REFLECTION ON TEACHING A POSTGRADUATE, PROJECT-BASED LEARNING COURSE WITH DIVERSE DISCIPLINES

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Abstract

This paper is a teaching reflection on the delivery of the postgraduate, project-based learning (PBL) engineering course (subject) that is common to five Masters of Engineering program at School of Engineering, RMIT. The data was sourced from end-of-semester surveys of the perceptions of students who completed the course between 2017, when we taught the course for the first time, and 2019. The analysis showed substantial improvements in overall satisfaction, percentage of agreement on the project-based learning helping students to work well with peers, and percentage of agreement that students became more able to apply the theories to practice. The mastery in teaching such a course, especially when the students from various disciplines are involved, demands an adaptive teaching approach wherein the instructors or teachers experiment to continuously improve on the shortcomings in subsequent offerings to enhance the students' learning experience. A PBL course that is well-designed, well-supported, well-implemented, and well-taught can engage students by improving their comprehension, helping them to work well with

peers, improving their communication, and assisting them to apply theories to real application or practice.

Keywords

Project-Based Learning, Engineering, Teaching Reflection, Feedback, Diverse Disciplines

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1. Introduction

In recent years, many engineering programs (both at the undergraduate and postgraduate levels) have incorporated PBL activities to introduce students to more real-world engineering environments. It is desirable to involve students in a collaborative and cooperative learning environment to better prepare them for skills demanded in the current workplace (Kitching, 2015). PBL aims to simulate professional conditions by exploring a problem that may be solved in anyways or a project that may be implemented in many ways (Stewart, 2007). PBL adopts constructivist learning theory where students construct their knowledge or skills based on experience through actual or simulated projects (Rosales & Sulaiman, 2016). For students, PBL has many benefits, including improved comprehension, higher motivation, opportunity for critical evaluation of ideas, enhanced communication skills, and improved ability to apply theory to a real application (Stewart, 2007; Larmer and Mergendoller, 2010; Markham, 2011; Wurdinger & Qureshi, 2015). Therefore, PBL as a form of learning is gaining popularity among many engineering programs at universities across the globe. However, the diversity of defining features of PBL (Thomas et al., 1999; Diehl et al., 1999; Marx et al., 1994) along with lack of a universally accepted PBL model has led to a great variety of PBL research and development activities (Thomas, 2000; DeFillippi, 2001; Frank et al., 2003; Bell 2010).

1.1 Objectives and Scope of the Study

Although there is a relationship between deep learning and PBL, it is still unclear why some students struggle to learn in this style of learning (Lang, 2018). One of the defining features of PBL projects is that they are focused on questions or problems that "drive" students to encounter the central concepts and principles of a discipline (Thomas, 2000). Therefore, teaching a PBL course that is common to several disciplines is a challenge. This paper is a teaching reflection on the delivery of postgraduate, project-based learning (PBL) engineering course that is common to five different masters engineering programs at the School of Engineering, RMIT. It gives an account of the challenges in teaching project-based learning courses with diverse disciplines and lessons

learned during the process. Reflecting on teaching practices on a PBL course that has students from diverse disciplines will complement and supplement the knowledge in this area.

2. Method

2.1 PBL Course Context

This paper discusses the teaching reflection of PBL a course titled 'OENG1118 Sustainable Engineering Practice and Design' in the School of Engineering, RMIT University. This course, which runs in semester 1, is a common core course of an integrated Master of Engineering program that includes five different disciplines—civil, environmental, mechanical, robotics and mechatronics, transport, and logistics). The main objective of this new suite of integrated Master of Engineering programs is to develop high-level knowledge and skills in engineering that will enhance participants' ability to successfully practice as engineers. The majority of the students are full fee-paying, international, postgraduate students. OENG1118 was introduced in 2016, and we began co-teaching this course from 2017. Different teaching modes and contact hours were experimented with and adapted in the past three years (2017-2019) as follow:

1. In 2017, the course was taught in block mode in every alternating week for six teaching weeks with four hours of teaching in each allocated week. Each four-hour class involved lectures followed up by clarification of queries on project work (feedback). No separate hours were allocated for feedback sessions. Self-directed learning hours were 84 in total. The assessment task of this course was combined with another common course, 'OENG1116 Modelling and Simulation', of the integrated Master of Engineering program. OENG1116 also ran in block mode in every alternating week.

