Comparison between "Project-Oriented" Learning and Problem-Based Learning (PBL) in Design Subject

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Abstract:

Problem-based learning (PBL) is getting wide acceptance among the academia in institution of higher learning. PBL is a student centred approached in teaching and learning. "Project Oriented" learning is widely used in teaching design-based courses. On the other hand Problem-Based Learning establish from medical schools. Looking at both approaches in teaching and learning, there seems to be some similarities. This paper describes author's personal experience in teaching design courses by "project-oriented (POL)" or project-based learning at the Faculty of Mechanical Engineering, University Technology Malaysia. The comparisons between these approaches are described. Similarities and differences of both teaching approaches are discussed. The author's experienced in implementing this teaching technique provides some enlightening experience to be shared.

Keywords: problem-based learning; project oriented learning; industrial design; design project; design process

1. Introduction

From Plato's Academy to the modern university, knowledge has been transmitted orally over 2000 years. Although the original Socratic Method required a dialog between teacher and students, the lecture, as it was developed in the medieval university, did not. Originally, lecturing was the only way that knowledge stored in the book could be transmitted to a large number of students; the word "lecture" is derived from the Latin *legere* "to read." Many centuries after the invention of movable type and other significant advances in technology, lectures continue to be the primary mode of instruction in higher education. The reasons for their popularity are not hard to adduce; lectures are cheap, since a single teacher can lecture to an auditorium full of students; they are easily changed and updated; and they are efficient in covering material quickly. Finally, and perhaps most important, the methods is familiar to students and teachers alike, and the roles are clearly define.

However, the traditional lecture method, in which the instructor does all or most of the talking, has a number of drawbacks. Lectures of this sort are based on "learning by listening," which is a disadvantage for students who prefer to learn by reading, or by doing, or by some other method. Although the traditional lecture conveys factual information very well, it is not well suited to the higher levels of learning; critical thinking, analysis, and problem solving must be learned by doing. In traditional lecture class, the student is passive, has little control over the flow of information, and is reduced to playing stenographic role. Moreover, research has shown rather that students frequently forget, or never learn, much of the material taught through lectures.

Looking at this phenomenon, various task forces, professional associations and other groups have recommended educational changes designed to better prepare students to participate fully and productively in today's technology-based workplaces and those of the 21st century. The key skills listed include critical thinking, problem solving, teamwork, verbal and written communication, ability to do research, and lifelong learning. Authority like Ministry of Higher Education (MOHE) has imposed Institution of higher Learning to implement teaching and learning method as mentioned above to be practiced among our local students, MQF (Malaysia Quality Framework under MOHE) and some other bodies like Engineering Accreditation Council (EAC) has made a progress in redefining our teaching and learning approaches in local universities. These organizations also emphasized the need to prepare our students to become successful citizens. A common theme among systemic reform advocates has been that current curriculum and pedagogy often fail to prepare students to use what they have "learned" to solve real problems, which they encounter in the workplace or in a democracy.

Intuitively, teachers know this is true. We know that what we teach in one class is not often transferred to other classes. To meet this concern and help students become more independent and interdependent learners, some faculties have adopted active learning, cooperative learning techniques and developed connections among courses. These strategies do move us along the continuum towards self-directed learning, but there is another step, which better suited to our curriculum and syllabus in design programme: Project-Oriented Learning (POL). Before we go to POL, let us look what is PBL in the first place?

2. What is PBL

Problem-based learning, also known as PBL has its origins in medical education – more specifically in the clinical aspects of medical education. PBL is not new. This educational approach has been used in medical schools for at least 3 decades. In 1969 McMaster University of Health Sciences developed a new medical school curriculum using problem-based learning as its foundation. This new approach was to be used throughout the entire 3-year curriculum. In the early 1980s, other medical schools had adopted a curriculum based on PBL, some as a parallel program for subsets of students, others in specific courses or as an entire curriculum. Not until more recently, however has PBL been embraced by institutions of higher education in areas of education other than health related.

As PBL has been disseminated and adapted to meet specific curriculum needs, it has evolved. Many institutions have design "hybrid" approaches to their curriculum, blending PBL with elements of conventional instructional approaches. However, in spite of the variations in implementation, some elements will always be required to make PBL effective ad true to its intent:

- Learning is student centred. Students are encouraged to become actively engaged in the process and become responsible not only for their own learning.
- Learning occurs in collaborative environments. Students will work in small groups of 5-10 individuals and build teamwork skills as they try to solve the problem together.
- Teacher act as facilitators, called "tutors." Teachers do not lecture to deliver content, but guide students in the process of discovery, inquiry, analysis and reporting.
- Problems are the stimulus for learning and are a vehicle for the development of problem-solving skills. Problems have no single"right" answers; students learn by trying to solve the problem. Ill structured, complex problems provide the focal point(s) and stimuli for the course, curriculum and/or program.

They thus pose situations which learners are likely to be faced with in real life. PBL can be said to be characterised by "carefully selected and designed problems that demand from the learner acquisition of critical knowledge, problem-solving proficiency, self-directed learning strategies, and team participation skills." In a PBL setting, learning is student centred and the teachers tends to act as facilitator and resource guide rather than solely as a provider of knowledge and information.

PBL encourages students to identify their learning needs and determine the resources they will need to use to accomplish their learning. With the independent learning comes considerable collaboration with other students and faculty. Collaborative work among students facilitates their comprehension of the problem and the application to future situations. Collaboration is essential skill for students to gain, as they will most likely be working as members of teams in their respective work places. PBL is now widely used at all levels of education and for most disciplines.

2.1. The PBL Process

PBL has been described by Barrows and Tamblyn (1980) as a process of "hypothetic-deductive" reasoning: students to acquire data to solving the problem, synthesize the data into hypotheses, and then test those hypotheses by collecting additional data. The process can also be thought of as a cycle of analysis-research –report. In a PBL environment, students are asked to solve a given problem. The problem is posed to the students before relevant information has been presented through any medium, including texts or lectures, about the subject mater underlying the problem.

Students work in small group of 5-10 to analyse the problem and determine what information they already have and what information they do not know and need to learn in order to solve the problem. First, student brainstorm ideas that could be possible solutions or ideas that could lead to solutions after more information has been gathered. In other words they proposed hypotheses. Then, they list facts based on their prior knowledge and generate questions or "learning issues" about what kind of knowledge or information they need to acquire to explain the fundamental causes of the problem. Each student, or a group of students, select one or more learning issues to research and develops a plan of action: what to investigate and how to go about investigating it. The learning issues define the focus of the self-directed learning process. New information is acquired through self-directed learning, when students work together discussing, comparing, and reviewing what they have learned. Students do research on the learning issues using a variety of resources. Students may work in groups or individually, but time is available for independent study.

Students' return to the group and report on what new information they have gathered. They review the problem and assess progress in light of the new knowledge. Hypotheses are revised. New learning issues may arise. The cycle is repeated until the problem has been resolved. Once they are finished with a problem, student engaged in self and peer assessment of their performance. The instructor, acting as a tutor, facilitates the process by asking probing questions, monitoring the problem-solving process and making resources available.

3. What is POL?

Project Oriented Learning (POL) is basically "learning by doing" whereby students will acquire knowledge while undertaking design project/s. This approach is commonly used for the core courses in design. For instance in Industrial Design Programme, the courses are been tough by utilising this method. Since the courses are multi- disciplinary in nature and involve some hands-on skills therefore POL is much more appropriate and effective means of teaching design. Students will start-off their learning process immediately after getting the design brief which contained all the project requirements and the learning outcome expected. The Lecturers will act as supervisor and assist students throughout their problem solving phases and getting the expected solutions. Design process theories are fully applied during the learning process and lecturers will assist/supervise the students during all the phases in the design processes. Student will investigate on topics related to the problem being studied. For instance, students will study the aspects of ergonomics when human machines relationship is considered for inclusion in the problem-solving project. Other theories related to the problem solving will be highlighted during students presentations scheduled for the particular semester. This process will go on until final design solution and objective of the design exercise projects are achieved. A panel consisting of design lecturers based on predetermined methods will carry out assessment and grading. Reflection of students learning outcome will be reviewed and necessary action for will be taken into consideration future improvement on teaching & learning by POL approach.

3.1. The POL Process

In a POL environment, students are asked to solve a given problem. The problem is posed to the students before relevant information has been presented through any medium, including texts or lectures, about the subject matter underlying he problem. Each subject starts with an overview – the scope of the subject, objectives, learning outcomes, expected generic skills acquired, the teaching approaches, and the assessment. The students are told how learning in the subject ensues from the design problems – the minor and major project assignments. The assignments comprise 100 percent of the assessment that particular semester. There is a range of learning resources (Fig. 1) to support the students' learning processes – notes, lectures, discussions, presentations, practical, etc. Students are furnished with "project brief" prior to project commencement. The brief covers important issues derived either from simulated problem or real-life problem. This brief is presented orally by lecturer or given as handouts. Students will study the project requirement stated in the brief and thus begin their learning process.

In design course, the students are required to work in-group depending on the project requirement. Group work is normally carried out at research stage where the students are required to gather data, analyse, synthesize and evaluate them. The number of students in a group again depends on the complexity level of the project. Four to five students assigned in a group are a usual number. The group formed will analyse the problem and determine what information they already have and what information they do not know and need to learn in order to solve the problem. Design students will normally apply their creative thinking skills (e.g. brainstorming, synectics, analogy and morphology) to define the given problems and what other information need to be gathered. Then, they will list facts based on their prior knowledge and generate questions or "learning issues" about what kind of knowledge or information they need to acquire to explain the fundamental causes of the problem.

Each design student, or a group of students, select one or more learning issues related to the design problem to research and develops a plan of action: what to investigate and how to go about investigating it. The learning issues or problems define the focus of the self-directed learning process. New information is acquired through this self-directed learning approach. Design student work together discussing, comparing, reviewing what they have learned and practiced. Students do research on the learning issues/problem using a variety of resources. Students may work in groups or at times, individual effort is required so as to train them to be more independent. Students will make full use of the information to write a proposed specification (in design we do not propose solutions yet) in form of project report. Design project proper will commence from this point onwards.

While students carry out their project as planned, concurrently lectures, studio sessions will supplement them with information/knowledge required (as stated by the course syllabus). As the project progresses, new knowledge and new learning issues are acquired throughout the semesters. Depending on each stage in the POL students are assessed on the project assignment based on the students' report, design sketches, drawings, engineering drawings, mock-up, models, presentation panels and oral presentation. These entire project assignments, which are referred as "design portfolio" or "design project package", constituted the final project assessment for any design courses at the end of a particular semester.

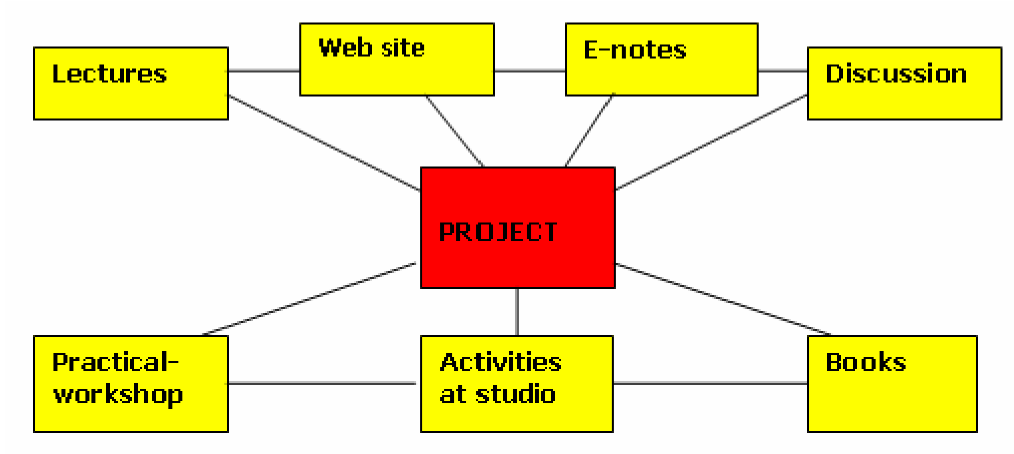

Fig. 1. Range of learning resources.

4. PBL and POL - Similarities and Differences

In the earlier paragraph we have come across the process and mechanism required to run both approaches. This section will discuss similarities and differences found between PBL and POL. To discover these aspects we can again refer to the processes involved in PBL and POL.

At the beginning of the process, PBL and POL students are posed with a "problem" The similarity is that both are given a specific "real world" problem. Students will commence their work soon after they have been given verbal or documented problem brief. The difference here is that for design students they are given a design brief which stipulate some design aspects that required the students to achieve at the end of the project. On the other hand, PBL students have to discover the underlying problem on their own before been presented with any relevant information. POL students are given some basic information (some problem scenarios) on what the problem is all about. From this point on, the POL students will come out with their own project planning whereby the design process will actually took place.

PBL students have to start on their learning process by analysing the problem using their prior knowledge and collecting more information and data as they go along. PBL students will generate questions or "learning issues" in order to explain the fundamental causes of the problem. POL student on the other hand will generate ideas soon as they have collected data, defining the problem and prepared a list of "design specification" or "design criteria". POL students gain knowledge when they came across information/data on aspects relevant to their problem solving. Lecturers will facilitate students by giving lectures on stipulated design topics and also monitoring / supervising students closely.

PBL students gained their knowledge through collecting information as well as fulfilling their problem solving project/assignment. PBL students produce reports and presentation at the end of the project whereas POL students are also required to produce reports in addition to design sketch/drawing, engineering drawing, models/ prototypes and oral presentation. PBL students finish off the project by having a self and peer assessment while POL students will have a project review session between students and lecturers. This session allows both parties to reflect and highlights on all aspect of knowledge and skills acquired during the POL process.

POL does not only allow design students to gain knowledge on their own but also trained them the skills of "learning by doing". Through this approach they are not only be able to acquire knowledge but also be able to demonstrate their hands-on skills. In PBL the students learning performance is assessed based on how they carried out the problem based-project and graded exam papers/reports. In POL, students learning process are assessed on their project package "project portfolio" as well as students' involvement in the whole design processes.

5. Assessment method in POL

Assessment of students' work in POL is based on the portfolio presented at the end of the project work. POL assessment will allow instructors to evaluate students on theoretical knowledge and practical ability (Hands-on). Research report and design project report will determine students' ability to absorb theoretical knowledge. Sketches/drawing, engineering drawing, mock-up, model/prototype, and presentation (Oral & Visual) would reveal students' practical ability and application of theories learned (Fig. 2). Continuous assessment is being practiced so as to monitor students' performance for each stage of the design processes. Students are being monitored and supervised to ensure that they are capable of getting the right information/data and achieved the objectives for each phases of the project. Students in design courses are generally not being assessed through test or final examination. Therefore in POL, test and examination are rarely being used to assess or graded students learning outcomes. Most of the core courses in design programme are being assessed through project assigned to students on individual basis or group-based design project. This approach is common for any Art and Design School. Individual students will be assessed on the project items / artifacts. These consist of research report, project report, design sketches and drawings, engineering drawings, mock-up / models / prototypes and finally the project presentation (visual and oral presentation). Each item in the portfolio will be graded according to the stipulated marking scheme. Students learning outcome is reflected on what the students achieved from each of these assessed artifacts. *'Rubric method'* (a method use to analyse aspects of team working) is utilised by instructors to assess how far the students are able to work collectively.

