

## Outcomes of Problem-based Learning (PBL) Implementation from Students' Perspectives

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### Abstract

Problem-based Learning (PBL) is known to develop and enhance generic skills. The prevailing question is whether the same benefits can be seen for “passive” Malaysian students. In the 2004/05-2 semester, fourth year chemical engineering undergraduates who took Process Control and Dynamics, which was taught using PBL, were surveyed at the end of the semester to assess the generic skills outcomes. The result was overwhelmingly positive, with most of them agreeing or strongly agreeing that PBL had developed or improved their generic skills. The outcome of this study had positively shown that PBL was just as effective even in the supposedly passive Malaysian education culture.

*Keywords: Problem Crafting; Effective Problems; Engineering Education; Problem-Based Learning; UTM Experiences*

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### 1. Introduction

Problem-based learning (PBL) is gaining acceptance in engineering education world-wide [1]. PBL is favored because it promotes deep learning as well as enhances generic skills, which are highly desired by employers [2]. In the last two years, the move towards student-centered instruction, including PBL, has been picking up pace in Malaysia.

The onset of outcome-based education (OBE) as a requirement for accreditation for engineering programmes in Malaysia is creating further interest on PBL. Under OBE, in addition to knowledge in the specific engineering disciplines, graduates must be equipped with generic skills, such as communication, problem solving, life-long learning, team-working and ethics. As a teaching methodology, PBL can be designed to fulfill not only the content requirements, but also the generic skills required under OBE. However, given the passive nature of Malaysian students, there are doubts whether PBL can yield the outcomes as in western countries.

In Universiti Teknologi Malaysia (UTM), there are pockets of PBL implementations in several faculties [3, 4, 5]. In the Faculty of Chemical and Natural Resources Engineering, UTM, PBL is implemented to cover 70% of the Process Control and Dynamics subject, which is a subject for fourth year Chemical Engineering undergraduates. At the end of the pioneering multi-section macro implementation during the 2004/05-2 semester, a survey was carried out to assess students' perspective on generic skills gained from PBL. In this paper, the results of the generic skills outcomes surveyed on is presented and discussed.

### 2. Problem-based Learning (PBL)

Problem-based learning (PBL) is a philosophy that can be translated to design a teaching and learning environment to develop the desired essential skills in engineering graduates. In PBL, learning is initiated through a realistic problem that has engaged the learner to find a solution [6, 7]. Students collaborate in small teams to identify, find and construct knowledge on new concepts that they need to learn in order to solve the problem. However, the students are by no means left on

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their own without being guided. In PBL, lecturers become coaches to facilitate students through the PBL process. Students must be properly facilitated during the problem identification and synthesis stage. Lecturers must also give feedback during the problem presentation and provide a closure at the end of the PBL case.

There are many benefits of PBL on students. Among them are [6]:

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

Nevertheless, there are many issues that must be thought out, planned, researched and checked for a successful PBL implementation. It is also important to note that PBL is not a “one-size fits all” strategy [8] that can be copied from one institution to another without taking into account the background and the system of the specific institution. Thus, monitoring of the process and outcomes must be regularly carried out.

### 3. Process Control and Dynamics

Process Control and Dynamics is a three credit hour subject for fourth year undergraduate chemical engineering students. Three to five sections of the same class are offered each semester, with a maximum number of 60 students per section, each taught by a different lecturer. The subject deals with mathematical modelling of process dynamics, and control systems design and analysis of chemical processes. The systems that are dealt with in the class range from simple equipment, such as storage tanks, heated tanks, heat exchangers, and furnaces, to more complex ones such as distillation columns, reactors, dryers and evaporators. Students need to understand and visualize a process in operation, and relate mathematical theories to the physical reality. This is the first time that they have to deal with processes in dynamics instead of steady-state. Thus, students need a strong background in mathematics and other chemical engineering concepts, learned earlier, to fully appreciate the class material.

The subject is notorious for the high number of failures (usually around 30%, sometimes as high as 45%), low passing grades (mostly in range of 40-50%)

and a challenging content. Those who fail mentioned that they do not understand the material, and those who passed with low passing grades indicated that they barely understood the material and did not have good understanding of the subject. Many who graduates prefer to forget the subject.