2. In 2018, the block mode teaching and combination of assessment task with OENG1116 was discarded. The course was instead taught each week (for 12 weeks), which included a two-hour lecture that was immediately followed by a one-hour dedicated feedback session and another one-hour dedicated feedback session on the next day. Both teachers and one tutor were present in the feedback sessions. Self-directed learning hours were 84 in total.

3. In 2019, the course was taught each week (for 12 weeks), which included a two-hour lecture and three one-hour feedback sessions on a separate day. These feedback sessions were conducted back-to-back but in different class locations. Only teachers were present in the feedback session. Self-directed learning hours were 84 in total.

In the OENG1118 PBL course, students were instructed to work in a group, choose any product or project, and investigate processes or measures that will improve the sustainability of the product or project. Regardless of their specific disciplines, students were able to contribute to this task. This task was conceived as a simulation practice of real-world problems in an industry setting (i.e. we as the client and students as the designers or consultants). Because students came from different disciplines with varied background knowledge and skills, we allowed the students to choose groups by themselves and imposed no restrictions on the composition of the group (i.e. students from different disciplines could form a group; they didn't have to be in the same discipline).

Students applied concepts of whole-of-life engineering design and learned to integrate the elements of sustainable engineering practice. Students examined the impact of materials and processes used in engineering applications by performing community-impact assessments, social impact assessments, life-cycle assessments and life-cycle costs of some typical engineering systems. The major assignment tasks were to create a draft report that demonstrated the application of the weekly skills to their chosen product's life cycle by week five followed up with final report that demonstrated the application of all the weekly skills to their chosen product's life cycle. Students were strongly advised to ensure that the application of each skill is communicated. In 2019, we also requested students to include a table of their responses to all the feedback comments on their draft report when submitting their final report.

The lectures guided students through important principles and concepts and assisted inappropriate problem-solving techniques. The feedback sessions helped students to connect theory to practice, and reinforce the principles and concepts learnt in the lectures. The lectures, feedback sessions, and assessment tasks helped students learn many useful techniques for engineering activities, including skills in interacting with staff and fellow students in a smaller group setting, communication, and leadership.

2.2. The Measures

In this study, we collected the perceptions of cohorts of OENG1118 students in three consecutive years—2017-2019 through questionnaire surveys. We also asked the students to provide written responses about aspects of the course the student liked and aspects that needed improvements. Questionnaire surveys included five specific questions about students' perceptions of problem-based learning and overall satisfaction were completed during the normal course

experience survey at the end of semester one. The questions were measured in Likert Scale (1 to 5: Strongly Disagree to Strongly Agree). The first two statements examined students' perceptions of whether this PBL course led the students to learn new skills and whether the lecturing style in this PBL course contributed to their learning, as follows:

- *"I am learning a lot of new skills in this course."*

- *"The lectures I attended contributed greatly to my learning in this course."*

The next two statements captured whether students were able to apply theories that were covered in the class to their project and whether their experience in PBL will help them to work well with peers in future, as follows:

- *"I understand how to take theories explored in the course (through readings, lectures and discussions) and apply these principles in my practice."*

- *"My experience with project-based learning in this course will help me work well with peers in the future."*

Finally, the last question measured students' overall satisfaction as follow:

