Problem-based Learning in Facilities Planning: A Pilot Implementation

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ABSTRACT: In Universiti Teknologi Malaysia, Problem Based Learning (PBL) is proposed as an alternative to lectures in moulding engineering graduates to acquire attributes that are required to excel in today's k-economy. To investigate if PBL is viable for undergraduates in the Faculty of Mechanical Engineering, a pilot implementation of PBL in Facilities Planning, a subject required for final year Mechanical Engineering undergraduates with specialization in Industrial Engineering was executed. With 60 students in the class, the whole syllabus of the subject was covered using three main PBL problems. PBL was conducted with the help of industrial partners: a semiconductor company, and a furniture factory. The outcome of the implementation was highly encouraging. Students were able to illustrate good understanding of the content, while progressively exhibiting maturity in their generic skills, such as communication, team-working, self-directed learning and problem-solving. However, several aspects of the execution can be further improved.

INTRODUCTION

The shift from elite to mass education, together with a growing emphasis on contribution to graduate employability, are among the major challenges faced by higher education institutions. To cope with these challenges, more and more universities foster the implementation of more student-centered and competencies driven curriculum. Problem-Based Learning (PBL) is among of the well known approaches inspiring these changes.

Within PBL environments, students work on unstructured realistic problems that do not usually have a single right answer. Students work in teams to understand and solve problems, while at the same time, conduct self-directed learning on contents that are the intended learning outcomes. One of the aims in implementing PBL is to better prepare students for professional practice by shifting the focus of education from teaching to learning. PBL can also be used to develop teamwork and communication skills. However, students cannot be expected to develop these skills automatically; through the learning environment and effective facilitation, students are encouraged and guided to develop the necessary skills and attitude [1,2].

In Universiti Teknologi Malaysia (UTM), PBL is one of the active learning techniques that were recommended to be adopted by lecturers. As such, several lecturers from each faculty were trained in a series of workshops conducted by outside experts.

In the second semester of the 2004/05 academic year, the Faculty of Mechanical Engineering at Universiti Teknologi Malaysia implemented a newly developed PBL curriculum for Facilities Planning, a subject required for final year undergraduates with specialization in Industrial Engineering. This was the first attempt on implementing PBL fully for this course; in the previous semester, the course was taught using a hybrid of co-operative learning and lectures.

This paper provides details of the execution, and the challenges faced during the PBL implementation. Improvements that can be made in future implementations will also be highlighted.

PROBLEM-BASED LEARNING (PBL)

In PBL, learning is initiated through a realistic problem that has engaged the learner to find a solution [2, 3]. Students collaborate in small teams to identify, find and construct knowledge on new concepts that they need to learn in order to solve the problem. Among the many benefits of PBL on students are [2]:

- Critical thinking, analysis and synthesis to identify and solve complex problems
- Information mining to find, evaluate and use suitable learning resources
- Cooperatively work in a team
- Effectively communicate in verbal and written form
- Self-confidence and self-worth
- Continual and independent learning

PBL is characterised by the following features [3,4]:

a. A realistic problem, which captures the students' interest, is the starting point of learning
b. The problem challenges students' existing knowledge, attitudes and competencies, leading them to identify new knowledge (or learning issues) needed, and shortcomings that need to be corrected.

c. The responsibility and direction of learning is assumed by the students; faculty members are only there to facilitate students' thinking, learning and group functioning to help them resolve the problem.
d. Information mining from various sources, and utilization of evaluation to analyse what is really useful.
e. The process of identifying learning issues and problem-solving is as important as acquiring new knowledge to arrive at the solution.
d. Students learn in cooperative teams, where they need to interact and communicate to share knowledge, discuss their understanding and debate conflicting opinions.
e. Synthesis of various knowledge and information to arrive at the solution.
f. Reflection of the students' learning experience.

Figure 1 shows the complete cycle of a PBL process [5]. This framework is modified from [4]. The whole process can be divided into 6 main stages.