### 4. Survey of Outcomes

In the 2004/2005-2 semester, all three sections of the Process Control classes offered were synchronised to be covered using PBL (about 70% of the syllabus) and the rest using cooperative learning (CL) and mini lectures. Each section had a maximum of 60 students. The total number of students from the three sections was 170.

At the end of the semester, after taking their final examinations, a survey was made during a forum between the students who had undergone PBL and top academic administrators of UTM to evaluate the outcomes of the Process Control class using PBL. The questions in the survey may be grouped into the following areas:

- Self-directed learning. This category includes interest and motivation for learning, knowledge integration, as well as real-world application of knowledge.
- Information mining. This category includes finding information from different sources, and technical reading skills.
- Team-working. This category includes listening and accepting ideas from others, and adapting to different kinds of people.
- Communication. This category includes being able to convey and defend ideas, as well as explain technical concepts.
- Problem solving and thinking skills. This category includes problem solving, critical thinking and having multiple views of a problem.
- Self esteem. This category includes confidence and self-worth.

The highest mean score of the survey was 5, based on a 5-point Likert scale. There were 151 respondents out of a total of 170 students.

### 5. Results and Discussion

The results of all questions in each category surveyed were calculated in the form of the mean score. A mean score greater than 3 signifies a positive response, while a mean score that is less than 3 denotes a negative one.

The distribution of response for two statements in each category is also shown.

In the self-directed learning category, the students agreed that PBL helped them understand the subject (mean = 4.0), learn new concepts on their own (mean = 3.9), relate subject to industrial application (mean = 4.1), increase interest in the subject (mean = 3.8), and integrate knowledge from different areas (mean = 3.9).

Figures 1 and 2 shows distribution of the students' response to two statements under this category. Referring to the distribution, nearly 80% of the students agreed or strongly agreed that PBL helped them understand the subject. This is indeed gratifying, considering the response of students when the subject was taught using lectures. Furthermore, more than 80% of the students were able to relate the subject to real-world application. For both questions, less than 5% of the students disagreed or strongly disagreed.

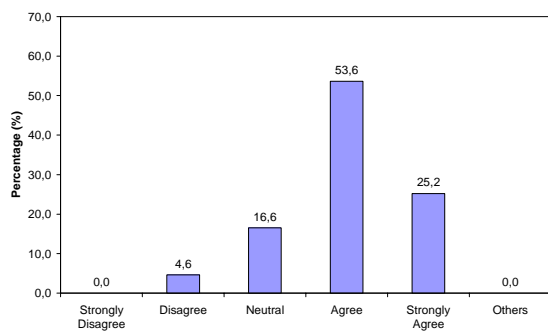


Figure 1. Distribution of response for the statement: PBL is effective in helping me understand the subject.

Under the information mining category, students agreed that PBL increased their ability to find information from different sources (mean = 3.8), and increased their ability to read and comprehend technical material (mean = 3.8). The distribution of response for both statements are shown in Figures 3 and 4.

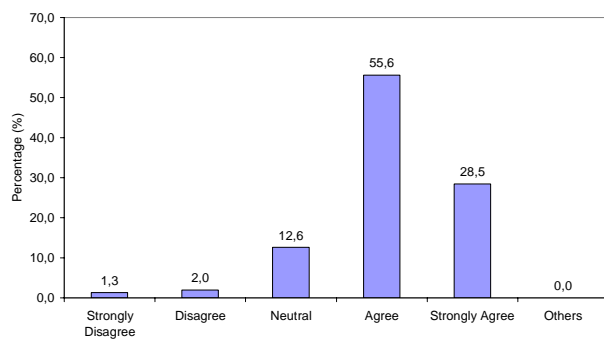


Figure 2. Distribution of response for the statement: PBL is effective in helping me relate this subject to industrial application.

Referring to Figures 3 and 4, nearly 70% of the students agreed that there was an increase in their ability to find information from different sources, and slightly more than 70% agreed that they had improved their reading and comprehension of technical material. This does not only signify their self-directed learning ability, but it also shows that the students were able to be independent in learning. In the lecturers' previous experience while conducting lecture based classes, it was very difficult to get students read text books on their own. Most would give the reason that they simply could not understand what they had read and just give up after the first try. Using PBL, however, had managed to force and motivate students to read and acquire the ability to comprehend seemingly impossible technical material.