- *Overall, I am satisfied with the quality of this course*

We acknowledge that the five statements may not fully capture the effectiveness of a PBL environment to meet the expectations of the students with diverse knowledge backgrounds. However, the results from this teaching reflection will provide some evidence for course coordinators to better design such complex, postgraduate, PBL courses to enhance the students' learning experience and increase satisfaction. Quantitative data analysis was limited to overall percentage agreement, distribution of responses and percentage increase across three years period. The written responses were summarized based on thematic analysis.
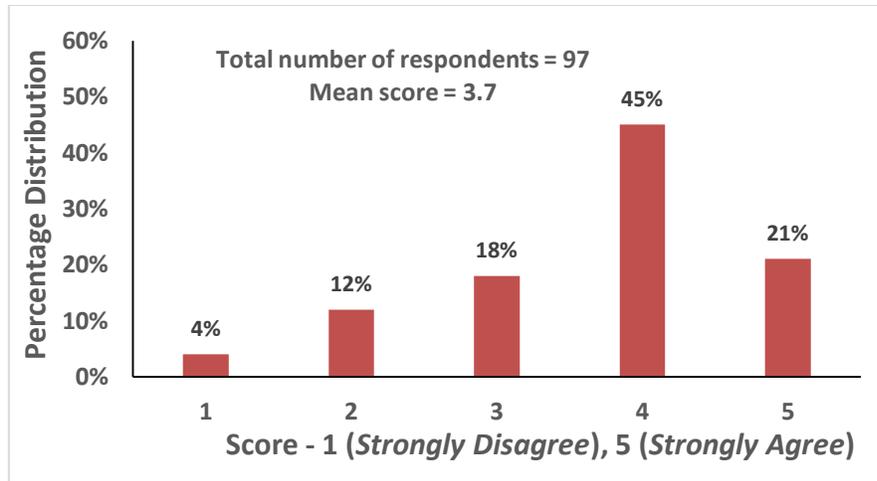
3. Results

The results from the survey for three years are shown in Table 1. Figure 1 shows the distribution of the responses for "My experience with project-based learning in this course will help me work well with peers in the future." Table 1 shows the percentage of students who agreed with the statements. We had a total of 136 students with 69 respondents (50.73% response rate) in 2017, a total of 163 students with 58 respondents (35.58% response rate) in 2018, and a total of 104 students with 51 respondents (49.03% response rate) in 2019.

Table 1: *Results of Student Course Experience Surveys of the OENG1118 PBL Course from 2017-2019*

Statements	2017	2018	2019	Percentage increase
	% agree	% agree	% agree	
1. I am learning a lot of new skills in this course.	62	69	72	16.1%
2. The lectures I attended contributed greatly to my learning in this course	57	59	75	31.7%
3. I understand how to take theories explored in the course (through readings, lectures and discussions) and apply these principles in my practice	61	65	78	27.8%
4. My experience with project-based learning in this course will help me work well with peers in the future.	65	66	84	29.2%
5. Overall, I am satisfied with the quality of this course	49	55	73	48.9%
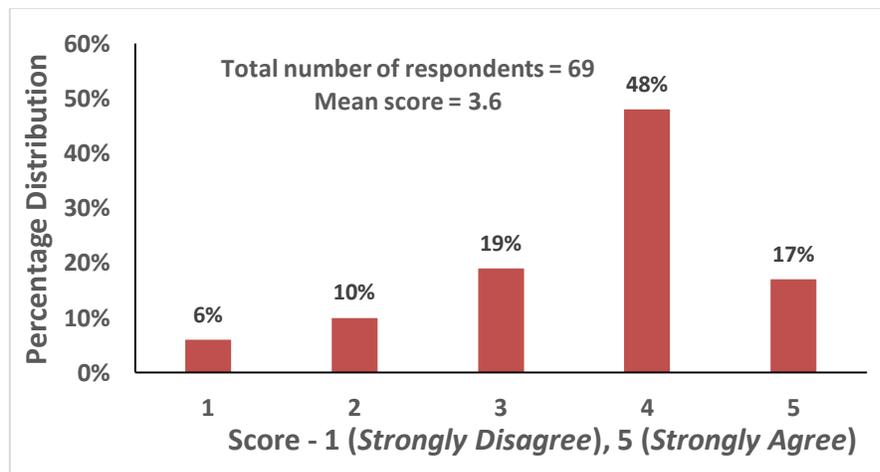
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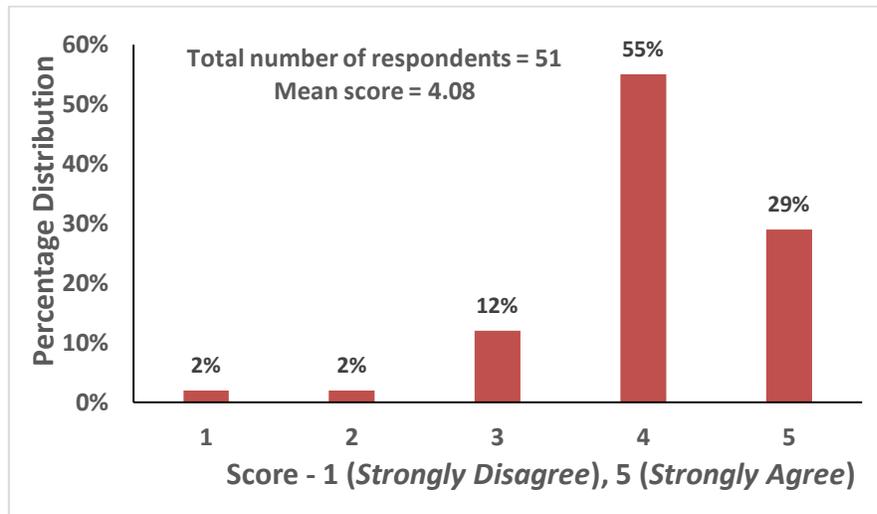
(c)