6. Assessment method in PBL

Giving students the opportunity to evaluate and reflect on their own learning is a key element in PBL. The self-assessment phase of PBL sessions allows the facilitator to help students with assessing their own performance in solving a problem. Self-assessment in PBL allows the students to compare their performance with the goals that they set for themselves before the problem started. It allows them to develop the skills to monitor their own learning outside the academic environment and helps them move towards the elusive goal of becoming life-long learners.

An effective assessment tool must also provide the ability to report on student progress in a fair and objective manner. The first option is by giving objectives questions to students to test on students' understandings of what the learning outcomes are for the course. The second option is to create a problem statement the solution of which requires the student to demonstrate the desired depth of understanding of the learning outcomes.

Next, during the self assessment phase the student are encouraged to discuss the quality of learning resources used and how well they had progressed towards meeting their individual learning objectives.

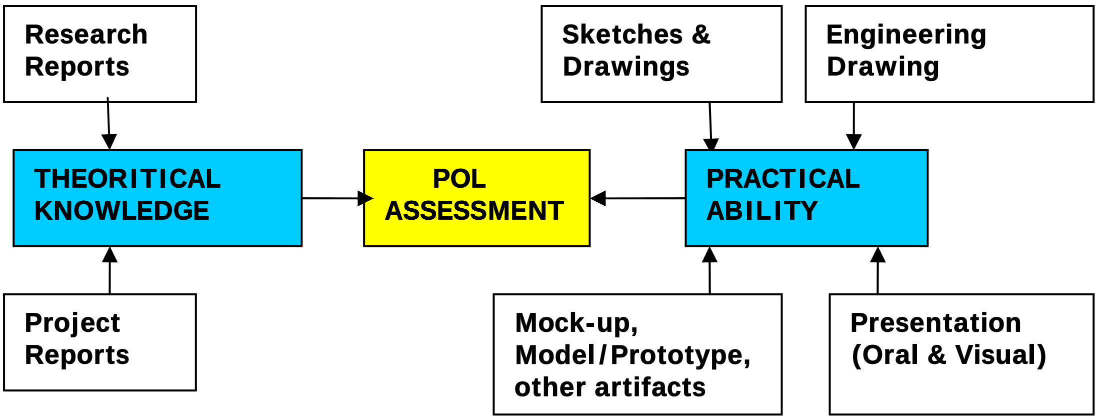

Fig. 2. POL assessment method.

Group performance assessment is also carried out to detect group problems and try to apply corrective action. The assessment of the artefact (depend on what is required by instructor) provide an indication of how well the students did at each phase of their problem solving project and whether any major concepts were not learned.

Grading the artifacts using detail criteria provides a mechanism to report on student's progress. As with any essay or report grading there is variability in the basic grading. On the whole however, the use of the graded artifacts is an excellent means of assessment in PBL (Robert Waters, 1996). Traditional assessment methods such as the infamous midterm and final examinations, term papers, assignments were also being used (Fig. 3).

7. Discussion & Conclusion

This paper presented author's personal experience in teaching design courses by "project-oriented (POL)" or project-based learning at the Faculty of Mechanical Engineering, University Technology Malaysia. The comparisons between these approaches are described to reveal similarities and differences of both teaching approaches. As what has been discussed in this paper there are similarities and differences at some approaches or stages for each of these teaching methods. However, from the author's observation and experience both of these approaches are found to be suitable for design courses. The most important issue that an instructors needs to be aware is that these approaches should ultimately achieved students' learning objectives and learning outcomes. Since POL and PBL is a student-centered teaching approach, instructors should take into account the teaching environment, which includes the facilities and fully understood whether these methods could achieve the expected learning outcomes of a particular course. Apart from that, an effective assessment and evaluation program should be meticulously planned and executed so as to ensure that students are deriving the maximum benefits from both PBL and POL being conducted effectively for the given teaching and learning environment. Instructors in design courses whom are dealing with creativity should give a try on PBL and as well as POL with the aim of enhancing teaching and learning methods.

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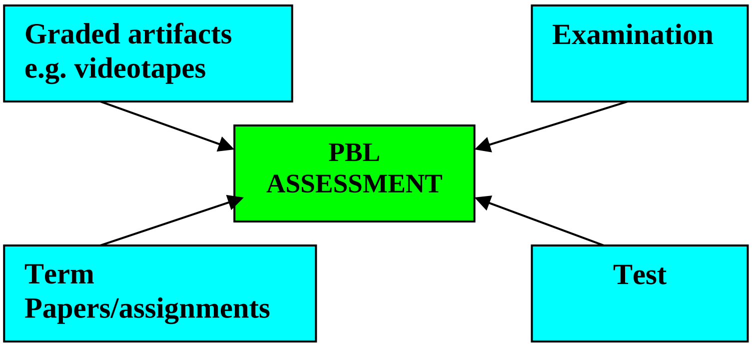

Fig. 3. PBL assessment methods.

Cooperative Learning Technique: Implementation and Assessment

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Abstract

The Outcome Based Education (OBE) is implemented at Universiti Putra Malaysia in order to achieve the ultimate goal of providing quality education to the students. The implementation of OBE requires practicing successful strategies in teaching. One of these strategies is called cooperative learning (CL). CL is a method of learning in which students work in small groups on structured learning tasks (e.g., homework assignments, laboratory experiments, or design projects) under conditions that meet specified criteria. The present study summarizes the experience of implementing formal cooperative learning (FCL) at the Department of Civil Engineering, Universiti Putra Malaysia, Malaysia. The course entitles Hydraulics and Hydrology (course code KAW 3412) is used to evaluate the experience in implementing FCL. The cohort of students taking the course is 73 and the cohort is divided into 19 groups. Peer rating evaluation is used to check individual and group accountability. Results showed that students peer evaluation for the above course is found to be poor and not representative since 17 groups gave excellent rating (100%) for themselves while only 2 groups gave very good rating (87.5%). However, evaluations conducted by the lecturer revealed that only 16 groups scored between 70 to 75% (satisfactory rating) while the rest scored between 66 to 69% (ordinary rating). For future evaluation, it is recommended to train the student to be more reasonable when conducting such evaluation. Beside this disadvantage, there are many educational and social advantages associated with implementing CL compared with traditional teaching which is based on competitive and individualistic philosophy.

Keywords: assessment; CL; civil engineering; implementation; peer rating

1. Introduction

In traditional approach of college teaching, instructor spent the allocated class time in lecturing and students watching and listening. Usually, for any given assignment to the class, students work individually without any cooperation between them. This centered teaching method is found to be poor and not successful because active learning methods requires the students in any class to solve problems, answer questions, formulate questions of their own, discuss, explain, debate, or brainstorm during class. On the contrary, cooperative learning (CL) includes the above teaching activities and it can be described as an active college teaching instructional method. Cooperative learning (CL) is a simple idea in which students of the class are divided into groups and the students within the group are working together to accomplish shared instructional goals. The main objective of practicing CL is to maximize learning benefits. In CL, the groups receive the instructions from the lecturer about a given assignment and they work together in order to improve their understanding and maximize the acquired knowledge. It is intended to adopt CL in various institution of higher education. This is because it is one of the teaching tools required by Outcome Based Education (OBE). Recently, the competition in higher education is increasing and credibility of the degree given by any institution of higher learning is subjected to assessment particularly for institutions that adopted OBE as instruction policy. Cooperative learning has many important outcomes that make it one of the most valuable tools in college teaching. The multiple outcomes of CL can be classified into three major categories: effort to achieve, positive relationships, and psychological adjustment and social competence. The research clearly indicates that cooperation, compared with competitive and individualistic efforts, typically results in positive interdependence and promotive interaction. The bi-directional relationships of various outcomes have influence on each others as shown in Fig. 1.

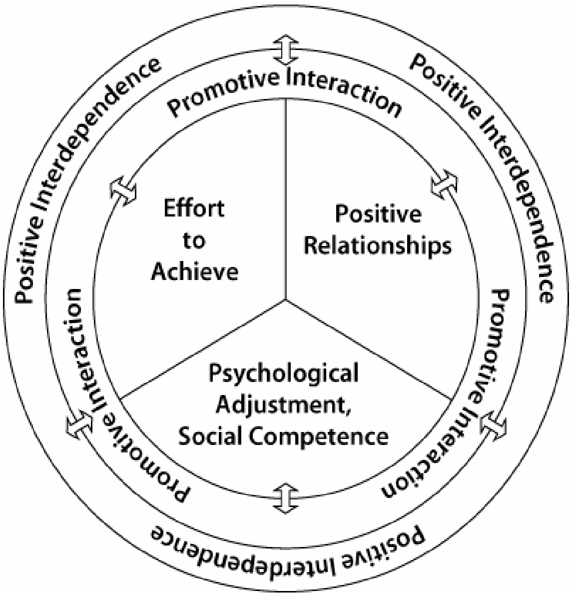

Fig. 1. Outcomes of CL. [1]

2. Selected Related Literature

CL is an important teaching approach and recently many professors realize the need of such method in college teaching. Many researchers summarized their experience in using CL to teach subjects of various natures. In this study, a special emphasis will be given to the literature related to application of CL for engineering program.

Kaufman and Felder [2] designed a peer rating system to account for individual performance in team projects and the system incorporate statistical tests. The proposed system was applied for students teams doing projects at the North Carolina State University, NC, USA. Thousand et al. [1] designed a peer rating system to account for individual performance in team projects for chemical engineering program at the North Carolina State University. Felder and Brent [3] extensively discussed the accreditation criteria used to evaluate all American engineering programs since the beginning of 2001 and they concluded that the potential of the new system used to improve instruction depends strongly on how well engineering faculty understand it and appreciate the extent to which their full involvement in it is crucial. Felder and Brent [4] reviewed the experience of forming teams for cooperative learning for engineering students and they recommended getting the student to work together effectively than simply putting them in groups and asking to do something. Haller et al. [5] used a conservation analysis as a methodology for understanding how students taught and learned from another. They found that group members generally engaged in two types of teaching-learning interactions namely, knowledge sequence (students took a distinct teacher and pupil roles) and collaborative sequence (students worked together with no clear role differentiation). Felder et al. [6] found that the cooperative learning compared with traditional college teaching has many advantages to the engineering students such as high retention, high grade, high critical levels, improve attitude, improve ability to solve computer problems, work independently, and better interaction. Felder [7] recommended that for students to learn in meaningful manner, they must be actively engaged in the learning process.

3. Elements, levels and Implementation of Formal Cooperative Learning

The cooperative learning can be effective compared with traditional teaching with competitive and individualistic philosophy if its main elements are achieved. The elements of CL are shown in Fig. 2. The Positive interdependence considers effort and contribution of each student in the group as indispensable for group success. Face to face interaction includes students oral explanation for solving, checking and understanding problem with sharing knowledge and reviewing related concepts. Individual and group accountability can be done successfully if the students are divided into groups of smaller size and individual test is given to each student in the group. However, the random selection of a student to present group work is another effective way to conduct individual accountability. Peer evaluation rubric is available for checking student contribution, input and positive role in a group. Interpersonal and small group skills usually taught the students within the group the leadership, decision making, trust building, communication, and conflict management skills. Group processing includes group discussion to deliberate on helpful and not helpful actions, obstacle faced and how to avoid it in future and plans to achieve goals. There are three levels of cooperative learning and these levels are Informal Cooperative Learning (ICL), Formal Cooperative Learning (FCL) and Cooperative Base Groups (CBG). ICL is an active learning involving groups that stay together for a class period or less to answer questions or solve problems. No strict compliance with the five elements of CL. FCL is learning method in which the student groups stay together for extended periods up to the entire course to produce a product (assignments, design project, presentation, and laboratory work) and compliance with the CL elements is required. CBG is a method in which student group stay together to provide mutual academic and personal support, possibly for several years. It is useful for academic work and/or advising [8].

4. Implementation of FCL at the Department of Civil Engineering, UPM

The Outcome Based Education (OBE) is adopted by the Universiti Putra Malaysia (UPM) and Civil Engineering subjects are taught considering OBE requirements such as program outcomes and course objectives. FCL is used in teaching a course called Hydraulic and Hydrology I (course code KAW 3412) and the experience in teaching the course is used to evaluate the implementation of FCL. The cohort of students taking this course is 73 and about 35% of the cohort is female and it is with good racial mix. The class is divided into 19 groups based on student latest Cumulative Grade Point Average (CGPA), race, and gender. The students in each group will work together to solve problems given in the class, assignments and prepare reports. The instructor made the students aware about all the elements of the FCL (as discussed in the above preceding section) during the first class session when groups are formed. Towards the end of the semester, peer rating form is distributed to the group in order to conduct individual and group accountability. The form used for peer rating is shown in Table 1. For all assignments, laboratory reports and reports for site visits are handed in by groups and names of students participated are written on the assignment/report front page and one grade is given per group. To check the individual and team accountability, peer rating form (Table 1) is distributed to each student of the cohort. After filling in the form, students submit the form to the instructor and he used it for student evaluation. A sample of individual mark calculation per group is shown in Table 2. In case of the course KAW 3412, it is found that the Adjustment Factor (IF) is 1 and this can be attributed to the fact that students in the groups gave the same rating to themselves. The adjustment factor and final individual grade are calculated using the flowing formulae [8]:

$$Adjustment\ Factor = \frac{Individual\ Average}{Group\ Average} \qquad (1)$$

$$IF = Group\ Average\ x\ Adjustment\ Factor \qquad (2)$$

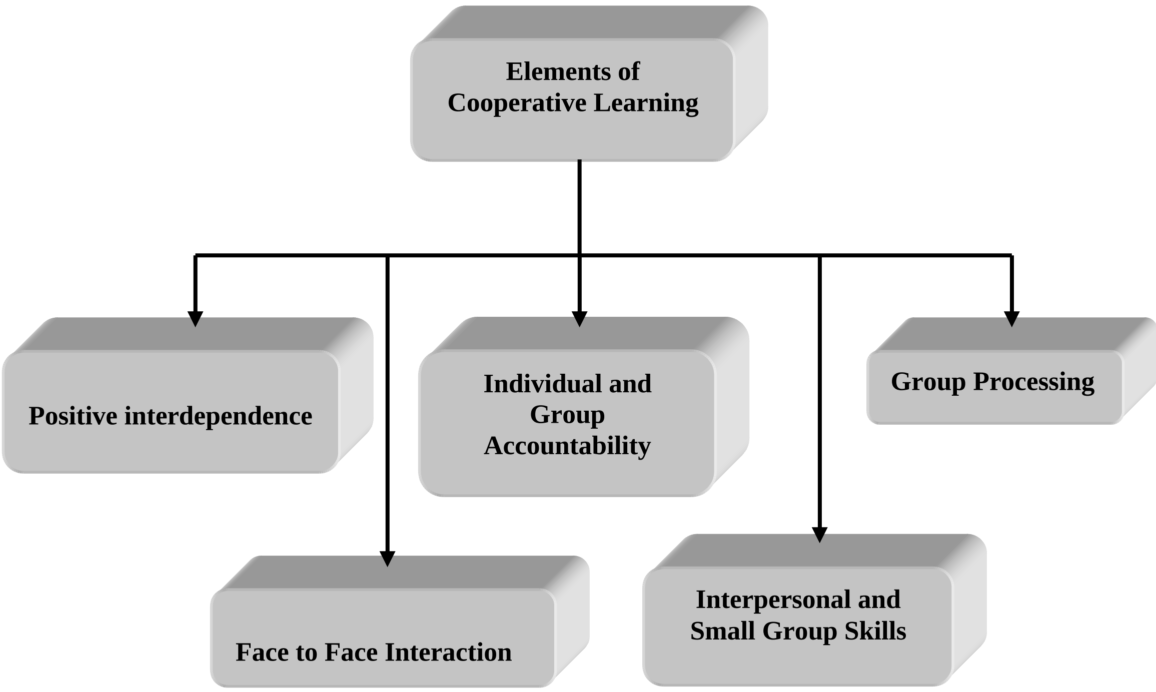

Fig. 2. The elements of cooperative learning.