Meet the problem. The students read the problem scenario, reflect and articulate probable issues individually. They are encouraged to do background reading on the possible learning issues.

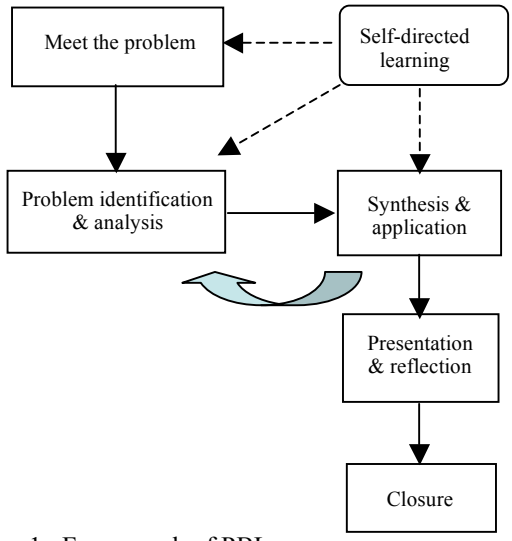

Figure 1. Framework of PBL process

Problem identification and analysis. The teams reach a consensus on the problem statement. They analyse the problem through brainstorming to generate ideas. At this stage, they also identify appropriate existing knowledge and the learning issues that must be tackled through self-directed learning. Facilitators guide the students so that they are on the right track checking and questioning the learning issues identified.

Synthesis and application. Students report their discovery from research and self-directed learning to their own teams. Information is shared and critically reviewed so that the relevant ones can be synthesized and applied to solve the problem. Facilitators at this stage must ensure that the coverage of the problem is sufficient, and probes students on accuracy and validity of the information obtained. This can be an iterative process, where students may need to re-evaluate the analysis of the problem, pursue further learning, reporting and peer teaching.

Solution presentation and reflection. The solution to the problem is presented to the class, followed by more probing questions by the facilitator to ensure deeper learning. Students are asked to reflect on the content as well as the process.

Closure. The facilitator integrates various knowledge learnt from solving the problem and encourages students to give their opinion on the value and usefulness for future learning and application to the work place. The facilitator also summarizes crucial principles and concepts, as well as eliminates any doubts that arise from the students.

BACKGROUND ON IMPLEMENTATION

In the Faculty of Mechanical Engineering, SMI 5843 - Facilities Planning course was chosen to implement fully PBL approach. The choice was simply because of the readiness of the lecturer who had undergone a series of PBL training on PBL.

There were 60 students registered for the class. There are 14 weeks in a semester. The class sessions were conducted for a period of 2 hours, twice a week. A proper classroom setting was used so that group discussions can be held comfortably.

12 heterogeneous groups were formed based on race, gender, learning styles based on the index of learning styles by Felder and Silvermann, and their academic result. Each team consists of 5 students selected by the lecturer based on the criteria given earlier. The first week of the class was an induction on PBL and an ice-breaking session for the groups. Pre-course notes on PBL were given and the groups had to discuss and present their understanding on PBL – the what, why, dos and don'ts in PBL. At the end of the first week the groups came out with the group's rules and regulations. The lecturer also explained what is expected from the course, and the class rules and regulations.

INDUSTRIAL COLLABORATION

Before the semester started, two companies were contacted to assist the students in their learning process. One is a multinational company producing semiconductor and the other one is the largest furniture company in the southern part of Peninsula Malaysia.

The students planned and arranged the plant visits, first, to the semiconductor company. The objectives of this visit were, (1) to have an overview of the role of an industrial engineer as a facilities planner, (2) to develop better relationships among group members. The factory visit was made on the second week of the semester. During the visit, the head of the Industrial Engineering Department briefed students on the role of an industrial engineer, particularly as a facilities planner. During the plant tour, a team of industrial engineers demonstrated some of the facilities related projects and how they were conducted, and stressed on the importance of working as a team. The company and the engineers were very supportive and encouraged the students to contact them if they have any questions later.