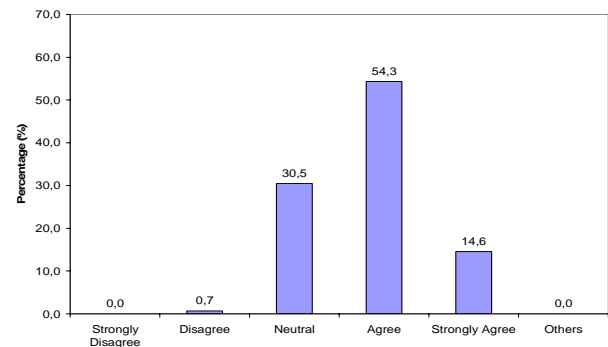


Figure 3. Distribution of response for the statement: PBL helps me to increase my ability to find information from different sources.

In team working, many of the students strongly agreed that PBL improved their ability to work in a team as a responsible team member (mean = 4.4), and adapt with students from different backgrounds and abilities (mean = 4.4). They also agreed that PBL improved their ability to listen and accept other people's opinions and criticisms (mean = 4.0), and deal with conflicts within their teams (mean = 3.8). Figures 5 and 6 illustrates the distribution of response for two statements under this category.

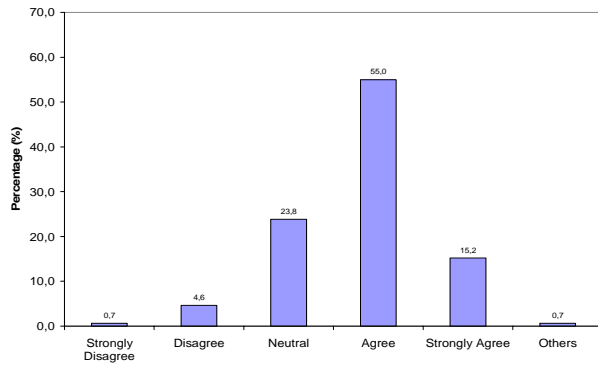


Figure 4. Distribution of response for the statement: PBL helps me to improve my reading and comprehension on technical material.

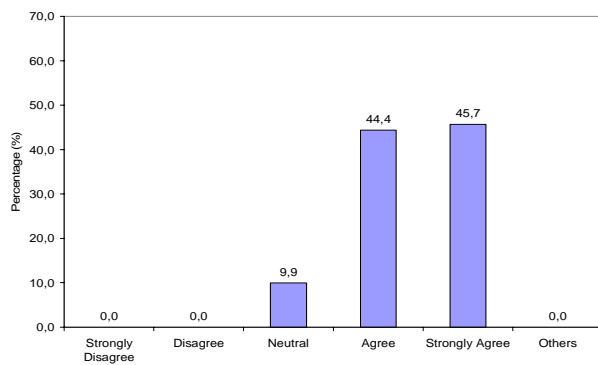


Figure 5. Distribution of response for the statement: PBL improved my ability to work in a team as a responsible member.

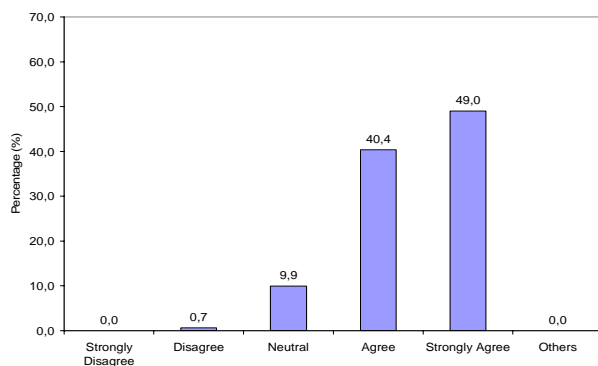


Figure 6. Distribution of response for the statement: PBL improved my ability to adapt with students from different backgrounds and academic abilities.

