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Promoting Problem-Based Learning (PBL) in Engineering Courses at the Universiti Teknologi Malaysia*

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In this paper, the authors describe the efforts in promoting the implementation of Problem-Based Learning (PBL) at the Universiti Teknologi Malaysia (UTM), Johor Bahru, Malaysia, which is essentially the groundwork phase of the University-wide PBL project. The move to train a core group of lecturers to implement PBL was initiated in 2002. The litmus test on the effectiveness and the possible applicability of PBL in engineering courses at the UTM was conducted in the first semester of the 2003/04 academic year in *Process Control and Dynamics*, a required subject for fourth year students in the Department of Chemical Engineering in the Faculty of Chemical and Natural Resources Engineering. The outcome of the pilot implementation was highly successful in that the Department allowed PBL to be implemented in other classes. This also encouraged other faculties to promote the implementation of PBL. Since then, there have been several implementations in the Faculty of Chemical and Natural Resources Engineering, the Faculty of Mechanical Engineering, the Faculty of Electrical Engineering, and the Faculty of Civil Engineering.

INTRODUCTION

The Universiti Teknologi Malaysia (UTM), Johor Bahru, Malaysia, is a technology-based public university that produces the highest number of engineering graduates in Malaysia. The University's mission is to provide quality education for the masses, in line with the vision of Malaysia. The UTM is neither elitist nor egalitarian. There are a variety of students from different academic and social backgrounds who meet the academic requirements pursuing engineering degrees and diplomas. Given the myriad of students entering the University, the UTM is committed to provide quality education for all to the future technical workforce and leaders of Malaysia.

In order to produce quality graduates, the UTM had recently come up with attributes to reflect its graduates. UTM graduates shall have sound disciplinary and professional knowledge, high self-esteem and effective skills in communication, teamworking, problem solving and life-long learning. To achieve the desired outcomes of expertise in content knowledge, positive attitudes and abilities in generic skills, student-centred teaching and learning techniques, especially Problem-based Learning (PBL), are highly encouraged.

PBL originated and gained wide acceptance in medical education. However, in the last decade, there has been a growing movement throughout the world to adopt PBL in other fields, including engineering. Many implementations are reported in North and South America, Europe and Australia.

Initially, there were many lecturers at the UTM and faculty administrators who were sceptical that PBL could be effective. One of the major concerns is the high number of students in a class that could cause difficulties in facilitation and assessment. Whereas

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most PBL implementations have less than 30 students per class, a typical class at the UTM consists of 60 to 70 students; some common subjects may have up to 120 students. In addition, adopting PBL with just 14 weeks in a semester to cover the required content is challenging, if not impossible. There were also those who were just resistant to any form of change. It was clearly evident that persuading lecturers to adopt PBL was going to be an uphill battle.

In this article, the authors describe the ongoing efforts by the Active Learning Taskforce at the UTM to convince lecturers to adopt PBL in the various engineering curricula. Successful outcomes of PBL in the subject *Process Control and Dynamics*, which is the most important evidence in gaining the acceptance of lecturers and faculty administrators at the UTM, is also included.

PROBLEM-BASED LEARNING (PBL)

Problem-Based Learning (PBL) is one of the learning strategies that are based on student-centred learning. The implementation of PBL in higher education has been discussed widely in many disciplines, such as medicine, engineering, education, etc. In 1969, McMaster University in Canada introduced Problem-Based Learning (PBL) into its medical school in an effort to provide a multi-disciplinary approach to medical education and to promote problem solving in its graduates [1].

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. 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 that they require. PBL practitioners often claim that their learners are more motivated and independent in their learning.

PBL is based on constructivist learning theory. It is suggested by a number of proponents of PBL, notably by Savery and Duffy, that PBL is consistent with current philosophical views of human learning, particularly constructivism [2]. According to constructivism, learning occurs when learners construct their own knowledge or understanding based on their prior knowledge, environment and previous experiences [2]. Hence, an approach like PBL, which encourages self-directed learning and knowledge construction, the evaluation of personal understandings and interpretations against those of others, and ongoing cognitive restructuring, is perceived as congruent with learning theory. PBL might be considered as one practical actualisation of constructivist philosophy.

