The Implementation of PBL in Physics for Engineering Technology Courses: A case study for Faculty Of Engineering Technology, Universiti Teknikal Malaysia.

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Abstract

Outcome- based Education is essential for engineering faculties today and Problem Based Learning is one of the elements under its umbrella. Problem based learning is a recent phenomenon in Asian region. Problem based learning is the cognitive sciences on how we learn which can improve learning skills. The strategies of the problem-based learning include students identifying and analysing the problem and later arriving to the solutions. Hence, the idea of the problems should come first before answers drives PBL. It consists of Cooperative and problem solving techniques which are the part and parcel of this learning. In terms of the role of lecturer, he or she acts as a facilitator. Given such benefit, Faculty of Engineering Technologies of UTeM strives to implement the Outcome-based education in its courses. This paper discusses the plan for the implementation of Problem based learning for Technical Physics for first year students. It covers the strategies in using PBL in the classroom. This paper focuses on the pedagogical methods used in teaching Physics for the students. The respondents consist of 43, first year, students who are majoring in Bachelor of Engineering Technologies (Industrial Electronics).. They have been exposed to cooperative learning prior to this study. This study adapts several researchers' approach and seeks to identify, analyse, and address teamwork values that first year under graduate students experience when learning technical physics and solving the problem We expect positive outcomes related to students' teamwork values which include the collaborative skills, engagement and motivation, higher order thinking and problem solving skills

Keywords: Problem Based Learning, Cooperative Learning, Engineering Technologies, Communication; Groupwork;

1. Introduction

Nowadays the technologies change rapidly. Hence, the changing technologies require students especially in engineering and technologies engineering program to develop long life learning and self-learning skills, which are essential elements of an ongoing ability to respond to advances in technologies(Eduardo Montero, May 2009). The industry demands and expects a wide range of these generic skills from engineers, in addition to a high degree of technical competence (R.A Buonopane, 1997). Hence, Problem-based learning (PBL) approach is the new method in teaching and learning sphere which helps student to fulfill the requirements of industries. The Problem –based learning has gained a world-wide interest as an innovative technique that engage learners for deep learning, and develop a multitude of crucial professional skills, especially self-directed learning and problem solving (J.Stoble, 2007). These skills are essential in graduates for this era. In engineering and engineering technologies, PBL develops and promotes deep learning, thinking and problem solving skills which are required by industries. These generic skills promote positive attitude among students who have gone through

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the PBL environment (J.J Dudertant, 2008;B.J Dutch, 1999). Given the benefit of the PBL method, this paper focuses on an implementation of PBL in Technical Physics for the first year student for Bachelor Of Engineering Technology (Industrial Engineering) of UTeM.

2. Engineering Technologies in UTeM.

The Faculty of Engineering was established on 10 June 2011, located at the Industrial Campus, Ayer Keroh, Melaka. The engineering technologies differs from the pure technologies. The engineering technologies produce graduates who are dedicated to the growth and implementation of prevailing technology within a field of engineering. Engineering technology education is more applied than the more theoretical science based engineering degree education. Technologists collaborate with engineers in various projects by applying basic engineering principles and technical skills. The work of technologists consists of the technological range like product expansion, manufacturing, construction, and engineering operational tasks. However for pure engineering, students are more focused on research and design. As industries are more application-oriented realm, PBL is seen as one of the most important methods that can trigger the skills required by industries.

3. Problem Based Learning.

Problem-based learning (PBL) is an interactive instructional approach and has attracted much interest since its administration at McMaster University overfour decades ago (R.Polaco, P .Calderon and F. Delgado.1999). It has gained prominence as a way of instruction in a wide variety of disciplines including medicine, engineering,and education among others (Edens, 2000; Edwardsand Hammer, 2004; Eldredge, 2004; Fink, Enemark,and Moesby, 2002; Jones, 2006; Kwan, 2000; Saarinen-Rahiika and Binkley, 1998; Sahin, 2009, in press; Selcukand Sahin, 2008; Stonyer and Marshall, 2002). PBL wasnot a popular mode of instruction in physics until last decade or so (Duch, 1995, 1996; Raine and Collett,2003; Sahin, 2007; Sahin and Yörek, 2009).The history of PBL and its definitions are covered in detail by Gijbels et al. (2005) and by Prince (2004) amongst others. The key characteristic of PBL, according to Gijbels et al. (2005) is posing a 'complex problem' to students to initiate the learning process. Torp and Sage (2002) stated that PBL is a focused, experiential learning structured around the investigation and tenacity of chaotic, real-world problems. Students are engaged problem-solvers who identify the root problem and the conditions needed to discover a solution. As a result, they become independent and self-directed learners. PBL is implemented in a small group tutorial in which students work through scenarios which provide the context for learning; involve ill-structured, interesting, open-ended, and real-life problems to motivate students and stimulate discussion (Levin,2001). In this approach, learning is more student centered ,and less teacher-directed. Self-directed and team learning are two key features of PBL (Creedy and Hand, 1995; AngeloT.A, 1995).