The second industrial visit, this time to the furniture factory, was made on the fourth week of the semester. The visit was also organized by the students. The objective of this visit was to understand the process of making furniture since all the PBL problems set up for the course were based on the furniture industry. The owner of the company was very supportive in allowing students to revisit the company at any time, letting the factory be used as the case study and allowing his personnel to provide any information needed at any time, provided that they ask permission first.

INFUSING PBL IN THE SYLLABUS

Altogether there were 3 main problems designed to cover the whole course. Each problem consists of 3 sub problems. The sub problem was given in progress by following the syllabus. The problems were designed to fulfil all the content learning outcomes expected form the course. The learning outcomes for each chapter were established and the sub problems were used to achieve the desired outcome. Tutorials were also provided around a week before the problems were due as a guide for the students to ensure full coverage of their solution to the problem. Table 1 illustrates a portion of the course planning. Table 2 shows the timeline of the problems, tutorials, tests and presentations for the whole course. Apart from these, pop quizzes, pop questions and 2 minutes individual presentations were done along the way to ensure students readiness and understanding. A check list listing individual contribution and participation was kept.

Table 1: Expected content learning outcomes from the problems and schedule.

Topic	Learning Outcome	Problem Given	Date Given	Due Date
		Problem 1		21/12
Facilities Location	a. Use quantitative and qualitative approaches to solve problems in facilities location.	case 1A	2/12	
	b. Logically quantify the qualitative data and combine both types of data to evaluate site selection.	case 1A		
	c. Analyse the single and multiple location problems for optimal solutions.	case 1B	9/12	
	d. Apply contour analysis method to relocate the near optimum solution and demonstrate the understanding of its concept	case 1C	16/12	
		Tutorial 1	18/12	21/12
		Presentation		23/12

Table 2: Timeline for PBL Implementation

2 Dec	**Problem 1** given (case 1A)
9 Dec	Case 1B given
16 Dec	Case 1C given
18 Dec	Tutorial 1 given
21 Dec	Problem 1 and tutorial 1 due
23 Dec	Problem 1 present
23 Dec	**Problem 2** given (case 2A)
30 Dec	Case 2B and 2C given
18 Jan, 05	Tutorial 2 given Problem 2A,2B and tutorial 2 due
25 Jan	**Problem 3** given (case 3A)
25 Jan	Problem 2A and 2B present
27 Jan	Test 1
1 Feb	Case 3B given
1 Feb	Tutorial 3 given
3 Feb	Problem 3A ,3B and tutorial 3 due
15 Feb	Problem 3 present
17 Feb	Test 2
24 Feb	Tutorial 4 given
24 Feb	Case 2C and tutorial 4 due
1 March	Case 2C present
3 March	Final

RESULTS AND ANALYSIS

Figure 2 shows the comparison of results when PBL was conducted with results of the same course from the previous 2 semesters, which were also taught by the same lecturer. The graph clearly shows that students who had undergone PBL (60 students) achieved better result as compared to using lectures (31 students) and a hybrid of CL and lectures (30 students). Although the number of students doubled from the last 2 semesters, the result shown that they performed better by using the PBL approach in learning.

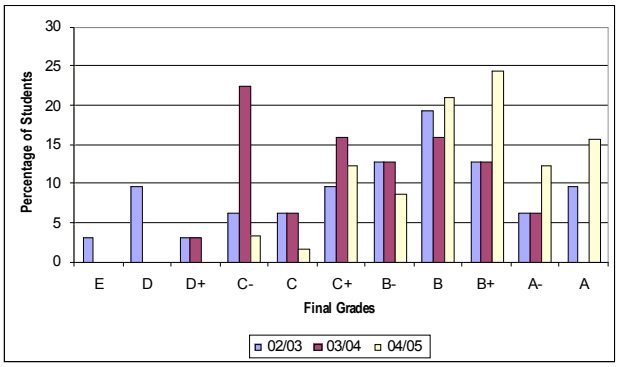

Figure 2: Comparison of Results

With regard to assessments, final examinations for all semesters were 40% as required by the Malaysian Engineering Accreditation Council. There were slight differenced of distributing another 60% marks for the course work for all the 3 semesters. This is as shown in Table 3.