Table 1. is adapted from Felder and Brent [8]

Name of Group Members	Rating **	Remarks

Signature : Date :

** The rating for every group member are:

1. Excellent: distinguished performance and carried load more than assigned to him/her (100%)

2. Very good: consistently did his/her share, very well prepared and cooperative (87.5%)

3. Satisfactory : Usually did what he/she suppose to do with acceptable level of preparation and cooperation (75%)

4. Ordinary : Often did what he/she was supposed to do with minimally prepared and cooperative (62.5%)

5.Marginal : Sometimes failed to show up or complete assignments and rarely prepared (50%)

6. Deficient: Often failed to show up or complete assignments and rarely prepared (37.5%)

7. Unsatisfactory: Consistently failed to show up or complete assignments and unprepared (25%)

8. Superficial : Practically no participation (12.5%) No show:

9. No participant at all (0%)

The main problem faced is that students peer rating for the 19 groups of the course KAW 3412 is found not reasonable and big differences are found between the student evaluation and that conducted by the lecturer. Fig. 3 shows the histogram for the two evaluations. From the 19 groups formed, 17 groups gave excellent rating for themselves while only 2 gave very good rating for themselves. The marks for excellent and very good ratings are 100% and 87.5 % respectively. The real evaluations conducted by the lecturer reveled that only 16 groups scored between 70 to 75% (satisfactory rating) while the rest scored between 66 to 69% (ordinary rating). So, it is strongly recommended to train the student to be more reasonable in conducting such evaluation. The peer rating evaluation revealed that the students are biased to their colleagues and they were not sincere enough to do fair and real evaluation. This can be attributed to their non-confrontational culture and lack of familiarity to the method of evaluation. This simple type of peer rating appears to be not successful in calculating students grade. Felder and Brent [9] highlighted that CL may create considerable difficulties for instructors most notably dysfunctional groups and student resistance or hostility to group work. Thousand et al. [1] designed a peer rating system for accounting individual effort. Such a method has also been attempted by Ohland (as cited in Felder and Brent [8]). The instructor can select and/or develop a peer rating system that considers the culture and student background. The questionnaire with identified rubric for such peer rating system should be more rigorous with details.

Beside the educational advantages, implementations of FCL also have social advantages particularly for a multi racial society. Thus, more positive interpersonal relationships between students form various races can be achieved. This kind of relationship leads to greater psychological/social well being of individuals involved in FCL. On the other hand, students stress, anxiety, and shyness are decreased besides increasing individual ability to build and maintain caring and committed relationships in performing the assigned task. This will help to increase the tolerance and harmony between the races in the country.

5. Conclusions

The present study summarizes the experience of implementing formal cooperative learning (FCL) at the Department of Civil Engineering, Universiti Putra Malaysia, Malaysia. The course entitles Hydraulic and Hydrology I (course code KAW 3412) is used to evaluate the experience in implementing FCL. The cohort of students taking the course is 73 and the percentage of male students is 65 % while the percentage female students is 35%.

Table 2: Sample of student rating given by one group taking the course KAW 3412

Group Names	Vote 1	Vote 2	Vote 3	Vote 4	Individual Average	Group Average	Adjustment Factor	Final Individual mark
PHOON CHEE HOE	87.5	87.5	87.5	87.5	87.5	87.5	1	87.5
GAN WEI KENT	87.5	87.5	87.5	87.5	87.5	87.5	1	87.5
SUFRIADI BIN AVELINO	87.5	87.5	87.5	87.5	87.5	87.5	1	87.5
IZNI BINTI MOHD ZAHIDI	87.5	87.5	87.5	87.5	87.5	87.5	1	87.5

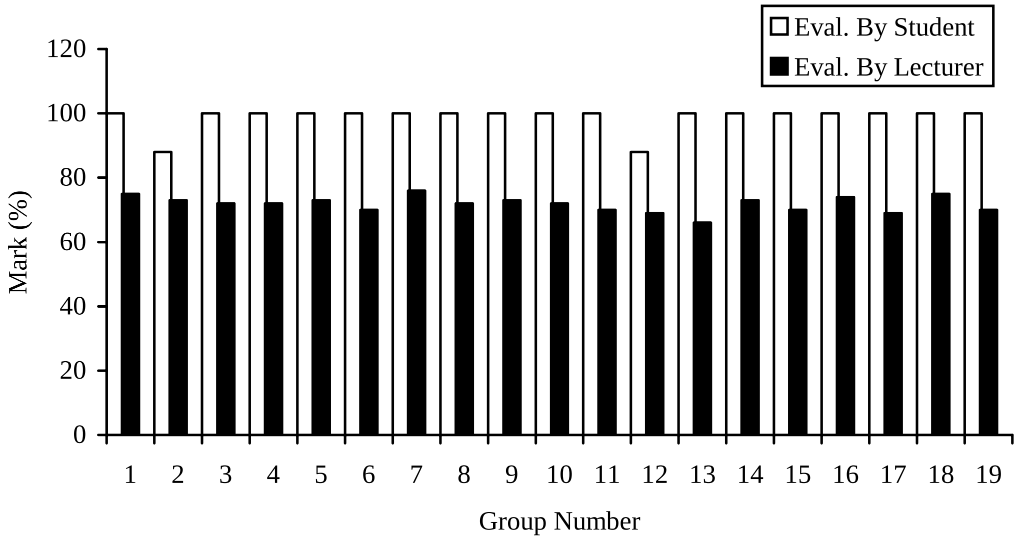

Fig. 3. Comparison of groups evaluation for the subject KAW 3412.

The cohort contains all races forming the Malaysian society. 19 groups were formed based on student latest Cumulative Grade Point Average (CGPA), race, and gender. Various elements of CL is considered in the implementation of FCL beside using peer rating evaluation to check individual and group accountability. The result of students peer evaluation for the above course is found to be poor and not representative because the students gave high rating for themselves. 17 groups gave excellent rating (100%) for themselves while only 2 groups gave very good rating (87.5%). However, evaluations conducted by the lecturer revealed that only 16 groups scored between 70 to 75% (satisfactory rating) while the rest scored between 66 to 69% (Ordinary rating). For future evaluation, it is recommended to train the student to be more reasonable when conducting such evaluation. The students are biased to their colleagues and they were not sincere enough to do fair and real evaluation. This can be attributed to their non-confrontational culture and lack of familiarity to the method of evaluation. Simple type of peer rating appears to be not successful in calculating students grade. The instructor can select and/or develop the peer rating system that considers the culture and student background. The questionnaire with identified rubric for such peer rating system should be more rigorous with details.

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Cub Prix Experience: A Case Study on Implementation of POPBL in UTHM

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Abstract

Project-Oriented and Problem-Based Learning (POPBL) is a new educational approach to improve the quality of teaching and learning. Shifting from the conventional teaching and learning to POPBL requires a change in paradigm as well as system set up. This paper reports the experience of implementing POPBL at UTHM, particularly with regard to the participation in a national motorcycle race competition, the Petronas Sprinta AAM Malaysian Cub Prix Championship. One of the important elements is complementing experience-based-mechanic solutions with a more holistic solution using systematic engineering approach. Another important element includes augmentation of soft skills such as communication skills, managerial abilities, leadership, and teamwork. In general, the students, UTHM staff and the experience-based-mechanic have developed good relationship among each other which leads to the capability in solving real engineering problems.

Keywords: Project-Oriented and Problem-Based Learning (POPBL); Outcome Based Education (OBE); Problem Based Learning (PBL)

1. Introduction

Problem-based learning (PBL) is a curriculum model designed around real life problems that are ill-structured, open-ended, and ambiguous. It engages students in intriguing, real and relevant intellectual inquiry and allows them to learn from these life situations [1]. PBL originated from the medical education in 1969 [2] and has been implemented in various undergraduate and graduate student programmes around the world. Studies by previous researchers have shown that the push for a shift from conventional to this innovative method is driven by the demands of employers to recognize graduates who not only excel in technical knowledge but also in non-technical skills, abilities and traits, which are known as soft skills [3].

The past President of Institution of Engineers, Malaysia (IEM) had put a futuristic view that the new engineering education and training model shall build its strength on the fresh definition of engineering, which is more comprehensive, necessitating work at the frontiers of knowledge and relevant to the needs of the modern world [4]. PBL answers this as it is one of the best approaches to produce such engineers since it emphasizes on the task of learning more to the students themselves.

In Universiti Tun Hussein Malaysia, changing to PBL is certainly a challenge. It requires changes not only in the paradigm but also the system setup that involves huge amount of energy, time, facilities and costs. The mode of delivery and assessment was revised to suit the PBL approach in the existing curriculum of the undergraduate programmes. Existing facilities such as classes, discussion rooms and teaching aids equipment were upgraded to accommodate the needs of the delivery. Numerous hours were spent to develop the academic staff. External and internal courses, seminars and educational visits were conducted continuously either at university level or faculty level. Not only that, coaching among staff is also carried out to ensure that the valuable experience can be shared among others.

At the faculty level, several subjects were assigned to implement PBL in their teaching and learning. The staffs were given the task to renovate the teaching methodology to ensure the learning become more self-directed and student-centred. Assessment schemes were improved, not only to evaluate students on their cognitive intelligence but comprehend their soft skills as well.

This paper discusses the implementation of Project-Oriented and Problem - Based Learning (POPBL) in one of the subjects, Diploma Engineering Project. It shares the experiences of several academic staffs in translating the problems and challenges that they faced during their participation in the AAM Malaysian Cub Prix Championship into several project titles. It also discusses how POPBL is being implemented and assessed through out the semester.

2. Diploma Engineering Project

Diploma Engineering Project is a subject offered in the undergraduate programmes of the Mechanical and Manufacturing Engineering Faculty. The subject is introduced in the second semester and offered to the final year diploma students. It is a 3-credit-hour subject, where the students will have a 3-hour meeting with the lecturer each week. The subject is a product-oriented project, where the students have to design, analyse and fabricate a product according to their project title.

The aim is to have a subject that can integrate the mechanical engineering subjects offered by the faculty. At the end of the subject, students will have the ability to apply the knowledge of mathematics, science, and engineering, acquire in-depth technical knowledge and competence, adapt and use techniques, skills and modern engineering tools, appreciate aesthetic values through application of personel judgement and creativity, communicate effectively using appropriate mediums, work effectively in groups and recognise the need to engage in life-long learning.

3. Participation in AAM Malaysian Cub Prix Championship

The AAM Malaysian Cub Prix Championship, a grand event which was first started in 1992, is a national motorcycle race organised annually by Safe Aim Mutual Sdn Bhd. The race is divided into categories which are Expert (2 stroke, 125cc), Novice (4 stroke 110cc) and Wira (4 stroke 110cc). Ten series of racing event are held at different states for each series (Table 1) and the points for the participating teams and riders' championship will be accumulated at the end of the season. The overall champions will be the ones with the highest championship points.

Table 1. 2007 Cub Pix Championship Series

Siries	Location	Date
01	Kluang, Johor	14-15 April 2007
02	Litar Sepang - Utara	28-29 April 2007
03	Kuantan, Pahang	12-13 Mei 2007
04	Kota Baharu,Kelantan	25-26 Mei 2007
05	Kuching, Sarawak	16-17 Jun 2007
06	Kota Kinabalu, Sabah	30-1 Jun/July 2007
07	Taiping, Perak	28-29 July 2007
08	Batu Kawan, Pulau Pinang	18-19 Ogos 2007
09	Litar Sepang – Selatan	3 -4 November 2007
10	Kuala Lumpur	17-18 November2007

The faculty participation in the race started in September 2006, during the 9th series of the 2006 Championship. The team, UTHM Motorsports comprises ten academic staff, three supporting staff, three profesional riders and one profesional mechanic. The team has two functional units which are:

a. the academic, research and development unit that is responsible for the development of the motorcycle, and
b. the racing unit that is responsible for the management and participation of the race.

The team participated in all three categories and managed to modify and upgrade four factory fitted motorcycles to compete in the race.

The objectives of the participation were not only to win the championship, but more towards the development of staff in research, development and commercialisation and also enhancement in the teaching and learning system. Problems faced during the race were expected to contribute to better research activities and improve the implementation of PBL or POPBL in teaching as well as in final year project.

4. Implementation of POPBL

The implementation of POPBL was conducted in several phases:

4.1. Phase I: Problem identification

During series of races, the team encounters a lot of problems and challenges. The problems faced by the riders, the mechanic and the team were identified and documented. Some of the problems were solved during the race but most of the time; the problems were discussed during the post-mortem.

Besides self-experience, some of the problems were identified during discussions and interview sessions with other competitors or suppliers. The team also observes the competitors' motorcycles and mechanics. Not only that the team managed to identify the problem faced, but they also managed to get the experience-based mechanic solutions from them. These were vital information since the unproven hypothesis can be used for research and teaching purposes.

4.2. Phase II: Clustering of problem.

Problems then were gathered and clustered. The purpose is to identify which problem should be solved by the team, which could be given to other academic staff for their research and which could be given to the students for their final year project.. Among the considerations were:

a. depth of the problem.
b. duration of expected completion.
c. expertise available.
d. facilities available.
e. cost.

4.3 Phase III: Formulation of project title

The identified problems were then formulated to form suitable titles. These titles were then given to the team or those had been assigned by the faculty to become the supervisors. The titles and the supervisors' name were then posted on the notice board at the beginning of the semester.