The definition of learning by constructivists is related with the principles of PBL that have elements in common with those of adult learning and life-long learning. In PBL, students use their existing knowledge in order to learn, rather than being treated as a *blank slate*. The process of enquiry fosters self-directed learning; and students *learn how to learn* so that they are better able to apply problem-solving to new situations in the workplace and in the community [3].

Many researchers have shown the effectiveness of PBL in enhancing students' performance in learning. The results of 43 empirical studies on PBL in tertiary education suggest that students in PBL are better in applying their knowledge as they suggest a robust positive effect from PBL on the skills of students [4]. In engineering, PBL was recommended and implemented, particularly because it promotes deep learning and problem-solving skills [5][6]. Other engineering implementations also noted enhanced generic skills and the promotion of positive attitudes among students who had gone through PBL [7][8].

Essentials of PBL

PBL is a philosophy that has to be adapted to the specific conditions and situation of an 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 [9].

Nevertheless, there are essential features of PBL. The starting point of learning in PBL is a realistic, if not real, problem. 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. It is essential to note that PBL is not only about giving problems and solving them in the classroom, but it is also *about creating opportunities for students to construct knowledge through effective interactions and collaborative inquiry* [9].

In PBL, the lecturer is a facilitator or coach, whose role is to make the learning process visible, instead of making the content visible as in traditional lectures. Since assessment drives learning, the modes of assessment must also be modified to appropriately evaluate students for the desired outcomes that have been designed for the problem.

Students become problem solvers who have to be actively involved in the learning process. Students being exposed to PBL for the first time must be prepared and motivated. It is absurd to expect students to readily have the skills for PBL, especially when they have been experiencing traditional lectures. Therefore, students must be exposed to skills like teamworking and problem solving prior to engaging in PBL.

PBL in the Curriculum

There are several strategies that can be utilised to infuse PBL in the engineering curriculum. The strategies employed depend upon the readiness and empowerment of the academic staff, as well as the facilities that are available. Figure 1 illustrates three approaches to infuse PBL in the curriculum as suggested by Tan at the mega, macro and micro levels [9].

Implementing PBL at the mega level requires high-level commitment, not only from all levels of administration, but also from academic staff. As shown in Figure 1, an example of such an implementation is when students undergo the entire third year of a programme, or an entire programme in PBL. This would require a major revamp of the course curricula that should be aligned to the programme's objectives and outcomes.

At the macro level, certain subjects in the curriculum are designated to be taught utilising PBL. Formally designating subjects ensures that PBL will be consistently implemented, no matter who is in charge of the subject. A macro implementation requires departmental approval and the commitment of the lecturers teaching the subject. Subjects that are offered in multiple sections would require coordination between lecturers.

A micro-level approach requires the least amount of resources and coordination. This is where PBL can be used as a methodology for certain topics in a course within a certain amount of time. Hence, this approach is highly recommended for those who are trying out PBL for the first time.