Figure 1: *Distribution of Responses for "My Experience with Project-Based Learning in this Course will Help me Work Well with Peers in the Future" – (a) 2017 (b) 2018 and (c) 2019*

One of the key observations that are apparent from Table 1 is the continuous improvement in students' satisfaction over the three years along with substantial improvements in the percentage of agreement on project-based learning helping students to work well with peers and to be able to apply the theories into practice. As a result, there has been 48.9% positive increase in students' satisfaction in 2019 as compared to 2017. The distribution of students' responses in Figure 1 shows that on average, students perceive that experience with PBL will help them to work well with peers in the future. This perception has substantially increased in 2019 as compared to 2017.

Further, we examined the written responses about aspects of the course the student liked and aspects that needed improvement. Based on that feedback, we made improvements in the subsequent offering, summarized as follows:

3.1. Feedback in 2017:

Things students liked: Course content; examples; explanations; real-world projects.

Things students stated need improvements: 4-hour evening classes are too long; too-few classes meant limited opportunities to interact with teaching staff; the shared project with OENG1116 is confusing/problematic; imbalance of students' contributions to group projects; an unclear link between the course content and the assessment tasks.

3.2. Feedback in 2018:

Improvements that we made based on 2017 feedback: Offered weekly, 2-hour, day-time lectures plus feedback sessions; separate project work of OENG1118 and OENG1116; changed assessment tasks to align entirely with OENG1118 content; allowed students to form their groups.

Things students liked: Clear explanations in lectures; a practical value of the content; sufficient learning materials; group discussions that support learning and networking; meeting other students; sufficient assistance provided in feedback sessions.

Things students stated need improvements: Unclear assessment requirements; few practical/industry examples; no access to slides before the lecture; no worked examples in the feedback sessions.

3.3 Feedback in 2019:

Improvements that we made based on 2018 feedback: Clarified assessment requirements; provided more-detailed feedback on project reports; emphasised the practical use of the content; presented additional practical/industry examples; presented worked examples in the feedback sessions if requested; shared slides before the lecture; went through assessment documents and learning materials in the feedback sessions.

Things students liked: Course content/topics, although new to students, are interesting, important, and relevant; online resources and tools provided are useful; recorded lectures allow students to revisit the event.

Things students stated need improvements: Too much weight on group assessment tasks, for which some groups had unbalanced contribution and commitment.

Through the students' written feedback, it can be observed that students appreciated the value of PBL and the course content, as evidenced by the use of keywords like "course contents", "real-world projects", and "practical value" under the item "Things students liked". The majority of the feedback was about the lecture hours, clarity on the assignment tasks, feedback sessions, etc. rather than the inherent nature of the PBL as a form of learning. In the next section, we discuss the relevance of these results in planning and teaching a postgraduate, PBL course.

