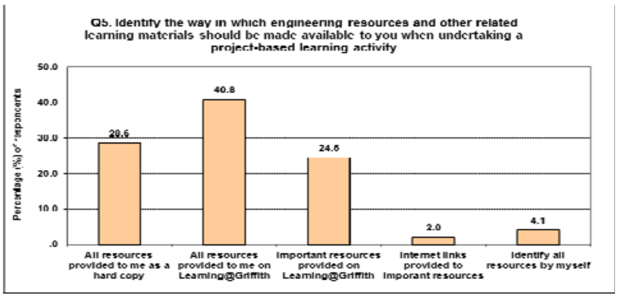

Figure 4 Provision of learning resources

Strategy 4 Provision of learning resources: Figure 4 shows that 65.3% of the respondents see online portal as an important medium for providing learning and teaching resources. However, a significant amount of students (28.6%) would prefer to receive hard copies of this information. This indicates that both online and hardcopy learning and teaching resources accommodate nearly all students.

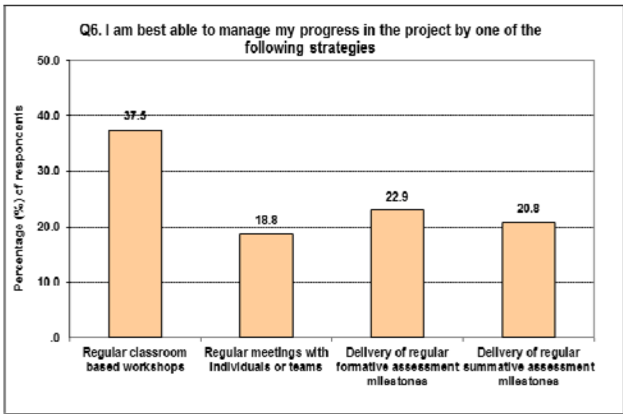

Figure 5 Activities that help manage the progress

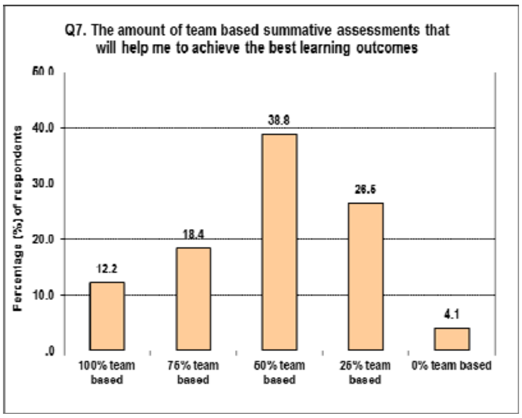

Figure 6 Summative assessment items

Strategy 5 Activities that help manage the progress of the project: Figure 5 shows that the respondents are relatively evenly divided in terms of the way in which they want to get regular feedback on their progress. Certainly the fact that 37.5% of the respondents prefer regular classroom based workshops is possibly because this is the way most lecture-based courses are taught. So this provides a comfortable environment for them to undertake their project-based learning. The results also show that the cohort of students is split between those who want to have regular personal contact with a tutor or lecturer (56.3%), compared to the remaining 43.7% of students who prefer to be given feedback through assessment items. Again this second group of students is reasonably evenly split between those who prefer formative and those who prefer summative assessment. It suggests that a combination of these all activities would incorporate all types of students.

Strategy 6 Team and individual-based summative assessment items: Figure 6 shows that almost all students responded (95.9%) believe that team-based summative assessments help them to achieve the best learning outcomes. However, the responses from the students do indicate that the amount of team-based summative assessment should not be 100%. Only 12.2% of students indicate that they want 100% of team-based assessment. The average response would appear to support approximately 50% of the summative assessment to be based on team-based aspects. Although teams may help them to achieve their best learning outcomes, the team-based assessment is probably not allowing them to show off their own personal learning outcomes as well as when individual assessment items are employed. Therefore, a mixture of both team-based and individual-based summative assessment items are more attractive to the majority of students.