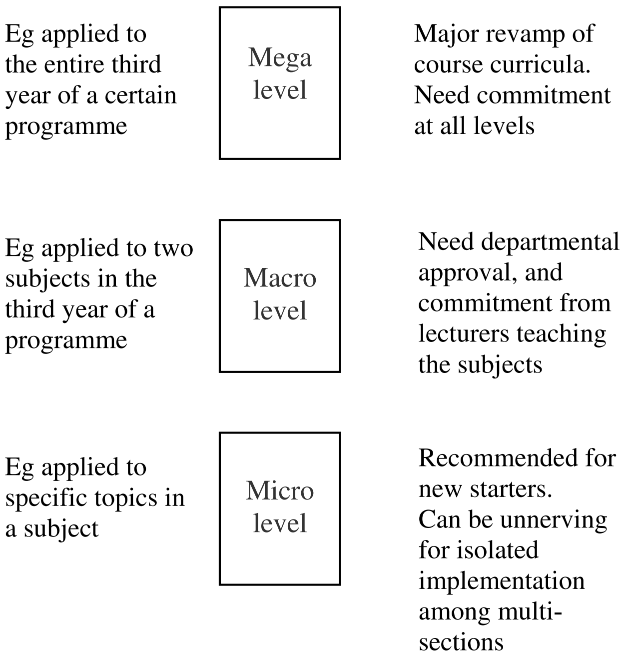

Figure 1: Different approaches of infusing PBL.

LAYING THE GROUNDWORK

A gradual, non-drastic approach has been taken to raise awareness and educate lecturers and students on key techniques during the groundwork period, which took about two years. A group of student-centred lecturers were chosen to form a central committee, called the Active Learning Taskforce, to facilitate the promotion of PBL to all levels of the academic community at the UTM. This is a difficult and uncertain period where the taskforce and core-group were moving against the tide to plant the initial seeds of change – the major tasks were to introduce, convince and train. The natural progression is essential in winning academics' hearts and minds, and thus the support of the academic community.

Four initial series of workshops held on PBL had been sufficient for a total of 40 lecturers in the central and faculty core-groups to implement PBL. Meetings were held to update and share information and ideas as pioneers in the University. However, even after these workshops, most of the lecturers who went through the training were apprehensive and reluctant to make the drastic change from lectures to PBL.

Two lecturers in the active learning task force, who were teaching the same subject, decided that a micro-level implementation was needed as an initial trial. Without actually implementing PBL, the concept would remain theoretical, vague and out of reach.

PILOT IMPLEMENTATION AT THE UTM: *PROCESS CONTROL AND DYNAMICS*

Process Control and Dynamics is a required course for fourth year undergraduate chemical engineering students. It is a three credit-hour course, which means that there are three hours of classes per week, for 14 weeks. The course is notorious for the high number of failures (usually around 30%) and low pass grades. The course deals with the mathematical modelling of process dynamics, plus control systems design and an analysis of chemical processes. Students need to understand and visualise a process in operation and relate mathematical theories to the physical reality.

They also need a strong background in mathematics and other chemical engineering concepts, learned earlier, to fully appreciate class materials.

In a typical lecture-based Process Control class, students seemed to understand the materials, but most failed to perform in the quizzes and tests. Queries for questions were normally met with a deafening silence. Asking questions only made students uneasy and they avoided eye-contact. It was also normal to see students nodding off to sleep, especially when the lectures were packed with mathematical derivations and analysis. It is not surprising, therefore, to see studies reporting that students can only recall 70% of the material presented during the first ten minutes and 20% of the material of the last ten minutes [10].

In the first trial, PBL was implemented over a period of four weeks in two of the five sections offered in the first semester of the 2003/04 academic year. Sections 2, 3 and 4 used lectures, while Sections 1 and 5 were taught using cooperative learning and PBL. The lecturers teaching the two sections had undergone the PBL workshops and decided to try and cover some particularly difficult topics in the syllabus with PBL. Section 5 consists of weak students, who usually have low motivation. All sections sit for the same tests and final examination, which were taken individually. All the answer scripts in the tests and examination were graded by the lecturer who set the respective questions to ensure consistency. Details of this first PBL implementation can be seen in Khairiyah et al [8].

Students' Results and Response

The students in both sections had already gone through informal and formal cooperative learning during the first seven weeks of class. Therefore, by the time they were exposed to PBL for the first time, they had already acquired key skills for learning, communicating and completing assignments in a team. All teams also had to overcome the storming stage to reach the norming stage, and some had even reached the performing stage. In order to prepare them further for PBL, a briefing on the definition and stages of PBL was given. The students were given motivation and urged to trust the lecturers.