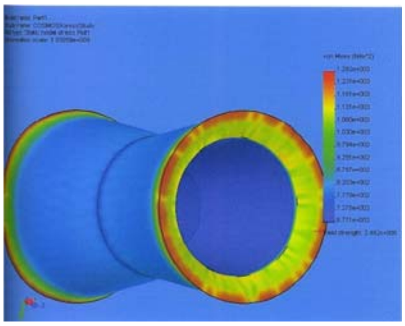
4.4 Phase IV: Implementation of POPBL

The implementation of POPBL was carried out during the second semester of 2006/2007 session. A total of 119 students registered for the subject but only 30 were chosen to be involved in the Cub Prix project. The chosen students were then divided into 15 groups that consist of two students per group. A total of 8 supervisors, among the academic staff appointed by the faculty were involved to monitor the group.

During the project, each team underwent three development stages:

a. *Gathering information stage:* During this stage the students will search for related literature, conduct researches, and interview the racing team to obtain information especially the experience-based mechanic solutions to start their project. This unproven hypothesis will later be explored using structured engineering techniques. The students will have to communicate with different groups to obtain information since there were titles that relate with each other.
b. *Processing stage*: During this stage the students will process the information and obtain solutions to complete the project. They need to sketch or redraw the design using Computer Aided Design (CAD) software, perform analytical analysis and simulations using suitable engineering software or do experimental work. Scale model or prototype were developed using the Rapid Prototyping (RP) machines. Fig. 1 shows some of the processing works done by the students.
c. *Applying stage*: During this stage the actual model was built and fabricated using specified materials. Students applied the knowledge and skills they learnt during their in-house skill training. The models were then tested on the motorcycle during the actual race. The results and feedbacks from the racing teams were given back to the students for continuous quality improvement (CQI).

The project progress was monitored closely by their supervisors during the weekly meeting. The meetings were structured according to the master schedule set by the project coordinators. This would ensure the groups had enough time to produce their prototype which could be tested during the race for quality improvement. At the end of the semester, each group will have to give an oral presentation and showcase their finished product in a one day seminar.



(a)

(b)

Fig. 1. Processing work done by the students: (a) Stress analysis using FEA software (b) Casting to produce project parts.

4.5 Phase V: Assessment

The assessments were divided into:

a. Log book and discussion (10%) which consist of their written project summary, written progress work, written weekly report and discussions with supervisors.
b. Project Final Report (40%) which consists of introduction, background and theories, planning and methodology, results and discussions, conclusion and suggestions.
c. Oral presentation and demonstration (35%) which consists of the seminar paperwork, delivery, understanding of the problems and the ability to respond to questions.
d. Product (15%) which consists of its idea and creativity.

The assessment of item (a) and (b) were carried out by the supervisors and item (c) and (d) were carried out by the assessors appointed by the faculty during the one day seminar.

5. Soft skill survey

The paper also presents a survey to study the improvement of students' soft skills during the implementation of POPBL. Questionnaires developed by the university soft skills committee were given to the students before and after the completion of the subject. The questionnaires focused on seven soft skills and the descriptions were as follow:

a. Communication skills:
- ability to respond and practice active listening skills
- ability to give oral presentation with confidence at different levels of audience
- ability to use technology in presentation
- ability to communicate using different languages.
- Ability to expand interpersonal skill.

b. Problem solving skills:
- ability to identify and analyze problems in a complex and indistinct situation and make justified assessment.
- ability to develop thinking skills such as explain, analyze and evaluate
- ability to seek ideas and give alternative solutions.
- ability to think "out side the box"
- ability to understand and adapt in different working culture and environment.

c. Team Work:
- ability to work, interact and build good relationship with others to achieve the same objective.
- ability to understand and play alternate roles as a leader and a follower.
- ability to identify and respect others' traits, behaviour and beliefs.

d. Continuous learning and information management
- ability to explore and manage related information from different sources.
- ability to accept new ideas
- ability to engage in life long learning

e. Entrepreneurship skills
- ability to identify business opportunities
- ability to develop business plans
- ability to develop, explore and grab business opportunities
- Ability to work independently

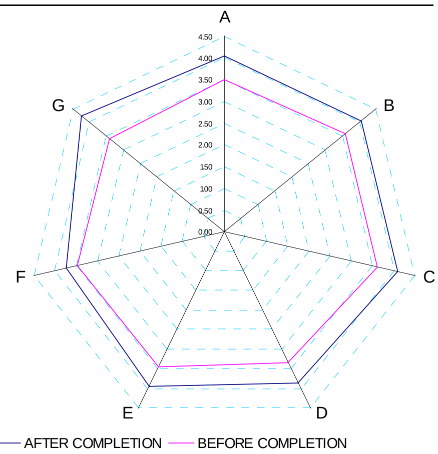
f. Moral and profesional ethics
- ability to understand economical, sosial and environmental effects in profesional practice.
- ability to analyze and make decisions in solving ethical problems.
- ability to practice ethics besides having the responsibility to the society.

g. Leadership skills
- knowledge on basic leadership theories
- ability to lead a project
- ability to supervise team members

The Likert Scale was used to obtain the information required for this study (Table 2). The result of the survey was analyzed and the mean score for each soft skill is shown in Fig. 2.

Table 2. Interpretation of the Likert Scale

Score	Scale Interpretation
1	Poor
2	Bad
3	Moderate
4	Good
5	Excellent



A : Communication skills
B : Problem solving skills
C: Working in a team
D : Continuous learning and information management
E : Entrepreneurship skills
F : Moral and profesional ethics
G : Leadership skills

Fig 2. Soft skills improvement during the POPBL implementation

6. Discussion

6.1 POPBL implementation

The attempt to implement POPBL in the subject taught has uplifted the teaching and learning process in the faculty. The method has not only improved the students' attitude but also the quality of the academic staff involved. The comparison between the conventional method and POPBL is shown in Table 3.

6.2 Soft skills survey

The result shows improvements in all studied areas when POPBL was implemented. From Table 4, the improvement is most significant in leadership skills. This is expected since the project emphasizes on team efforts and depends a lot on leadership and team work. During execution, little emphasis was given on professional ethics and moral. This is reflected on the result shown in Table 4. The second most significant improvement is the continuous learning and information management skills. The improvement is expected since the students not only received information on internet and literature study, but also are able to gather sufficient information during their interviews with the racing team.

Table 3. Comparison between conventional method and POPBL

No	Conventional Method	POPBL
1	Titles formulated were lecturer dependent	Titles formulated were based on real problems
2	Supervisor dominant	Student-oriented in problem solving.
3	No opportunity for CQI.	Received feedback from team members after race for CQI
4	Projects were independent of each other	Projects were interrelated with each other
5	Communication within the group	Communication across teams
6	Completed products were stored in laboratories and workshops.	Completed products were used in races.
7	No risk and low cost	High risk and cost dependent
8	Less attention to safety consideration.	More serious in safety consideration during the execution of project since the result would give impacts to the success of the team.
9	Moderate motivation among students	High motivation among students due to the importance of the completed products.
10	Less attention in engagement of life long learning	Extensive practice of life long learning.
11	Unlikely to be patented.	Have potential to be patented.

The result also shows a 13% improvement in entrepreneurship skills. This is unexpected since less emphasis was given by the supervisors in the skills. The improvement might come when the students interact with the riders, mechanics and suppliers during the gathering information stage.

7. Conclusion

This paper concludes that the experience gained from the participation of AAM Cub Prix Championship opens the opportunity to improve the teaching and learning system in the faculty. Through tough time in the races, the team managed to translate and transform the real problems into projects. The experience gained by the team also managed to help the academic staff to be better supervisors and facilitators.

Table 4. Improvement of soft skills in percentage

Soft skills	Improvement (%)
Leadership skills	19
Continuous learning and information management skills	14
Communication skills	13
Entrepreneurship skills	13
Problem solving skills	12
Team Work	11
Moral and profesional ethics	7

During the project, the students had the opportunity to portray themselves as real mechanical engineers, not only to solve real problems, but also to produce products which were used in real races. This gave them extra motivation since they could see their contributions put to use. The subject also helped the students to improve their soft skills. This is very important since they will graduate and enter the real engineering world that needs those traits and skills.

The racing team also get the benefit of sharing their knowledge and experience with the students especially the mechanic and riders. The output of the project really gave them the shortcut in solving their encountered problems.

In general, the students, UTHM staff and the experience-based-mechanic have developed good relationship among each other which leads to the capability in solving real engineering problems.

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A Problem-Based Learning Approach in Teaching Mask Design for MOSFET Fabrication

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Abstract

Problem-based learning (PBL) has been introduced at Universiti Tun Hussein Onn Malaysia (UTHM) for almost two years as a new innovative teaching method for engineering education. This paper highlights an alternative way of teaching mask design for MOSFET fabrication using PBL approach as a student centered-learning approach. The learning process has been successful using the Facts-Ideas-Learning Issues-Action Plans (FILA) chart as a PBL technique. Four groups of students have been assigned a project topic which meets the curriculum objectives and have industrial relevance. In this project, the students work independently; learning new Computer Aided Design (CAD) tools to create their own mask design using contact printing method. It is said to be a cost effective and simple technique for mask design. The students also have the opportunity to be involved "hands-on" in fabrication process of MOSFET (Metal-Oxide-Semiconductor Field Effect Transistor) where they perform the photolithography technique in order to transfer the pattern from the masks onto the wafer and hence complete the fabrication process. The fabrication process was done in UTHM Microelectronics Cleanroom. In addition, the students also prepare the presentation and the documentation of the project. The paper concludes by discussing the benefits and advantages to the students after completing the project.

Keywords: PBL; FILA chart; mask design; MOSFET fabrication

1. Introduction

Problem based learning (PBL) method has been applied widely by the higher learning institutions all over the world such as McMaster University, Harvard University, University of Manchester, National University of Singapore and Aalborg University. In Malaysia, Universiti Malaya, Universiti Islam Antarabangsa Malaysia, Universiti Sains Malaysia and Universiti Teknologi MARA have used this method especially in medical field. As for Universiti Tun Hussein Onn Malaysia (UTHM), this method has been applied in teaching and learning in the field of engineering and technology.

PBL already widely known may be defined differently. However, it is basically a problem solving skill which requires students to do and be active [1]. It is a learning approach that is most commonly constructed around a series of problems selected by a lecturer [2]. At UTHM, PBL was successfully introduced two years ago as a new innovative approach to teaching and learning and it has been widely applied in various disciplines, including engineering and technology. The PBL approaches to teaching in the engineering discipline include, but are not limited to, the following characteristics [2]:

i. Using stimulus material to help students discuss an important engineering problem, design task or issue,
ii. Presenting the problem as a simulation of professional industry practice or a real life workplace situation,
iii. Guiding engineering students to utilize critical thinking and direct and/or providing limited resources to help them solve the problem,
iv. Getting students to cooperatively work in a team to complement each others work, not compete with one another, in an environment where they have access to a lecturer who facilitates the groups learning process,
v. Getting students to identify their own learning needs and developing their information literacy skills to locate, evaluate and manage resources that are useful to help them solve engineering problems,
vi. Self-assessment to evaluate their learning process

In Microelectronics, subject teaching mask design for MOSFET fabrication is quite a challenge. The students have to master the fundamental theories before they get personally involve in a laboratory session where they are working on fabrication process of MOSFET via UTHM Microelectronics Cleanroom.

In this paper, the authors highlight an alternative way of teaching mask design for MOSFET fabrication using PBL approach as students centered-learning.

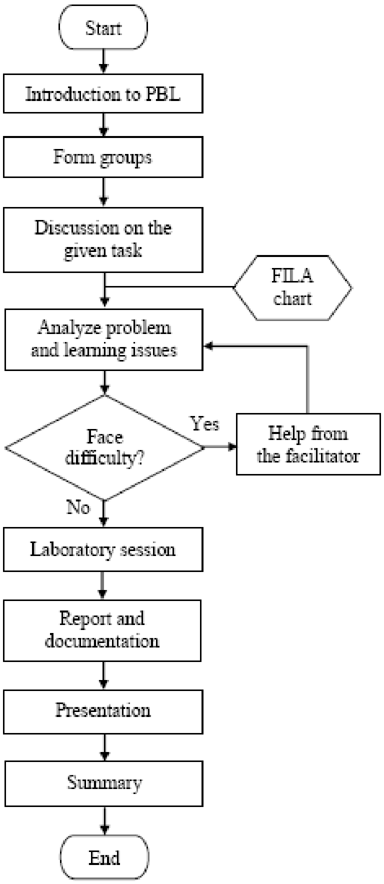

Fig. 1. The process of PBL.

2. PBL Implementation

2.1. PBL Process

The idea of PBL in this particular topic is the concept of student centered-learning where they personally perform the self directed-learning for a given task. The process of PBL applied in this topic is shown in Fig. I.

The process starts with an explanation about PBL itself from the facilitator. Then, students are instructed to form group of six with a total of four groups all together. Once they are in one group, self directed-learning begins. They themselves will conduct the discussions on the given task, analyze problems and issues, and here they will fill up the Facts-Ideas-Learning Issues-Action Plan (FILA) chart in order to get to the solutions.

If they face any difficulty along the process, they are very much welcome to ask any questions to the facilitator. Then, they will continue to start the laboratory session where they are involved hands-on directly. The laboratory took place at UTHM Microelectronics Cleanroom. After they run the session, they will prepare the report and document the project. At the end, the group will present their findings and work where it should comprise of all subject's requirement as stated in the syllabus. Lastly, the facilitator will come out with the summary, give feedback on the PBL process, request the students to reflect on their solution, explain the problem, and assess their work and commitment throughout the learning process.

2.1. PBL Technique

The technique used in this PBL process is the FILA chart. It has been introduced by the National University of Singapore to facilitate students in teaching and teaming sessions. It is used widely in all field to generate students skill in effective communication, creative and analytical thinking, deep understanding, leadership and teamwork or independently.

Table 1 shows the standard FILA chart that is used in the PBL session especially during group discussions. It is created to list out all the facts in the problem, ideas to manage the problem, learning issues in order to manage the problem and action plan in seeking information.

Table 1. Standard FILA chart

Facts	Ideas	Learning Issues	Action Plan
Facts in the problems	Ideas to manage problem	Learning issues in order to manage problems	Action in seeking information

As guidelines for facilitators, they have to fill up the FILA chart and discuss among themselves before giving out the project to the students. These will help the facilitators while conducting the PBL sessions. The FILA chart does not end here; it will fill up again as regular discussions are made along the PBL process.

3. The development of mask design for MOSFET fabrication - An example of PBL

The goal of the project was the development of a mask design for MOSFET fabrication. Such masks are required in order to form a certain pattern on the wafer surface in the fabrication process. Masks are used to protect parts of the wafer from the high intensity UV light that will remove the photoresist coated earlier. Different masks are used when creating each of the different structures on the wafer.