Referring to Figure 5, more than 90% of students agreed or strongly agreed that their ability to be a responsible member of a team increased (more than 45% strongly agree), and none of them disagreed. Referring to Figure 6, nearly 90% of students agreed or strongly agreed that they have improved their ability to adapt with students from different backgrounds and academic

abilities (49% strongly agreed), and less than 1% disagree. In fact, many students express satisfaction in being able to closely work with students of different races. Some had also expressed that they were able to have more patience and come to a compromise in working with students that have different capabilities as well as targets.

In communication, students agreed that PBL improved their ability to convey and defend their ideas to their friends (mean = 3.9), and explain and describe technical concepts (mean = 3.8). The distribution of response for both statements are shown in Figures 7 and 8.

Referring to Figures 7 and 8, more than 70% of the students agreed that they had improved their ability to convey and defend their ideas, as well as explain technical concepts. Although more than 60% agreed, slightly less than 15% strongly agreed and less than 3% strongly disagreed. This is because most of them felt that they still need to improve and practice more in this aspect. Since communication is a skill that needed to be developed more opportunities provided by PBL is required.

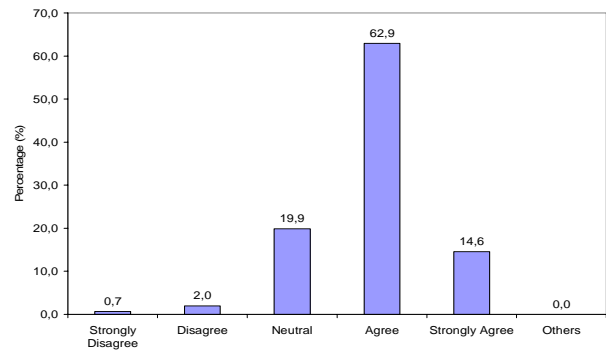


Figure 7. Distribution of response for the statement: PBL improved my ability to convey and defend my ideas and opinions to my friends

In the problem-solving category, most students agreed that PBL improved their ability to solve technical problems systematically (mean = 3.8), as well as think critically and view problems from different perspectives (mean = 3.9). Figures 9 and 10 illustrates the distribution of response for both statements.

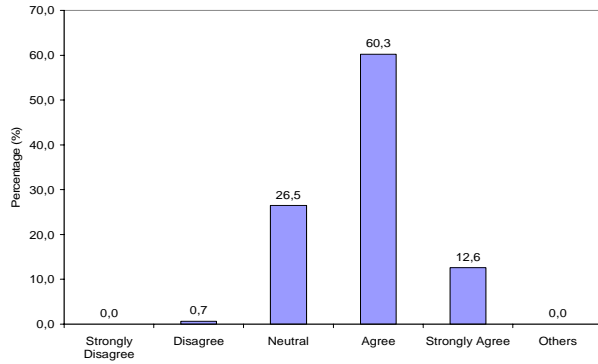


Figure 8. Distribution of response for the statement: PBL improved my ability to explain and describe technical concepts.

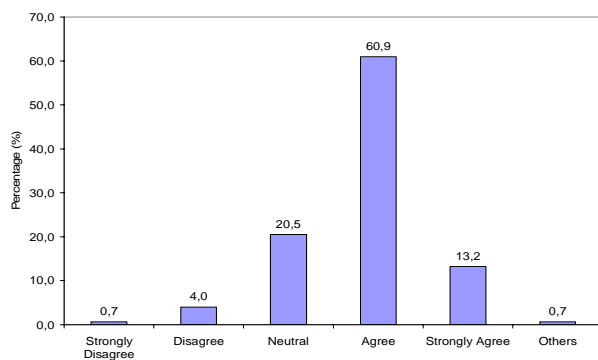


Figure 9. Distribution of response for the statement: PBL improved my ability to solve technical problems systematically.