During the 13th week, all students taking the subject sat for a test, in which question 2 looked at the topics covered using PBL. Figure 2 shows the marks distribution for question 2 of students from all five sections. S1, S2, S3, S4 and S5 refer to Sections 1, 2, 3, 4 and 5, respectively. The average for Sections 1, 2, 3, 4 and 5 were 20.25, 10.85, 9.3, 5.15 and 13.76, respectively. The total marks for the question was 33. Students in Section 1 performed the best among all sections (the lecturer for Section 1 did *not* set the question nor marked the answer scripts). More than 60% of the students in Section 1 scored above 20 for the question. The class average, 20.25, is about twice the highest average for lecture-based classes. The performance of students in Section 5 was a pleasant surprise. Although most of their marks were clustered around 5 to 15, more than 40% of the students in Section 5 scored higher than 15, and only about 5% scored less than 4. With an average of 13.76, students' performance was better than for the lecture-based sections.

A questionnaire was given to students to assess their perception of PBL and to determine if PBL had helped improve their generic skills. The results are summarised in Table 1. The summary of questions are listed in the first column, and the percentage of students giving positive and negative response for Sections 1 and 5 (ie S1 and S5) are tabulated in the

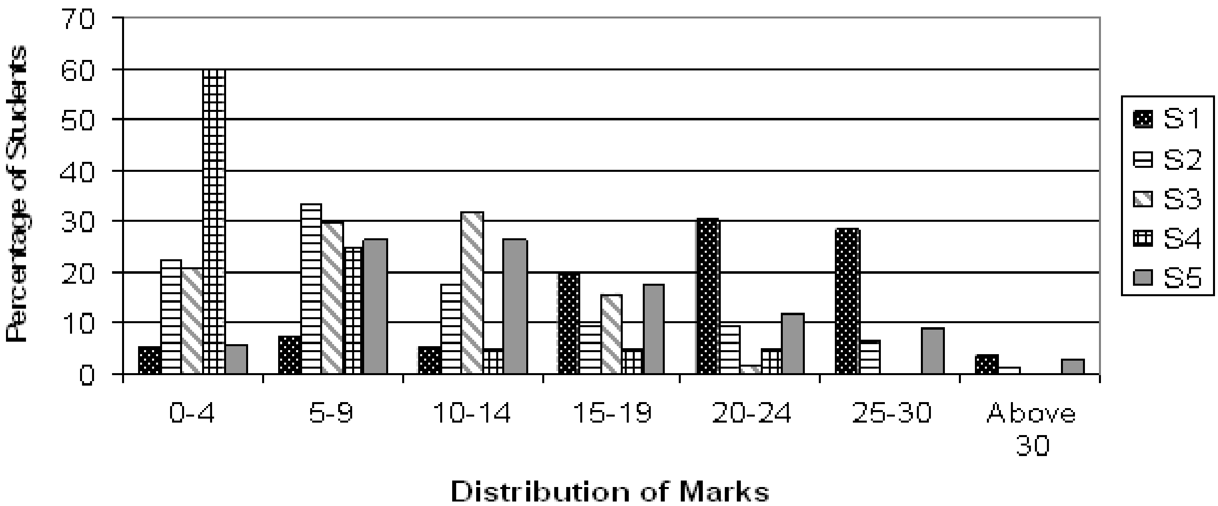

Figure 2: Distribution of marks for question 2 (PBL topics).

Table 1: Results of the questionnaire.

Questions Posed (Simplified)	Positive		Negative		Undecided	
	S1	S5	S1	S5	S1	S5
Feelings on PBL?	65	75	8	2	33	17
Learned more in PBL compared to traditional lecture?	73	79	17	13	10	8
Recommend PBL in other subjects?	96	96	4	4	0	0
Attend another course using PBL?	95	94	0	6	5	0
Problem-solving ability	76	96	15	4	9	0
Self- directed learning and motivation	87	96	7	4	6	0
Interaction and teamwork skills	89	100	7	0	4	0
Self-confidence	70	84	18	8	12	8

respective columns. Those who gave both positive and negative responses, or those who were undecided, are grouped under the *Undecided* columns for S1 and S5.