It was designed and created using an AutoCAD software and printed onto the transparency films. There are four masks used in the fabrication process; diffusion mask to define source and drain region, gate mask to define gate region, contact mask for creating contact hole ,and metal mask to create the metal contact.

The student groups started the project with basic knowledge in MOS transistor theory, CMOS processing technology, Lithography technique, Modu-Lab Trainer series of semiconductor processing modules and had to study the AutoCAD software to create their own mask design using contact printing method. Accompanying courses were on IC Design, Cleanroom Technology, Electrical Characterization and Performance Estimation. One of the students served as a group leader and another as a secretary and is responsible for scheduling, reporting project progress, presentating, and organizing regular project meetings with the facilitators. In addition, the student team gained valuable experience in project management and teamwork, acquiring technical knowledge in microelectronics.

The project is completed in ten three-hour laboratory periods by students working in groups of six with high motivation and improvement in their performance. It involved "hands-on" fabrication process of MOSFET where the students perform the photolithography technique in order to transfer the pattern from the masks onto the wafer and hence complete the fabrication process. It is said to be a cost effective and simple technique for mask design. The project topic that has been assigned meets the curriculum objectives and has industrial relevance.

4. Conclusion

Throughout the learning process of PBL, the students learn how to handle problems found in real-world projects via UTHM Microelectronics Cleanroom that is equipped with semiconductor processing modules that similar to "real" semiconductor fab lab in the industry. Thus, this gives the students a greater appreciation for the delicacy, precision, and complexity of the process. In addition to the technical skills learned in the process of completing the project, students learn how to work as a team, develop self-directed learning strategies, manage time and resources, and present the results of their work in oral and written form.

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POPBL Experience: A First Attempt in First Year Electrical Engineering Students

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Abstract

With all the rapid change and progress in the world, little has changed in the way engineering graduates are taught. Project Oriented Problem Based Learning (POPBL) has become widely accepted as an educational strategy especially in engineering education. This paper discusses a review of a first attempt of POPBL for the first year electrical engineering students in Electrical Circuit Theory (BEE 1113) course for Faculty of Electrical and Electronic Engineering undergraduates at Universiti Tun Hussein Onn Malaysia (UTHM). The target of this POPBL is to complete three tasks related with experimental setup, computer simulation and designing circuit application related with RLC circuit. Students are working as a team to accomplish the task. The project is successfully completed in the given duration. Throughout the duration, undergraduates are working with a minimum supervision to distribute the subtasks, learn new computer simulation tool, determine the most suitable methodology flow and prepare the presentation materials and the documentation of the project. Close observation and rubric methods assessment has been used for evaluation. Analysis from grades distribution and questionnaires reveal that learning outcomes is improved.

Keywords: Project Oriented Problem Based Learning (POPBL); first year student; electrical circuit theory

1. Introduction

Various techniques have been used in education system to provide excellent learning process. However, the objective of the learning process is still to provide student with clear understanding on certain subjects and thus able to apply the knowledge in real life situation. Project Oriented Problem Based Learning (POPBL) is one of the methods used in education system particularly in the university [6]. POPBL is student oriented learning approach and it is believed to be the effective learning strategy for students. Without much supervision from their lecturers, students seek the information needed independently and think analytically to solve the given problem. Experiences through group discussion learning ensure the success learning outcomes. Furthermore, it also encourages students towards self-directive study. It provides more conducive environment such that the student work collaboratively with other colleagues to complete the task given rather than sit and listen to the lecturer. On a contrary, lecturer-based practice has shown that the delivery of knowledge is not good enough. Students tend to be bored and lost during the teaching session.

Educators who teach engineering courses require much effort to deliver the adequate knowledge to the students. On the other hand, students often prefer learning through practical aspect because it is easier for them to get the concepts and idea of the learning process. The POPBL technique emphasize on practical method throughout the learning process. Teaching engineering courses using POPBL has been conducted in many universities and across many area of study [1] [2] [3] [4] [5]. POPBL help students to develop creative and independent thinking in solving a problem. It is the important skills for the engineering graduate when they will become an engineer later. Working on a group with effective communication is a must to convey every possible idea, provide student with extra training for personal skills improvement. Moreover, they involve in hand-on activities instead of sitting and listening to the lecture. The hand-on skills is crucial for each engineering student. The implementation of POPBL brings out not only the knowledge, but also the value added which benefit the engineering graduate student. Using POPBL approach, student would able to get deep understanding on the certain subject where they learn through solving problem.

Realizing the advantages of the POPBL method, we have introduced this technique to the first year engineering student in UTHM with the intention to gain the experience as well as to provide students with deep understanding on the fundamental engineering subject. It is also to provide students with good learning attitude from the early phase of the study. As the POPBL approach is considered new to the student at UTHM, this has become a great challenge for them in order to adopt the new learning curves. POPBL is not used widely in all courses in UTHM and this gives negative perceptions to the student whereby they have much burden compared to the lecture-based method.

This paper discussed the introduction of POPBL in teaching Electrical Circuit Theory (BEE 1113) at FKEE, UTHM. It provides useful experience to the student as well as lecturers as this approach was the first to be implemented. Results from assessment and student feedback through questionnaire are discussed. In addition, the comparison of grades distribution between POPBL and previous lecture-based method is also presented.

2. Course overview

The POPBL approach was introduced to the first year student in the Faculty of Electrical and Electronic Engineering, UTHM through Electrical Circuit Theory (BEE 1113) subject. It is one of the fundamental subjects for the Bachelor of Engineering (Electrical) with Honours in UTHM and it is also a prerequisite to several advance subjects. Generally, this subject discussed about the properties of electrical components and basic circuit analysis techniques. Furthermore, students also learn how these electrical properties are applied in the electronic circuits. It comprises a total of 42 contact-hours for lectures and 24 contact-hours for practicum session. There are 62 students enrolled for this section and all of them are from matriculations and STPM program. Previous education background tends to be spoon-feeding. For that reason their perception as well as feedback on the POPBL techniques is valuable for further enhancement. Basically, the implementation of POPBL has several objectives. The objectives are as follows:

(i) Provide hands-on understanding of electrical instruments such as millimeters (digital and analog), power supply and storage oscilloscope.
(ii) Be able to conduct experiment and prove it using computer simulation.
(iii) Be able to conduct technical presentation effectively.
(iv) Be able to write technical report and poster presentation effectively.
(v) Be able to work in groups efficiently.

3. Implementation

This practicum session (three hours per week) starts with training in basic laboratory skills with a number of experiments, and concludes the semester with group projects lasting five weeks as shown in Table 1.

Table 1. Schedule of POPBL

Item		Marks		Total Marks	%
Practicum	Practicum 1	10	80	200	20% from the course works of BEE 1113
	Practicum 2	10			
	Practicum 3	10			
	Practicum 4	10			
	Practicum 5	10			
	Practicum 6	10			
	Practicum 7	10			
	Practicum 8	10			
POPBL	Progress Presentation 1	10	120		
	Progress Presentation 2	10			
	Final Presentation	30			
	Poster Presentation	20			
	Group management	5			
	Attitude	5			
	Final Report	40			

For these, students work in groups of four to five. It was decided by the lecturer based on the matriculation/STPM background. The standard group projects provide an experience of team working and an opportunity for students to explore a topic in considerably greater depth than in normal laboratory sessions. The group projects are also considerably more open ended than the experiments encountered previously and may involve material that the students have not yet met in their lecture courses. For the POPBL projects clearly defined topics (application of RLC circuits) were chosen that required an understanding of material that had not been covered in the lecture courses. The RLC circuit project was chosen and this project consisted of a number of tasks as shown in Table 2.

Table 2. Problem Crafting for POPBL

Task	Description
Task 1	Students are required to experimentally observe and verify the RLC circuit for series and parallel connection. Go to the respective laboratory and conduct your experiment there. Attendance will be recorded as a mechanism for performance assessment.
Task 2	Students are required to conduct experiment using any computer simulation tools available for example MATLAB®, Or CAD® PSpice, or Multisim® Electronic Workbench to prove the results in task 1
Task 3	Student are required to design any practical application of RLC circuit that you can found in control and communication circuits such ringing circuits, peaking circuits, smoothing circuits, resonant circuits, and filters. Creativity and innovative aspect must be considered in this task.

4. Assessment

The POPBL assessment strategy should be made on the student's learning process and the final result of the task [7]. The projects were assessed continuously and the rubric matrix is used by the examiners to evaluate student performance. It is divided into three main evaluation parts; with oral presentation (Table 3), process skills (Table 4) and report writing (Table 5).

The focus of the assessment is on the presentation session whereas students need to show their understanding on the work they have completed and also provide good justification on the methodology they choose. Each student from a group must be participating in the progress presentation particularly in the question and answer session.

Table 3. Oral presentation evaluation rubric matrix

RUBRIC MATRIX©Afandi Ahmad ORAL PRESENTATION					
Elements	Marks				
	1	2	3	4	5
TEAMWORK All members played a role and contributed to the presentation	Only one member played a role.	A few members played a role.	Some members played a role.	Most members played a role.	Everyone played a role.
CREATIVITY Able to present information interestingly using various relevant presentation tools, eg. graphs, charts, diagrams.	No used of presentation tools.	Used one or two presentation tools.	Used a few presentation tools.	Used some presentation tools.	Used various and relevant presentation tools.
CLARITY Able to articulate and convey information clearly.	Much hesitancy in presentation.	Some hesitancy in presentation.	Clear presentation.	Quiet smooth and clear presentation.	Smooth and clear presentation.
ORGANISATION Able to present ideas and information systematically	Presentation of information was unclear and unsystematic.	Presentation of information was quiet clear and quiet systematic.	Presentation of information was clear and systematic.	Presentation of information was quiet concise and clear.	Presentation of information was concise and clear.

Table 4. Process skills rubric matrix evaluation

RUBRIC MATRIX©Afandi Ahmad PROCESS SKILL					
Elements	Marks				
	1	2	3	4	5
TEAMWORK Able to cooperate and contribute to the team	Attended some meetings. Not interested. Did not participate in discussion.	Attended all meetings. Relatively quiet at discussion.	Attended all meetings. Participate in discussion.	Attended all meetings. Played an active role in identifying and getting tasks done.	Attended all meetings. Led and managed the group to achieve tasks.
CREATIVITY Able to generate original ideas relevant to managing the problem	No ideas. Not interested.	Attempted to participate by building on ideas proposed by team members.	Generated 1-2 ideas.	Generated 3-5 ideas.	Generated more than 5 ideas. Ideas were relevant to the problem.
REASONING Able to clarify and identify the facts	Could not identify the facts in the problem.	Tried to identify a few ideas but they were not the key ideas.	Identified a few facts. Still not able to solve the problem.	Identified most of the key facts. Able to solve the problem almost accurately.	Identified all the key facts. Able to solve the problem accurately.
RESEARCH Able to obtain information from the various sources independently	Needed much guidance in obtaining information.	Needed some guidance in obtaining information.	Obtained information independently but from a limited source.	Obtained information independently from a few sources.	Obtained information independently from diverse sources.

Table 5. Process skills rubric matrix evaluation

RUBRIC MATRIX©Afandi Ahmad REPORT WRITING			
Elements	Marks		
	1	3	5
ORGANIZATION Able to organize their report effectively	No table of contents; no page numbering; unsuitable title and sub-title.	Table of contents not in sequence; inconsistance page numbering; not relevant suitable title and sub-title.	Table of contents in logical sequence; page numbering; suitable title and sub-title.
PRESENTATION Able to present their ideas original ideas in an appropriate order and all the ideas supported by information.	No main idea presented; ideas are presented in an order that distracts from clear communication; ideas are not supported by information	Main ideas are presented to some extent; ideas are not presented in an order that adds clarity; some ideas are supported by information and logic.	Main ideas are clearly presented; ideas are presented in an appropriate order; ideas are supported by information and logic.
GRAPHICS Able to choose relevant graphics to support their ideas.	No use of pictures, models, diagrams, charts, tables and graphs.	Some appropriate use of pictures, models, diagrams, charts, tables, and graphs.	Effective use of pictures, figures, models, diagrams, charts, tables and graphs.
LANGUAGE Able to write their report effectively.	Errors in sentence structure, punctuation, terms, spelling and standard usage impair readibility.	Sentence structure, punctuation, spelling, and standard usage errors are noticeable, but do not seriously impair readibility.	Generally error free in regards to sentence structure, punctuation, terms, spelling and numerical standard.
CONTENTS Able to organize their report with sufficient information based on the requirement.	Most of the report requirements are not complete.	Some proposal requirements are complete.	All report requirement are complete.

5. Results and Discussion

In order to evaluate the effectiveness of the POPBL implementation, we have compared to the distribution grades of lecture-based approach as shown in Table 6. The number of student achieved higher grade is increased almost 6% and all student pass the course. Fig. 1 shows a bar-graph of grades distribution where there has reduction in lower grades.

5.1. Student Feedback

As well as the standard anonymous questionnaires completed by all students at the end of a module, students' views on the projects were also obtained through open-ended questions.

Most of the student said that they learn more and have improved much not only on the subject, but also their attitude towards self-directed learning. In question one, 53% students strongly agree that POPBL project encourage them to integrate and skills from different disciplines as shown in Fig. 2. The skills includes effective communication, technical writing, time management, team works, electrical circuits theory, laboratory practical, computer simulation, and research skills. Fig. 3 shows that 45% students strongly agree that POPBL improve oral defense presentation and confidence level to stand what they have done to complete the task. Fig. 4 show that 40% student strongly agree that group discussion is important to complete the task while Fig. 5 reveal that 40% students strongly agree that they get deeper understanding on RLC circuits and even electrical and electronic engineering subject. The average rating for this question is 1.97 (1 is strongly agreed and 6 is strongly disagree) which describe that most student have better experience in the learning process.

From the questionnaire given, 57 students fill in the free comment sections to give feedback on the POPBL experience. Generally, more than half of the students agreed that POPBL improve their learning process as well as other skills such as communications. The remaining 11 students feel that the POPBL require much time and thus are not agree if POPBL is implemented in other courses. Some samples of student feedback shown in Fig. 6.