4. The steps of Problem Based Learning (PBL)

PBL, which has constructivist underpinnings, is a philosophy that needs to be adapted to the specific condition and environment of the institution and the nature of the field in which it is applied. This can be seen in the different models of PBL implementation throughout the world. The typical PBL cycle, as shown in Fig. 1 (Khairiyah Md Yusof,2010;Ahmad Hadi Ali,2007) basically consists of

- Phase 1: problem restatement and identification,
- Phase 2: peer teaching, synthesis of information and solution formulation.
- Phase 3: generalization, closure and reflection.

Problem Based Learning (PBL) follows a simple cycle. The role of the tutor shifts with each stage of cycle. The tutor must dictate the stages of the Problem-based learning to learners. Walsh (2005) identifies steps which have been implemented by many researchers. The steps are as follows:-

1. Identify the problem
2. Explore the pre-existing knowledge
3. Generate hypothesis and possible mechanisms
4. Identify learning issues
5. Self study
6. Re-evaluation and application of new knowledge to the problem
7. Assessment and reflection of learning

In this study, the Problem based learning (PBL) is introduced to the first year students. The first year's curricular was chosen because it has been recognized as significant opportunities for improvement in four year curricular and various institutions have been used the opportunity in different ways. Duffy and Cunnigham , and Weiss discussed them as driving force for learning in which they:

- Deliver the intended learning outcomes.
- Assess learning process and the achievement of learning outcomes.
- Provide context of learning as well as professionals practices
- Stimulate and train thinking skills.
- Cater for teaching and learning activities.

In PBL, unstructured problems are used as the starting point of learning, developing deep interest among students to gain new knowledge and integrate current ones, and driving them to think critically and creatively to find the solution to the problem (D.R. Woods,1996,200;D.Boud and G.Felleti,1997, O.S Tan,2003). The strength of PBL in shaping attitudes as well as creating interest and excitement on learning otherwise dry content, and motivating students to cultivate interdependence in learning, thinking and problem solving together in theirs teams teams and among teams.(Khairiyah Md Yusof, 2010).

5. Implementing PBL for Technical Physics (BTNH 1213).

In this study, lecturers need to prepare the models and problem for the PBL. The stimulus is designed to guide the students on what they need to study and discuss among their group. The lecturers also prepare many resources like books, journals and other source like internet . Lecturing the physics to engineering technologist is a challenging task as the students have to solve the current problem which reflects the real world task. The solution to the problem requires knowledge of basic engineering concepts which the students need to master. In PBL, the students develop the communication skills to engender team work and critical thinking skills to solve the problem. The development of knowledge is a process in which students encounter complex questions, comprehend problem, conduct original investigation and filter information through their social and cultural context. Experience an ideologies are essential elements in PBL. Learning from experience and practicing ideologies are keys to complete their mission successfully (Ahmad Hadi Ali,2007)
This study sought to answer the following research questions:
i).Is there any change in the affective outcomes of undergraduate students with respects to teamwork values before and after the problem based learning intervention?
ii). Can the students solve the problem collaboratively within the allocated time ?
iii). Can the students apply prior study in discussing effectively in groups in order to solve problem?
iv). How does the use of peer evaluation help in assessing group's teamwork values?
The present paper was shaped by the social development theory of Lev Vygotsky (1978).

6. Vygotsky's Social Development Theory

Lev Vygotsky (1896-1934) was famous for his Social Development Theory which is one of the foundations of constructivism. It emphasises three main themes:

Themes:

1. Social interaction plays a vital role in the cognitive development process. Social learning precedes development. He states: "Every function in the child's cultural development appears twice: first, on the social level, and later, on the individual level; first, between people (interpsychological) and then inside the child (intrapsychological)." (Vygotsky, 1978).
2. The More Knowledgeable Other (MKO). The MKO refers to anyone who possesses a better understanding or a higher ability level than the learner, with respect to a particular task, process, or concept. The MKO could be coach, teacher or also peers, a younger person, or even computers.
3. The Zone of Proximal Development (ZPD). The ZPD is the distance between a student's ability to perform a task under adult guidance and/or with peer collaboration and the student's ability solving the problem independently. Vygotsky stated that learning occurred in this zone.