Referring to Table 1, students, on the whole, viewed PBL positively. It is interesting to note that, although the percentage of those who were totally positive about PBL was not very high, the percentage of students who would recommend that other subjects use PBL and would like to attend more classes with PBL was very high (nearly 100%). This is because even though some students were undecided, they would still recommend PBL and realise that they can benefit from PBL.

Those students who liked PBL commented that PBL made the subject more interesting, generating a happy and conducive environment for learning. They enjoyed *cracking their brains* to meet the challenge of solving the problem, and actually appreciated the knowledge gained. Some were even relieved that PBL stopped the *spoon-feeding* culture. Many of them noted that they learned more systematically, and were better prepared for class. These students also obviously benefited from their groups. They found group discussions to be helpful, and were able to gain a better level of understanding from explaining to, and arguing with, their group members. Some students felt that the quest for information to fill in knowledge gaps to solve the problem provided the motivation for them to think and learn, not just for the sake of examinations.

Those who did not like PBL had stated similar reasons: there was too much work involved in the active learning approach, which depleted their time for other subjects. They also disliked free-riders.

It was found that 73% and 79% of students from Sections 1 and 5, respectively, responded that they had learned more with PBL compared with traditional lecture. An astounding number mentioned that they felt sleepy, bored and lost concentration in traditional classes, and were thus unable to grasp most of what had been lectured. Students who felt that they had learned more in lecture-based classes noted that it depended upon a person's attitude and sense of responsibility. Many students also considered that it was dependent on a lecturer teaching abilities, and if assignments were given.

Most students felt that PBL increased their problem-solving abilities, self-directed learning and motivation for learning, interaction and teamwork skills, as well as level of self-confidence. Some students, who tended to be reserved, claimed that they had become vocal and defended their opinions in group discussions. They were not afraid to offer their view-point, even if their idea might be wrong. Consequently, they did not feel shy to speak up in class anymore. Students also noted that they were able to learn how to tolerate and accept differences, communicate with different people, and had made good new friends, even among different races. Many reported that they felt motivated to learn because they felt responsible towards their group to help solve the problem and contribute in discussions. It was found that 70% and 84% from Sections 1 and 5, respectively, responded that PBL had increased their confidence levels. They felt more confident of themselves to present and face examinations.

In comparing Sections 1 and 5, it is interesting to note that the percentages of positive response for an increase in the stated generic skills are higher for Section 5, which is the class with weaker students. This difference in responses may be because some students in Section 1 felt that they already had the confidence, motivation, problem-solving and communication skills. Therefore, they felt PBL did not make much of a difference in improving their abilities in this regard. The weaker students from Section 5, on the other hand, felt that they have gained a lot from PBL.

It is normal to find students with low self-esteem and low motivation in repeat classes. They usually have difficulty in understanding complex concepts taught in lecture-based Process Control classes. The normal percentage of failure for repeat classes was at least 50%, sometimes as high as 70%. With PBL, these students were able to understand better by actively discussing and undertaking assignments with their team-mates and adopting a more positive attitude. Some students even called up their team-mates in the morning to wake them up for 8:00 am classes. Having others rely on them, and the desire to complete the case study, provided the much needed motivation to learn on their own. All these factors, in turn, increased their self-confidence. These positive changes in outcomes and attitudes were also noted in other studies [7].

SUBSEQUENT IMPLEMENTATIONS

Figure 3 shows the grade distribution of the subject for four semesters taught by the same lecturer using different techniques. The passing mark at the UTM is 40%. For all four semesters, the final examination took up 50% of the total marks because of the requirement from the Malaysian Engineering Accreditation Council. As seen from the graph, there was slightly above 30% failures when lectures were used to teach *Process Control and Dynamics*. In the same semester, the majority of students scored between 40% and 59%.