Table 6. Comparison of grades distribution between POPBL and lecture-based approach

<table>
<tr><th rowspan="3">GRADES</th><th colspan="4">PERFORMANCE PERCENTAGE</th></tr>
<tr><th colspan="2">POPBL</th><th colspan="2">POPBL</th></tr>
<tr><th>WITHOUT</th><th>WITH</th><th>WITHOUT</th><th>WITH</th></tr>
<tr><td>A</td><td>1.11</td><td>4.84</td><td rowspan="6">35.56</td><td rowspan="6">41.94</td></tr>
<tr><td>A-</td><td>3.33</td><td>3.23</td></tr>
<tr><td>B+</td><td>4.44</td><td>4.84</td></tr>
<tr><td>B</td><td>6.67</td><td>11.29</td></tr>
<tr><td>B-</td><td>8.89</td><td>8.06</td></tr>
<tr><td>C+</td><td>11.11</td><td>9.68</td></tr>
<tr><td>C</td><td>17.78</td><td>29.03</td><td rowspan="5">64.44</td><td rowspan="5">58.06</td></tr>
<tr><td>C-</td><td>15.56</td><td>12.90</td></tr>
<tr><td>D+</td><td>11.11</td><td>11.29</td></tr>
<tr><td>D</td><td>12.22</td><td>4.84</td></tr>
<tr><td>E</td><td>7.78</td><td>0.00</td></tr>
<tr><td>TOTAL</td><td>100</td><td>100</td><td>100.00</td><td>100.00</td></tr>
</table>

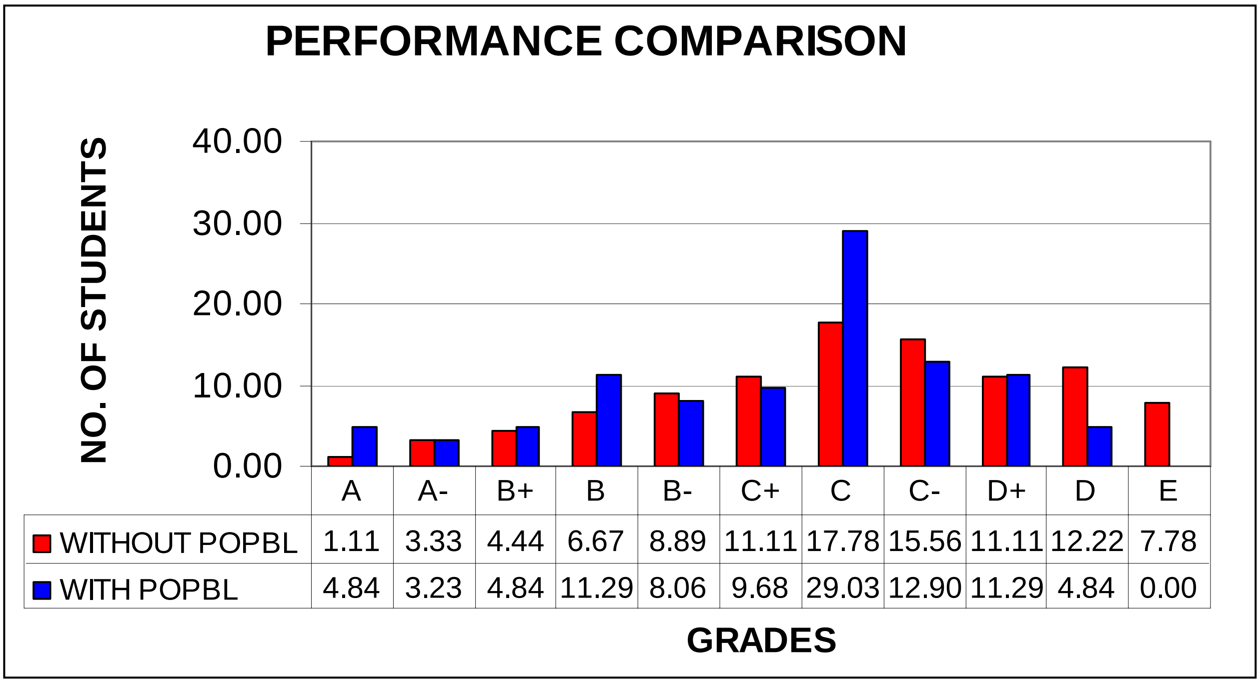

Fig. 1. Comparison of distribution grades for student performance in BEE 1113

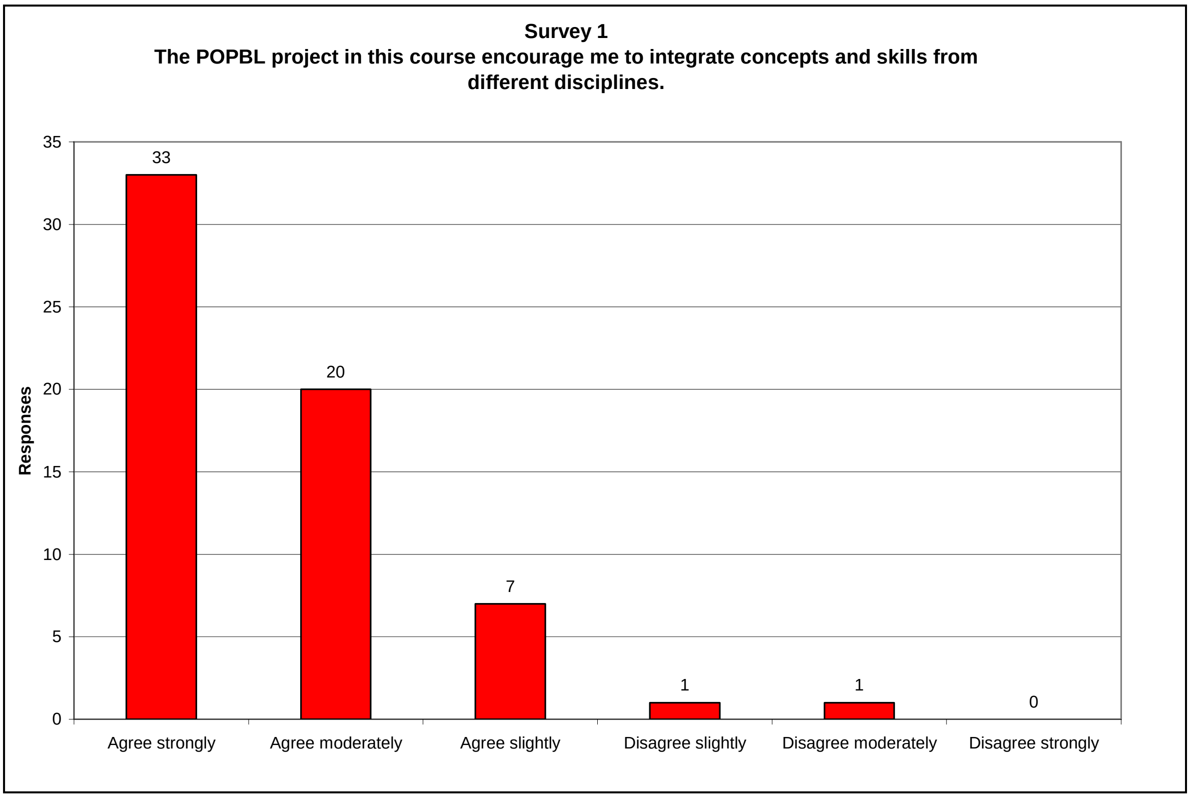

Fig. 2. Student feedback (integration concept and skills from different disciplines)

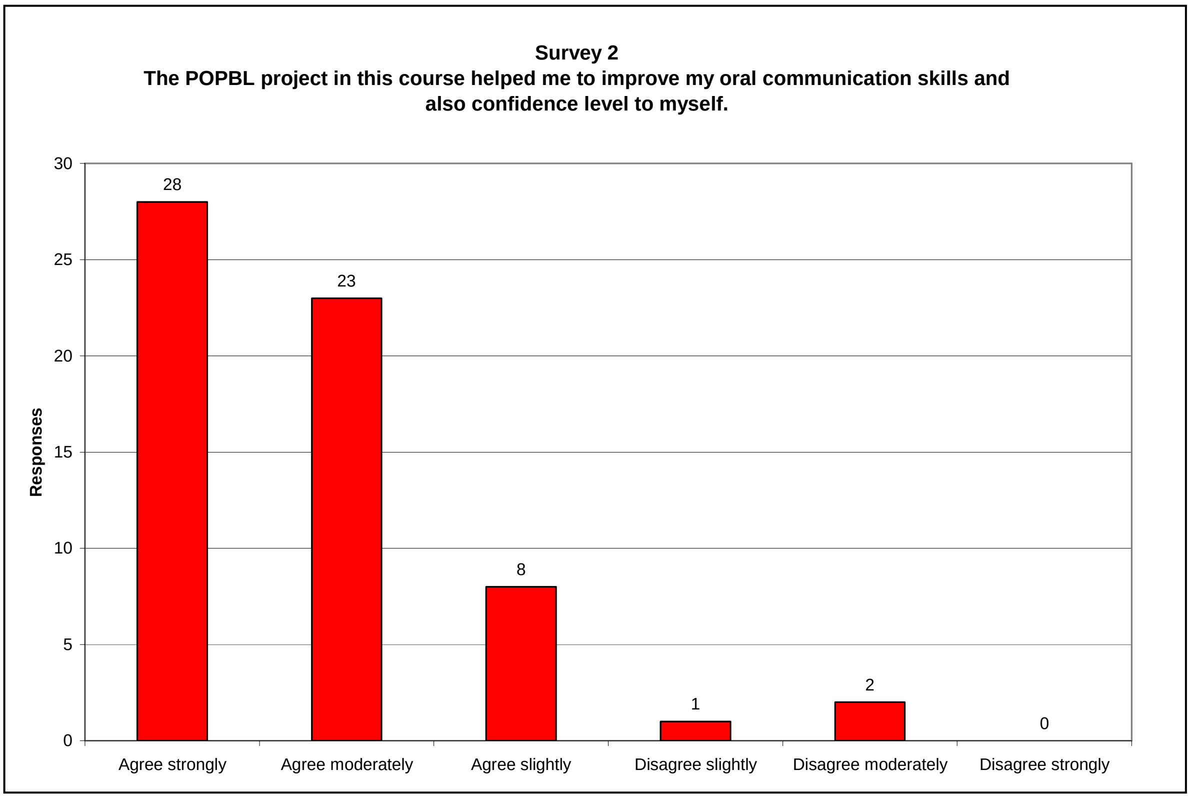

Fig. 3. Student feedback (communication skills and confidence level)

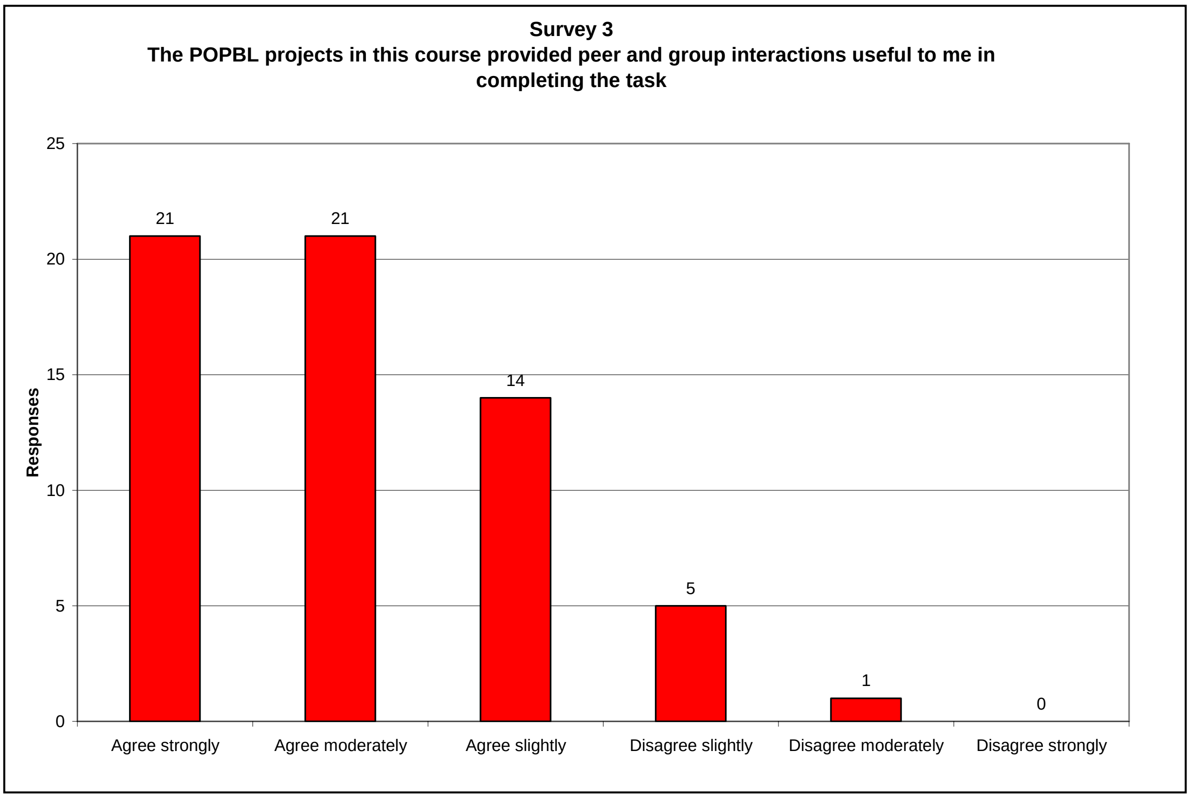

Fig. 4. Student feedback (the important of group function in the POPBL)

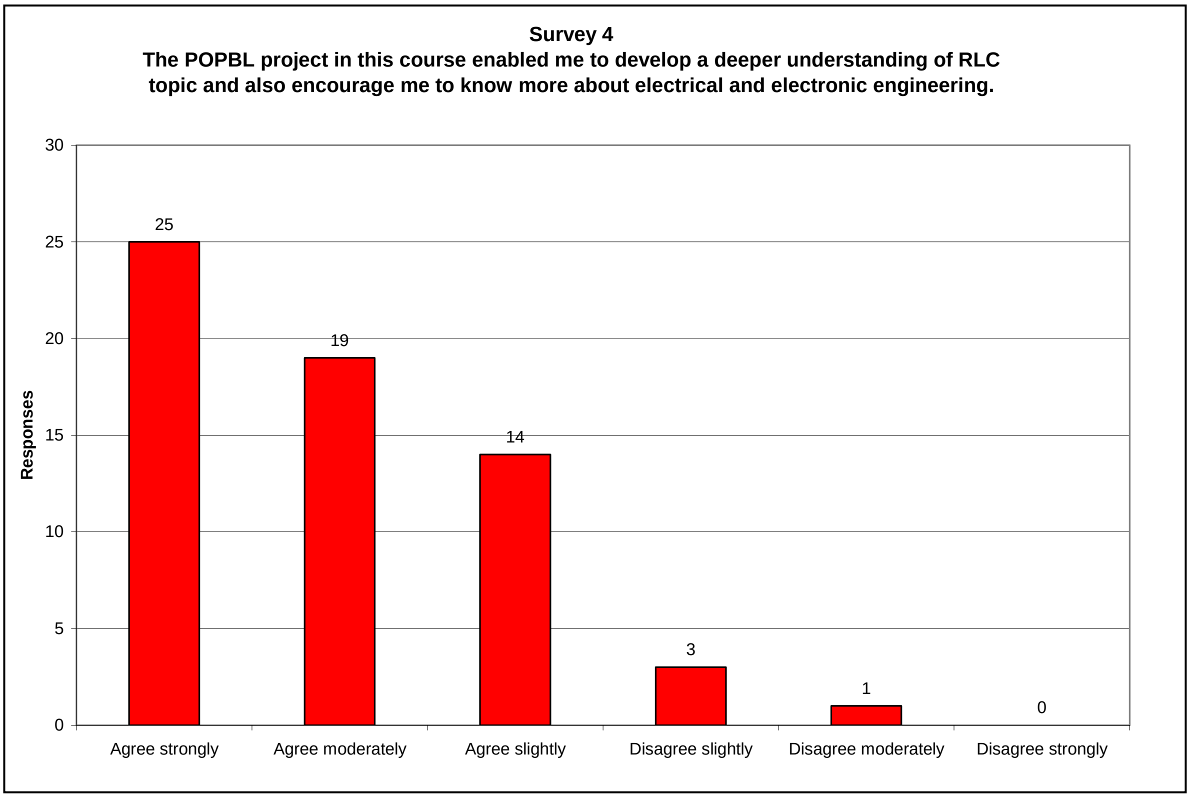

Fig. 5. Student feedback (understanding of the RLC topic)