Source: Learning theories.com

Hence, Vygotsky concentrated on the links between people and the sociocultural context in which they act and interact in shared experiences (Crawford, 1996). According to Vygotsky, humans use tools that are developed from a culture, such as speech and writing, to mediate their social environments. Initially, children develop these tools to assist solely as social functions, means of communicating their needs. Eventually, the internalization of these tools leads to higher thinking skills.

6.1 Materials And Methods

PBL was conducted after the semester break. 76 students are divided into 3-4 members in a group The duration of this problem was 4 weeks. The tasks include briefing, solving problems, meeting at home, filling the form progress and presenting. The role of lecturer is as a facilitator who is facilitating and scaffolding the process. He/she is also motivating the students during the process.

The design for the study is a survey through questionnaires. The questionnaires were given to a group of 76 students enrolled in a PBL curriculum. The survey was conducted a few weeks during the PBL lesson and after the completion of the PBL curriculum. All students returned the questionnaires. The questionnaire measured students' perceptions of PBL in terms of four skills; Ability to work in group, The PBL method, The PBL tutor and Teaching resources.

A score from 1 to 5 was given for each component, with scores ranging from 1 (strongly disagree) to 5 (strongly agree). The questionnaire is accompanied with rubric to describe each level.

Analysis of data was done using SPSS (version 17.0). Independent sample test was performed to determine whether students' perception of PBL has changed throughout the PBL process. The significance of demographic factors on the changes was assessed through independent sample test.

6.2 Content validity

Content validity of the test was established by reviewing existing literature. Most of the items intended to measure the variables in this study were adopted from previously validated instruments. Hence, the major aspects of the topic were adequately covered by the items included in the test.

6.3 Reliability

Cronbach α's were used to measure the reliability. Alpha coefficients for factors in this study ranged from 0.77 to 0.80. As the values for all of the variables involved are above 0.7, they are accepted as reliable.

6.4 Findings and Discussion

The findings cover the demographic profile and the factors. In addition, the influence of demographic profile on the factors was also determined through t-test.

6.5 Demographic profile

Among 76 students, 100% were young (< 19), Malay Muslim and 65.8% were male and 34.2 % were female. The majority of students come from low social economic status (42.1%) while 26.3% constitutes middle and high class population. Most students were diploma holders (78.9%) while 21.1% came from matriculation colleges. In terms of students' performance, most students (52.6%) acquire 3.0 to 3.4 of CGPA result. All students have not had any previous experience in Problem –based learning environment.

6.6 T-Test results and discussion

Mean marks discrepancy was analysed for students opinion of the pre and post PBL environment. A t-test was conducted to find significant difference. The independent t-test performed on the pre-post survey yielded statistically significant improvement at the $p < .05$ for all the factors. Table 1 shows the t-test result for both the pre and post PBL environment for all the variables; groupwork (gw), motivation (m), tutorial (tu) and teaching resources (tr).

TABLE I: T-TEST SCORE FOR PRE AND POST PBL ENVIRONMENT FOR ALL CATEGORIES

Category	**Pre**		**Post**				
	M	**SD**	**M**	**SD**	**t**	**df**	**Sig (2-tailed)**
Groupwork	3.8	0.47	4.2	0.47	-3.53	74	0.001
Motivation	3.3	0.34	3.5	0.34	-2.88	74	0.005
Tutor	3.6	0.54	4.0	0.50	-3.06	74	0.003
Teaching Resources	3.4	0.54	4.1	0.50	-5.79	74	0.000

In terms of Groupwork, four features out of seven show significant difference; learning issues, independent learning, improvement of physique skills, improvement of communication skills. Students perceived that the learning issues generated in the PBL are the most important starting point for their learning activities. This is in line with a study conducted by Doody (2009). However, this contradicts the result of another question arise from the questionnaire; whether the students can study independently from the learning issues. The score generates high score from students

as well. This issue should be probed further through interview sessions. The students also perceived significant improvement on learning skills. Sadlo and Richardson (2003) stated that the quality of learning is improved through the implementation of PBL in institutions. This is in line with the study of Kay (2000). In terms of communication skills, the present study contradicts Doody's (2009) findings which stated that students did not feel that PBL assist their communication skills. Another two features, group discussion and recommendation of PBL to others do not show any significant difference. However, they retain the high frequency in the mean score. Table II shows the results.