Figure 3 shows when the teaching and learning mode was changed to active and cooperative learning (CL). The percentage of failures among students dropped to 17%. This time, only 19% of students scored between 40 to 59%. Most of the students in the class obtained overall marks of 60-79%, which is a marked increase from the results of traditional lectures conducted in previous semesters. Another section conducted in lectures in the same semester still had 30% failures and low passing marks.

Referring to Figure 3, the percentage of failures became progressively smaller when the subject was taught using 70% CL and 30% PBL (2%), and then 70% PBL and 30% CL (0%). Most students also scored between 60% and 79%. In the latest semester, less than 18% of students scored below 59%. These are mainly students who did not really participate and did not take full advantage of PBL.

As a consequence of the successful implementations, the Department allowed PBL to be executed in all classes of *Process Control and Dynamics*. To date, up to 70% of the syllabus is covered using PBL, while the rest is covered using CL and mini lectures.

The improvements seen in Figure 2 may be attributed to the CL and PBL combination. Improvements in subsequent semesters may also be due to the better facilitation skills of the lecturer as more experience was gained after several implementations.

FEEDBACK FROM STUDENTS

There were also numerous feedback comments obtained from students. Indeed, students who had experienced PBL after one semester appreciated PBL more once they realised the skills and positive attitudes gained. One student in the first PBL implementation wrote the following:

> *PBL opens my eyes on how university life should be. I was able to view the word*

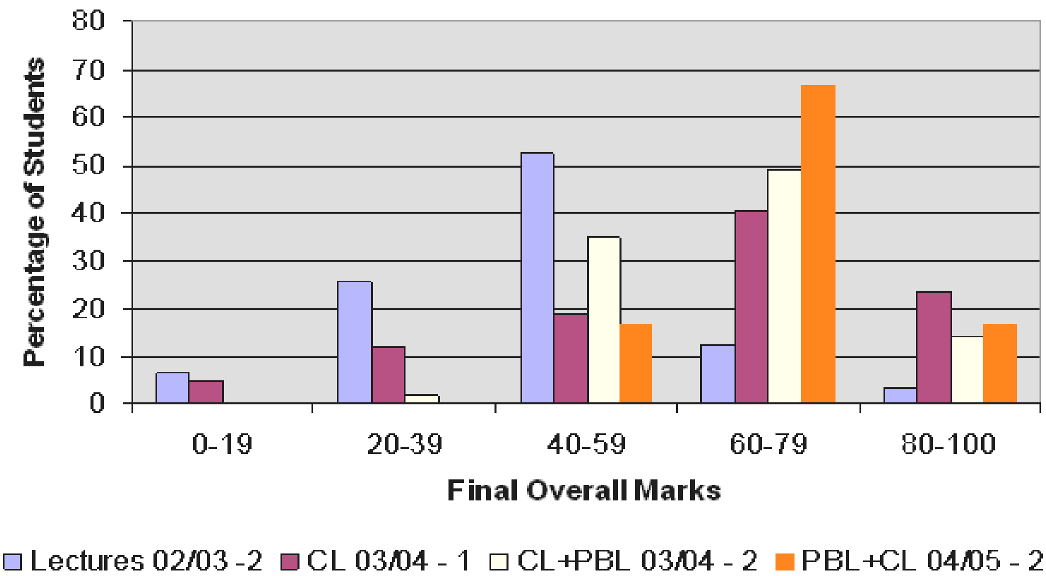

Figure 3: Grade distribution using different techniques.

> study *from a helicopter view. From what I see among my coursemates, PBL did change some of them from exam orientated to a learning style that is not only restricted to the syllabus. I'm able to think outside the box and think further, even though the changes are not drastic, it is a good thing for me.*

Another wrote the following:

> *PBL improved my generic skills. Now I feel more comfortable to work in a group and have confidence to solve problems. At least I won't feel scared when facing a problem that I have never seen before.*

From the response obtained, PBL helped students to mature as learners, although they may initially have resisted (*Now I feel like a student in university, and not in school*). They actually appreciated that they were given the chance to think and explore on their own, and not be spoon-fed (*PBL really works! No spoon-feeding 'coz we're grown-ups. This is the best and most enjoyable class!*).