1. POPBL is more challenging because they have overall evaluation and very details.
2. It totally different. But same a little bit. But actually the POPBL give me more advantages compare to disadvantages.
3. POPBL make students to be more independent. Students will try to solve the project by their own ways.
4. Help the students to gain knowledge of the concepts and formula, compare the other course without POPBL is just on exam orientation.
5. Its fun to have POPBL, and thankfully that not every subject has POPBL since we have to focus for our final.
6. POPBL will bring up many problems that cannot be seeing in other course without POPBL. Because POPBL is a program that make student to face the real-world problem.
7. I think POPBL project makes me understand better in the RLC topic.
8. With POPBL in particular course, it helps me to be a good presenter also increased my understanding.
9. There are a lot of discussions in POPBL, and it shows me that discussion can helps us in learning.
10. I think the POPBL project is more effective. POPBL also made me easy to understand certain topic – RLC in this case.
11. I will know more about the electrical and electronic engineering. Without POPBL, I have no experience in conduct any research.
12. After POPBL, we all more confident with our course.
13. Very different, it’s because with this POPBL it improve my knowledge and work as a team.
14. With POPBL, I can understand more about the topic practically.

Fig. 6. Student comment on the overall POPBL approach

5.2. Learning Outcomes

Clearly, implementation of the POPBL in the first year engineering student has greatly improved students' learning process. The important thing is that student learnt themselves how to use relevant software to be used in the project. They take their own initiative to learn different software which is MATLAB®, OrCAD® PSpice, or Multisim® Electronic Workbench. In addition, they discussed the advantages and disadvantages of the software during final presentation. Student is trained to have good learning attitude for seeking knowledge. Besides, they also studied indirectly several advanced topics in which will be teaching next semester.

At the end of the POPBL, most of the students appear with an improvement on their learning motivation. Students are preferred on learning through practical approach. In the POPBL, they have to expert with instrumentation and measurement devices such as oscilloscopes and multimeter. Thus, implementing POPBL at the early program for undergraduate in engineering provide strong foundation to be self learners throughout undergraduate program.

In the groups, students need to participate actively to finish the task given. This provides cooperative learning skills among student which affect to others subject they takes. All the soft skills must be train from the beginning of the study for their career development and of course for the country development in the future.

6. Conclusion

Through the POPBL implementation students have experienced great learning process. As the objectives of learning is to help students to get deeper understanding on the subject, POPBL on the first year engineering student has a lot of potential to keep its momentum until graduation. Designing good and suitable POPBL problem crafting is crucial, so that student adequate soft skills as well as to ensure successful learning outcomes.

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Implementation of Problem-Based Learning (PBL) in Foundation Physics Subject

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Abstract

Foundation physics is a must to engineering students. It offers basic concept in engineering field. This paper describes PBL implementation to engineering students at Universiti Tun Hussein Onn Malaysia. They are taking electrical and electronic course for diploma program. The subject is Physics 2 offered by Centre of Science Study in second semester session 2006/2007. 24 students were divided into four groups with each groups comprises of 6 members. A physics lecturer act as a facilitator of the program. As a novice in PBL, a sub-topic of temperature and heat was selected as a trigger problem. It takes four weeks to conduct the PBL session including briefing, problem solving, presentation and assessment session. Group members play an important role in their mission to solve the problem. It was achieved by planning good group strategies as well as maintains good teamwork. Students show excellent improvement after the PBL program. They are able to work as a good team member, excellent presenter, improved interpersonal communication and critical thinking.

Keywords: problem-based learning (PBL); engineering; physics; temperature and heat; generic skill.

1. Introduction

Since decades students are trained to study base on lecture-based learning. Lecturers prepare lecture notes or module from many sources; books, journals, internet and also from research findings. Then enter a class to deliver their lectures or idea to students. Students just sit down and listen to the lectures. Sometimes they take notes and doing exercises given by lecturer. This one way communication creates a passive education and learning situation in the class. Lecturers act as an active and dominant role in the class while students as a passive learner. The assessments are based on assignments, quiz, test and final exam. In this way the students are only trained on how to answer questions. This traditional learning method resulting in less student's competent in the subject, and also the soft skill or generic skills as well.

Lecturing physics to engineering students is not an easy task. It is even more so considering that future engineers with basic engineering concept need to be more competent. The development of knowledge began to be viewed as a process which individuals must grapple with complex questions, tackle problems, conduct original investigations and filter information through their social and cultural context. They manage to learn from experience and practice ideologies to complete their mission successfully. As these ideas converged with other contextual forces, problem based learning emerged as an innovative education and learning approach.

PBL is an approach or concept in which it is acknowledged that learners should develop metacognitive skills and thus it is expected that students use reasoning abilities to manage or solve complex problems [1]. This approach was created by Barrows and Tamblyn [2]. Using this approach students are divided into small teams and did not receive traditional lecture, instead they used a 'problem pack'. When compared to traditional approach groups, students worked in PBL format were seen to have increased motivation, problem solving and self-study skills [3].

Realizing these needs to prepare future professional engineers, in 2005, Universiti Tun Hussein Onn Malaysia (UTHM) formally embarked on a bold yet challenging journey into the world of PBL [4]. Venturing into new uncertainties territory, some lecturers at UTHM were successfully managed to conduct PBL in broad area of science and engineering. Nor Haslina Hashim reported PBL implementation on civil engineering undergraduate students [5], Afandi Ahmad reported for computer engineering undergraduates [6], Suhaimi Makminin reported for chemistry [7] and Elizabeth Anthony reported on effective communication studies [8].

This paper will describe the early PBL implementation on electrical and electronic engineering diploma students taking Physics 2 (DSF1973) offered by Centre of Science Study, UTHM. They were doing PBL in second semester session 2006/2007.

2. PBL Implementations in Foundation Physics Subject

As PBL is still new to physics lecturer whose most of them teaching foundation physics to engineering students, PBL was conducted at the end of semester. Four weeks were allocated for PBL including briefing, problem solving, presentations and assessment session. 24 students were divided into four groups comprises of 6 members. Fig. 1 shows the entire process of PBL.

2.1. Creating problem/ trigger

The issue of complexity of problem design is something that is a challenge to facilitators implementing PBL. In order to designing problem or trigger, four physics lecturer were sitting down to discuss and designing a problem. A sub-topic of temperature and heat was chosen as a trigger problem. Decision was made to use lecturer's room as a trigger problem. The students were requested to find some solutions on how to control heat transfer at lecturer's room

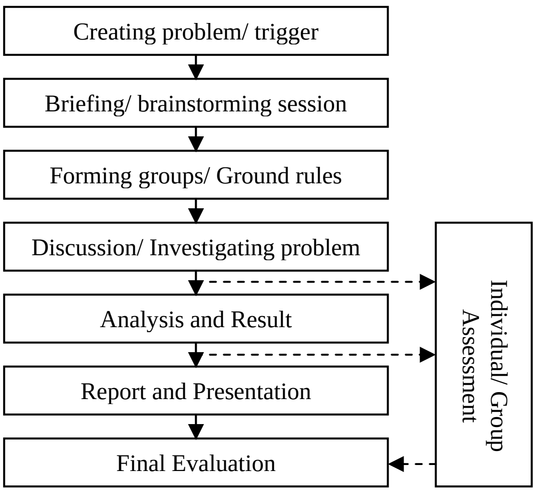


Fig.1. Flowchart of entire PBL process.

as well as saving electricity expenditure per month. Below are the problem statement given to students.

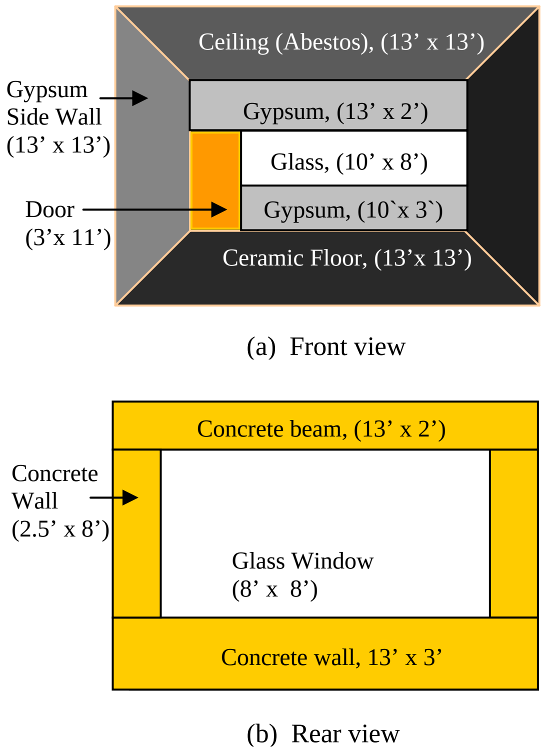
UTHM spends hundreds of thousand RM every month for utilities purposes, especially for electrical power. As a responsible member of UTHM, we should concern how to save electricity to minimize the cost of lighting and air-conditioning.

Trigger 1 shows a typical diagram of lecturer's room. If you are maintenance officer or as an engineer, write proposals and your justification, how to overcome the problem. Among other things that you have to consider are the heat transfer through the walls and the choices of materials used as walls.

As an added trigger, diagrams of lecturer's room were given. It will help students to think and generate ideas on how to solve the problems. The diagrams of lecturer's room (Trigger 1) are shown in Fig. 2.

2.2. Briefing/ brainstorming session

Briefing session was conducted in the first week of PBL session. In this session, facilitator gives briefing on PBL to students. They includes introduction to PBL and handing the problems to each groups. The session was conducted interactively and any preliminary problems arises is discussed and solved in the class.



(a) Front view

(b) Rear view

Fig. 2. Diagram of lecturer's room, Trigger 1.

2.3. Forming groups/ Ground rules

After the briefing session, the students were divided into four groups with 6 members in each group. The groups was also comprises of all races and gender. At this stage, the group will specify group's vision, mission and group outcomes for the rest PBL process. In order to ensure team commitment, team members need to work together through a team-building activity to develop ground rules to which they all feel able to be bound and committed. Such ground rules can form the basis of a 'contact' between team members. The following are the example of group's ground rules:

(i) Attend meeting punctually.
(ii) Complete task given on time with good quality.
(iii) Listen when another member is speaking.
(iv) Speak up if there is disagreement.
(v) Say what comes to mind.
(vi) Give and receive feedback towards one another which is supportive and constructively critical.
(vii) Shared responsibility for the progress of the process and outcomes of the team.

2.4. Discussion/ investigating problem

In this level each group will seat together to discuss the problem. It was starting by listing down each fact encounter from the problem statement. Any ideas related to the problem and trigger were generated and summarized by each member and noted down. Then they will discuss learning issues that can help them to solve the problem. Finally they search for information from every resource including books, journal, notes, manual and internet. All of these processes were listed in FILA table as shown in Table 1. At the same time they were practicing their generic skill during interview session with related individual or organizations.

Table 1. FILA table.

Facts	**Ideas**	**Learning issues**	**Action plan**
List the facts in the problem.	List as many ideas as you can generate to manage the problem.	List the topics that you need to learn in order to manage the problem.	List a plan to show how, what and where you intend to seek new information.

2.5. Analysis and result

At this stage students gather all information and findings from their problem solving activity. Analysis such as calculation and explanation on the problem findings were converged and verify to form final result. Each group will review and critique their result to determine the final solution.

2.6. Report and presentation

This is the final stage. Each group drafting their report, make conclusion and finally writing a full report. They are also trained to present in front of their friends and facilitator thus improved the communication skills.

2.7. Individual/ group assessment

During the PBL process, the students were assessed by facilitator individually and as a group. Individually the students were assessed as in Table 2. Each group members were also gave the same form to assess their friends. In group they were assessed base on teamwork, creativity, reasoning and research performance.

Table 2. Individual assessment form.

No	**Assessment topics**	**Marks**
1	Actively assisting in making group's decision	
2	Perform the task given effectively.	
3	Provide good ideas to group.	
4	Always attend meeting.	
5	Always motivates and encouraging team members.	

* 1 for lowest mark, and 5 for highest mark.

2.8. Final evaluation

In the final week, each group will present their result in front the friends and facilitator. The facilitator will evaluate the presentation as well as group's report. Individual and group's assessment during the PBL session were also considered in the evaluation session.

3. PBL Assessment and Discussion

Final result of assessment or evaluation is a proof of performance of PBL. It is an ongoing process aimed at understanding and improving student's learning. It involves in expectations, setting appropriate criteria and high standards for learning quality, systematically gathering, analyzing and interpreting evidence to determine how well performance matches those expectations and standards, and using the resulting information to document, explain and improve performance [9].

In PBL process, the students were assessed individually and as a team continuously during the session. The final evaluation will gathered all of these continuously assessment with presentation and final report. The facilitator as well the students themselves will perform the assessment based o the set criteria and standard.

During the PBL session each group will sit together in PBL class, discussing problem arises including team problems, making short term and long term decision on how to solve the problem, take action and review the action taken. Each team member shows good cooperation to their group although there are some disagreements among them, but they were able to solve the problems. The team leader plays very important role in controlling the team members. Some soft skill such as leadership, motivation, cooperation, teamwork and critical thinking were developed during the session. Sometimes the group comes to discuss with facilitator to discuss some problems. Here they were assessed on group's commitment to ensure that all the team members participate actively in the meeting.

Besides the ongoing group's assessment, the students were also assessed individually. In this process both facilitator and students has an opportunity for assessing student's performance. Some of them successfully accomplish the standard criteria as needed in the individual assessment form. Some of them were successfully score a full mark of criteria. But a few of the students could only score a lower mark especially by their friends. This shows that there are still exists some lack of cooperation and contribution of the students to the group. However some of them shows good communication and interpersonal skills especially during interview session with lecturer, officer, staff and through telephone conversation. Overall, the students were successfully show respective value such as punctuality, highly motivated, encouraging and always do the best in their task during the PBL.