One of the main reasons for implementing PBL is to enhance the generic skills of students, such as communication skills, team-working, self-directed learning and problem solving. Throughout the implementation these values were nurtured. At the end of the semester a questionnaire was distributed with regard to the values. Figure 3 shows the result of the survey. Among all the generic skills, team-working achieved the highest rating. More than 90% of the students agreed or strongly agreed that PBL promotes team-working skills. For the rest of the

generic skills, which are problem-solving, self-directed learning and communication skills, almost 70% of the students agreed or strongly agreed that PBL enhances those skills. Less than 7% disagreed that PBL helped them to develop problem-solving, self-directed learning and communication skills.

Table 3: Course Work Marks Distribution

Semester	Tutorial /Quiz	Test	Projects
2002/03	3 (10%)	2 (20% each)	1 (10%)
2003/04	3 (10%)	2 (15% each)	2 (10% each)
2004/05	4 (10%)	2 (10% each)	3 (10% each)

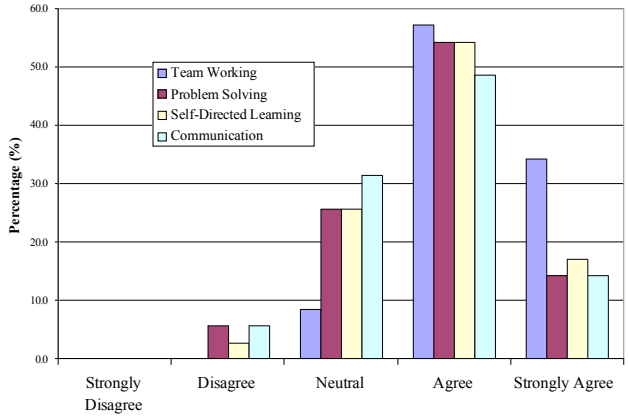

Figure 3: Survey of generic skills on students at the end of semester

CONCLUSION AND RECOMMENDATIONS

PBL is a challenge, not only to students, but also to lecturers. Those who do not understand will think that those who implement PBL are not doing their work as lecturers, though the time spent for the course could be triple of the traditional lecture-based approach. Similarly, students new to PBL might think that the lecturer is making their life difficult by asking them to do what they do not know. Why make things more difficult than it should be and just teach them everything that you know.

The benefit of using PBL may not reach the desired outcomes if the lecturer failed to follow the right methods, such as students' role rotation, individual commitment, continuous motivation, continuous facilitation and assessment. Students' reflections and log books must be read and should always be taken into account in the PBL implementation. Getting the industries involved, the right class setting, proper time-tabling, enough references are some of the other factors that also must be considered for a successful implementation of PBL.

REFERENCES

1. Woods, D. R., *Problem-based Learning: Helping Your Students Gain Most from PBL*, 3rd Edition (1996).
2. Duch, B. J., Groh, S. E. and Allen, D. E. *The Power of Problem-based Learning*, Stylus Publishing, Virginia, USA (2001).
3. Boud, D. and Feletti G. *The Challenge of Problem-Based Learning*. New York: St. Martins' Press (1997).
4. Tan, O. S., *Problem-Based Learning Innovation: Using Problems to Power Learning in the 21st Century,* Thomson Learning, Singapore (2003).
5. Khairiyah MY, Azila AA, Mohd. Kamaruddin AH, Syed Ahmad Helmi, Mimi HH and Azila NMA, "Problem-based Learning in Engineering Education: A Viable Alternative for Shaping Graduates for the 21st Century?", Conference on Engineering Education, Kuala Lumpur (2004).