There were, of course, negative responses, especially in the initial phases, although in the end, there were much fewer; among them: *I hate PBL! I'm here to learn Process Control and not anything else!*

Another comment gave the following strong opinion:

> *PBL? WHAT ARE YOU TRYING TO DO? CHANGE OUR MENTALITY? WHY DON'T YOU CHANGE US FROM THE BEGINNING IN FIRST YEAR? INSTEAD OF IN FINAL YEAR?*

Some students were undoubtedly angry and were unable to accept PBL, especially those who had lagged behind and had to take the Process Control class in their final year instead of earlier. In order to overcome this problem, students are now being prepared for PBL in their first year.

Nevertheless, even though they may dislike PBL, most students could not deny its benefits. Many realised that in applying PBL, the responsibility of learning is being handed back to them, as evidenced in the following comment:

> *I think PBL is good, but students (including me) tend to think negatively about it at first. Even though I dislike it, I have to admit that it brings a lot of good effects instead of bad ones. For me, you'll only get to feel the negative effect if you're not prepared – this means that it's your own fault if you feel PBL didn't help you much, and it's also because of yourself that you gain in PBL. So everything depends on yourself. It teaches me to be independent.*

Weak students were also able to gain much from PBL. Before embarking on PBL, there were concerns among lecturers that weak students would be left behind because they would not be able to learn on their own. However, the opposite actually occurred, as seen by the results in the first implementation. This is further supported by comments made by students who were considered to be weak, as shown in the following statement:

> *I love PBL. It is a different kind of learning. Although I think it is almost* sunset *that I manage to experience PBL, nothing is ever too late. PBL forced me to read. It made me learn, study, read and practice. The most precious benefit I get from PBL is I read. The greatest pleasure I get from PBL is friends. The best thing about PBL is appreciation. I'm now clear about the right strategy to learn; before this, I used to cry. And now, I really know how to communicate!*

In another feedback given by a supposedly weak student:

> *I like PBL because it really makes me work for my studies and I feel smart doing it. Even though I won't score high in my exam or final, I actually understand what control is. I think the essence of studying a certain subject is to understand it properly so you can still refresh it later when working. I strongly feel and believe that PBL helped me increase my acquisition and prepare for my career and life as I learn to cooperate and learn with others, teach others and it really shows that everyone actually has the potential to become a leader. This is the first time I felt that the book I bought is worth it because I have been reading the book all this while. When you understand the subject and love it and enjoy it, only then you gain the motivation to study more.*

CURRENT STATUS

At the UTM, PBL has been implemented across all the disciplines. After the initial implementation in chemical engineering courses, PBL implementation spread out into other engineering fields, such as mechanical engineering, civil engineering and electrical engineering. PBL also has been introduced into other disciplines at the UTM such as social science courses like education and human resource management (HRM).

Educating administrators, lecturers and students on CL and PBL was a major focus. *Road shows* on CL and PBL were held in all faculties to create awareness on the need for change in teaching and learning techniques. Evidence of implementations and outcomes in the form of students' performances and responses were also shared during the road shows. Experience obtained from giving presentations in different faculties have also given exposure and enriched the knowledge of the taskforce members to the different perspectives and problems faced by lecturers. Other than road shows, technical papers and articles have also been written to disseminate information on the techniques and implementation.

Taking a gradual approach, lecturers who were apprehensive of the rather drastic change to PBL are encouraged to implement cooperative learning first. This enabled them to experience facilitating group dynamics and active learning. Then, PBL was implemented at a micro level, ie over a segment of two to four weeks, before moving on to possibly whole-class implementation. After implementing PBL in their respective classes, the lecturers become the faculty champion and resource person, by sharing their experiences. Based on the authors' experiences, this approach, coupled with organising awareness talks to each faculty, has attracted other lecturers to try to implement PBL in their classes and won over faculty administrators.