At the end of the session, the students were evaluated by facilitator on their presentation skills and report writing. The facilitator will select any team member to present their result. This will encourage each team members know what they are doing, without leaving their friends alone to complete the presentation. From the presentation session, the presentations slides were made interactively with some simple animation and picture to clearly describe their result. In addition some calculation and discussion were successfully shown to prove their result. Amazingly the students also show some new variable and method to solve the PBL problems. It shows that they were doing extra references than in the books.

The final evaluation was depends on the full report. It shows all the activity done by the team including group's meeting, minutes, FILA table, group's strategies, group's commitment and step-by-step of problem solving technique. The report was also presented in an interesting approach and clearly expresses the group's identity.

4. Problems and suggestions

Although the PBL can be assume successfully accomplish, but there are still some deficient aspect encountered during the session.

(i) Lack of time. There are about ten topics must be covered in the second semester which temperature and heat is one of them, there are insufficient time to allocate all them in one semester.
(ii) Costly. The expenses such as for transport, material and communication burden the students.

As a suggestion the syllabus maybe can be revised to accommodate necessary topics in PBL in one semester. If the expenses cost is very high, facilitators may be could prepare some cost effective or low cost problems. But there still some cost to sacrifice in order to accomplish a quality mission of PBL. Finally the cooperation and participation of students and facilitators are the key factor for the successful of PBL.

5. Conclusion

The problem-based learning of foundation physics was successfully implemented to electrical and electronic engineering students. From the facilitator observation generally the students were starting to understand the concept of PBL. Some soft skill or generic skills are starting to develop among the students such as leadership, interpersonal and self-directed learning skill. They are also trained to be punctual, actively generating ideas in group and good motivator to the friends.

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A Problem-based Learning (PBL) Model for Engineering & Technical Courses

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Abstract

Problem-based learning (PBL) is an inductive learning approach that uses a realistic, unstructured problem as the starting point of learning. Students have to fill in a knowledge gap (also called the learning issues) before they are able to solve the problem. Unlike areas such as medicine and law, which are more naturally and thus, easily adaptable to PBL, implementing PBL in engineering courses in the traditional semester system set-up is challenging. Nevertheless, several engineering courses in Universiti Teknologi Malaysia have successfully implemented PBL since 2002 for an average class of 60 students. After making numerous refinements to improve and weed out problems, the PBL model implemented currently in these courses has reached a stable plateau. The PBL model, which is divided into three phases, takes into account practical issues during implementation as well as assessment of the PBL process. The use of e-learning is also integrated into the PBL environment to enhance learning and out-of class facilitation. This paper provides a detailed description of the PBL model currently adopted in engineering courses in UTM.

Keywords: Problem-based learning (PBL), engineering educatoion

1. Introduction

The current requirements of the Engineering Accreditation Council (EAC) Malaysia for all undergraduate engineering programs to comply with Outcome-based Education (OBE) [Engineering Accreditation Council, 2006] has resulted in a serious appraisal of both the curriculum and the way students are taught. The professional skills required means that pedagogies other than lectures must be applied. In addition, the pedagogies should engage students to learn, as well as develop their learning process.

Problem-based learning (PBL) is an inductive learning, team-based approach that focuses on developing thinking and learning skills in students. Unstructured problems (which may be real or simulated realistic ones) are used as the starting point of learning, creating deep interests among students to learn new knowledge and integrate existing ones, and forcing them to think critically and creatively to solve the problem [Tan, 2004; Woods, 1996, Woods, *et al.*, 2000]. A PBL learning environment can easily accommodate all the desired generic skills outcomes required by the EAC. Nevertheless, the strength of PBL lies in shaping attitudes as well as creating interest and excitement in learning otherwise dry content, and motivating students to cultivate interdependence in learning, thinking and problem-solving together in their teams and among teams.

In a third year chemical engineering course, a student posted the following comments about PBL in the course electronic forum:

"… At first, when we started the class with case study 1a, i take the class so lightly by just study in class and do nothing at hostel .... but then , when we start the discussion in class, i was the one who sit and do nothing ...., and it really made me feel PRESSURED .. hohoh ... **i don't wanna be the black sheep in the group and later on i started study like hell .... and for heaven sake, i think i can strongly give opinions and argument to the cases** .... hahaha .... IT'S ALL ABOUT THE PRESSURE. In class, that's the awesome part .. **I've never seen a class a 2 hour class where no one is sleeping .. even yawning** ... my gosh .... and for those sleepy heads in class for sure are pressured to see everyone so gutsy and up on their toes to give opinion and take part in class ... everyone struggling to state and protect their opinion which make the class in some sort of debating ...hohoh ..."

In Universiti Teknologi Malaysia (UTM), PBL had been implemented in several undergraduate engineering courses since 2003. Prior to implementing PBL, a number of lecturers had also implemented cooperative learning in their courses. Since 2002, the university had encouraged academic staff to apply active learning techniques in their classes. To promote the implementation of active learning, including PBL, the university formed an Active Learning Taskforce in 2004.

2. Background on PBL

PBL is a philosophy that has 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. Therefore, there is no "one-size-fits-all" approach to PBL that can simply be implemented from one institution to another [Tan, 2003].

There are, however, essential features of PBL. The PBL approach sought to embed small groups of students in the role of a professional and present them with a messy, unstructured, real-world problem, based within the context of the profession, to solve. This is, in fact, the major driving force for learning. The problem should be well crafted to engage and immerse students in learning new issues, as well as challenge existing knowledge, skills and attitude. Students are then guided by cognitive coaches through the problem solving process and develop high levels of generic skills and attributes, along with the content specific knowledge and skills they require. PBL practitioners often claim that their learners are more motivated and independent in their learning. The PBL pedagogy sought to make students' thinking visible – it is no longer about making content visible as in the traditional mode.

PBL is one the learning approaches with underpinnings on cognitive and social constructivist learning theory [Jee Park, 2001]. Through PBL, a learning process will be more active compared to the traditional learning situation. According to Boud [1985], PBL is a learning process that is centered on `a problem', a query or a puzzle that the learner wishes to solve. In PBL, a problem acts as a stimulus for learning where students have to understand and analyze the problem from multi-perspectives individually or in groups. The problem will drive the learning where students are not only required to seek a correct answer for the problem, but they have to interpret the problem, gather needed information, identify possible solutions, evaluate options, and present conclusions that are related to the problem.

3. The UTM PBL model

The UTM PBL Model requires students to be divided into teams of four or five. Team-working is crucial in determining the success of PBL for students. Consequently, cooperative learning (CL) is integrated into the UTM PBL Model, where CL structures, such as the jigsaw structure, can be used to develop team-working and team-based learning skills in students.

The UTM PBL process model is modified from the one proposed by Tan [2003] to suit the environment in UTM. This model is suited for facilitating small groups within a large class. Since the typical class size in UTM is about 60 students, there are usually between 12 to 15 teams (4 to 5 students in a group) that have to be facilitated. Good team-working between members is developed through cooperative learning techniques, and evaluated using peer-rating, which is then used to calculate an autorating factor that is multiplied to the overall group marks. The teams may be facilitated using a floating facilitator model, all at once during overall whole-class discussion, or virtually through electronic forums. The model include the use of e-learning because currently, many of the lecturers involved in PBL integrate e-learning into the learning environment to include activities to reach the desired educational objectives, such as creating realistic problems to encourage immersion, facilitating students and providing scaffolding, as well as providing additional platform for discussion and peer teaching [Zaidatun, et. al, 2007].

Fig. 1 shows the complete cycle of a typical PBL process implemented in UTM. As mentioned earlier, this framework is modified from Tan [2003]. The whole PBL process can be divided into 3 main phases. Phase 1 is necessary to prevent students from jumping to conclusions and try to rush to solve the problem without first understanding it. Phase 1 consists of the following steps:

Meet the problem. Problem scenarios are given a day or two before class time. Lecturers who use e-learning will normally up-load the problems on the class e-learning site and require students to bring it to class. The students read the problem scenario, reflect and articulate probable issues individually. They are encouraged to do background reading on the possible learning issues before coming to class. A reading list for each week may be up-loaded on the class e-learning site. Students are asked to restate the problem in their groups to enable them to get the same mental picture of the problem and eliminate sweeping assumptions or biases.

Problem identification and analysis. The teams reach a consensus on the problem statement. They analyse the problem through guided brainstorming to generate ideas. At this stage, they also identify appropriate existing knowledge (what we know), additional data or information needed (what we need to know) and the learning issues that must be tackled through self-directed learning. During a two-hour class period, each team is required to discuss and submit a problem restatement and problem identification before the problem restatement and identification are discussed with the whole class. Facilitators probe and guide the students so that they are on the right track in understanding the problem, as well as the learning issues identified. Self-directed learning may also be monitored by the facilitator during a class session. An electronic forum on the case study is put up on the class e-learning site so that students may discuss the problem with the whole class while being monitored and facilitated by the lecturer.

Once the problem has been identified and analysed, self-directed learning will take place among team members. Nevertheless, students may need to return to Phase 1 once they have more information and knowledge. In Phase 2, the students undergo the following steps:

Self-directed learning, peer teaching and reporting. Facilitators may give references or activities to provide scaffolding for students to learn new concepts. Students report their discovery from research and self-directed learning to their own teams. Part of this step may be performed in the classroom in the presence of facilitators. To facilitate this phase and ensure that students are able to learn the concepts correctly, each member in a team prepare peer teaching notes for his/her team mates and submit a copy to the facilitator. Team-based peer teaching can then be held during class time while being monitored by the facilitator. For difficult and/or critical concepts, an overall class peer teaching can be held, where one or two teams can be selected to present and conduct discussions. Normally, by the end of the semester, all teams would have had the responsibility to conduct an in-class peer teaching session. Students will also normally discuss concepts learned in the electronic forum for the case study. At this point, students may also be asked to re-evaluate their problem identification sheet to reassess the problem.

Synthesis and application. 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. Usually at this time, the electronic forum will be inundated with discussions, questions, ideas and suggestions to solve the problem.

Upon solving the problem, the students enter the third phase, where they go through the following stages:

Solution presentation and reflection. The solution to the problem is presented in the form of a report and an oral presentation 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. This stage may be completed in a one-hour class period. Each student is required to submit a learning and reflection journal at the end of a case study. There is also an overall discussion on material and skills learned from the case study in the electronic forum.

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. Different solutions that arise from different teams will be compared and discussed to ascertain the better solution.

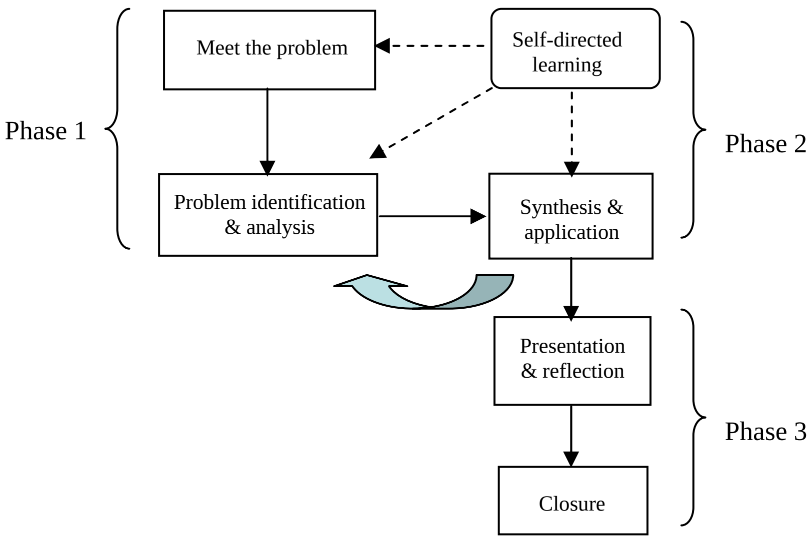

Fig. 1. Framework of the PBL process

The facilitator also summarizes crucial principles and concepts, as well as eliminates any doubts that arise from the students. In this model, the facilitator must also be the content expert so that he/she will be able to give a proper closure.

4. Implementation of the UTM PBL Model

The PBL model given can be used on students at different levels in university. However, students facing PBL for the first time must be trained for crucial skills essential for PBL, such as team working, and learning as well as thinking skills. First-timers must also be motivated and encouraged more often than experienced students. In addition, students may need more guidance in the first one or two problems. This can be in the form of in-class sessions, and scaffoldings (as well as how to use them). Facilitators of students who are new to PBL must also be aware of the emotional cycle that students go through to help them persevere the initially "painful" and "confusing" process.

The duration of problems can be varied from a week, to a whole semester. It is advisable to divide long problems (ie. those that take two weeks or more) into parts, each with a short report submission. This is to force students to be consistent in learning, and avoid last-minute work.

Scaffolding can be given in different forms. When there are problems of time constraints (which is common in semester system in UTM where there is only 14 weeks in a semester), it is allowable to provide specific references or articles on the learning issues. Experts from a specific field that is required in the problem can also be included; these experts can be available on-line, or asked to give advice on certain days before the due date of the problem. It is possible to incorporate formal CL structures as part of a scaffolding activity. Choosing the appropriate scaffolding, which is part of problem crafting, should be carefully thought out and planned.

It is evident that lecturers must be trained and supported to implement PBL in their courses. In UTM, the extent of PBL and CL implementations and support vary from faculty to faculty in UTM. While a few faculties are working towards institutionalizing the method of teaching and learning, many still leave the choice to lecturers. However, the enforcement of outcome-based education (OBE) for engineering programs and quality assurance (QA) for non-engineering programs is forcing faculty administrators to think about consistent and systematic distribution of outcomes from each course in a program.

The Active Learning taskforce had held numerous awareness forums, seminars and road-shows involving students, academic staff, and faculty administrators since 2004, to encourage a gradual change in teaching and learning. Although the appointment of the taskforce had expired in 2006, regular CL and PBL training workshops are still being conducted by former members, enlarging the pool of interested and trained lecturers in UTM. It is not surprising, therefore, to hear of students from different faculties reporting that they had gone through CL and PBL from lecturers who had attended the workshops.

University-wide support is provided by the Center for Teaching and Learning (CTL). There are regular teaching and learning courses being held for all lecturers, including CL and PBL. Awareness programs are also being organized by CTL. Prodded and guided by the CTL, all faculties are slowly moving towards revising the curriculum of their programs according to the outcomes. These efforts are very encouraging in supporting new and current micro and macro implementations of CL and PBL in UTM.

5. Final remarks

The UTM-PBL Model put forth in this paper provides a general framework for implementing PBL. Theoretically, this framework can be implemented for large classes as it uses the floating facilitators, though this is not ideal. Although the model has been mostly implemented in engineering and technical courses, it is flexible enough to accommodate other disciplines.

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