TABLE II: T-TEST SCORE FOR PRE AND POST PBL ENVIRONMENT FOR GROUPWORK CATEGORY

Features	**Pre**		**Post**				
	M	**SD**	**M**	**SD**	**t**	**df**	**Sig (2-tailed)**
Group Discussion	4.2	0.71	4.3	0.52	-0.56	74	6.58
Learning Issues	3.6	0.79	4.2	0.55	-3.71	65.7	0.000
Independent learning	3.5	0.79	4.2	0.54	-4.55	65.2	0.000
Group climate	3.8	0.56	4.1	0.66	-1.69	74	0.095
Improve physique skills	3.6	0.88	4.1	0.65	-2.67	74	0.009
Improve communication skills	4.1	0.67	4.4	0.55	-2.24	74	0.028
Recommend PBL to others	3.8	0.78	4.1	0.73	-1.52	74	0.133

With regards to PBL method, four features show significant difference in improvement; motivation, well-informed, effective, receptive, interest in tutorial and importance of subject. Table III illustrate the details.

TABLE III: T-TEST SCORE FOR PRE AND POST PBL ENVIRONMENT FOR PBL METHOD CATEGORY

Features	**Pre**		**Post**				
	M	**SD**	**M**	**SD**	**t**	**df**	**Sig (2-tailed)**
Motivation	3.8	0.74	4.1	0.63	-1.83	74	0.07
Well-informed	3.4	0.79	3.8	0.94	-1.85	74	0.07
Effective	3.6	0.83	4.1	0.66	-2.77	70.4	0.007
Fun	4.1	0.77	4.2	0.87	-0.28	74	0.78
Receptive	3.4	0.64	3.9	0.88	-2.70	74	0.009
Interest	3.5	0.73	3.9	0.63	-2.70	72.6	0.009
Importance	3.7	0.61	4.0	0.55	-2.38	73.0	0.020

The PBL method which puts emphasis on group discussion and peer collaboration is in line with Vgotsky's (1978) two main themes, MKO and ZPD .

On different notes, the features of PBL tutor show that tutors performed well throughout the session as the significant difference is noted in four out of five features. The facilitator's function is to guide students in their learning. The guidance involves strength in steering the group, adequate intervention, high enthusiasm, use of stimulations. Table IV illustrates the significant features: strong, adequate intervention, enthusiasm and stimulation in learning activities.

TABLE IV: T-TEST SCORE FOR PRE AND POST PBL ENVIRONMENT FOR PBL TUTOR CATEGORY

Features	**Pre**		**Post**				
	M	**SD**	**M**	**SD**	**t**	**df**	**Sig (2-tailed)**
Strong	3.6	0.76	4.0	0.70	-2.67	74	0.009
Adequate intervention	3.6	0.68	3.9	0.61	-2.13	74	0.036
Enthusiasm	3.5	0.60	3.8	0.64	-2.59	74	0.012
Stimulation in using various sources	3.8	0.65	4.1	0.61	-2.006	74	0.049
Stimulation in learning activities	3.7	0.66	4.1	0.63	-2.66	74	0.01

The teaching resources are perceived well by the students as all features show significant improvement; facilities, e-learning environment, duration. The present findings correspond to a study conducted by Doody (2009) and O'Neill,Singh and O'Donoghue (2004) which showed that virtual earning environment was helpful for students.

TABLE V: T-TEST SCORE FOR PRE AND POST PBL ENVIRONMENT FOR TEACHING RESOURCES CATEGORY

Features	**Pre**		**Post**				
	M	**SD**	**M**	**SD**	**t**	**df**	**Sig (2-tailed)**
Facilities	3.5	0.86	4.0	0.49	-3.27	58.9	0.002
e-learning environment	3.4	0.86	4.2	0.68	-4.31	74	0.000
Duration	3.3	0.72	4.0	0.68	-4.75	74	0.000

Additional analysis was conducted to determine the influence of demographic profiles and the main factors. *t*-test was used to analyse the relationship . It revealed that there was no statistically significant difference between them. This is in line with other studies which discovered that students' profiles were not strong indicators of PBL success (Bishop-Clark, 1995; Doody, 2009).

Conclusion

After the 4 week sessions, much significant improvement can be noted based on the t-test result of the first and second survey. Overall, all categories, group work, motivation, tutor and teaching resources show significant difference in which improvement is noted throughout the session. Eventually, the students become more involved in group work, more enthusiastic and independent in their learning through PBL, more independent and motivated under the tutor's facilitation and more positive about the facilities provided in PBL environment.

However, some limitations exist during the study. The interview which was scheduled to be conducted had to be postponed for some technical problems. Hence, some issues in the questionnaires which need more probing cannot be verified. The follow-up study will commence soon. In addition, the students' interaction in *facebook* also need to be taken into account in the future study to provide richer data.

Future studies should observe the tutors' opinion and perceptions on PBL method. Moreover, the comparison of PBL and non-PBL group should be conducted to gauge the similarities and difference. As the present study is studying the use of PBL in Physique classroom, other courses should be included in the future studies.

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