In promoting CL and PBL at the grassroots level (mainly by word of mouth) by the core group, most found it easier to convince the younger lecturers. Nevertheless, there had been senior lecturers who were initially sceptical, but they somehow turned around and at least agreed with the idea of the need for active learning in the classrooms. Mentoring lecturers in PBL are also took place in some faculties.

The administrators at the UTM have decided to go for PBL by stages, through the bottom-up, top-down approach. Lecturers are not forced, but volunteer to use PBL as one of their teaching approaches. The aim is to have a macro implementation of PBL, with at least 10% of the total contact hours in all undergraduate programmes. Each programme will have to determine the strategic placement of PBL in the curriculum that will yield the greatest impact of its benefits to students. In order to ensure that the plan is implemented, the University administrators are applying subtle pressures on the faculties to report all PBL applications. The Faculty administrators, in turn, are expected to keep track and ensure that lecturers who have received training apply PBL in their classes.

To support the lecturers who want to implement PBL in their classes, regular meetings are conducted with members of the Active Learning Taskforce. A portal is currently being planned to provide ready references, forms and an electronic forum for lecturers interested to discuss PBL. Training on CL and PBL are conducted on a regular basis at the University and faculty levels. Co-teaching and/or mentoring with experienced lecturers are also encouraged. Crucial support from the faculty level allows lecturers who implement PBL to choose a suitable subject, time slot and classroom. In order to ease the burden of lecturers in terms of the increased workload, especially in the initial stages of implementation, student tutors or teaching assistants should be assigned to them. Furthermore, a proper classroom setting is also important because classrooms or lecture theatres with fixed chairs cannot be used for team discussions in CL and PBL.

There is also a move to prepare students for PBL. In the 1st semester of the 2005/06 academic year, first year chemical engineering students were prepared for the skills required for PBL in their *Introduction to Engineering* course. The learning environment in this course is designed to develop skills in teamworking, problem-solving, communication, interpersonal, reflective thinking, self-directed learning and peer teaching. There is industrial involvement in crafting the final PBL case. The company also provides extra incentives for students by sponsoring a challenge trophy for the best PBL team and the best team player, as well as a small token of prize money for the winners.

E-Learning and PBL

In order to ascertain the potential of e-learning in helping the implementation process of PBL, a study was carried out to find out students' perceptions towards PBL through e-learning. E-PBL is the implementation of PBL through any Learning Management Systems (LMS). At the UTM, Moodle, an open-source LMS, is used. Through e-learning, learning can take place anywhere and anytime through the communication tools that it has. The study was conducted in the Faculty of Education at the UTM in Skudai [11].

The findings from the case study show that students often feel that the use of PBL through e-learning is relevant in their studies and future work (mean = 4.19). The highest mean score is 5 based on a 5-point Likert Scale. For other factors, such as reflective thinking (mean = 3.69), interactivity (mean = 3.26), tutor support (mean = 3.87), peer support (mean = 3.24), interpretation (mean = 3.59), the means were less than 4 but above 3 [11].

Students also felt that some e-learning tools, such as electronic fora, chatting and electronic journals, help the process of implementing PBL. E-learning is needed to help in the implementation of PBL among university students, especially in the discussion session. Through e-learning, the problem can be posted earlier before the lecture session starts. In addition, discussions among students and students and between students and a lecturer can be continued outside the class.

FINAL REMARKS

On the whole, the move towards encouraging lecturers to adopt PBL seemed rather sluggish, especially in the initial stage. This is because time is needed for those initiating the change to be trained, implement and gain experience in the techniques. Time is also needed for others to be convinced and to prescribe the change. Most importantly, those promoting the technique must be able to show evidence that PBL is effective for engineering education.

The Active Learning Taskforce and core groups are well aware of the efforts, patience, determination and resilience required to successfully promote University-wide implementation of PBL. Nevertheless, with clear intention, goals and plan of action, coupled with support from the highest level of the University's key personnel, the Taskforce and core groups are optimistic that a well-coordinated University-wide implementation of PBL will materialise in the near future.

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