Strategy 7: Formation of study teams: Figure 7 shows that the overwhelming majority of students (76.0%) believe that students should be free to form team members themselves. In combination with the previous strategy, this identifies that students believe that team work plays an important role in their learning. However, they would prefer to choose the team members themselves, rather than being allocated to a team by the instructor using any of the criteria. This identifies the importance of peers in supporting student learning, especially when the learner has control over the selection of their peers.

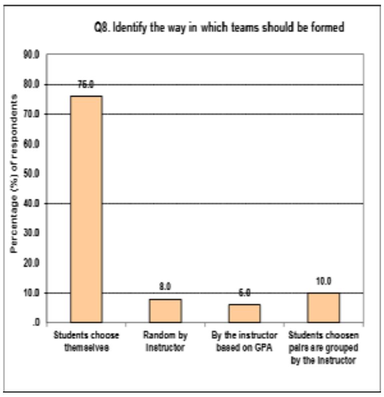

Figure 7 Formation of study teams

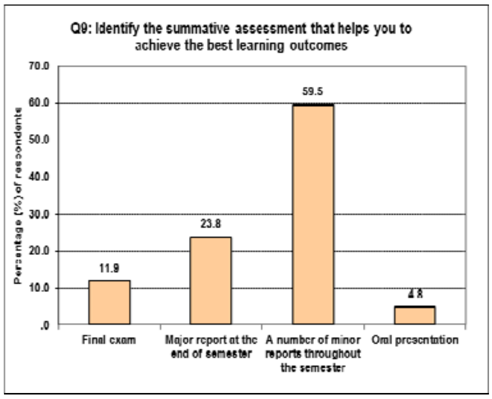

Figure 8 Types of summative assessment items

Strategy 8 Types of summative assessment items: Figure 8 shows that only a very small proportion of students (11.9%) see a final exam as the best summative assessment in terms of helping them to achieve the best learning outcomes. An even smaller proportion (4.8%) believes that an oral presentation is the best way to achieve this. It is clear that students feel that a written report is the best way for them to achieve the best learning outcomes. However, 59.5% of the students believe that this report should be distributed over a number of smaller reports, which would allow them to manage their time rather than one big assessment item at the end of the semester.

Strategy 9 Distribution of individual marks from a team mark: Figure 9 shows that only a very small proportion of students (8.2%) believe that marks should be equally distributed to all students in the team (Method 1). The remaining 79.6% of students believe that the individual mark awarded to a student should be based on the contribution they make to the team's outcomes (Method 2, Method 3, Method 4 and Method 5). Those who contribute above the average should be rewarded and those who contribute below the average should be penalised. However, a significant proportion (32.7%) of the respondents believes that the reward for above average contribution should be limited so that some students are not encouraged to take over the project (Method 5).

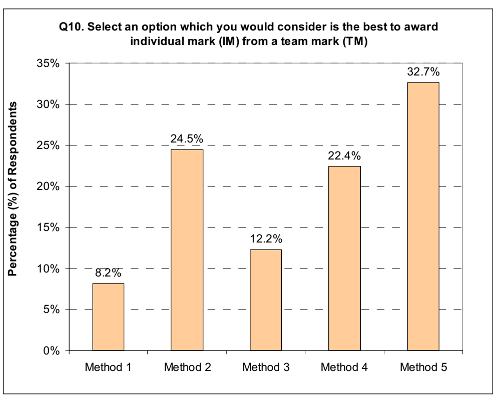

Figure 9 Methods to allocate individual marks from a team mark

Discussion

The results discussed in the previous section show that the blended approach, if designed appropriately and carefully, might help to minimise the problems of both standalone traditional lecture-tutorial approach and project-based learning approach. The following strategies to mix traditional teaching with project-based learning are favoured by majority of the respondents of an undergraduate engineering design course:

- provide background information leading to the project-based learning course,
- provide as much information as possible for the course both online and in printed copies,
- involve both students and teaching staff in setting the direction, scope and timing of activities,
- use a variety of strategies to monitor the progress of the project,
- provide evenly balanced team-based and individual-based assessment items,
- use a number of minor reports throughout the semester as summative assessment items, and
- use a fair method to distribute individual marks from a team mark.

Next step in this research would be to implement these favoured strategies and to evaluate the students' actual performance and learning in the blended course.

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