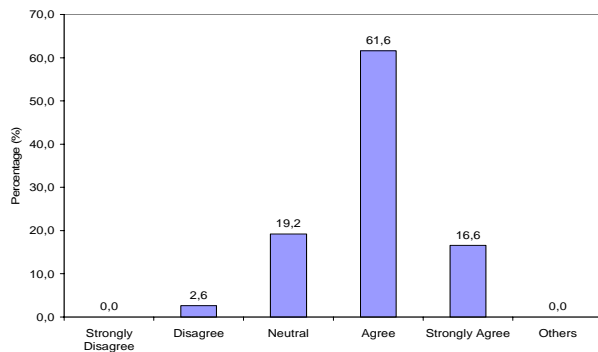


Figure 10. Distribution of response for the statement: PBL improved my ability to think critically and view problems from different perspectives.

Referring to Figures 9 and 10, about 75% of the students agreed or strongly agreed that their problem-solving and thinking skills had improved. Similar to communication, these skills require time to develop and nurture. This is the reason most of the students (more than 60%) agree, rather than strongly agree with the statements.

Finally, in self-esteem, most the students agreed that PBL helped them develop confidence in their decision

making process (mean = 3.8), helped them realise they were capable of accomplishing difficult tasks (mean = 3.8), and gave them a sense of satisfaction and accomplishment (mean = 3.8). Figures 11 and 12 shows the distribution of response for two of the statements in this category. Referring to the figures, about 70% of the students agreed that PBL helped them develop confidence in their decision making process and gave them a sense of satisfaction and accomplishment. Only less than 3% of the students disagreed or strongly disagreed.

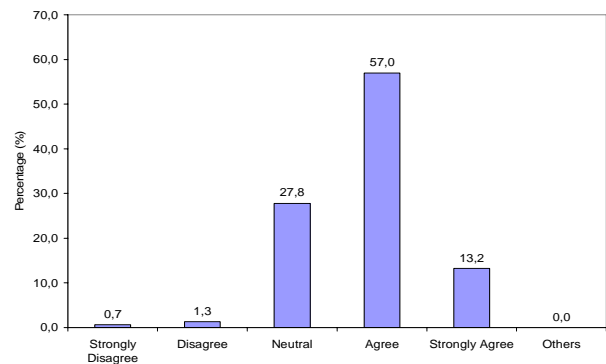


Figure 11. Distribution of response for the statement: PBL helps me to develop confidence in my decision making process.

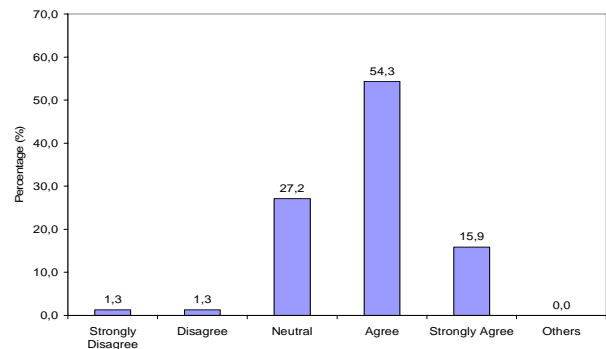


Figure 12. Distribution of response for the statement: PBL gives me a sense of satisfaction and accomplishment.

On the whole, the feedback on generic skills acquisition as a consequence of PBL was overwhelmingly positive. The highest mean achieved, 4.4, was on team-working. The lowest mean, at 3.8, was still considered to be high on the positive side. Most of the outcomes that scored a mean of 3.8 had a smaller number of those that strongly agreed, which indicates that more could be and should be done in the corresponding skill to enhance it further. Nevertheless, the percentage of those who disagreed or strongly disagreed remain small – most of the time at less than 5%, which was acceptable. This was expected since a small number of students were not happy and did not

participate much in the PBL process. Thus, they were unable to gain the benefits as those who had participated.

## 6. Conclusion

Based on the survey of students who took Process Control and Dynamics, PBL was found to be effective in developing and enhancing generic skills in students. The mean score ranged from 3.8 to 4.4, showing a highly positive inclination of the students in agreeing that their generic skills had improved as a result of PBL.

For all the generic skills surveyed, more than 70% agreed or strongly agreed, and less than 5% disagreed or strongly disagreed with the statements given. This shows the overall satisfaction among students who had undergone PBL in developing their skills. The small number of students who disagreed was acceptable, since it would be impossible to please all of them. From the study, it is clear that “passive” Malaysian students could accept, and flourish with PBL.

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