4. Discussions and Conclusions

PBL is relatively challenging to plan and enact. The mastery in teaching such a course, especially when the students from various disciplines are involved, demands an adaptive teaching approach wherein the instructors or teachers experiment to continuously improve on the shortcomings in the subsequent offerings to enhance the students' learning experience. This was evident when we undertook the teaching role for the postgraduate course 'OENG1118 Sustainable Engineering Practice and Design', which had students from five different engineering disciplines. We shifted away from long-hour block mode teaching to short-hour lectures accompanied by dedicated feedback sessions for additional, personalized, face-to-face interactions with the students. We continuously developed our project brief; increasingly related the course content and weekly skills to the project tasks; and increasingly demonstrated relevant, real, practical applications. As a result, as shown in Table 1 (and the written feedback from students in section 3), we have been able to achieve greater student satisfaction, and increase the students' confidence to apply the theories to practice and work well with peers. During this process, we learned that some fundamental aspects need attention to teaching PBL courses, as described in the following paragraphs.

First, running a PBL course in block mode or combining assignments with other complementary courses may not work well, as found in this study. In particular, long teaching hours (4 hours) and self-directed learning with limited opportunities for students to interact with teaching staff are detrimental to PBL learning. This is evidenced by the low percentage of satisfaction in 2017, shown in Table 1 (and also the written feedback from students) when the course was taught in block mode. It is desirable to have short teaching hours (around 2 hours) to convey relevant theories to guide students through the project followed by more hours allocated to the feedback sessions where students group can interact face-to-face with teachers as they develop their ideas and

products. Also, in feedback sessions, students' groups can critique one another's work, referring to rubrics and examples, which is very important in PBL.

Second, it is critical to clarify the assessment requirements, and how the weekly skills relate to the assessment (project) and in real-world practice. Clarifying and re-emphasizing the weekly skills that students learn in a particular week in the lecture followed by a clear explanation of the application of the skills to the assessment task would, to some extent, remove the ambiguity of the open-ended nature of PBL. Further, how these skills will be assessed should be specified in detail in the marking rubrics for the assessment task. This action is very important as we observed that the majority of international students were not familiar with the PBL style of learning; and therefore, re-emphasizing the PBL teaching philosophy, learning outcomes, and assessment task requirements each week is critical. Also, we observed that providing detailed feedback and opportunity for revision during a project makes PBL attractive to students. We noticed that the students revised their project reports to superior quality by addressing the detailed feedback provided at various stages of the project. Through this process, students learn that creating high-quality products or performances do not result from a first attempt and that a revision is an important step of real-world application.

Third, the formation of groups to work in the PBL course is challenging. We found that students had more-positive experiences when they self-selected their group members than when we allocating them to groups. Sufficient time can be allocated (15 to 20 minutes) during initial lecturers (weeks 1 and 2) for the students to select group members. If some students are struggling to form a group, teachers can facilitate the formation of the group by allocating them to small groups. During the project, some groups may develop an unbalanced contribution and commitment to the project, affecting the engagement of the other sincere students. Therefore, tools like "SparkPLUS" (Willey and Gardner, 2010) may be used to enable students to conduct peer assessments of group members. When students know that their group mark will be individualised by redistributing the average group mark according to their contributions, sincere students have an incentive to maintain high engagement in the project.

Fourth, the underlying basics of traditional learning and teaching are also very important. Basics include course structure and contents, course learning outcomes, assignments tasks, marking rubrics, and feedback on assignments being clear to the student. Recording of lectures, relevant

online project videos, lively discussions, guest speakers from industry, etc. are also valued by the students.

This study has some limitations. We only examined the five statements that may not fully capture the effectiveness of a PBL environment to meet the expectations of the students with diverse knowledge backgrounds. In the future, more questions capturing students' demographic variables, comprehension, motivation, opportunity for critical evaluation of ideas, enhanced communication skills, and the ability to apply theory to a real application would provide more insights on the effectiveness of PBL. That would also enable us to conduct detailed statistical analysis which we could not conduct in the present study due to the limitation of the data availability. A rigorous statistical analysis including students' demographic variables such as age, gender, work experiences would increase the robustness of the results.

In conclusion, a PBL course that is well-designed, well-supported, well-implemented, and well-taught can engage students by improving their comprehension, helping them to work well with peers, improving their communication, and assisting them to apply theories to real application or practice.

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